A mixed-methods evaluation of the 'Closer to Home' community intervention programme for preventing frail and elderly hospital admissions in NHS Forth Valley

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Signed: *Maria Cristina Martin*
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Publications derived from this research

The research presented in this thesis is partly based on the following publications, which arise from the author's original research and where the author was the main contributor.

- Martin, M.C., Bouamrane, M.-M., Kavanagh, K. and Woolman, P., 2017. Preventing frail and elderly hospital admissions: developing an evaluation framework for the 'Closer to Home' quality improvement programme in NHS Forth Valley. In: *Proceedings of the 2017 International Conference on Digital Health (DH '17)*. New York, NY, USA: Association for Computing Machinery. pp.231–232. DOI: http://dx.doi.org/10.1145/3079452.3079481
    - This paper provides a framework for the evaluation of the 'Closer to Home' programme described in more detail in Chapter 2.
- Martin, M.C., Bouamrane, M.M., Woolman, P., Kavanagh, K. and Young, D., 2019. Characteristics and hospital activity of elderly patients receiving admission avoidance home visits: A population-level record linkage study. In: *Studies in Health Technology and Informatics - MEDINFO 2019: Health and Wellbeing e-Networks for All*. [online] International Medical Informatics Association (IMIA) and IOS Press.pp.556–560. DOI: https://doi.org/10.3233/SHTI190284
    - This paper provides a preliminary analysis investigating the baseline characteristics of the full research cohort.
- Martin, M.C., Bouamrane, M.M., Kavanagh, K and Woolman, P., A mixed methods evaluation of the 'Closer to Home' admission avoidance home visiting programme in Scotland. (in draft)
    - This paper presents the main results of the mixed methods evaluation including the qualitative enquiry utilising normalisation process theory and the quantitative retrospective cohort study

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forward to one day telling you about this journey and thanking you for being a good napper and a little light of encouragement.

Abstract

Due to increasing pressures on healthcare services resulting from unscheduled care, healthcare providers are increasingly seeking to develop alternative care pathways to reduce avoidable hospital admissions for frail and elderly people. Previous research indicates mixed results on the effectiveness of such programmes. This thesis reports the results of a mixed-methods evaluation of a community-based programme called *'Closer to Home'*, aimed at preventing hospital admissions among frail and elderly people living in the NHS Forth Valley health board in Scotland.

The evaluation sought to 1) understand the structures and operational processes of the programme, 2) identify whether participation was associated with reduced hospital activity outcomes and 3) understand the benefits and barriers to implementation. The methods used in the evaluation included process mapping in an exploratory research phase to understand the programme processes, a scoping literature review to identify key features of previous studies evaluating community-based admission avoidance interventions, a quantitative retrospective cohort study evaluating the programme's effect on hospital activity outcomes and a qualitative study using Normalisation Process Theory (NPT) to analyse stakeholders' perspectives on the programme implementation.

This research found no evidence to support the hypothesis that the programme is associated with reduced hospital activity, but it also highlighted the difficulty in objectively evaluating such programmes due to non-randomised roll-out, characteristic of community-based interventions. Healthcare professionals however, perceived clear benefits in the provision of 'Closer to Home' services extending beyond merely preventing hospital admissions.

This research provides the first comprehensive mixed-methods evaluation of a hospital admission avoidance programme within NHS Forth Valley. It is clear that 'Closer to Home' services have a key role to play in the local healthcare ecosystem but that the lack of full integration into the healthcare system prevented them from reaching their full potential and that the assessment of such services against healthcare resource use provides a limited view of the associated

benefits, highlighting the need to expand the focus of evaluation of such programmes on outcome measures that capture wider impacts.

Contents

Clarification of terms and abbreviations

The following key terms and abbreviations used throughout this thesis are outlined as a reference for the reader.

NHS Forth Valley: A National Health Service (NHS) health board area located in the central area of Scotland.

Reshaping Care for Older People (RCOP) programme[1]: A Scottish government strategic programme supporting the vision that older people "are valued as an asset, their voices are heard and they are supported to enjoy full and positive lives in their own home or in a homely setting."

'Closer to Home' programme: A collective of community-based interventions aimed at avoiding unnecessary hospitalisation for frail, elderly patients in the NHS Forth Valley health board of Scotland. Its three main components are the Enhanced Community Team (ECT), GP Fellows programme and the Advice Line for You (ALFY).

Enhanced Community Team (ECT): A component of the 'Closer to Home' programme comprising a multidisciplinary team whose main aim is to avoid unnecessary hospitalisations for frail and elderly people through provision of equivalent home- and community-based medical care for medical conditions that can be effectively treated in a community setting.

GP Fellows: A fellowship programme for GPs in training, aiming to bridge the gap between primary and secondary care. GP Fellow became a core aspect of the ECT, providing additional support and medical expertise to the multidisciplinary team.

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[1] NHS Scotland, The Scottish Government and COSLA, 2011. *Reshaping Care for Older People: A Programme for Change 2011-2021*. Available at: <https://lx.iriss.org.uk/content/reshaping-care-older-people-programme-change-2011-2021>

Advice Line for You (ALFY): A component of the 'Closer to Home' programme aiming to prevent unnecessary hospital admissions through a nurse-led telephone advice line providing medical advice, referral to onward services for people over the age of 65.

Information Services Division (ISD) Scotland: a division of NHS Scotland providing health information and intelligence, supporting quality improvement in health and care

SPARRA (Scottish Patients at Risk of Readmission and Admission)[2]: a risk prediction tool developed by the Information Services Division in Scotland, predictive of a person's risk of emergency hospitalisation within the next year

[2] NHS National Services Scotland, 2012. *Scottish Patients at Risk of Readmission and Admission (SPARRA): A Report on the Development of SPARRA Version 3*. [online] Available at: <https://www.isdscotland.org/Health-Topics/Health-and-Social-Community-Care/SPARRA/SPARRA-Model/>

Chapter 1 Introduction

1.1 Motivation

Population ageing has been described as a defining characteristic of developed countries (Crilly, 2007). Based on 2014 National Population Projections, the Office for National Statistics reported that the population of over 75s in the UK would rise from 5.2 million in 2014 to 9.9 million by 2039 (90.4% increase) (Office for National Statistics, 2015). In Scotland these figures are expected to increase from 0.43 million to 0.8 million (85% increase). In the first ten years of the projection period in Scotland, this population is expected to rise by 29% (0.43 million in 2014 to 0.56 million in 2024) (National Records of Scotland, 2015).

The implications on health and social support systems have prompted governments to place increased priority on developing programmes aimed at providing alternatives for elderly patients requiring additional care. In Scotland, ageing issues prompted the Scottish government to develop the 2011-2021 'Reshaping Care for Older People' strategy, with the vision that 'older people in Scotland are valued as an asset, their voices are heard and older people are supported to enjoy full and positive lives in their own home or in a homely setting' (NHS Scotland, The Scottish Government and COSLA, 2011, p.5)

A wide variety of interventions have been developed as a result, at different stages of the patient journey (Levin and Crighton, 2017). Common among these are integrated care initiatives, which bring together care services "either by vertically integrating between acute and community and social care or horizontally across acute services" and are usually complex, with several inter-connected parts (Kumpunen et al., 2019, p.4). Admission avoidance programmes are among these integrated care initiatives, bringing together multidisciplinary teams to provide hospital-level care in the community and home, as an alternative for older patients requiring acute medical care. One such programme developed under the 'Reshaping Care for Older People' strategy in Scotland, is the 'Closer to Home' programme, a collection of initiatives implemented in NHS Forth Valley aimed at providing community and home-based alternative for elderly patients who may otherwise require unscheduled secondary care medical assistance.

The effectiveness of integrated care and admission avoidance programmes for older people has been of considerable interest to healthcare and health policy researchers in recent years. However, studies evaluating these programmes have thus far found mixed – and at times conflicting – results regarding the effectiveness of these programmes, particularly around their impact on emergency hospital activity (Liljas et al., 2019; Huntley et al., 2017; Shepperd et al., 2016; Caplan et al., 2012; Low, Yap and Brodaty, 2011; Shepperd et al., 2009a).

This research aimed to evaluate the 'Closer to Home' programme, to understand its impact on emergency hospital utilisation and also to understand the wider impacts and challenges faced by the programme. A mixed-methods approach – using both quantitative and qualitative methods – was employed for this research. This evaluation provides the first comprehensive assessment of a hospital admission avoidance programme within NHS Forth Valley and aims to add to the existing body of research around these programmes.

1.2 Research aim and questions

The overall aim of this research was to provide a comprehensive evaluation of the effect and benefits of the 'Closer to Home' hospital admission avoidance community-based intervention programme, aimed at preventing hospital admissions among frail and elderly people living in the NHS Forth Valley health-board in Scotland.

This work sought to investigate the following research questions:

RQ1. What were the structures and operational processes of the 'Closer to Home' programme?

RQ2. Is participation in the 'Closer to Home' intervention associated with reduced hospital activity outcomes?

RQ3. What benefits and barriers to the 'Closer to Home' intervention were identified by key stakeholders involved in implementation or delivery of the programme?

RQ1 was primarily investigated in Chapter 4 (*'Exploratory Phase and Process Mapping Results'*), using a desk-based review of policy and operational documents of the 'Closer to Home' programme, followed by a detailed process mapping of key services and activities within the NHS Forth Valley health board. The descriptive

analysis of the 'Closer to Home' services use and activity also addressed RQ1 and was presented in Chapter 8. The quantitative study design and methods used to address RQ2 were informed by the scoping review presented in Chapter 5 and the narrative review of quantitative evaluation approaches presented in 0. The data collected and used towards addressing RQ2 was described in Chapter 7 (*'Quantitative Data Collection'*). RQ2 was investigated in Chapter 9 (*'Quantitative Analysis and Results'*) using a 'retrospective cohort study' design and statistical models including logistic and Cox proportional hazards regression to assess the quantitative effect of the programme on hospital activity outcomes. Finally, RQ3 was investigated in Chapter 10 (*'Qualitative Analysis and Results'*), using a theory-based approach to analyse the benefits and barriers to implementation of 'Closer to Home' from transcripts of semi-structured interviews with health and social care staff. The research questions are related to the research phases and thesis chapters in more detail in Chapter 2 (*'Methodological Framework'*).

1.3 Thesis outline

An outline of the thesis is provided below, along with key research contributions.

- **Chapter 2 Methodological Framework**
  introduces the overall evaluation approach and underpinning framework that guided the evaluation along with an overview of the main methods employed at each phase of the project.
- **Chapter 3 Overview of policy context in NHS Scotland and 'Closer to Home' in NHS Forth Valley**
  describes in detail the motivation and national policy context for this research as well as introducing the 'Closer to Home' programme and its local context.
- **Chapter 4 Exploratory Phase and Process Mapping Results**
  outlines the resulting descriptions and process maps developed in the exploratory phase of this research. Its main contribution is to provide an in-depth description and process analysis of the key specific components of the 'Closer to Home' programme as outlined in the evaluation framework for this research (presented in Chapter 2).
- **Chapter 5 Scoping Literature Review**

provides a review of the existing evidence on the effectiveness of community and home-based interventions providing preventative treatment for elderly patients, with the secondary aim of identifying the methods used for evaluation of such interventions. The main contributions of this chapter included: i) a synthesis of the evidence on the effectiveness of community and home-based hospital avoidance interventions and ii) the identification of the scope of methods employed for evaluating these interventions. This chapter was instrumental in further informing the methods employed in this research.

- **Chapter 6 Narrative Review of Quantitative Evaluation Approaches in Observational Research**

  provides the rationale for the specific methods selected for the quantitative evaluation in this research, reviewing a range of existing methods, discussing their suitability and describing the methods selected in this research. This chapter was essential given the wide range of methods available, and the complexities associated with handling confounding in observational research. The main contributions of this chapter included: i) the selection of the 'retrospective cohort study' as an appropriate study design for this evaluation and ii) the identification of methods that effectively handle confounding, including *matching methods and multivariable regression*. In combination with the results from Chapter 5 (scoping review), these findings informed the design of the quantitative analysis (see Chapter 9) employed in this research.

- **Chapter 7 Quantitative Data Collection**

  describes in detail the quantitative data available for use in the evaluation of the 'Closer to Home' programme. The main contribution of this chapter is to provide an in-depth description and documentation of the data pertaining to the programme, including reviewing data quality issues and limitations, as outlined in the evaluation framework for this research (presented in Chapter 2).

- **Chapter 8 Services Use and Activity**

  provides a descriptive analysis of the use and activity of each the 'Closer to Home' services. Its main contribution is to provide insight into the

operational processes of the programme and into the level of reach of the programme.

- **Chapter 9 Quantitative Analysis and Results**
  provides the results of the retrospective cohort studies comparing the effect of each of the 'Closer to Home' interventions on hospital activity outcomes (specifically emergency inpatient hospitalisation, emergency department attendances and emergency inpatient length of stay). The main contributions of this chapter include: i) a quantitative evaluation measuring effect of the 'Closer to Home' programme, which found no evidence that the programme is associated with reduced hospital activity, and ii) a brief discussion of the methodological challenges associated with objectively evaluating such interventions retrospectively.
- **Chapter 10 Qualitative Analysis and Results**
  provides the results of the qualitative analysis of semi-structured interviews with health and social care staff, exploring their perspective on the benefits of the 'Closer to Home' programme and barriers to implementation using Normalisation Process Theory (NPT). The main contribution of this chapter included finding that the benefits of the programme extend beyond merely preventing hospital admissions. However, the benefits were not fully realised due to significant barriers to implementation at scale. As a consequence, the programme was ultimately not successfully embedded into routine care. These results complemented the quantitative results (presented in Chapter 9), providing a more nuanced and in-depth understanding of the lack of effect on hospital activity outcomes observed.
- **Chapter 11 Discussion and Conclusion**
  summarises the main findings of this research, addressing each research question and relating the findings to each other. Reflection on the limitations of this research and its findings is provided and suggestions are made for future work and new avenues of study that emerged from this research.

1.4 Main contribution

The main contribution of this multidisciplinary, health informatics research is the provision of the first comprehensive, mixed-methods evaluation of a hospital admission avoidance programme within NHS Forth Valley. The 'Closer to Home' programme employed new policies and new models of care that had never been implemented before. This research provides the first comprehensive look at the data collected surrounding the programme, the first robust statistical analysis quantitatively evaluating the intervention effect and the first qualitative enquiry analysing the views of those involved in the 'Closer to Home' programme.

This research adds to the existing body of evidence on home and community-based hospital avoidance programmes, namely that the effectiveness of such programmes remains uncertain and subject to local contextual factors and that their evaluation, implementation and full-benefit realisation remain challenging. This research also highlights the practical difficulties in retrospectively evaluating such programmes and highlights the need to expand the focus of evaluation of such programmes on other outcome measures that capture wider impacts than merely healthcare resource use.

Chapter 2 Methodological Framework

This chapter describes the overarching methodological framework used to conduct this research and the six main phases of the framework. The detailed methods employed for each study phase are described at the beginning of each corresponding chapter representing the outputs from the study phases (mapped out in Section 2.1). This chapter describes the overall process and summarises the sequential study phases, providing an overview of the methods employed in each of these phases. It is important to note at the outset that the evaluation work was conducted retrospectively, meaning this research is completely observational.

The six phases of this research were guided by Glasgow, et al.'s implementation science RE-AIM (Reach Effectiveness Adoption Implementation Maintenance) framework for evaluating public health impact in health promotion interventions (Glasgow, Vogt and Boles, 1999).

The use of research frameworks is recommended towards improving research quality as it helps facilitate rigorous evaluation by providing theoretical and practical guidance, helps simplify complex processes and helps to contextualise results among other benefits (Ibragimova and Phagava, 2021; Bradford et al., 2019). The RE-AIM framework is one of the most widely applied frameworks for evaluating the implementation of healthcare interventions (D'Lima, Soukup and Hull, 2022; Fynn et al., 2020). The framework takes a holistic approach to evaluation, aiming to capture the complexities of a system that needs to be evaluated as a whole, and how idiosyncrasies and context affect effectiveness. When conducting this research, the RE-AIM framework was being rolled out within Forth Valley as a standard for evaluation among the governing bodies delivering service redesign in older people's care. These features made RE-AIM an appealing option for use in the 'Closer to Home' context.

Other frequently used frameworks for guiding the evaluation of healthcare interventions which also aim to capture contextual complexities and identify mechanisms for change include the Medical Research Council (MRC) framework for implementing and evaluating complex interventions, the Consolidated Framework for Implementation Research (CFIR) and the realist evaluation approach (Bradford et al., 2019). These and other frameworks have been reviewed

and compared elsewhere (Bradford et al., 2019; Fynn et al., 2020). The main reasons RE-AIM was selected to guide this research over other frameworks were that 1) it is a structured framework with clear components, lending itself to clear reporting and relevant to both process and outcomes meaning it is applicable to a wide range of evaluation objectives (e.g. when compared to MRC and CFIR frameworks) (Fynn et al., 2020), 2) in seeking a guiding methodological framework, it is more comprehensive, systematic and granulated that some more loosely defined frameworks (e.g. realist evaluation) (Kaminska, 2016) but not too broad or highly complex (e.g. CFIR) (Bradford et al., 2019), and 3) there is a wide body of literature on the use and development of RE-AIM, with examples of its application (Fynn et al., 2020).

The use of RE-AIM led to the development of an evaluation framework used for guiding the overall research approach, which has also been described elsewhere (Martin et al., 2017). The evaluation framework consisted of the following aspects:

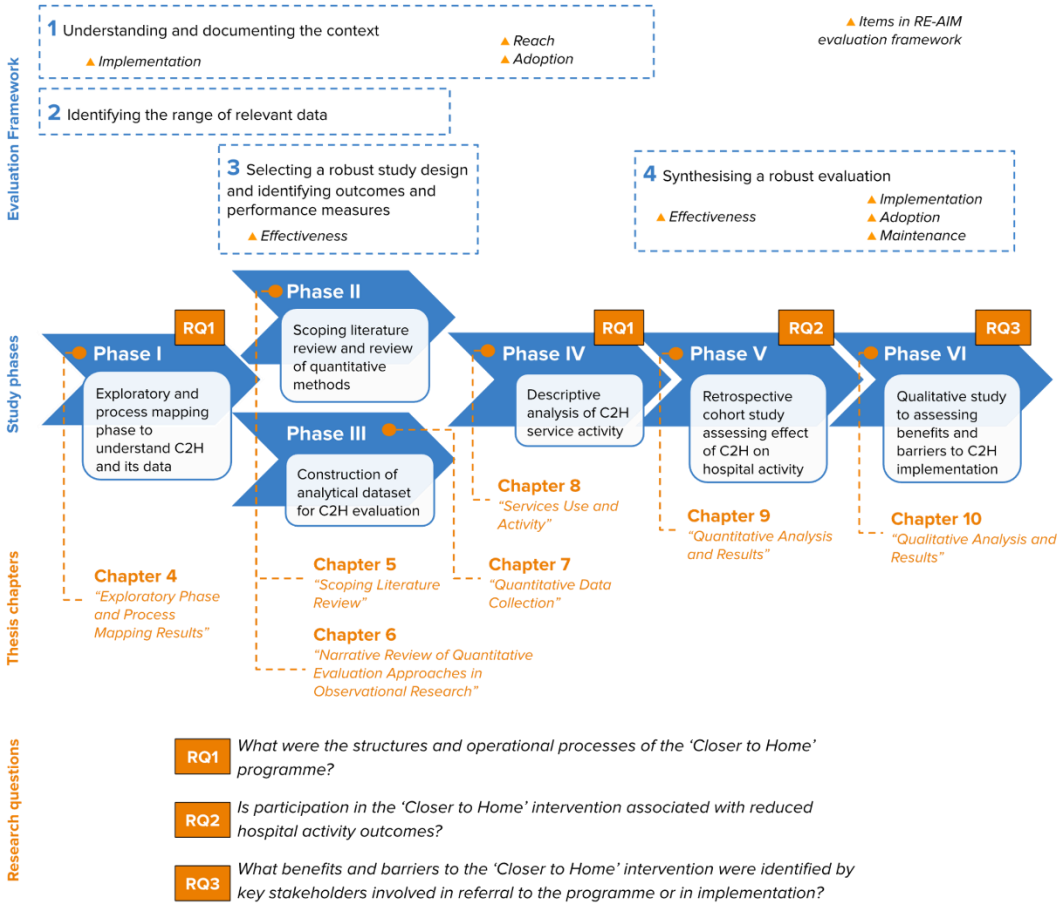
1. *Understanding and documenting the context*
2. *Identifying the range of relevant data*
3. *Selecting a robust study design and identifying outcomes and performance measures*
4. *Synthesising all of the above into a coherent evaluation of the 'Closer to Home' programme*

Several study phases resulted from adopting this evaluation framework as the overall methodological approach. The study phases and how they relate to the evaluation framework are described in the next sections.

2.1 Overview of Study Phases

The study phases along with the corresponding evaluation framework components are illustrated in Figure 2.1.

Figure 2.1 – Study phases and how they relate to the developed evaluation framework for 'Closer to Home,' thesis chapters and research questions



- **Phase I** consisted of an exploratory phase, aiming to provide an in-depth understanding the 'Closer to Home' programme. In addition, the data available in relation to NHS Forth Valley's elderly population and data collection processes were mapped out in this phase. *(Phase I results are documented in Chapter 4 'Exploratory Phase and Process Mapping Results').*
- **Phase II** consisted of a review of the scientific literature which included: i) a scoping literature review to identify key features of previous studies of home and community-based interventions aiming to reduce avoidable hospital admissions *(Chapter 5 'Scoping Literature Review')* and ii) a narrative review of quantitative methods used in observational research *(0 '*

- *Narrative Review of Quantitative Evaluation Approaches in Observational* Research*').*
- **Phase III** occurred in parallel to Phase II and consisted of the development of an analytical dataset for evaluation of the 'Closer to Home' programme using data linkage and cleansing techniques validated through consultations with clinicians and data managers in Phase I *(the construction and resulting datasets are described in Chapter 7 'Quantitative Data Collection').* Phases II and III related to the third aspect of the evaluation framework, to select a robust study design and identify outcomes and measures for assessing effect.
- **Phase IV** consisted of a descriptive analysis of the service activity of the 'Closer to Home' programme service activities, investigating the reach and adoption of the range of services in order to understand and document the programme context *(Chapter 8 'Services Use and Activity').*
- **Phase V** consisted of a retrospective cohort study where elderly patients from the full Forth Valley population were selected based on their exposure to 'Closer to Home' interventions to identify whether receipt was associated with reduced hospital activity outcomes for frail, elderly patients in Forth Valley *(Chapter 9 'Quantitative Analysis and Results').*
- **Phase VI** consisted of a qualitative study involving semi-structured interviews with key stakeholders (healthcare staff involved in implementation or delivery of 'Closer to Home') to identify the benefits and barriers to implementation of 'Closer to Home' interventions in the view of the participants *(Chapter 10 'Qualitative Analysis* and Results*').*

  Phases V and VI comprised the main quantitative and qualitative strands of this research assessing the effect of 'Closer to Home,' which together aim to synthesise the main findings of this research into a robust evaluation of the programme.

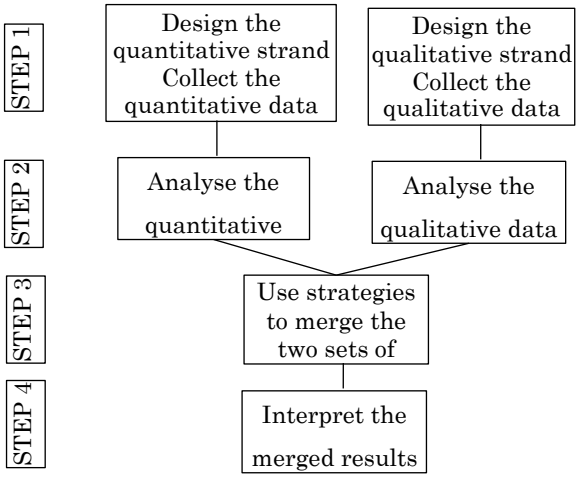
Each of the study phases have been linked to the corresponding research questions it sought to answer in Figure 2.1.

2.2 Mixed methods study design

In accordance with the RE-AIM framework, this research combines both quantitative and qualitative methods in an effort to provide a holistic evaluation of the 'Closer to Home' programme.

The use of mixed methods is widely accepted and recommended as an appropriate study design for the evaluation of complex interventions (Datta and Petticrew, 2011; Blackwood, 2006; Campbell et al., 2000). Blackwood states that "there is international agreement that mixed methods are useful not only in evaluating complex interventions, but also in defining their components" (Blackwood, 2006, p.613), which has very much been the case in this research. Qualitative approaches were required in Phase I to collect information through informal meetings and interviews to develop process maps of the 'Closer to Home' services and visual maps of the available data. The qualitative outputs of Phase I were used to guide the quantitative construction of the analytical datasets. In addition, mixed methods approaches were required throughout Phase III when constructing analytical datasets, through continuous consultation with information services and the 'Closer to Home' service leads validating the quantitative steps taken. Qualitative methods to identify relevant themes as part of the literature reviews' thematic analysis were required in Phase II. Phases IV and V were conducted using quantitative methods. These phases were complimented by the qualitative study conducted in Phase V, for further interpretation of the study results. In practice, the qualitative and quantitative research activities were conducted in parallel as illustrated in Figure 2.2.

Figure 2.2 – Steps involved in mixed methods research (Creswell and Plano Clark, 2011)



2.3 Phases with hypotheses and aims

2.3.1 Phase I – Exploratory and process mapping phase

The first phase of this research was exploratory, intended for the familiarisation with the range and scope of 'Closer to Home' interventions and related data. It involved several informal consultations with service leads and clinicians as well as NHS Forth Valley information services. Two main lines of investigations were followed in this phase: 1) an in-depth description of the context of the 'Closer to Home' services and general elderly care and 2) a review of the data and data collection processes pertaining to the 'Closer to Home' services and elderly patients in Forth Valley. This phase was essential in order to address the first two steps of the evaluation framework: i.e. *i) to understand and document the broader context and ii) to identify the range of relevant data.* Not only was this essential to the following phases, but it was also necessary in order to document the context and potential transferability of the results of this research.

The main outputs of this phase were: process maps and detailed descriptions of each of the 'Closer to Home' services as well as the data collection processes, which are further described in Chapter 4 (*'Exploratory Phase and Process Mapping Results*), addressing the first step of the evaluation framework.

This phase alongside Phase IV, contributed towards answering the first research question ("*RQ1. What were the structures and operational processes of the 'Closer to Home' programme?")*

Phase I Aim:

1. Understand and document the particular structures and operational processes involved in the 'Closer to Home' programme, including data collection processes

2.3.2 Phase II – Scoping literature review and review of quantitative methods

The main purpose of Phase II was to review the scientific literature to further instruct the most appropriate study design for this research, as well as to identify the range of existing models of care and outcome measures used for such evaluation studies. Initially, a scoping review was conducted to identify key features of the studies evaluating home and community-based interventions aiming to reduce avoidable hospital admissions for elderly patients, using a

systematic approach. The scoping review not only enabled the identification of the main study designs and outcomes being used in the assessment of effectiveness of such interventions, but also provided a better understanding of the key features of these interventions and the current evidence of their effectiveness. The results are described in Chapter 5 (*'Scoping Literature Review'*).

Given that this research was limited to observational methods – and partly as a result of the scoping literature – it was further established that quantitative observational study designs and methods are complex, require careful consideration and offer a variety of options, hence a further investigation of the literature on such methods was undertaken. A discussion of these methods and the rationale for the selection of the final study design for the quantitative evaluation are provided in 0 (‘

Narrative Review of Quantitative Evaluation Approaches in Observational Research), including the justification for the selection of:

- The retrospective cohort study design with confounder adjustment
- The use of matching methods, specifically direct matching and propensity score matching where a pre-defined control group could not be determined
- The use of multivariable logistic and Cox proportional hazards regression, particularly a multiple-failure Cox extension model (Anderson and Gill model), accounting for use of matching where appropriate (conditional logistic regression and robust variance estimators in Cox regression)
- A combined approach using causal diagrams and empirical covariate selection to identify potential confounders
- The use of missing data indicators for handling missing data in analysis

2.3.3 Phase III – Construction of analytical dataset

The main aim of Phase III was to construct an analytical dataset that could be used for research. This phase involved thorough study and consultation with information services on all the available datasets pertaining to the 'Closer to Home' programme and the elderly population in Forth Valley, in order to understand the linkages between them and any significant data quality issues. This process resulted in the building of mind maps of relevant databases available within NHS Forth Valley information services along with detailed descriptions, and identification of data quality issues (described in *Chapter 7 'Quantitative Data Collection'*), addressing the second step of the evaluation framework. This phase also involved significant work to develop database queries (Structured Query Language scripts) that processed the raw data into a form that was both usable for research and addressed the data quality issues identified. The aim was to bring together the several data sources identified, containing information relating to the 'Closer to Home' programme and elderly patients in Forth Valley to obtain optimised datasets that could be used for research. The construction of the analytical dataset and its contents are also described in Chapter 7 (*'Quantitative Data Collection'*).

Phase III Aims:

III.1. To gain an in-depth understanding of the relevant data available and the linkages between different data sources

III.2. To identify any data quality issues and take best course of action to resolve or improve them where possible

III.3. To construct an analytical dataset maximising use of available data pertaining to the general elderly population in Forth Valley

2.3.4 Phase IV – Descriptive analysis of service activity

The aim of Phase IV was to describe the service use and activity of the 'Closer to Home' programme, using the research-ready datasets compiled in Phase III. Documenting the use of the service contributes towards understanding and documenting the context, as part of the evaluation framework, specifically providing some insight into the level of reach of the programme. This phase alongside Phase I, contributed towards answering the first research question ("*RQ1. What were the structures and operational processes of the 'Closer to Home' programme?")*

2.3.5 Phase V – Retrospective cohort study assessing intervention effect on hospital use

Phase V involved a retrospective cohort study comparing 'Closer to Home' patients to comparable groups of patients, carefully selecting appropriate control groups for each of the interventions. One of these interventions (the Enhanced Community Team) required the use of matching techniques to identify a suitable group. As determined by the narrative methodological review conducted as part of Phase II, several matching strategies including direct covariate matching and propensity score matching with varying numbers of matches per controls and varying calipers (closeness of matches) were explored and are reported.

Identification of potential confounders for inclusion in multivariable models involved a combination of causal diagrams and empirical covariate selection, as determined by the narrative methodological review conducted as part of Phase II.

The primary analytical method for measurement of effect was a variation of the standard Cox Proportional-Hazards model that enabled time-dependent covariates and repeated measures (Andersen and Gill model also known as the 'counting process' model). Conditional logistic regression was also used in the analysis of the Enhanced Community Team where matched control groups were used and logistic regression was used in the analysis of the GP Fellows programme.

The specific methods employed are described in further detail and the full findings of this phase are reported in Chapter 9 ('Quantitative Analysis and Results'). This study phase directly contributed to answering the second research question ("*RQ2. Is participation in the 'Closer to Home' intervention associated with reduced hospital activity outcomes?").*

Phase V Aims:

III.1. Assess the effect of each 'Closer to Home' intervention on hospital activity outcomes – namely emergency inpatient hospitalisation, emergency department attendance and emergency inpatient length of stay – appropriately accounting for confounding

III.2. Examine the characteristics of the full study population, highlighting key differences

III.3. Identify potential confounders for consideration in any analysis

2.3.6 Phase VI – Qualitative study assessing benefits and barriers to implementation

Phase VI involved a qualitative enquiry into the 'Closer to Home' programme to analyse the implementation process, in particular identifying the main benefits and barriers to implementation. This phase involved semi-structured interviews with 18 key stakeholders in the 'Closer to Home' programme, ranging from clinicians to senior managers and policy makers, specifically those involved in implementation or delivery of the programme. Interview transcripts were obtained in order to conduct qualitative thematic analysis. The methods employed are described in detail in Chapter 10 (*'Qualitative Analysis and Results'*). Normalisation Process Theory (NPT) (May et al., 2009) was used as the thematic framework for analysis. The results of this phase are also described in Chapter 10. This study phase directly addressed the third and final research question *("RQ3. What benefits and barriers to the 'Closer to Home' intervention were identified by key stakeholders involved in implementation or delivery of the programme?")*

Phase VI Aim:

- Analyse the implementation process of 'Closer to Home', identifying main benefits and barriers, by drawing on Normalisation Process Theory.

2.4 Research governance and ethics

This research was considered a service evaluation, as retrospective analysis was conducted on primarily locally held, routinely collected data to evaluate a quality improvement programme. The research and development officer for NHS Forth Valley confirmed that all the phases of the proposed study did not require NHS ethics or research and development approval. Caldicott approval within Forth Valley and the Information Services Division (ISD) Scotland was obtained for the request for prescribing data (ID: CAL00000619, approved 22/03/2018) and for SPARRA (Scottish Patients at Risk of Admission and Readmission) scores (ID: CAL0000775, approved 31/07/2019, extension approved 16/06/2020), which were not locally held in Forth Valley. University departmental ethics approval was obtained for conducting the qualitative enquiry in Phase IV (ID: 829, approved 18/10/2018). A data management plan was put in place prior to starting the research study to ensure the data was securely stored and processed. All data was pseudonymised, meaning that the raw data was anonymised and given a code name, with the key for code names stored in a separate location from the raw data within NHS Forth Valley's IT systems. All analyses were conducted on pseudonymised data and only aggregated data are reported in the results of this study and in any related publications.

Chapter 3 Overview of policy context in NHS Scotland and 'Closer to Home' in NHS Forth Valley

The aim of this chapter is to provide an overview of the national and local context for the implementation of the *'Closer to Home'* programme in NHS Forth Valley, the regional healthcare delivery programme which is the focus of this research. This chapter begins by discussing the national policy context for older people's care in Scotland, the 2011-2021 Reshaping Care for Older People (RCOP) strategy (NHS Scotland, The Scottish Government and COSLA, 2011). The regional delivery of the strategy in the NHS Forth Valley health board, is then briefly described, including implementation of the 'Closer to Home' programme and other closely related services.

3.1 National policy context for older people's care in Scotland

Demographic changes and financial pressures on the NHS occurring within Scotland mean that previous and current models of care for older people are no longer sustainable in the long-term (NHS Scotland, The Scottish Government and COSLA, 2011). Rather than being designed to monitor and rehabilitate, these 'reactive' models were built on the assumption that care would always be required (ibid). Changing 'legacy' models has proved extremely challenging, since they often developed infrastructures with little room for adaptation and flexibility, which in turn hindered any substantial services redesign over time (ibid). Yet, the need for change is clear, hence the Scottish Government has been taking action in recent years to develop policies in order to promote the redesign of reactive models of care and develop new models that promote a more proactive approach to care, including supporting the independence of older people in Scotland and embracing an 'assets-approach' (ibid).

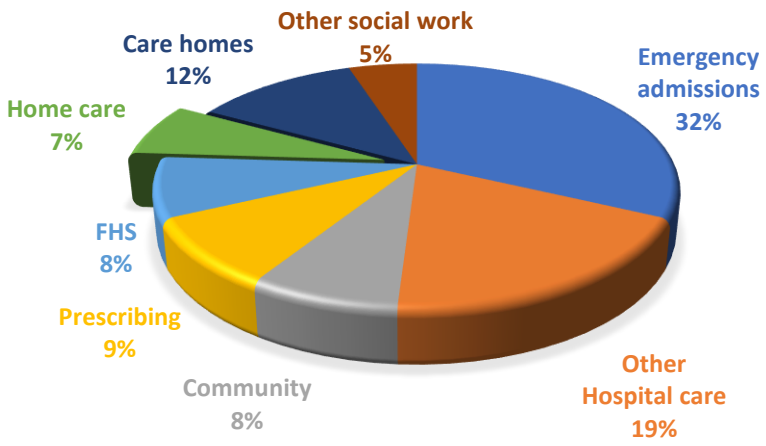
This section will further explore this need for change and will discuss the actions and policies that the Scottish Government has developed alongside the NHS and other stakeholder organisations.

3.1.1 The need for change in older people's care

One of the main strategic priorities of the Scottish Government is the provision of high quality care and support for older people (NHS Scotland, The Scottish Government and COSLA, 2011). The combined effects of demographic change and difficult public finance in the last two decades have caused this to be one of the most pressing issues Scotland faces (ibid). Aside from these pressures, this type of care provision is a "fundamental principle of social justice and is an important hallmark of a caring and compassionate society" (ibid, p.1).

In 2011, £4.5 billion of public funding was spent on health and social care for over 65s in Scotland, of which £1.4 billion a year was spent on emergency admissions, (based on 2007/08 figures) (ibid). Of the total expenditure, only 6.7% was spent on care at home (See Figure 3.1).

Figure 3.1 – Health and Adult Social Care Expenditure 2007/08 for Scottish Population aged 65+ (Total=£4.5bn) (NHS Scotland, The Scottish Government and COSLA, 2011, p.7)

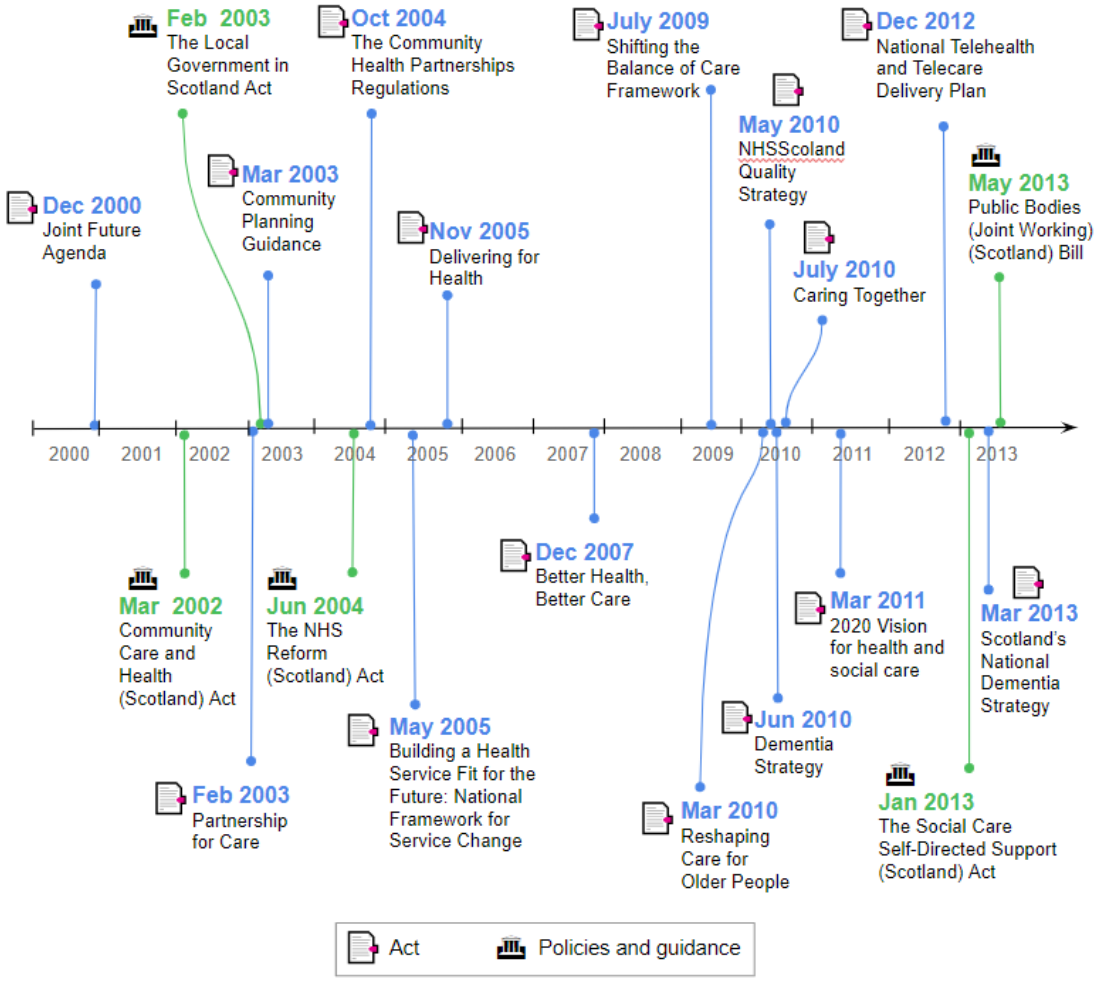


This expenditure is expected to continue growing as the population of this demographic grows. Previous models of care in place for older people in Scotland are unable to sustain the demographic changes and financial pressures on the NHS in Scotland, due to their lack of a preventative focus. Additionally, these models of care did not provide sufficient support for unpaid carers, who play a crucial role in helping older people remain at home, many of whom are older themselves. In 2011 it was estimated that "just over 3,000 people over 65 years in Scotland received more than 20 hours of paid care per week while over 40,000 people over 65 provide more than 20 hours unpaid care per week" (ibid, p.6). Older people are valuable assets to society and provide far more care and support than

they receive. Having this 'assets-approach' to older people promotes a focus on building their capabilities and independence and hence tackle the demographic changes and financial pressures. Part of changing the fragmented and disjointed models of care previously in place for their care is to change the attitudes that exist around older people and focus on personalised care, working with older people to design services that will truly help them.

The Scottish Government has considered all of these factors triggering a need for new models of care and has developed various national policies governing the changes that need to take place. One of these, called Reshaping Care for Older People (RCOP) which launched in 2010, is a national programme for change aimed at improving care for a growing population of older people in Scotland (ibid). Alongside RCOP, various other national policies have been put in place to support older people living in Scotland such as the *National Dementia Strategy* (2013), the *Self-Directed Support Strategy* (2013), the *Caring Together Carer's Strategy* (2010) and the *Living and Dying Well* action plan (2008) which followed from the *Better Health, Better Care* (2007) action plan for health and wellbeing. The national policy context for RCOP can be seen in Figure 3.2 in the form of a timeline.

Figure 3.2 – National policy context for older people's care - various policies over recent years aim to improve services for older people (Audit Scotland, 2014, p.13)



3.1.2 RCOP approach and commitments

Through the RCOP strategy, the Scottish Government has made several commitments to change the current models of care and prepare for an increase in demand with the overall aim of providing the best possible care for older people in Scotland. The RCOP vision (NHS Scotland, The Scottish Government and COSLA, 2011, p.5) is that:

> *'Older people in Scotland are valued as an asset, their voices are heard and older people are supported to enjoy full and positive lives in their own home or in a homely setting.'*

This vision relates directly to Scotland's national outcomes, specifically outcome fifteen (Scottish Government, 2016):

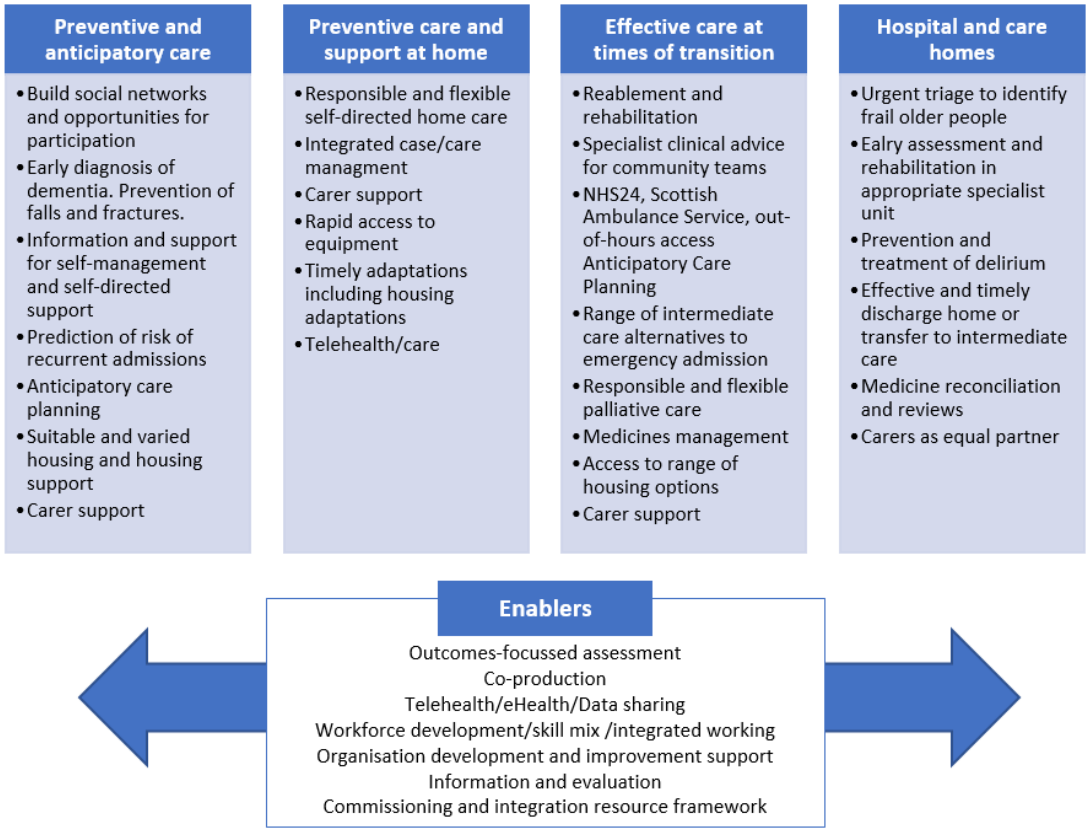
> *'Our people are able to maintain their independence as they get older and are able to access appropriate support when they need it.'*

The approach of the RCOP strategy has been outlined as follows (NHS Scotland, The Scottish Government and COSLA, 2011, p.20):

- 'Grow societal support for the philosophy of a mutual care approach; both in principle and in practice;
- Support a shift in expectation away from institutional care settings, towards community and home-based care;
- Nurture a philosophy of care that embraces self-management, supported self-care and re-ablement;
- Adopt an asset approach that value and empowers older people and their communities; and
- Promote the development of third sector organisations which harness the energy of local communities and provide services responsive to the needs of local people.'

In 2012, the Scottish Government's Integration and Reshaping Care policy team worked together with the Joint Improvement Team (JIT) and NHS Health Scotland to develop an outcomes framework for the RCOP strategy. The JIT was a partnership between the Scottish Government, NHS Scotland, COSLA, the third sector, the private sector, and the housing sector established in 2004 to facilitate health and social care integration (Joint Improvement Team, 2016). The full strategic outcomes model can be found in Appendix A, Figure A-1. One of its focuses was to shift towards greater investment in preventative measures and less in acute care services. Additionally, these outcomes can more clearly be seen in the Reshaping Care pathway developed by the Scottish Government, NHS Scotland and the COSLA in their review of RCOP in 2013. The pathway establishes four 'pillars' of interventions or approaches across primary, community and acute sectors (see Figure 3.3).

Figure 3.3 – Reshaping Care pathway including 4 'pillars' (The Scottish Government, NHS Scotland and COSLA, 2013, p.29)



It is evident that one of the strategies of the RCOP programme to fulfil its outcomes consists in shifting the care of older people towards care provision in the patient's own home and community. Results from the previously mentioned public engagement programme showed that a key message from stakeholders was that *"given the option, people want to stay in their own homes"* (NHS Scotland, The Scottish Government and COSLA, 2011, p.12). This key message is consistent with previous research, highlighting that older people prefer care at home over hospital care (Shepperd et al., 1998) and that for older people (i.e. over 65) living *'independently'* was synonymous with *'living at home'* (Roberts and Mort, 2009).

3.1.3 RCOP funding, partnership support and structure

One of the commitments of the RCOP strategy in 2011 was to double the proportion of the total health and social care budget for older people that was spent on care at home from 6.7% to at least 13%, to support the shift to care at home (NHS Scotland, The Scottish Government and COSLA, 2011)..

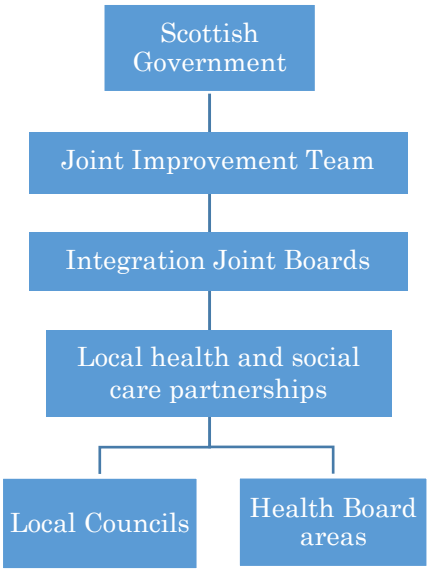
As part of the RCOP strategy, the Scottish Government set aside £300 million for a Change Fund, with the purpose of supporting the 32 health and social care partnerships across Scotland to carry out the RCOP strategy over a four year period (ibid). Each of the 32 partnerships were required to put together a programme of change (Local Change Plan) that satisfied the council, NHS Board, the third sector and independent sector, to access the Change Fund (ibid). From 2012, each partnership was required to put together a joint strategic commissioning strategy as a submission to access the Change Fund (Walker and Gillies, 2014). Once the four-year Change Fund ended in April 2015, an Integrated Care Fund of £100 million was set aside for 2015-16. Its purpose was to support new initiatives in the same way that the Change Fund did rather than to be used for existing initiatives funded through the Change Fund. Change Fund guidance in 2014/15 stated that partnerships should be doing their own planning to sustain existing initiatives.

Health and social care partnerships across Scotland existed during the development of the RCOP strategy but were formally put in place following government legislation in 2014 *(Public Bodies (Joint Working) (Scotland) Act 2014)* to implement health and social care integration. The legislation required that all partnerships needed to submit their local integrated care plans to the Scottish Government for approval by 1 April 2015 and fully integrated services were to be operational by April 2016 (The Scottish Government, 2015). Originally, each of these partnerships were given access to a member of the JIT. This meant that each partnership had access to support in putting together their local delivery plans and in the overall delivery of the RCOP programme.

Once the health and social care partnerships were officially established, an Integration Joint Board (IJB) was put in place for each of the partnerships to fulfil this supporting role. The IJBs "bring together local councillors, NHS Board members and senior staff from the relevant partner organisations along with carer, service user and third sector representatives, to oversee the work of the partnerships and ensure they deliver a number of key local and national outcomes" (NHS Forth Valley et al., 2016, p.1). The IJBs can receive various forms of funding from the Scottish Government for the development of local integration plans within local partnerships, such as the Delayed Discharge Fund and the

Integrated Care Fund. The structure of the governing bodies discussed can be seen in Figure 3.4.

Figure 3.4 – Structure of RCOP governing bodies

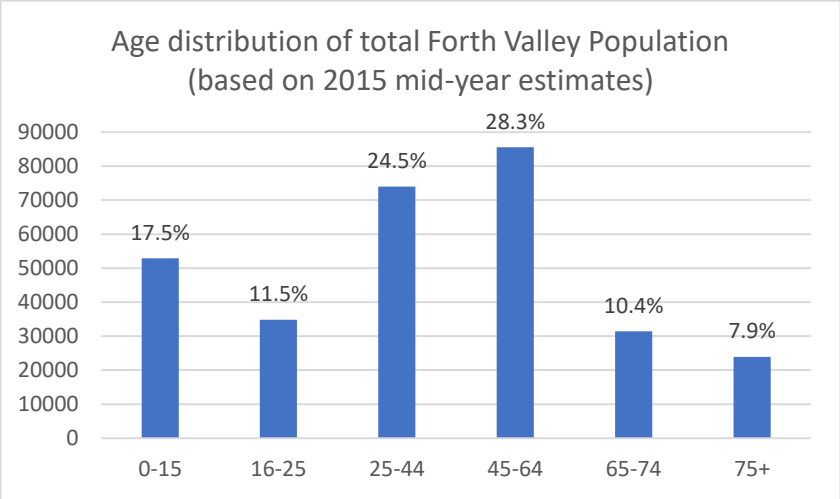


Various audits and reviews indicate improvement since the implementation of the RCOP strategy. Audit Scotland found that although the rates of emergency admissions have increased, the rates of bed days for those admissions per 1,000 population over 75 in Scotland have decreased by 10.3% from 2009/10 to 2014/15 (Audit Scotland, 2014; Hendry et al., 2016). Additionally, the rates of long-stay residents in care homes have reduced and the rates of telecare for over 75s have increased over this period (Audit Scotland, 2014).

3.2 RCOP in NHS Forth Valley – local context for 'Closer to Home'

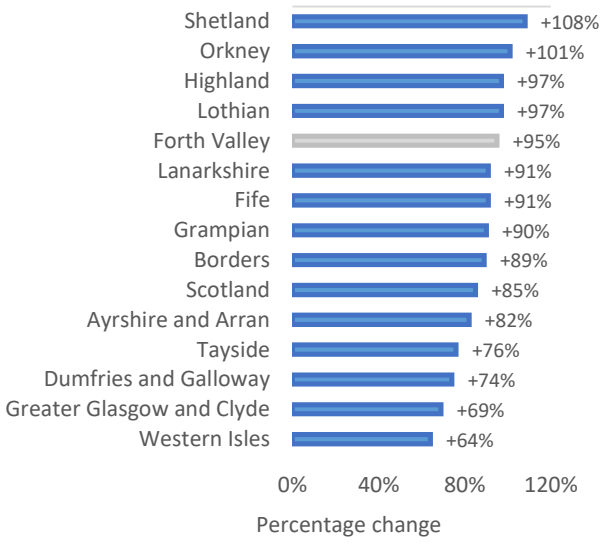
NHS Forth Valley, the health board of interest to this research, is one of the 14 regional health boards serving the Scottish population and is located in central Scotland. The health board administers an annual budget of £485.3 million (2016/17) and has a draft budget of £494.7 million for 2016/17 (The Scottish Government, 2016). The Forth Valley area has a population of 302,650 people, based on 2015 mid-year estimates (ISD Scotland, 2016). Of the total population, 18.3% are aged over 65 (See Figure 3.5).

Figure 3.5 – Age distribution of total Forth Valley Population based on 2015 mid-year estimates (ISD Scotland, 2016)



NHS Forth Valley is expected to see a 95% increase in its population aged 75 and over from 2014 to 2039 making it the health board with the fifth highest projected increase, exceeding the national average (See Figure 3.6). This NHS Board area is made up of three local authority areas: Falkirk, Stirling and Clackmannanshire. Clackmannanshire is the local authority area with the second highest expected increase in population over 75 in Scotland by 2039 (112% increase) (See Appendix A, Figure A-2).

Figure 3.6 – Projected percentage change in population aged 75 and over, by NHS Board area, 2014 to 2039 (National Records of Scotland, 2016, p.34)



There is hence a clear need for the new models of care in place in Forth Valley to sustain these demographic changes. To govern this change in alignment with the

RCOP strategy and government legislation on integration of health and social care *(Public Bodies (Joint Working) (Scotland) Act 2014),* two health and social care partnerships were set up in the Forth Valley area – one for Falkirk and one for Stirling and Clackmannanshire. For each of the two partnerships, in accordance with government legislation, an Integration Joint Board (IJB) was created to oversee and support the work of the partnerships. As one of the 14 health boards in Scotland, NHS Forth Valley has been a recipient of RCOP funding (both the initial Change Fund and the Integrated Care Fund).

With this funding, various initiatives or projects have been put in place within each of the two partnerships. Some of the initiatives span across the whole health board, however each of the two Forth Valley IJBs are responsible for running them within their partnerships. A timeline of significant events related to the RCOP strategy in Forth Valley can be seen in Appendix A, Figure A-3. Over the course of the Change Fund, around £7 million in total were allocated to the Stirling and Clackmannanshire partnership throughout 2011/12 to 2014/15 (NHS Forth Valley, 2015b). In the first year of funding (2011/12) about 15 projects were in place, increasing to about 30 projects and finally about 28 projects in the final year of the Change Fund. The projects all fit under one of five categories: Development of Intermediate Care Services, Anticipatory and Prevention, Carers, Supporting Service Users with Dementia and Mental Health conditions, or Developing Community Capacity/Community Supports (Niven, Middlemiss and McNairney, 2015).

Appendix A, Table A-1 contains full details on all the projects that were put in place using the Stirling and Clackmannanshire partnership Change Fund, along with their category and funding allocation.

As the Change Fund came to an end, The Integrated Care Fund was put in place for 2015/16 as discussed in the previous section. The Integrated Care Fund allocation for the Forth Valley NHS Board area can be seen in Table 3.1.

Table 3.1 – Funding allocation of the Integrated Care Fund for 2015-16 for the Forth Valley NHS Board area by Local Authority (The Scottish Government, 2014, p.7)

Local Authority	Allocation
Clackmannanshire	£0.96m
Falkirk	£2.88m
Stirling	£1.52m

Forth Valley total	£5.36m

One of the projects that received funding from the Integrated Care Fund was a programme called *'Closer to Home,'* a collection of initiatives aimed at preventing hospital admissions for older people and supporting their independence at home. To date, evaluation of the 'Closer to Home' programme has been limited to routine reports of activity without any use of comparison groups. This programme will now be discussed in detail in the following section.

3.3 'Closer to Home,' an NHS Forth Valley RCOP initiative

Having established the national policy context for the initiatives that have been developed as a result of the RCOP strategy, this section will proceed to give an overview of a specific initiative within NHS Forth Valley. This initiative, called 'Closer to Home,' is a direct recipient of RCOP funding. It was formally put in place in December 2015 (Falkirk Integration Joint Board, 2016). The programme covers a range of services across NHS Forth Valley that aim to enable older people to remain at home, through the use of various initiatives aimed at preventing admission to hospital. In its development, the integration of social care and health services has been a key element. This unique partnership aimed to bring together two differing organisations towards one goal of improving care for older people in the surrounding areas of Forth Valley. This section will briefly describe the individual sub-initiatives that form part of 'Closer to Home.' The three main components of the 'Closer to Home' programme are as follows:

1. **Enhanced Community Team (ECT):** A team of primarily nurses who provide admission avoidance care in the home of elderly patients referred by their GP or identified through other routes (e.g. ambulance service, community services) as requiring hospital-level care. A team of GPs (GP Fellows) was subsequently added to the team in the second year of the service.
2. **GP Fellows:** A team of General Practitioners (GPs) initially funded through a pilot GP Fellowship aiming to bridge the gap between primary and secondary care. They provide medical support and expertise to the ECT.

3. **Advice Line for You (ALFY):** A telephone advice line for people aged over 65, led by nurses, providing health advice, reassurance, information about local services and referral on to appropriate community services as required, with the primary aim of supporting older people to remain well at home.

3.3.1 Other services connected to 'Closer to Home'

Alongside 'Closer to Home' are a variety of community initiatives that contribute towards supporting frail elderly people to remain at home. These services interact with the 'Closer to Home' programme and may support a patient's recovery but are not expressly aimed at admission avoidance hence are not classified under the 'Closer to Home' umbrella.

1. **Community Nursing (CN)/ Night Nursing (NN) Teams:** These are teams of nurses who carry out home visit for patients who may need a short visit following a non-serious or non-recurring accident or illness. This service is different to the Enhanced Community Teams in that these nursing teams will generally provide a one-time service, while the ECT aims to provide care for acute presentations and provide support for a period of recovery time. Hence, CN/NN Teams may refer patients to the ECT after visiting them. Additionally, the nurses working in the CN/NN Teams, may also work within the ECT.
2. **Rapid Access Frailty Clinic (RAFC):** This clinic, widely referred to as the 'Frailty Clinic,' was set up in Forth Valley Royal Hospital in 2013 to give older people in the community access to a service providing specialist assessment for older people, with the aim of reducing avoidable hospital admissions and supporting older people in the community. The service is available to over 65s living in a care home requiring tests or treatment, or over 75s living at home who may require further assessment. During the assessment a range of blood tests, cognitive tests, X-rays and scans are carried out and the patient is seen by a consultant geriatrician. The service assesses both the patient's health and social care needs, as it runs in conjunction with social work, who are able to connect the patient with an appropriate care package or necessary support at home. This way they are normally able to return home the same day.

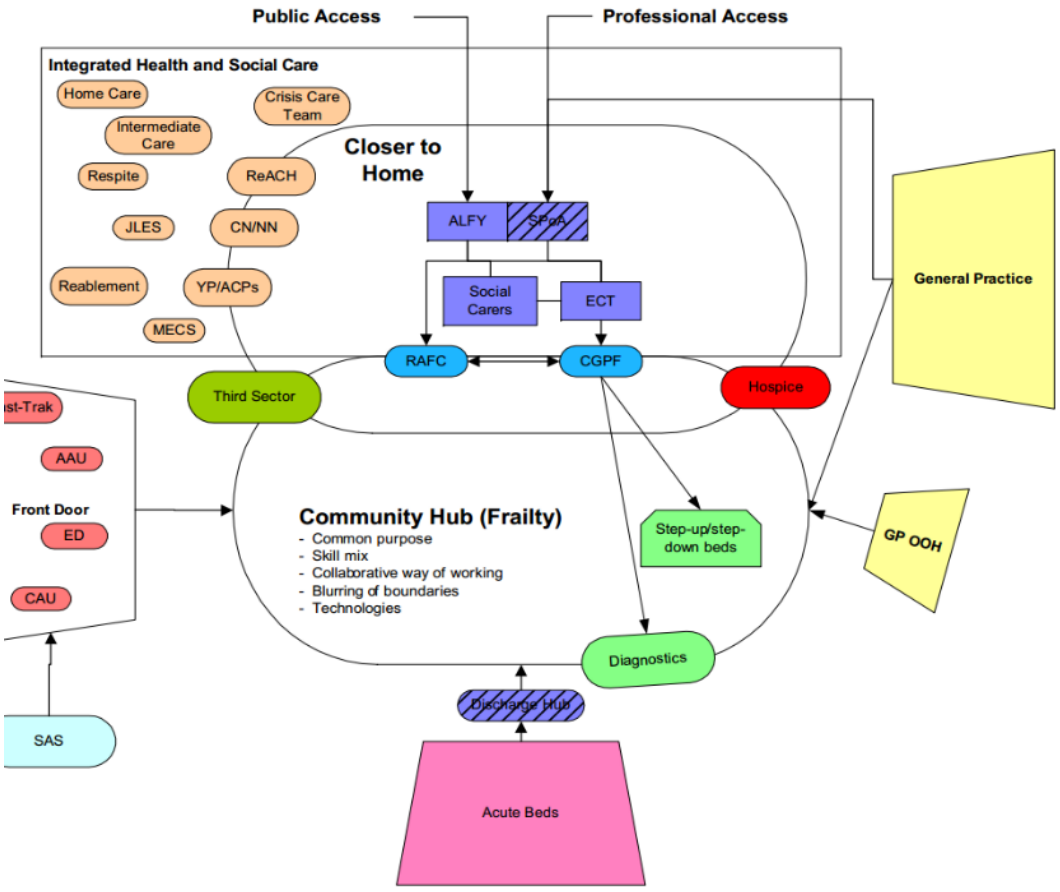
3. **Rehabilitation and Assessment in the Community and Home (ReACH):** Part of a Falls Management Programme, this is a service which provides four one-hour assessments at home for people who have had a fall, and 50% of these people are then referred to the Falls Management Clinic for further assessment and therapy. This re-ablement service is available to any patients over 16 years of age who may need it.
4. **Mobile Emergency Care Services (MECS):** This is a telecare service aimed at helping people with confusion or dementia, those who are frail, have a physical disability, a sensory impairment, predisposition to falls/accidents at home, or have been in a violent or abusive relationship, to live independently at home. The service installs equipment in a person's home such as an alarm unit with a trigger device, door sensors or pressure mats, which when triggered connect through a phone line to a control centre, open 24 hours a day. The service was a joint initiative between local councils and NHS Forth Valley.
5. **Anticipatory Care Planning (ACP) and 'Your Plan':** Both of these services are focussed on helping older people prepare in advance for future difficulties they may face and to help them put a plan in place for their care. ACP is normally associated with end-of-life care but is a service that can be used at any stage. It provides a way for patients to plan for a change in health status and provides an opportunity for patients to involve their family in their wishes for their care and discuss these with health professionals. During an ACP assessment, a nurse trained for ACP visits a patient home and will ask them some questions and encourage discussion surrounding their future care. During the session, nurses do not use a form to fill in and do not take notes but focus on making the discussion completely centred on the patient's wishes. *'Your Plan'* is a modified version of this service but does not require a nursing visit and instead takes the form of a document that the patients themselves fill in regarding their future care and wishes. The ALFY team promoted *'Your Plan'* and completed documents were sent back to the ALFY team. The purpose of *'Your Plan'* was to help patients begin thinking about their future care and their families' involvement, which can also trigger an ACP assessment if required.

6. **Joint Loan Equipment Service (JLES):** This medical equipment loan service is a joint initiative between local councils and NHS Forth Valley. The service provides patients with access to equipment that will help them live independently at home and prevent accidents such as shower chairs or walking trolleys.

In addition to the three main 'Closer to Home' services, these six additional services cover for the most part all the frail and elderly services in NHS Forth Valley.

Figure 3.7 displays a diagram created by the 'Closer to Home' evaluation team within NHS Forth Valley, displaying 'Closer to Home' services and how they were originally expected to interact with other services, however there have been various changes to the services which are further investigated in Phase IV of this research.

Figure 3.7 – Community Hub diagram created by the 'Closer to Home' evaluation team (NHS Forth Valley, 2016b)



3.4 Conclusion

This chapter has set the national policy context for the 'Closer to Home' programme in NHS Forth Valley, as well as put into perspective how it relates to national government policies and targets. The need for initiatives such as these is clear, and even more so the need to evaluate them in order to further instruct the constant improvement and adaptation of services put in place for the care for older people. Further, this chapter has described in detail the primary services of the 'Closer to Home' programme, along with a brief discussion of other interconnecting services. Providing this overview is an essential first step towards understanding the quality improvement programme with the aim of investigating its value and effectiveness. It also proves helpful in understanding where the programme sits within national policy implementations and what the services cover.

Chapter 4 Exploratory Phase and Process Mapping Results

Having introduced the national policy context for the 'Closer to Home' programme, this chapter provides the results of the exploratory phase of this research (Phase I), where the primary aim was to understand and document the particular structures and operational processes involved in the 'Closer to Home' programme. An in-depth description of the main components of the 'Closer to Home' initiative and a brief description of data collection processes involved are provided. The outputs of this chapter provide a documentation of context which contributes towards first stage of the evaluation framework used to guide this research ('Understanding and documenting the broader context') and address the first research question (*"RQ1. What were the structures and operational processes of the 'Closer to Home' programme?"*), as described in Chapter 2.

4.1 Methods

The primary methods used in Phase I were informal consultations with key members of staff knowledgeable about the 'Closer to Home' services and its data collection processes followed by concept and process mapping. In order to contact the relevant members of 'Closer to Home' for consultation, the information services manager for NHS Forth Valley made the appropriate introductions, usually by e-mail. Consultations were mainly within NHS Forth Valley, however several consultations were also made with NHS Tayside and NHS Fife as well as other services such as NHS National Services and the Information Services Division (ISD) for Scotland. These informal consultations, which took primarily took place between December 2016 and March 2017, were usually held face-to-face at a location suitable to the relevant person, however some consultations were made over the phone and several over e-mail. Notes taken during these consultations and internal documents shared following the consultations were used to develop the concept maps and process maps presented here. In addition, the qualitative study conducted in Phase VI presented the opportunity to gain an in-depth understanding of the roles and responsibilities involved in 'Closer to

Home,' relevant to Phase I, hence the resulting concept map developed from interviews with key stakeholders in Phase VI is included here.

Process mapping was used as a tool for breaking down complexity and gaining a shared understanding of processes, which is a main benefit of using this method within healthcare quality improvement (Antonacci et al., 2018). Process mapping has also been highlighted to not only help understand the activities ongoing within a process but also the connections and interactions between activities, departments or areas (Björn Andersson and Tobias Brink, 2013).

4.2 Main components of 'Closer to Home'

As briefly described in Chapter 3, the 'Closer to Home' programme covers a range of overlapping services; however, three main services are considered its main components. These are: the Enhanced Community Team (ECT), the GP Fellowship Programme and the Advice Line for You (ALFY). These three components will each be discussed in further detail and in order to help the reader understand how they relate to each other, this section will begin with a case study displaying the interaction of these services. Data collection processes are briefly discussed for each service, however specific details of data relevant to this research are described in detail in Chapter 7 *('Quantitative Data Collection'),* where the resulting datasets developed as part of Phase III of this research are described.

4.2.1 Case study – patient using ALFY, ECT and GP Fellows services

The following case study is provided to introduce and illustrate the use of the main components of the 'Closer to Home' programme. This case study is based on a promotional video developed by the NHS Forth Valley ALFY service (NHS Forth Valley, 2015a).

> *Moira Smith is 71 years old and lives at home but has been feeling dizzy and had a fall. She also hasn't been eating or drinking very much. Her daughter Jane is concerned about her and recalls receiving a leaflet about the Advice Line for You (ALFY) Service for over 65s. She decides to call late that morning on behalf of her mother as she is quite worried about her and gets through to a community nurse who begins by asking some details about the*

situation to ensure this is not an emergency and asks for consent from Moira to be able to speak to Jane about her. Jane describes the situation and the nurse gives her reassurance and tells her that they will send a community nurse out to see her at home that afternoon and assess the fall as she does not appear to be seriously injured. Once this has taken place, the community nurse confirms there is no serious injury but sees that Moira has reduced mobility due to the fall and is feeling more unwell and dizzy so to prevent an admission they decide to refer Moira on to the Enhanced Community Team (ECT). Following the visit, a letter is sent to Moira's GP to inform them of her fall and of the visit and that she has been referred to the ECT service. An ECT nurse provides a rapid response visit that evening to assess Moira, where they identify that she may have a urinary tract infection so they request relevant testing and provide medication for her pain as it has become more severe. The team also provides a thorough initial assessment to identify areas of need such as equipment needs.

For the next few weeks, community nurses, home care staff and a physiotherapist from the ECT go out to see her. Although she seems to be recovering from the fall and pain subsides, the nurses notice that Moira is still feeling dizzy and suspect a new infection so they decide to involve GP Fellows, a team of GPs who work as part of ECT and are able to specifically treat elderly and frail people in their homes but provide more specialised treatment than the ECT nurses and allied health professionals. A GP Fellow visits Moira at home and assesses her situation. He believes she will need to be admitted to a 'Step Up' bed (short-stay bed) under his care to be closely monitored for a day or two, get rehydrated and carry out specific diagnostic tests he thinks are necessary. Following results from the tests, the GP Fellow prescribes the necessary medication for Moira and she is able to return home, with a few more visits from the ECT until she can live independently at home.

4.2.2 Enhanced Community Teams

A core element of the 'Closer to Home' programme in Forth Valley is the Enhanced Community Team (ECT), aimed at providing care at home for older people after

having had an accident, illness or stay in hospital. The ECT service components and processes involved are described in this section. A process map describing the service can be seen in Figure 4.1.

4.2.2.1 Implementation

The ECT was rolled out in December 2015 with the first contact occurring 9th December 2015. The service aimed to then be progressively rolled out across the whole Forth Valley area in the first year by promotion to and contact with GP practices and emergency services. By June 2016, ECT covered all 57 GP practices in Forth Valley. As discussed and investigated in Phase VI of this research however, there was difficulty in encouraging its widespread use and promotion (presented in Chapter 10).

4.2.2.2 Team resources

From the start of the service, the core teams have consisted of nurses dedicated to ECT (ECT nurses). In 2016, the core ECT team consisted of one Advanced Nurse Practitioner and six Senior Staff Nurses funded by the health and social care partnerships in Forth Valley (Sharp, 2016). Funding was also provided for social care input which resulted in health care assistants also forming part of the core team. This core team has direct access and input from other resources however, which form part of other services, hence are not considered dedicated ECT resource. This includes access to allied health professionals (physiotherapists and occupational therapists from the Rehabilitation and Assessment in the Community and Home services described in Chapter 3, Section 3.3.1), community practice nurses (CPN) including night nursing and social work including home care staff. In January 2017, the additional resource of GPs called GP Fellows (described in Section 4.2.3) was made available to ECT. These services are managed separately but the ECT caseload is within their remit, hence they form part of the same team.

4.2.2.3 Care provided

The services provided by the ECT are designed to provide immediate support in the intermediate phase of arranging long-term support (NHS Forth Valley et al., 2016). Nurses are able to monitor vital signs, change dressings, provide medication and request sample testing, physiotherapists help people get back on their feet, occupational therapists may conduct equipment assessments and home

care staff can prepare food as well as aid with washing, toileting and dressing. The ECT service is generally provided for up to 7 days, however this is flexible according to a patient's needs (Sharp, 2016). Patients referred to ECT remain under the overall medical direction of their own GP (Sharp, 2016).

4.2.2.4 Range of conditions and pathways

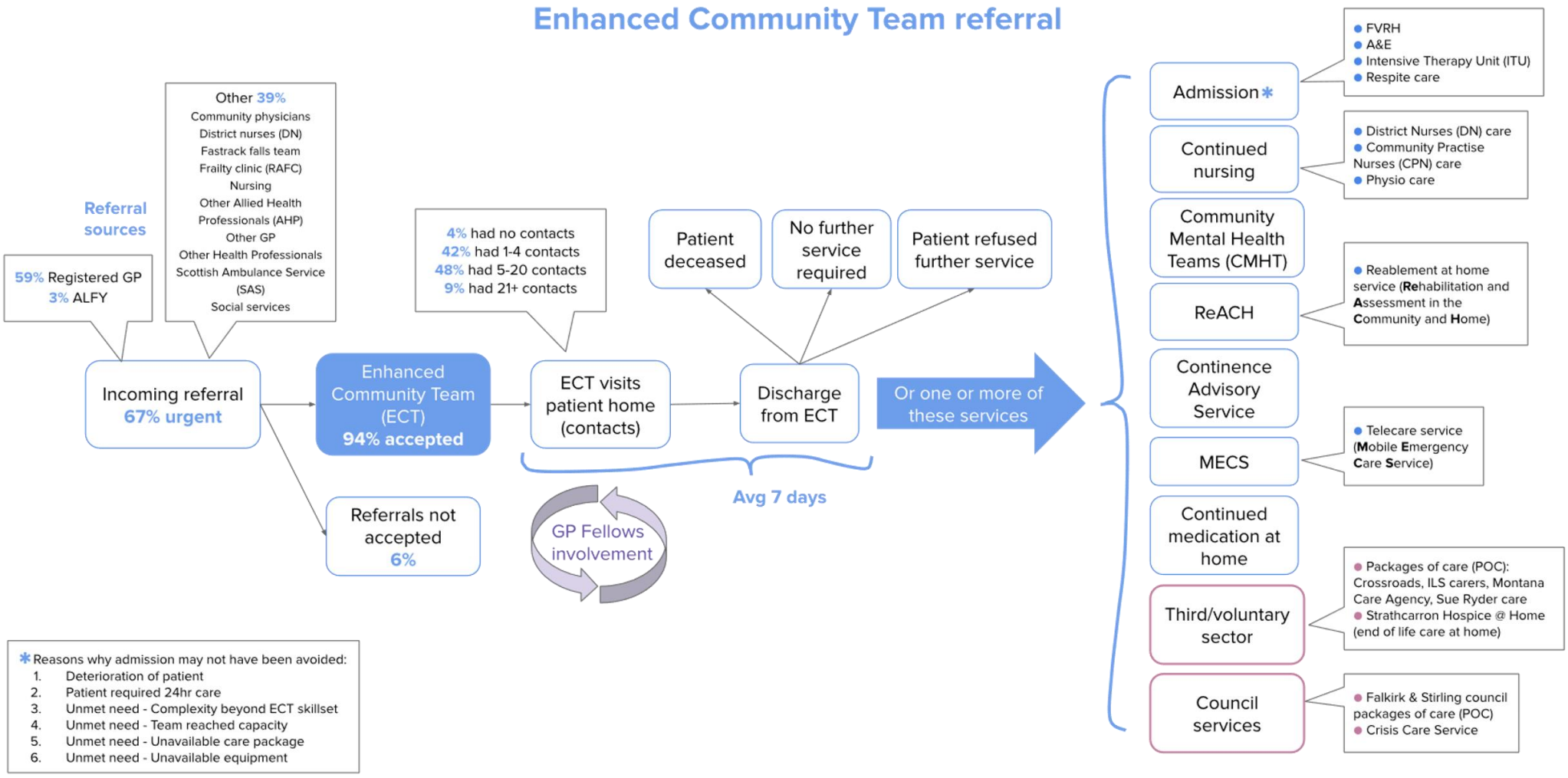
Referrals can be made to ECT through various sources including GPs, community services, the Scottish Ambulance Service and through the telephone advice line which is also a part of 'Closer to Home' ('Advice Line for You') as seen in Figure 4.1. Generally, the service is for patients over 65, however those under 65 with a chronic condition such as multiple sclerosis (MS), chronic obstructive pulmonary disease (COPD) motor neuron disease (MND) would be considered. In addition, to meet the service criteria, the patient should have been seen by a medical practitioner and have a diagnosis or reason for referral. The range of conditions typically seen by the ECT include chest infections, urinary tract infections, delirium, cellulitis, falls with no suspected fracture, acute exacerbations of chronic conditions and reduced mobility due to acute illnesses (Sharp, 2016).

In the first year of the service the service intended to have two main pathways (i.e. types of patients), one for 'unwell adults' which required that the patient had to have been seen by a medical practitioner and have a diagnosis or referral reason. This pathway was for patients requiring any of ECT's services to avoid hospital admission in a crisis or deteriorating condition and to provide post-discharge support for patients who still require medical attention which could be treated at home following a hospital stay (this is referred to as a "step-down" service). The second pathway was for 'uninjured fallers,' who mainly require AHP input but may benefit from the remaining ECT services. As the service developed, and pressures in hospitals in Forth Valley increases, the service found itself requiring a third pathway for 'discharge facilitation.' This pathway was for patients who were not able to be discharged from hospital primarily due to lack of social care arrangements. ECT took on these patients, primarily providing home care visits from their social work resource, which was not originally intended for the service (further investigated in Chapter 10). For many of these patients, healthcare needs were also identified where ECT healthcare professionals provided input accordingly.

4.2.2.5 Recording data

ECT record details of their patients and their care on the community information system MiDIS (Multidisciplinary Information System). The data entry process can be seen in Figure 4.3. Data entry is only possible at the ECT office base, where MiDIS is accessible. Hence, for home visits or any other activity outside the team base, there will be a delay between the occurrence of activity and the recording of data which may have implications on data quality (further discussed in Chapter 7). Discussion with several ECT nurses however indicated that members of ECT recorded some data on paper when visiting patients (such as the triage and general assessment forms – see Figure 4.3), which is then entered on MiDIS upon return to the office.

Figure 4.1 – Process map of ECT service including Jan-Sept 2016 (Quarters 1-3 statistics). Data source: (Henderson and Locke, 2016)



4.2.3 GP Fellows

The GP Community Hub Fellowship Programme was put in place to develop a new role that bridges the gap between primary and secondary care. The one-year fellowship enables GPs (called GP Fellows) to develop further experience working in intermediate care between the home and acute setting. Following the first year, GP Fellows have the opportunity to hold a two-year health board funded position as a community physician. The Fellowship Programme was piloted in NHS Fife and NHS Forth Valley, and officially launched in Forth Valley in January 2017. The GP Fellows in Forth Valley work very closely with the ECT and form part of the team, receiving referrals directly from them, but are managed separately. A GP Fellow's treatment within the ECT service may involve home visits for patients with complex conditions requiring care beyond the ECT nurses' skillset where they may also prescribe medicine and request further testing. Previously without the GP Fellows resource these patients would likely have been admitted to hospital. GP Fellows in Forth Valley also have access to 'Step Up' beds in Bo'ness Hospital, which are short-stay beds they can use to admit their patients where hospital equipment is required to continue care, as an alternative to acute hospital admission. Once the GP Fellows have carried out their treatment, they may hand the patient's care back to the ECT until necessary. Like ECT, the GP Fellows use MiDIS to record patient and activity information. The data entry process is the same as for ECT except that there is an additional form that they fill in specific to their needs, as seen in Figure 4.3.

Figure 4.2 – Concept map of GP Fellows Service

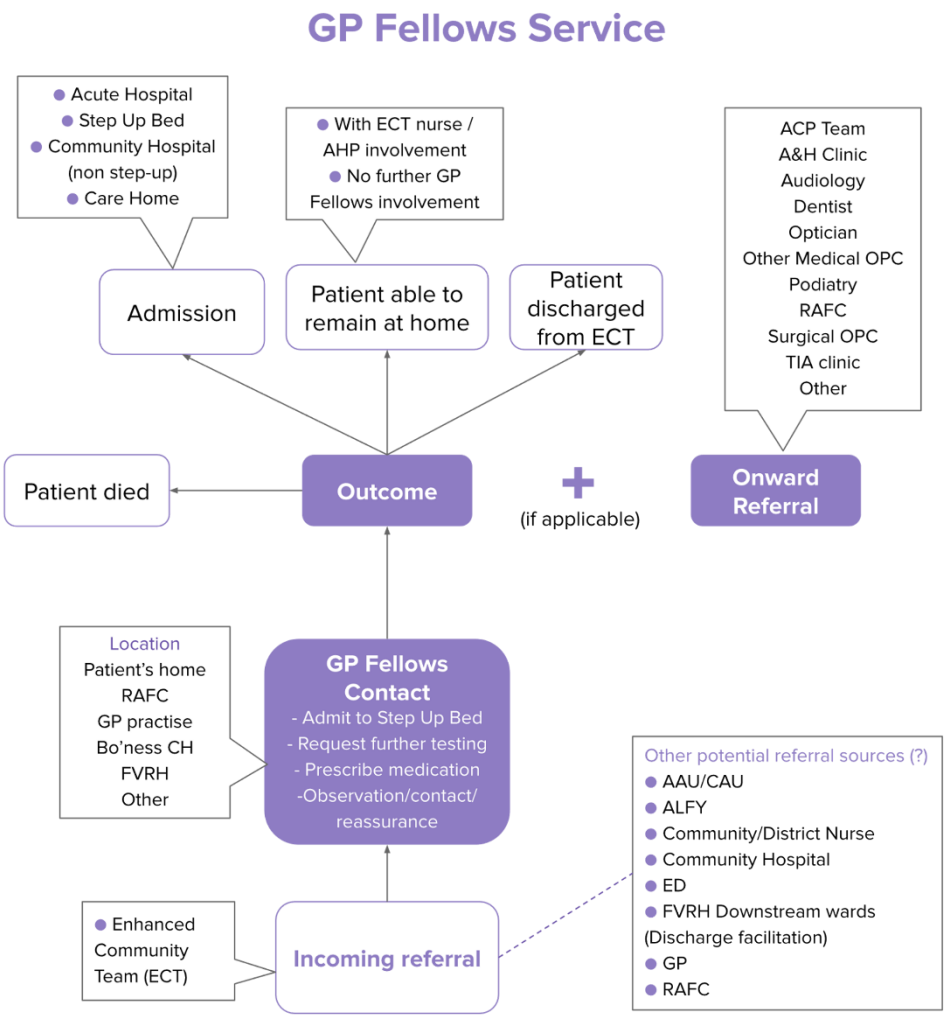
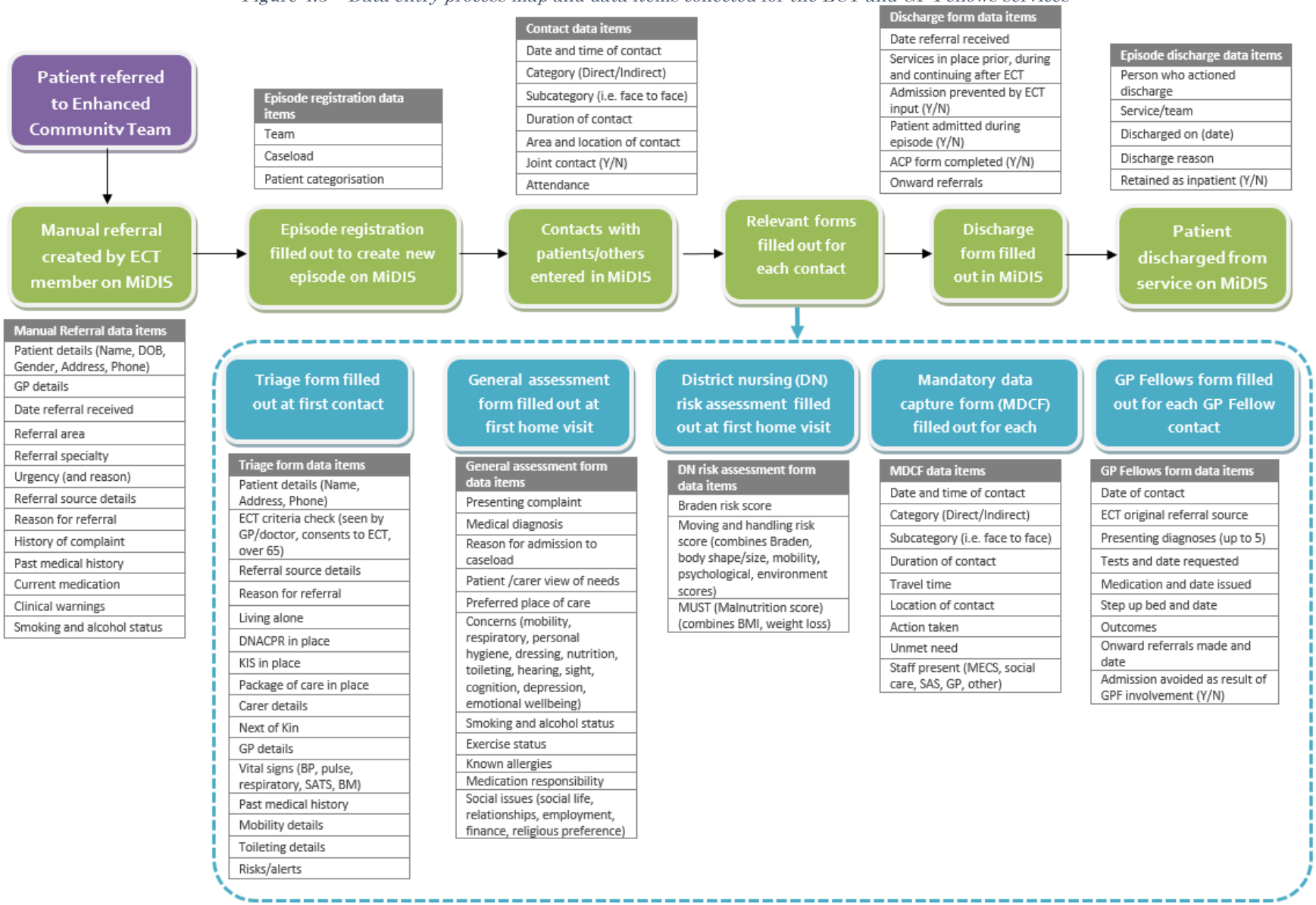


Figure 4.3 – Data entry process map and data items collected for the ECT and GP Fellows services



4.2.4 Advice Line for You

The Advice Line for You (ALFY) service was a nurse-led telephone service aimed at supporting older people to remain at home by providing advice on health and social care support or simply reassurance. Aimed at people over 65, it provided support 24 hours a day and began on the 1st December 2015. The advice line aimed to cater towards the need for simple reassurance or advice among elderly people in Forth Valley, aiming to prevent hospital attendances by providing appropriate advice or reassurance over the phone to avoid further deterioration where possible. Since its launch until September 2016, 45% of calls have been for the purpose of simple advice or reassurance (NHS Forth Valley, 2016a).

Figure 4.4 displays a concept map of the current ALFY service and its potential outcomes.

4.2.4.1 Implementation

Following the identification of a need for a service where elderly people can obtain simple reassurance and advice, the service was initially piloted in the Bo'ness area of Forth Valley, within the Falkirk partnership. Following positive feedback from the pilot, it was rolled out more widely across Forth Valley with promotional materials being sent to those aged 65 or over identified as being at increased risk of hospital admission (based on a Scottish Patients at Risk of Admission and Readmission score of 40 or above in September 2015 i.e. are said to have a 2 in 5 chance of being admitted to hospital in the prediction year) and posters advertising the service throughout hospitals and GP practices in Forth Valley.

4.2.4.2 Team resources

In contrast to a service such as NHS 24 (the national general healthcare advice line), this advice line is operated by experienced community nurses who are especially knowledgeable on the care provision and services available to over 65s in NHS Forth Valley. The service is provided through hospital-based telephone lines, however some night nurses also have mobile handsets through which ALFY calls are routed if they are on call for community nursing.

4.2.4.3 Recording data

While on a call, nurses primarily record data through electronic forms on the ward management system eWard, although they may also take paper notes, which are

later transcribed electronically, on their 'aide memoire' which guides them through the conversation (See Appendix A, Figure A-4). Until September 2018, when the ALFY service came to an end, ALFY collected data for incoming calls in a ward management system called eWard.

Figure 4.5 displays a process map of data entry and data items collected by the ALFY service.

Figure 4.4 – Concept map of ALFY service with routings from Jan-Sept 2016 data (Quarters 1-3). Data source: (NHS Forth Valley, 2016a)

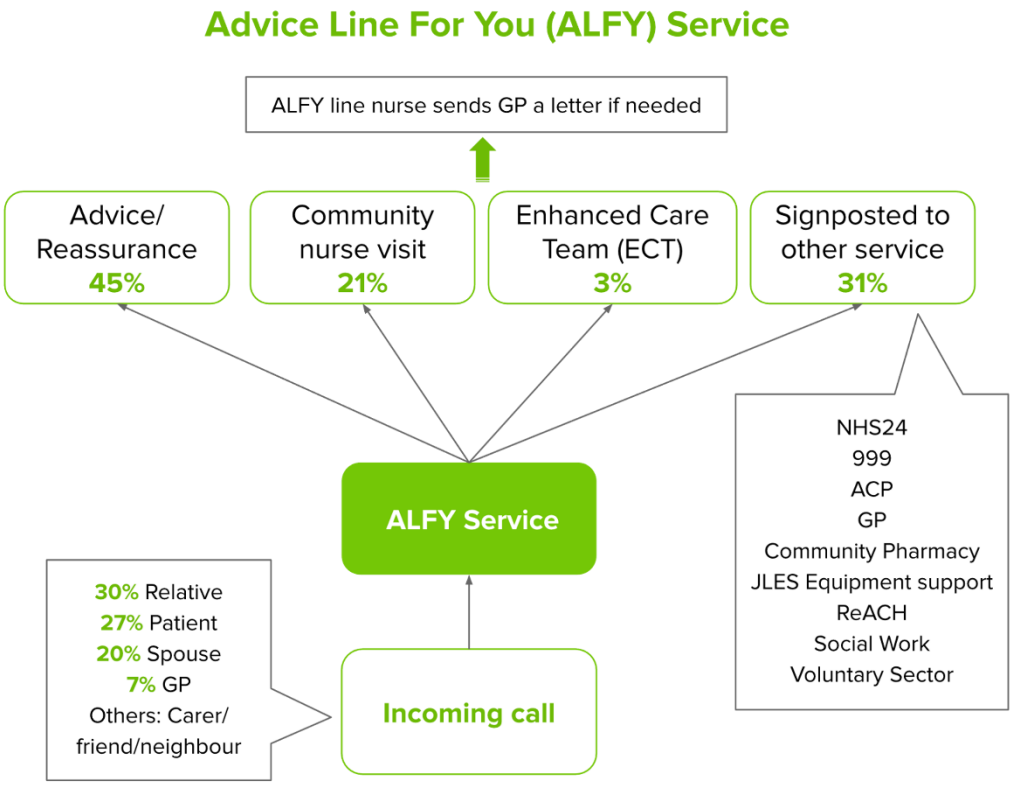
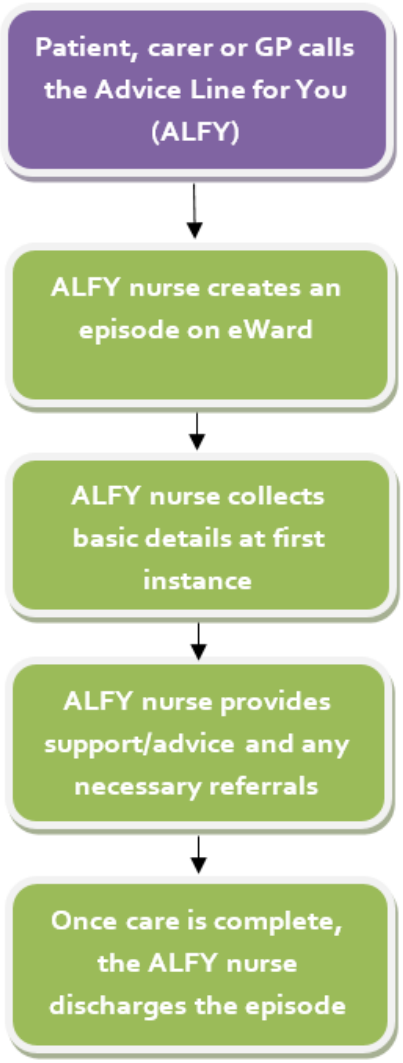


Figure 4.5 – Data entry process map and items collected for the ALFY service



ALFY calls data items
Name
DOB
Gender
Address
GP details
Date and time admitted to services
Ward (VALFY)
Specialty (Geriatric Medicine)
Presenting complaint
Admission type (ALFY telephone contact)
Admitted from (e.g. Private residence)
Discharge type
Discharged to (e.g. Private residence)
Outcome (recorded as signifiers)
Onward referrals (recorded as signifiers)
Date and time discharged from service

4.3 Roles and responsibilities in 'Closer to Home'

The main roles and responsibilities of staff members involved in each component of the 'Closer to Home' programme have been briefly described based on informal consultations taking place early on in this research, however, as previously described, the semi-structured interviews with staff taking place during Phase VI of this research provided an opportunity to gain further insight into the roles and responsibilities involved in the programme. Hence, the concept map developed based on participants' responses about their role has been included here in fulfilling the Phase I aim to document the structures and operational processes involved in 'Closer to Home' (Figure 4.6). The roles of the various interconnecting services and structures linked with 'Closer to Home' also became clearer in Phase

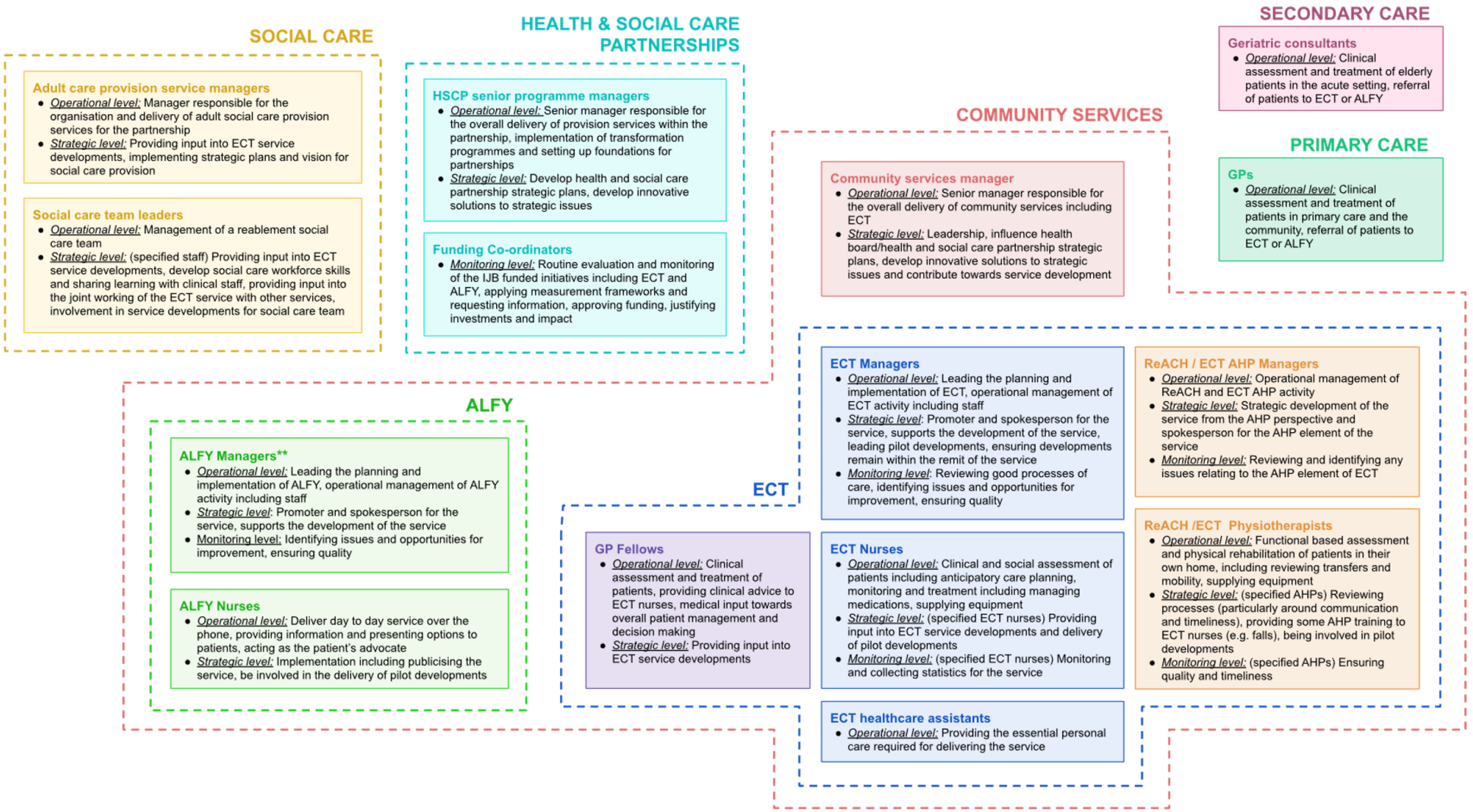
VI, including the role of primary care, secondary care, community services and Health and Social Care Partnerships which have been included in this concept map.

4.4 Summary and conclusion

This chapter has provided the outputs of Phase I of this research, the exploratory phase aimed at understanding and documenting the structures and operational processes involved in the 'Closer to Home' programme, primarily addressing the first research question and contributing towards the first stage of the evaluation framework focused on understanding and documenting the context. Towards addressing the first research question, namely, *'What were the structures and operational processes of the 'Closer to Home' programme?'* the following points summarise the findings from this exploratory phase.

- The exploratory and process mapping exercise confirms the 'Closer to Home' programme is a complex healthcare intervention, with various interconnecting parts, which have been well documented in this chapter
- The dedicated 'Closer to Home' components, namely the Enhanced Community Team (ECT), GP fellows and the Advice Line for You (ALFY) make use of a wide variety of existing community resources and are therefore interlinked with existing services and systems
- Aside from community services, primary care, secondary care and Health and Social Care Partnerships play key roles within the 'Closer to Home' programme
- There are data collection processes in place at least at each point of referral, contact and discharge from the 'Closer to Home' services, therefore it is feasible to use existing data to build an intervention cohort and understand activity of the services

Figure 4.6 – Concept map describing roles within 'Closer to Home,' based on responses from interviews with key stakeholders in Phase VI



**ALFY managers were not interviewed in Phase VI; hence, this description comes from the informal consultations, researcher's knowledge of the service and details provided by other respondents

Chapter 5 Scoping Literature Review

5.1 Purpose of this Review

Increased dependency on health care services by a growing population of elderly patients has led to a movement of healthcare provision towards community-based care. Various heterogeneous models of this type of care have been described (Young, 2009; Boult et al., 2009). This review is concerned with interventions providing home or home-setting treatment of acute or subacute medical conditions in elderly patients, at risk of unscheduled hospital admission. Various studies evaluate the effectiveness of these types of interventions, many of which are Randomised Controlled Trials (RCTs). In hospital avoidance schemes, it is often the case that randomisation is unfeasible or inappropriate (Steventon et al., 2012). Reviews of these studies usually include only RCTs (Shepperd et al., 2009a, 2016; Caplan et al., 2012). Some reviews also include non-randomised controlled trials (nRCTs) (Huntley et al., 2017; Low, Yap and Brodaty, 2011), however there are few that include all comparative study designs (Victor and Higginson, 1994). Hence this review is concerned with studies employing any comparative methodologies, including those where an RCT was not possible, which is the case in many healthcare environments, including the 'Closer to Home' programme, the community-based health care intervention of interest to the evaluation.

The aims of this scoping literature review are to review existing research on interventions providing home treatment of acute medical conditions in elderly patients, at risk of unscheduled hospital admission with the following three aims:

1) Document and identify themes, categories and classifications across the range of interventions
2) Identify methods and measures of effectiveness being used to evaluate the comparative effectiveness of such interventions
3) Review the existing evidence on the comparative effectiveness of these interventions

5.2 Methods

This is a scoping review which takes a systematic approach to reviewing existing evidence from a broad range of study designs and methods. Sucharew and Mucaluso (2019) describe the purpose of a scoping review as providing "an overview of the available research evidence without producing a summary answer to a discrete research question" and they highlight that it is a "particularly useful approach when the information on a topic has not been comprehensively reviewed or is complex and diverse" (2019, p.416). These features made the scoping review an attractive approach to the specific aims of the review previously outlined. The specific methods employed for this scoping review including information sources, search strategy, criteria and quality assessment are described in the following sections.

5.2.1 Information sources

The search was conducted using PubMed, CINAHL and additional hand search, for research articles published between 2004 and August 2018 inclusive, where studies were in English and pertained to human subjects. In setting the date limits, systematic reviews making a similar investigation as this review were searched. Upon finding a suitable review, the date of the search in the review was used as scientific justification in aiding the selection of a start date for this review. The identified review was of 'Complex interventions in preservation of physical function and independence in elderly people' published in The Lancet by Beswick et al. in 2008, however the search was conducted in 2005 (Beswick et al., 2008). In addition, in selecting the start year, the research motivation was that in 2004 the General Medical Contract (GMC) for General Practitioners (GPs) allowed them to "opt out of responsibility for providing out of-hours care to their patients, transferring responsibility to their local primary care trust," (The Care Quality Commission, 2014, p.8) which includes out-of-hours home visits. This would indicate a growth in the provision of home treatment through alternative interventions. Hence, the search start year was set as 2004.

5.2.2 Reference management and study screening

References were managed using Mendeley reference management software. Once duplicates were removed in Mendeley, results were imported into Rayyan, a web

application for screening of studies in systematic reviews, for the abstract screening of studies (Ouzzani et al., 2016). The results were exported as a CSV file and full-text screening was conducted on Mendeley with observations recorded on this CSV file. The file contains details of each study along with a decision, exclusion reason and tag for study design.

5.2.3 Search strategy

The search was for studies evaluating interventions providing home or home-setting treatment of acute or subacute medical conditions (including rehabilitation) in elderly patients, at risk of unscheduled hospital admission or institutionalisation by using the following search terms:

> *("older patients" OR "geriatric patients" OR "elderly" OR "older people") AND (("Nurse-led" AND "community" AND "care") OR ("Community based" AND "nursing") OR "Hospital at home" OR "Hospital in the home" OR "home versus hospital" OR "supported discharge" OR ("case management" AND "home") OR (("GP" OR "general practitioner" OR "nurse") AND ("home" OR "house") AND ("visits" OR "visiting") AND ("frail" OR "acute" OR "postacute" OR "chronic" OR "illness" OR "severely ill"))) AND ("effect" OR "effectiveness" OR "Evaluation" OR "case control" OR "retrospective study" OR "cohort study" OR "quasi-experimental" OR "quasi-experiment" OR "observational study" OR randomized trial OR randomized study)*

5.2.4 Inclusion and exclusion criteria

The University of York's Centre for Reviews and Dissemination's PICOS elements for a review protocol were used in this review (Centre for Reviews and Dissemination, 2006). Publications were included if they were articles published in the English language in peer reviewed journals and fit the following criteria:

- **P**opulation aged over 60 years of any gender living in any country, at risk of hospital admission or institutionalisation, excluding nursing home residents
- **I**ntervention providing short term home or home-setting treatment of acute or subacute medical conditions
- **C**ontrol group receiving usual care (including but not limited to acute hospital admission)
- **O**utcomes of intervention effectiveness in terms of patient's subsequent use or cost of health services, patient-related outcomes (including survival, quality of life and functional outcomes) and satisfaction with care

- Study designs employed are actual rather than proposed using primary data through randomised and non-randomised comparative designs (including controlled trials, quasi-experimental studies, before and after studies, prospective and retrospective cohort studies and case-control studies)

5.2.5 Extraction of information and thematic analysis

Several pieces of information were collected for each of the included studies relating to methodology and other study details. For each study the following elements were extracted: publication year, study location and setting, study design, sample size, target population (eligibility), intervention group definition, comparison group (control group) definition, matching strategy if one was used to select comparison groups, baseline assessments conducted, primary and secondary outcomes measured, follow-up period (or duration of outcome measurement), analysis performed (and adjustment factors used in the analysis) and results of outcome measures of each study. Data extraction was conducted in NVivo qualitative data analysis software by encoding details of each study into nodes representing each of the aforementioned elements.

After completing the data extraction instrument, thematic analysis was conducted finding classifications or themes for the majority of the items in the data extraction instrument. The following items were included in the thematic analysis: target population, setting, types of interventions, study design, baseline assessments conducted, study outcomes, analysis employed by the studies including adjustment factors and the findings of the included studies.

Meta-analyses were not performed primarily due to being outside of the remit of this review, however, in addition, the heterogeneity of interventions, study designs and outcomes would have made formal meta-analytic methods challenging, which is a feature of scoping reviews due to their broad scope (Sucharew and Macaluso, 2019).

5.2.6 Quality assessment of included studies

Assessment of study quality was conducted using the Downs and Black quality assessment for randomised and non-randomised studies (Downs and Black, 1998). This quality assessment tool was selected as it allowed for a consistent tool to be used across all the studies and it was originally developed to be suited for studies

evaluating healthcare interventions. The original assessment tool contained 27 items covering the following four domains:

(1) "Reporting (10 items)—which assessed whether the information provided in the paper was sufficient to allow a reader to make an unbiased assessment of the findings of the study.
(2) External validity (3 items)—which addressed the extent to which the findings from the study could be generalised to the population from which the study subjects were derived.
(3) Bias (7 items)—which addressed biases in the measurement of the intervention and the outcome.
(4) Confounding (6 items)—which addressed bias in the selection of study subjects.
(5) Power (1 item)—which attempted to assess whether the negative findings from a study could be due to chance." (Downs and Black, 1998, p.378)

A modified version of their checklist was used, as presented by Korakakis et al. (2018). This version modifies the scoring of the final item of the checklist (item 27) referring to the power of the study, where instead of giving a rating according to a range of study powers, the rating is given based on whether the study performed a power calculation or not, hence the maximum score for item 27 was 1 (a power calculation was conducted). Hence, the maximum score for the checklist was 28 instead of 32 and corresponding quality levels were given as previously reported (Hooper et al., 2008) as excellent (26-28); good (20-25); fair (15-19); and poor (<14).

The study quality scores were taken into account in the reporting of individual study findings, using the quality grading presented by Hooper et al. (2008)

- 1a (very strong): the findings are supported by the results of 2 or more studies of at least excellent quality
- 1b (strong): the findings are supported by at least 1 study of excellent quality
- 2a (moderately strong): the findings are supported by 2 or more studies of at least good quality
- 2b (limited): the findings are supported by at least 1 study of good quality
- 2c (weak): the findings are supported by at least 1 study of fair or poor quality
- 3 (consensus): in the absence of evidence, there is agreement by a group of experts on the appropriate treatment course
- 4 (conflicting): there is disagreement between the findings of at least 2 randomized controlled trials.

5.3 Search results

The Pubmed search yielded 323 articles and the CINAHL search yielded 227 articles. Additional hand search identified 27 articles. After duplicates were removed, a total of 421 articles were screened by abstract for inclusion. Of these, 379 articles were excluded based on the exclusion and inclusion criteria (reasons can be seen in Table 5.1), leaving 42 articles for full-text screening. Of these, 19 were excluded from the review as a result of not meeting the inclusion criteria and one was excluded due to lack of response on clarification from the author (full reasons can be seen in Table 5.2). This meant that 22 articles were included and data was extracted for each of these studies. The PRISMA diagram for the search results can be seen in Figure 5.1. Full references for the included studies and their assigned study codes used throughout this chapter can be seen in Appendix B Table B-1.

Table 5.1 – Abstract screening exclusions by reason

Article type	**47**
Study protocol	18
Intervention description or protocol	13
Process evaluation	7
Background discussion	6
Commentary	1
Conference proceedings	1
Letter to the editor	1
Population	**9**
Nursing home residents	3
Non acute telehealth	2
Nursing home or home care staff	2
Caregivers	1
Primary care nurses	1
Intervention	**197**
No intervention	59
Non acute case management or monitoring	29
Education, training or counselling for patients, caregivers or care providers	18
Primary care interventions including frailty screening, CGA, PHV	10
NH, assisted living or long term care	10
Discharge planning	9
Medical or surgical intervention	8
In hospital	7
Exercise and/or diet programmes	7
Social or psychosocial interventions	5
Palliative care	5
Medication management only	5

Fall prevention	5
Adult day or respite services	5
Community mental health	4
Nurse led cardiovascular dementia prevention	3
Non acute telehealth	3
Use of screening or stratification tools	2
Informal care	1
Infection prevention intervention in NH residents	1
Electronic health record	1
Comparison group	**22**
No comparison group	11
Other variations	11
Outcome	**3**
Characteristics of home care supporting clinics	1
Enrolment reasons	1
Unwanted incidents	1
Study design	**101**
Review	68
Exploratory case study	15
Exploratory pilot study	8
Cross sectional	6
Longitudinal study with no comparison group	2
Process evaluation	1
Discrete choice experiment	1

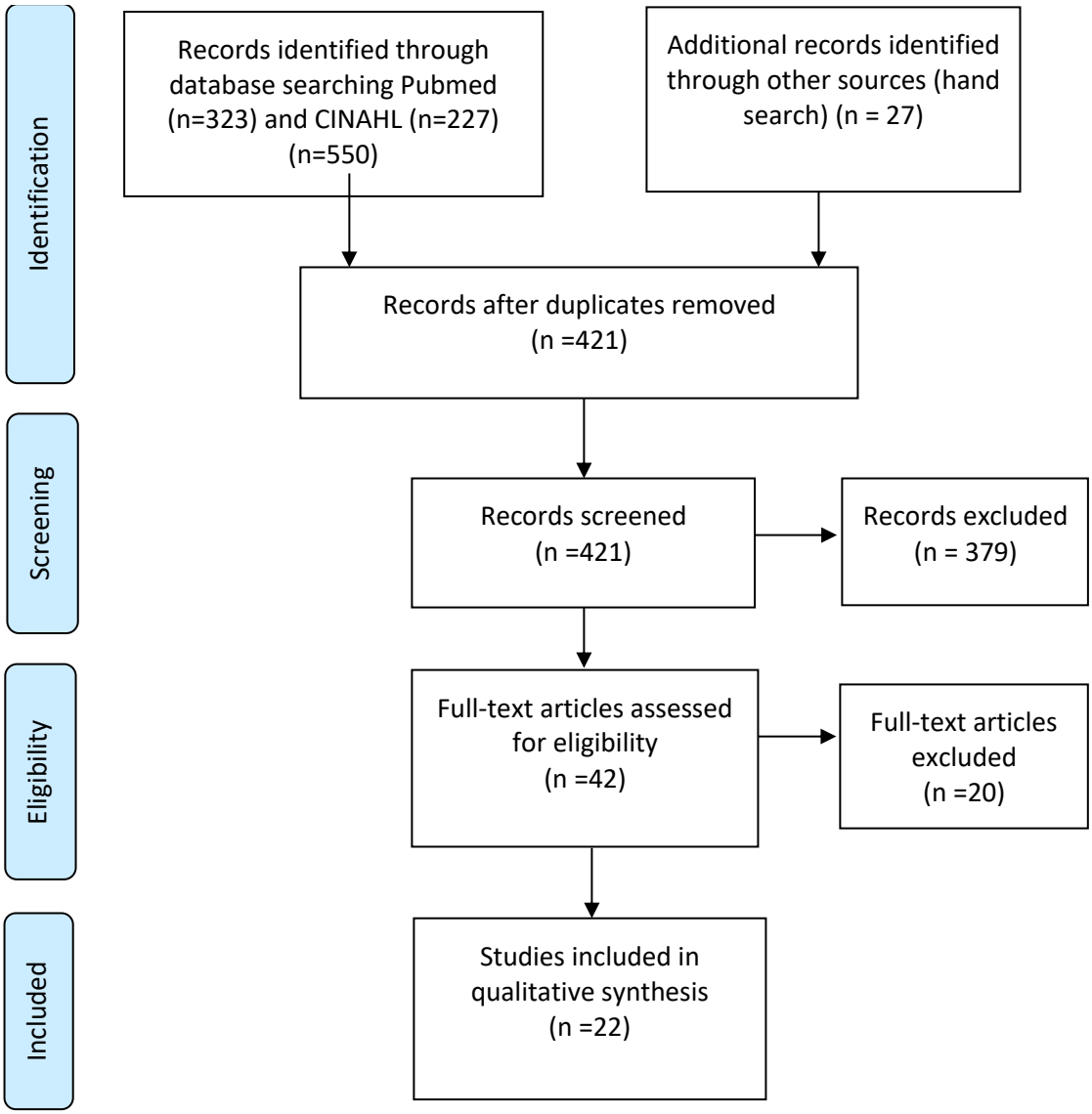
Table 5.2 – Full-text exclusion reasons

Study code	Exclusion reason
Cappelleri 2017	INT - Blood pressure monitoring in home with device vs hospital
Chow 2014	INT - Case management (education and monitoring post-discharge)
Courtney 2012	INT - Exercise programme (post-discharge plan with home visit and follow up calls)
Del Sindaco 2007	INT - Non acute disease management (long-term, intensive post-discharge follow-up)
Godwin 2016	INT - PHV (home visits for medically stable independent well elderly to identify any unmet needs)
Gregersen2012	Required clarification but no response from authors (primarily an in-hospital geriatric team, but with follow-up physio home visits which are not described)
Hofstad 2013	INT - Study protocol
Isaia 2010	CG - Comparing hospital at home patients with and without pressure ulcers
Janse 2016	INT - Primary care frailty screening, CGA and PHV
Jeffs 2005	INT - Patient education (Chronic disease self-management for COPD i.e. no treatment)
King 2018	INT - Primary care frailty screening, CGA and PHV
Kirkham 2014	INT - Home medication management
Looman 2014	INT - Primary care frailty screening and case management
Prasad 2014	INT - Primary care case management, coordination, transitional care and monitoring by one ANP
Rosenberg 2012	INT - Primary care CGA and case management
Shepperd 2017	AT - Study protocol

Sinclair 2005	INT - Patient education (two post-discharge cardiac support home visits i.e. no medical treatment)
Strupeit 2013	INT - Discharge planning with scheduled patient education and counselling home visits (i.e no medical treatment)
Thygesen 2015	INT - Discharge planning (with scheduled medication review and care planning home visits i.e. no medical treatment)
Watkins 2012	INT - Discharge planning (transitional care)

INT="Intervention," CG= "Comparison group," AT= "Article type"

Figure 5.1 – PRISMA diagram for review of home or home-setting treatment of acute or subacute medical conditions in elderly patients, at risk of unscheduled hospital admission or institutionalisation



5.4 Results of the thematic analysis

The following section aims to describe the results of the thematic analysis carried out on the information extracted for each of the included studies. The following items were included in the thematic analysis: target population, setting, types of interventions, study design, study outcomes, analysis employed by the studies including adjustment factors and the findings of the included studies. Full details collected for each of the included studies can be seen in Appendix B Table B-2.

5.4.1 Target population

All studies targeted patients aged 60 or over (only one study (Senior et al., 2014) also included those over 55 specifically for indigenous groups in New Zealand). The average age was 80.3 for intervention patients and 79.9 for comparison group patients. Ten studies (45.5%) targeted patients with a range of conditions (8 unspecified, 1 frailty and 1 acute medical or orthopaedic). The remaining 12 studies (54.5%) targeted patients with specific illnesses or conditions: three studies targeted Chronic Heart Failure (CHF), two studies targeted orthopaedic conditions, two studies targeted hip fracture surgery, two studies targeted four specific illnesses (community-acquired pneumonia, COPD, CHF or cellulitis), one study targeted specific acute and subacute infections and the remaining two studies individually targeted Chronic Lung Disease (CLD) and COPD. Details can be found in Table 5.3.

5.4.2 Setting

Out of the reviewed publications, 11 (50.0%) were European studies, 4 (18.2%) studies were conducted in Australia or New Zealand, 4 studies (18.2%) were conducted in Hong Kong, two were conducted in the USA and one in Taiwan. All studies except for one included both hospital and community elements either as part of the study design (recruitment) or as part of the intervention. The remaining study recruited and compared patients from the community exclusively. All studies except for one delivered interventional care primarily at home. One study delivered interventional care in short-stay residential care facilities in addition to the patient's home. Several of the studies were conducted within the same setting (same hospital or location) with either variations of a

similar intervention, or separate analyses of the same data (or subgroups of data). The unique interventions identified will be discussed in a separate section.

Table 5.3 – Setting, target patient category and specification of included studies

Setting	Study code	Patient category	Patient specification
Acute care hospitals and community at 3 sites in Buffalo, NY, Worcester, MA and Portland, OR.	Leff2005	Illness/condition-specific: four target illnesses	Attending ED or assessed at ambulatory setting as requiring admission for target illnesses (community-acquired pneumonia, COPD, CHF or cellulitis)
	Leff2006	Illness/condition specific: four target illnesses	Attending ED or assessed at ambulatory setting as requiring admission for target illnesses (community-acquired pneumonia, COPD, CHF or cellulitis)
2 Acute hospitals and community in Shatin and Taipo, Hong Kong	Kwok2004	Illness/condition-specific: CLD	Admitted to acute hospital for CLD and at high risk of readmission
	Kwok2008	Illness/condition-specific: CHF	Admitted to acute hospital for CHF and at high risk of readmission
University hospital and community in Vitoria-Gasteiz, Spain	Mendoza2009	Illness/condition-specific: CHF	Attending ED with exacerbation of HF with pre-existing CHF diagnosis
University hospital and community in Torino, Italy	Aimonino2008	Illness/condition-specific: COPD	Attending ED with exacerbation of COPD
	Isaia2009	Range of conditions (unspecifed)	Attending ED with acute illness covering a range of conditions
	Tibaldi2009	Illness/condition-specific: CHF	Attending ED with acute decompensation of CHF with pre-existing CHF diagnosis
Hospital and community in northern Taiwan	Shyu2013	Illness/condition specific: Hip fracture	Admitted to hospital for hip fracture requiring surgery
University hospital and community in Goteborg, Sweden	Ziden2008	Illness/condition specific: Hip fracture	Admitted to a hospital emergency unit with hip fracture requiring surgery
Tertiary referral teaching hospital and community in Sydney, Australia	Caplan2005	Illness/condition-specific: infections	Attending ED with targeted subacute and acute infections
	Caplan2006	Range of conditions (unspecified)	Admitted to acute hospital and referred for geriatric rehabilitation
Acute hospital, intermediate care hospital and community in Badalona, Spain	Mas2016	Illness/condition-specific: Orthopaedic	Attending ED or admitted to acute hospital for acute orthopaedic conditions
	Closa2017	Illness/condition-specific: Orthopaedic	Attending ED or admitted to acute hospital for acute orthopaedic conditions
	Mas2017	Range of conditions (acute medical and orthopaedic)	Attending ED, admitted to acute hospital or community patients for acute medical or orthopaedic conditions
2 Home visiting nursing service centres in Geneva, Switzerland	DiPollina2017	Range of conditions (frailty)	Community-dwelling identified as frail and at risk of hospitalisation
4 acute care hospitals and their community nursing services in Hong Kong	Leung2015	Range of conditions (unspecified)	Admitted to acute hospital for range of conditions and at high risk of readmission
Day hospital and community in Dublin, Ireland	Lewis2017	Range of conditions (unspecified)	Admitted to hospital, day hospital or attending outpatient geriatric clinic assessed as frail with complex needs
1 acute care hospital, 3 rehabilitation hospitals and community in Hong Kong	Lin2015	Range of conditions (unspecified)	Admitted to acute hospital at high risk of readmission
Tertiary hospital and community in Waikato, New Zealand	Parsons2018	Range of conditions (unspecified)	Admitted to acute hospital at risk of hospital readmission or institutionalisation
Hospital, short-stay residential care facilities and community in New Zealand.	Senior2014	Range of conditions (unspecified)	Admitted to hospital or rehabilitation service at high risk of institutionalisation
Hospital and community in London, UK	Wright2013	Range of conditions (unspecified)	Attending ED assessed having complex needs requiring hospitalisation

5.4.3 Types of interventions

This section aims to describe the types interventions evaluated within the included studies. The section will begin by describing the existing model definitions of interventions included in this review in order to define how they were classified in this review. A wide variety of interventions providing home treatment of acute medical conditions have been described in international literature (Leff and Montalto, 2004). Various models of comprehensive care models for older adults with chronic conditions have been described (Boult et al., 2009) as well as models of intermediate care defined as " 'care closer to home' by expansion and development of community health and social services" (Young, 2009, p.S21). Within these model descriptions, the main recognised model providing home treatment of acute and subacute medical conditions is the "hospital-at home" (HaH) model.

Hospital-at-home (HaH) has been described as "a service that provides active treatment by healthcare professionals in the patient's home for a condition that otherwise would require acute hospital inpatient care, and always for a limited time period" (Gonçalves-Bradley et al., 2017, p.6). Two main models of HaH have been described: admission avoidance and early discharge (Boult et al., 2009; Young, 2009). Shepperd and colleagues have conducted several reviews on HaH services resulting in two well-known Cochrane reviews of each of these models (Gonçalves-Bradley et al., 2017; Shepperd et al., 2016). These models were both identified within the reviewed studies.

An additional model was identified in the reviewed studies that did not appear to be explicitly described as a separate model in academic literature (Boult et al., 2009; Young, 2009). This may be because it is closely related to the early discharge HaH model hence, some authors may group it within this model, however, it has clear distinctions. The distinctive model could be described as 'post-acute discharge support' or 'restorative care,' which supports patients after hospital discharge (rather than 'early') for subacute medical conditions and may be at risk of readmission, but do not provide substitution for a hospital stay at discharge. Though literature describes "transitional care" which is "designed to facilitate smoother, safer, and more-efficient transitions from hospital to the next site of

care (another healthcare setting or home)," transitional care is concerned with the transition between settings rather than care provision after transition (Boult et al., 2009, p.2332)

Hence, the interventions within the reviewed studied were identified as being based on one or more of the following three models: admission avoidance HaH, early discharge HaH or post-acute discharge support. Some of the reviewed interventions included more than one of these models or combined these models with additional elements, which will be later discussed. This is as expected, as having multiple components is a defining characteristic of complex interventions (Campbell et al., 2007). The three models will be described in detail in the next section.

5.4.3.1 Admission avoidance HaH

In admission avoidance (also referred to as "substitutive") HaH models, care is provided in lieu of acute hospital care and they are characterised by "rapid response" teams (Young, 2009). Admission avoidance HaH "admit[s] patients directly from the community thereby avoiding physical contact with the hospital, or may admit from the emergency room" (Shepperd et al., 2016, p.8) after assessment confirming the "patient requires hospital-level treatment but can be treated safely at home […] by a HaH team that includes a physician, nurses, technicians, and rehabilitative therapists" (Boult et al., 2009, p.2332). Leff and Montalto (2004) further define admission avoidance HaH as meeting the following criteria:

(1) It provides care that substitutes entirely for an inpatient acute hospital admission.
(2) It provides an intensity of care, including medical and nursing care, similar to that provided in the hospital appropriate to the severity of the illness treated.
(3) It provides care that cannot be provided by usual community-based home care services (Leff and Montalto, 2004)

Due to the difficulty of defining the above criteria (e.g. What defines a hospital-level intensity of care?) and sometimes lack of clarity of descriptions in

interventions within the studies included in this review, rather than using this criteria explicitly, studies were categorised as admission avoidance HaH if the intervention was defined as "substitutive" for hospitalisation, "providing home hospitalisation" or if intervention patients were "otherwise necessitating admission." Interventions that were categorised as admission avoidance HaH achieved entire substitution of an inpatient acute hospital admission by means of either 1) hospital-level care at home or 2) supportive and diagnostic care at home combined with access to a specialised day hospital or clinic. These interventions were further identified as admission avoidance if their comparison groups were described as receiving usual inpatient acute care in "hospital" or "geriatric ward."

5.4.3.2 Early discharge HaH

After an initial hospitalisation, early discharge HaH substitutes the remainder of a patient's hospital admission by providing early discharge and acute care at home, involving rehabilitation that would usually be provided in a hospital. Specifically, "after a patient's medical condition has stabilised in the hospital, the patient returns home and is treated there by a HaH team consisting chiefly of nurses, technicians, and rehabilitative therapists" (Boult et al., 2009, p.2332). If it were not available then the patient "would not be discharged early and would remain on an acute hospital ward" (Gonçalves-Bradley et al., 2017, p.6). Studies were categorised as early discharge HaH if the intervention was defined with terms such as "early discharge HaH," "early discharge rehabilitation" or "home rehabilitation." These interventions were further identified as early discharge if their comparison groups were described as receiving rehabilitation in a "rehabilitation unit/ward," "intermediate care unit" or "geriatric ward" or receiving usual care in hospital without early discharge.

5.4.3.3 Post-acute discharge support

Post-acute discharge support was identified separately from early discharge models, as this model does not provide substitution for a hospital stay and does not provide discharge 'early' but rather supports a patients recovery at home for patients who may be at risk of further hospitalisation at discharge from the acute setting, with the aim of restoring or enhancing functional ability at home. This model was often combined with the admission avoidance HaH model after the initial discharge support, with the capability of offering admission avoidance HaH

in the event of a presentation of an acute condition after discharge, or access to a day hospital or specialised clinic to avoid an inpatient admission.

5.4.3.4 Identified types of interventions

All interventions provided either home treatment or support for acute or subacute medical conditions (including rehabilitation and post-discharge support) in elderly patients. Out of the 22 included studies, 18 unique interventions were identified. The interventions could be broadly categorised into admission avoidance HaH, early discharge HaH and post-acute discharge support, some including more than one of these models or combining additional elements, as previously mentioned. These can be seen in Table 5.4.

Table 5.4 – Intervention models and additional elements

Intervention models and distinctive additional elements	Number of unique interventions
Admission avoidance HaH	**6**
No further interventions identified	5
With access to day hospital, preceded by preventive home visiting	1
Early discharge HaH	**5**
Both early discharge HaH and admission avoidance HaH	**1**
Post-acute discharge support	**6**
No further interventions identified	2
In short-stay residencial care followed by supported home rehabilitation	1
With access to day hospital (for any further acute presentations)	1
With capacity for admission avoidance HaH (for any further acute presentations)	1
With capacity for admission avoidance HaH and access to day hospital (for any further acute presentations)	1
Total unique intervention models	**18**

The staff involved in care for each of the interventions are presented in Table 5.5 below. Full details of the 18 individual interventions can be seen in Table 5.6.

Table 5.5 – Medical and social care professionals involved in each intervention model observed in reviewed studies

Study code	Intervention group	G	P	N	PT	OT	SCW	Other
Admission avoidance HaH								
DiPollina2017	Admission avoidance HaH		●	●	●	●	●	Psychologists
Aimonino2008 Isaia2009 Tibaldi2009	Admission avoidance HaH	●	●	●	●		●	Counsellor
Leff2005 Leff2006	Admission avoidance HaH		●	●				
Mendoza2009	Admission avoidance HaH		●	●				
Wright2013	Admission avoidance HaH	●	●	●				

Caplan2005	Admission avoidance HaH		●	●	●	●		Hospital doctors (specialty unspecified)
Early discharge HaH								
Caplan2006	Early discharge HaH			●	●	●		Doctors (specialty unspecified)
Parsons2018	Early discharge HaH	●	●	●	●	●	●	
Shyu2013	Early discharge HaH	●		●	●			
Ziden2008	Early discharge HaH	●		●	●	●	●	Dietician
Mas2016 Closa2017	Early discharge HaH	●	●	●	●	●		
Both early discharge HaH and admission avoidance HaH								
Mas2017	Both early discharge HaH and admission avoidance HaH	●	●	●	●	●		
Post-acute discharge support								
Kwok2004	Post-acute discharge support	●	●	●				
Kwok2008	Post-acute discharge support	●		●				Cardiologist
Leung2015	Post-acute discharge support	●	●	●				AHPs (specifics unspecified)
Lewis2017	Post-acute discharge support			●	●	●	●	Pharmacist
Lin2015	Post-acute discharge support	●		●	●	●	●	
Senior2014	Post-acute discharge support			●	●	●		
Total		***11***	***11***	***18***	***12***	***10***	***6***	***8***

G=Geriatrician, P=Physician, N=Nurse, PT=Physiotherapist, OT=Occupational Therapist, SW=Social Care Worker

Table 5.6 – Intervention details for each included study

Study code	Available staff	Intervention specification	Intervention description	Avg duration	Num of visits (average unless otherwise specified)
Admission avoidance HaH					
DiPollina2017	P, PT, OT, Psychologists, SCW, N	Admission avoidance HaH (with access to day hospital, preceded by preventive home visiting)	Integrated care at home defined as formally coordinating existing services: home visiting nursing services with nursing teams and a community geriatric unit (CGU) team of home-visiting physicians, PTs, OTs, psychologists and SWs. Nursing teams were able to provide the same care they usually provide, as in the control group (includes management of patient needs and home hospitalisation).The physician performed home geriatric assessment in the following domains: cognition, mood, functional status, gait, nutrition, pain and medication review and adherence. Results were shared with the patient's physician and the nursing teams. CGU teams and nursing teams held meetings for any complex issues. Patients and nursing teams were instructed to contact patient's physician in an emergency and if unavailable, patients had access to a 24/7 medical call service from the CGU. A day hospital was also part of the provided services.	-	6.3 home visits/telephone consultations
Aimonino2008	P, G, N, PT, SCW, Counselor	Admission avoidance HaH	Immediate transfer home from ED by ambulance to physician-led substitutive hospital-at-home care (GHHS), provided by a multidisciplinary team of three geriatricians, 13 nurses, two PTs, one SW and one counsellor, with access to seven cars, in addition to usual ED care. Hospital-level care included blood tests, ECG, antimicrobials and other medicines, blood transfusions, surgical treatment of pressure ulcers, echocardiograms, echographs, Doppler ultrasonographies. Other care includes physiotherapy, occupational therapy, patient and caregiver disease management education and counselling. Patients requiring hospital diagnostics (e.g. x-ray, endoscopy) were transferred to hospital during the GHHS episode but returned home within a few hours. In first few days, patients receive daily physician and nurse visits, followed by daily nurse visits and physician visits every 2-3 days subsequently.	-	4.1 nursing, 9.9 physician
Isaia2009				-	-
Tibaldi2009				20.7 days	13.8 nursing, 11.1 physician
Leff2005	P, N	Admission avoidance HaH	Transfer home from ED or ambulatory site by ambulance for substitutive hospital-at-home programme, provided by physicians and nurses, evaluated by the physician either at ED or shortly after arriving home, where they were met by a nurse. The hospital-at-home program involved subsequent direct one-on-one nursing supervision initially for at least 8 hours (site 3) or 24 hours (sites 1 and 2), followed by at least daily visits from both nurses and the physician, who was available 24 hours a day for emergency visits. The program also included other care components such as medical equipment, oxygen therapy, IV fluids, IV antimicrobials, skilled therapies, pharmacy support, home radiology and diagnostic studies (ECG, radiography). A Lifeline medical alarm device was provided to patients without caregivers.	3.2 days	1.5 by physician, 1.4 nurse.
Leff2006				-	-
Mendoza2009	P, N	Admission avoidance HaH	Hospital at Home (HaH) unit after ED, including scheduled and urgent visits at home by internal medicine physician every other day depending on condition and a daily by a specialist nurse. Care included nursing and clinical evaluation, home ECGs, sample collection for laboratory tests. Discharge to primary care or cardiology ward in case of no response to treatment. Outside of normal working hours (8am-9pm), patients were instructed to call emergency services. Access to hospital X-ray and ECG services.	-	-
Wright2013	N, G, P	Admission avoidance HaH	Triage and Rapid Elderly Assessment Team (TREAT) following ED attendance. Admissions that were transferred to TREAT received CGA at the ED followed by prompt intervention and tailored rapid supported discharge on the day of admission, by a multidisciplinary team of a consultant geriatrician, specialist registrar, nurse practitioner, OT and an administrator. Immediately after discharge, a post-acute care enablement team provided short-term nursing support, monitoring and treatment for up to 5 days and a rapid access geriatric 'hot clinic' provided follow-up investigations and tracked recovery progress	Up to 5 days (nursing support)	-

			(unclear who provided the clinic and where it took place). TREAT was available during working hours on weekdays and -am-1pm on weekends or holidays.		
Caplan2005	P, N, PT, OT, Hospital doctors	Admission avoidance HaH	Transfer home from ED within 24 hours to admission substitution to hospital-in-the-home (HITH), provided primarily by nurses. Treatment according to diagnosis at ED, including medication administration, blood transfusions, IV antibiotics, subcutaneous enoxaparin injections and warfarin for DVT.	10.1 days	9 nursing, 0.8 physician, 0.9 hospital doctor, 0.2 PT, 0.1 OT
Early discharge HaH					
Caplan2006	N, PT, OT, Doctors	Early discharge HaH	Transfer home from inpatient hospital stay to early discharge rehabilitation at home provided by a hospital-based multidisciplinary team of nurses, doctors, PTs and OTs. Care provided include rehabilitation, treatment of any deterioration such as infections through IV antibiotics and provision of equipment.	15.97 days	20 rehabilitation team
Parsons2018	N, PT, OT, HA, P, G	Early discharge HaH	Early supported discharge for home-based rehabilitation from a team of healthcare assistants, registered nurses, PTs and OTs, providing home visits up to 4 times daily, 7 days a week up to 6 weeks. Weekly multidisciplinary team meetings with consultant geriatricians and close collaboration with GPs and practice nurses. Care provided utilised functional rehabilitation principles maximising recovery through incorporating exercises with ADL tasks, setting rehabilitation goals with a care plan. Once discharged from the team, patient care was returned to their GP. (Inclusion criteria: consented to being treated at home and agreed with the objectives set by the team)	-	Up to 4 home visits daily
Shyu2013	N, PT, G	Early discharge HaH	Early discharge subacute care model or comprehensive care model. The subacute care model included geriatric nurse consultation (CGA, physical, cognitive, functional and nutritional assessment before surgery), geriatrician evaluation based on assessment results before surgery, continuous rehabilitation beginning in hospital after surgery and continuing at home after discharge and early discharge planning (including assessment of home, caregiver's competence, family function, self-care ability, need for long-term care) providing care up to 3 months. The comprehensive care model included the components of the subacute model in addition to health-maintenance interventions to prevent falls (falls risk assessment), nutritional assessment (dietician referral based on results) and depression screening and management.	Up to 1 year	7.5 nursing and 2.5 PT for subacute model, 10.9 nursing and 3.2 PT for comprehensive care model.
Ziden2008	PT, OT, N, G, SCW, Dietician	Early discharge HaH	Geriatric home rehabilitation programme with supported discharge in addition to usual care (control), provided by a PT, OT, nurse and hospital geriatrician. During hospital stay the patient was offered an individually tailored rehabilitation programme and was accompanied by the PT and OT at discharge. Home rehabilitation consisted of PT and OT visits for up to 3 weeks, focusing on physiotherapy, encouraging confidence in locomotion and physical activity, with a focus on outdoor ambulation, in addition to at least one nurse visit (not able to fulfil for all patients due to resources). Hospital geriatrician was medically responsible for patient care during rehabilitation and patients could be readmitted where necessary. Access to a medical social worker and dietician where needed.	Up to 3 weeks	2.4 PT, 1.6 OT
Mas2016	P, G, N, PT, OT	Early discharge HaH	Rehabilitation at home (HHU) within 24 hours of discharge from the acute setting, from specialist geriatric health team providing CGA, MDT review and rehabilitation therapy but in a home setting, by rehabilitation medicine physicians, geriatricians, nurses, physiotherapists, and occupational therapists. Management of comorbidities and acute illness, with specialist nurses able to manage complex conditions such as severe functional loss and delirium with access to diagnostic techniques (e.g. blood tests, ECG) and acute treatments (e.g. IV treatments) from acute hospital.	50 days	5 physician, 15 nursing and 19 PT or OT
Closa2017				49.4 days	Up to 7 nursing visits and up to 5 therapy sessions per week
Both early discharge HaH and admission avoidance HaH					
Mas2017	P, G, N, PT, OT	Both early discharge HaH	Rehabilitation/early supported discharge at home (HHU - ESD) after discharge from the acute setting, or admission avoidance hospital-at-home (HHU - AA) after attendance at ED or from the community	46.6 days	Up to 2-3 visits per day

		and admission avoidance HaH	providing the same acute or post-acute protocol of usual care (control group) but in a home setting, with up to 2-3 visits per day. All the same staff providing usual care were available for both HHU - ESD and HHU - AA. Management of comorbidities and acute illness such as infections or heart failure, with specialist nurses and therapists able to manage complex conditions such as severe functional loss leading to immobility, delirium or behavioural symptoms, with access to diagnostic techniques (blood and microbiologic tests, ECG, radiology) from acute hospital.		
Post-acute discharge support					
Kwok2004	N, G, P (Respiratory)	Post-acute discharge support	Supported discharge program through intensive home visits by community nursing teams (CN). Initial visit in hospital for health promotion and education, encouraging use of a trained clerk telephone hotline in case of deterioration, as part of the intervention (any messages were relayed to nurses by pager). Post-discharge home visits within 7 days of discharge weekly up to 4 months and monthly thereafter up to 6 months for monitoring vital signs, health promotion and education, psychosocial support for patient and family, arrangement of health and social care services as required. Patients refusing home visits could be monitored by phone. Nurses had direct access via phone and pager to hospital geriatricians and respiratory physicians and could alter medication regimes and arrange urgent hospital outpatient and inpatient services after discussion. Prior to the intervention nurses received training and ward experience in management of chronic lung disease.	-	11.8 home visits, 10.3 telephone consultations
Kwok2008	N, G, Cardiologist	Post-acute discharge support	Supported discharge program through intensive home visits by community nursing teams (CN) in addition to usual care (control). Initial visit in hospital for health promotion and education (drug compliance and dietary advice), encouraging use of a trained clerk telephone hotline in case of deterioration, as part of the intervention (any messages were relayed to nurses by pager). Post-discharge home visits within 7 days of discharge weekly up to 4 months and monthly thereafter up to 6 months for monitoring vital signs, medication and compliance review, monitoring CHF control, health promotion and dietary and exercise education, arrangement of health and social care services. Patients refusing home visits could be monitored by phone. Nurses liaised with hospital geriatricians and cardiologists and could alter medication regimes and arrange urgent hospital outpatient and inpatient services after discussion. Average number of home visits per patient: 8.8. Average number of telephone calls per patient: 15.0.	-	8.8 home visits, 15.0 telephone consultations
Leung2015	N, P, AHPs, G	Post-acute discharge support (with capacity for admission avoidance HaH for any further acute presentations)	Post-discharge support ("virtual ward") to prevent readmission provided at home by a team of nurses, physicians, geriatricians and other AHPs. Hospital-level care included bloods measurement, insulin administration, wound dressing with first nursing visit for a health assessment within 48 hours from discharge, first physician visit within first week, with 4 visits per week on average. Other services provided at home visits by nurses included symptom monitoring, management and health education as well as psychosocial support for patients and carers. Patients and their carers also had access to extended out of hours service and telephone consultation service aimed at fast-tracking patients to other services such as enhanced nonemergency ambulance transport.	-	4 home visits per week
Lewis2017	N, PT, OT, SCW, Pharmacist	Post-acute discharge support (with capacity for admission avoidance HaH and access to day hospital for any	Community virtual ward (CVW) model, overseen by a clinical case manager (senior nurse working across primary and secondary care) providing risk stratification and conducting home visits and telephone consultations alongside a primary care team (including GP, public health nurse, PT, OT, SW and pharmacist). The CVW had access to a specialist therapist-led integrated care team for those at risk of admission due to functional decline, a nurse-led community intervention team for home-based interventions such as IV therapy, a day hospital in case of clinical or functional deterioration exceeding primary care team service and/or a planned admission to hospital, and increased social support including medication management and nutrition if required. Conditions managed include delirium, dementia, pain	3-7 months	Daily to 2-weekly nursing visits

		further acute presentations)	management, symptomatic polypharmacy, dehydration, heart failure, exacerbation of COPD, chest infection and cellulitis		
Lin2015	N, G, PT, OT, SCW	Post-acute discharge support (with access to day hospital for any further acute presentations)	Integrated Care and Discharge Support (ICDS), including risk stratification, multidimensional assessments (including CGA) and discharge planning in hospital, provided by link nurses (serving as 'link' between community and hospital care) working with geriatricians. After assessment, link nurses allocate patients to either 1) Integrated Care Model (ICM) case management with post-discharge home visits (wound care, home oxygen) and telephone support for high-risk patients with complex medical and social problems, provided by SWs, PTs, OTs and APN for around 3 months (44%) or 2) Home Support Team (HST) services, for patients requiring urgent social services, providing rapid and intensive community support (meal delivery, household cleaning, respite care and home assessment and modification) (56%). Link nurses, ICM case managers and HST hold weekly multidisciplinary meetings chaired by geriatrician. Access to rehabilitation in geriatric day hospital and fast-track or follow-up clinics.	75.8 days (ICM 101.5 days, HST 55.9 days)	-
Senior2014	N, PT, OT	Post-acute discharge support (in short-stay residential care followed by supported home rehabilitation)	Post-discharge 'Promoting Independence Programme' (PIP) to restore function and return patient to living in the community, coordinated by a case manager, conducting CGA with care plan development (integrating physical activity and ADL) in hospital and delivering supported discharge at a short-stay residential care facility, where care plan was delivered by a nurse, PT and OT, followed by home rehabilitation on discharge from residential care 3-4 times per week over 2 to 3 months by a rehabilitation assistant after which care was handed over to trained support workers when sufficient progress had occurred. PT and OT conducted a 3-month visit to re-assess care plan and if goals were attained, patients were monitored by phone and contacted monthly. Patients were referred to specialised care in case of decline. Prior to discharge from short-stay residential care, an OT conducted a home assessment for any modification needs.	2-3 months (rehabilitation)	3-4 home visits per week (rehabilitation)

G=Geriatrician, P=Physician, N=Nurse, PT=Physiotherapist, OT=Occupational Therapist, SW=Social Care Worker

5.4.4 Study design

Study design was classified according to Reeves, Wells and Waddington's (Reeves, Wells and Waddington, 2017) classification of study designs evaluating the effects of health care interventions (Box 2 in their paper). This was done to facilitate thematic analysis of study designs. Self-reported study design was also collected for comparison. Communicating study design is challenging outside of randomisation, with descriptions or labels often described ambiguously. Differences in how study designs are understood between research fields also cause these difficulties (Reeves, Wells and Waddington, 2017). Hence a standardised classification was used comparing the self-reported designs.

Thirteen experimental designs (where the researcher is actively involved in allocating study groups) and nine observational designs (where groups are identified based on existing information) were identified among included studies. Of the included studies, 11 (50.0%) were classified as randomised controlled trials (RCT), one (4.5%) as a quasi-randomised controlled trial (Q-RCT), one as a nonrandomised controlled trial (NRCT), which are experimental designs. Five (22.7%) were classified as concurrently controlled prospective cohort studies (PCS), one as a historically controlled cohort study (HCS), one as a retrospective controlled before-and-after study (CBA) and two (9.1%) as before-and-after studies (BA) (self-controlled), which are all observational designs. Both the self-reported and classified study designs can be seen in Table 5.7.

5.4.4.1 Randomised controlled trials (RCT)

Of the 11 identified RCTs, all except one used a traditional 1:1 intervention to control allocation, with only one study using a 2:1 allocation. The study stated that this was "to allow efficient functioning of the home rehabilitation service without affecting the power of the study" (Caplan et al., 2006, p.55). One study used randomisation with minimisation (Senior et al., 2014), which is a "method of ensuring excellent balance between groups for several prognostic factors, [with] treatment allocated to the next participant enrolled in the trial depend[ing] (wholly or partly) on the characteristics of those participants already enrolled" (Altman and Bland, 2005, p.843).

5.4.4.2 Quasi-randomised controlled trial (Q-RCT)

The term 'quasi-experimental study' causes particular ambiguity (Reeves, Wells and Waddington, 2017). Instead, here we classified a 'quasi-randomised controlled trial' (Q-RCT) using Reeves, Wells and Waddington's definition:

> *Individual participants, or clusters of participants, are allocated to intervention or comparator in a quasi-random manner. In health care evaluation studies, the allocation rule is often by alternation, day of the week, odd/even hospital, or social security number* (Reeves, Wells and Waddington, 2017, p.35)

The identified Q-RCT allocated patients into intervention or control nursing teams using sequential allocation (two clusters of participants based on geographic area were sequentially allocated to an intervention or control nursing team in their area) (Di Pollina et al., 2017). According to Reeves, Wells and Waddington, in a Q-RCT, "the allocation rule may be as good as random but, typically, gives rise to a less credible study" (2017, p.35).

5.4.4.3 Nonrandomised controlled trial (NRCT)

The 'nonrandomised controlled trial' (NRCT) as described by Reeves, Wells and Waddington takes on the following definition:

> *"…allocation to intervention and comparator is not random or quasi-random and is applied by research personnel*" (Reeves, Wells and Waddington, 2017, p.35)

This design has often also been described as a 'quasi-experimental study' or 'natural experiment.' One study was identified as an NRCT with allocation to intervention or control groups applied prospectively by researchers by an organisational factor (the intervention was applied to three hospitals and leaving care as usual in one hospital) (Leung et al., 2015). This study attempted to ensure balance between groups (similarly to minimisation previously described), by selecting from the control hospital patients that individually matched the characteristics of those allocated to the intervention group.

5.4.4.4 Concurrently controlled prospective cohort studies (PCS)

The 'concurrently controlled prospective cohort study' (PCS) design is defined as:

> *"A cohort study in which subjects are identified prospectively and classified as having received the intervention or comparator of interest on the basis of the prospectively collected information"* (Reeves, Wells and Waddington, 2017, p.35)

This design is similar to the NRCT but differs in respect to the method of allocation which is not based on application of the intervention according to some factor decided by research personnel but is rather determined by information that

is collected prospectively. Of the five studies classified under this study design, four of them considered patients in the intervention group to be those who consented to intervention (information collected prospectively), while those not consenting to the intervention were considered part of the control group. One of the studies did not explicitly state their allocation rule, however according to the researcher's best judgement of the description of the study, allocation appeared to be based on some information collected prospectively (Isaia et al., 2009). All of these studies had a concurrent control group (selected and followed-up during the same time period).

5.4.4.5 Historically controlled cohort study (HCS)

Like the PCS, the 'historically controlled cohort study' selects the intervention group based on information collected prospectively, however the control group is selected as a group that did not receive the intervention in a period prior to the intervention taking place, hence the comparison is not of contemporaneous groups. Within this study design according to Reeves, Wells and Waddington (2017), the historical control group is selected retrospectively, however for the included study fitting the description of a HCS, the control group was a historical group of patients who would have been eligible for the intervention and were prospectively identified prior to the intervention. For this study, the selected intervention group, was a group of eligible patients for the intervention after it was implemented regardless of whether they were treated or not.

5.4.4.6 Retrospective controlled before-and-after study (RCBA)

One study was identified as being a combination of two designs described by Reeves, Wells and Waddington (2017). These were the 'concurrently controlled retrospective study' (RCS) and the 'controlled before-and-after study' (CBA). The RCS is described as "a cohort study in which subjects are identified from historic records and classified as having received the intervention or comparator of interest on the basis of the historic information" and the CBA is described as a "study in which outcomes are assessed at two time periods for several clusters, […] [which are] classified into intervention and comparator groups" (Reeves, Wells and Waddington, 2017, p.35). Hence, this design retrospectively identifies several clusters of both intervention and control groups from record reviews, and

compares their outcomes during two periods, one before and one after the intervention.

In this design "observations usually represent episodes of care, so may or may not correspond to the same individuals during the two time periods" (Reeves, Wells and Waddington, 2017, p.35). One study was identified as a RCBA and fit this description, comparing groups of hospital admissions rather than groups of patients. The study compared a group of emergency department admissions regardless of whether they were treated or not, before and after the intervention, compared to control groups of admissions (Wright et al., 2013). This study measured outcomes through retrospective record review.

5.4.4.7 Before-and-after studies (BA)

Two studies were identified as before-and-after studies (BA), with intervention patient acting as their own controls. Both studies measured outcomes for a single group of patients exposed to the intervention 6 months prior to enrolment to the intervention as well as after the intervention, with one study measuring outcomes at discharge from the intervention for the 'after' period (Lewis et al., 2017) and the other study measuring outcomes 6 months after discharge (Lin et al., 2015). One study measured outcomes retrospectively through record review (Lewis et al., 2017), while the other measured outcomes prospectively (Lin et al., 2015) before and after the intervention.

Table 5.7 – Study designs (both classified and self-reported) of the included reviewed studies

Study code	Study design (classified)	Study design (self-reported)
Experimental – Randomised controlled trials (RCT)		
Aimonino2008	Randomised single-blind controlled trial (RCT)	Randomised single-blind controlled trial (RCT)
Tibaldi2009	Randomised single-blind controlled trial (RCT)	Prospective single-blind randomised controlled trial (RCT)
Caplan2005	Randomised controlled trial (RCT)	Randomised controlled trial (RCT)
Caplan2006	Randomised controlled trial (RCT) with 2:1 allocation	Randomised controlled trial (RCT)
Kwok2004	Randomised controlled trial (RCT)	Randomised controlled trial (RCT)
Kwok2008	Randomised controlled trial (RCT)	Randomised controlled trial (RCT)
Mendoza2009	Randomised controlled trial (RCT)	Prospective randomised study
Parsons2018	Randomised controlled trial (RCT)	Randomised controlled trial (RCT)

Senior2014	Randomised controlled trial (RCT) with minimisation by residential care needs ('high' or 'very high'), age, gender and living alone.	Randomised controlled trial (RCT)
Shyu2013	Randomised controlled trial (RCT)	Randomised controlled trial (RCT)
Ziden2008	Randomised controlled trial (RCT)	Randomised controlled study
Experimental – Quasi-randomised controlled trial (Q-RCT)		
DiPollina2017	Quasi-randomised control trial (Q-RCT) (two clusters of participants based on geographic area were sequentially allocated to an intervention or control nursing team in their area)	Prospective controlled trial
Experimental – Nonrandomised controlled trial (NRCT)		
Leung2015	Nonrandomised controlled trial (NRCT) (non-random prospective allocation to concurrent groups by research personnel applying intervention to patients from three hospitals and leaving care as usual for patients at fourth hospital as the control group)	Matched-control quasi-experimental study
Observational – Concurrently controlled prospective cohort study (PCS)		
Isaia2009	Concurrently controlled prospective cohort study (PCS) (allocation decision seems to be based on information collected prospectively, potentially availability of resources, specified as observational but allocation rule not described)	Prospective non-randomised observational study
Mas2016	Concurrently controlled prospective cohort study (PCS) (allocation based on patient and caregiver consent (assigned to control if declined treatment), i.e. allocation decision based on information collected prospectively)	Observational cohort study
Closa2017	Concurrently controlled prospective cohort study (PCS) (allocation based on patient and caregiver consent (assigned to control if not met), i.e. allocation decision based on information collected prospectively)	Quasi-experimental longitudinal study
Mas2017	Concurrently controlled prospective cohort study (PCS) (allocation based on patient and caregiver consent (assigned to control if declined treatment), and availability of resources i.e. allocation decision based on information collected prospectively)	Quasi-experimental longitudinal study
Leff2006	Concurrently controlled prospective cohort study (PCS) (allocation based on patient consent (received usual care if declined treatment) and operating hours of intervention (availability of resources) i.e. allocation decision based on information collected prospectively)	Prospective, non-randomised clinical trial
Observational – Historically controlled cohort study (HCS)		
Leff2005	Historically controlled cohort study (HCS) (slight modification of this design: both comparator group and intervention group selected prospectively, comparator group was a group of eligible patients observed prior to the implementation of the hospital-at-home programme, intervention group was a group of eligible patients treated, presented (and declined) or not presented (due to being outwith operating hours) with the option of hospital-at-home, after it had been implemented)	Prospective quasi-experimental study
Observational – Retrospective controlled before-and-after study (RCBA)		
Wright2013	Retrospective controlled before-and-after study (RCBA) (Several clusters identified retrospectively, one cluster including intervention patients and those matching their admission details, another cluster of all ED geriatric admissions, and a third cluster of the residual ED geriatric admissions not matching the intervention patients admission details. Observations represent episodes of care i.e. admissions as is usual with this design. Rather than adjustment for the before period observations, this study uses the comparator groups as reference groups.)	Pre- and post-retrospective cohort study
Observational – Before and after studies (BA)		

Lewis2017	Before and after (BA) (Single exposed cohort with outcomes measured 6 months before intervention and at discharge from intervention, retrospectively)	Quantitative observational study
Lin2015	Before and after (BA) (Single exposed cohort with outcomes measured 6 months before and after intervention, prospectively)	Prospective cohort study

5.4.4.8 Control groups

Control groups within the included studies were not often well described, which has also previously been observed in a review of hospital-at-home interventions (Shepperd and Iliffe, 2005b). Control groups were most commonly cited as being patients receiving usual hospital care. For the nine studies with admission avoidance HaH interventions, comparison groups were patients receiving usual hospital inpatient care (sometimes specified to be in a geriatric or specialist ward) in eight of the studies, while in one study, the comparison group comprised of patients receiving usual community home visiting and home hospitalisation (the intervention group was admission avoidance HaH through integrated care i.e. formal coordination of services with a community geriatric unit for HaH and home CGA (Di Pollina et al., 2017)). For the six studies with early discharge HaH interventions, comparison groups were patients receiving usual care in an in-hospital geriatric rehabilitation unit, or in a hospital ward where patients received usual rehabilitation sessions. For the study in which both early discharge and admission avoidance HaH were offered, the comparison group was made up of patients receiving usual inpatient hospital care followed by care in an intermediate care bed-based unit offering rehabilitation where necessary (Mas et al., 2017).

For the remaining six studies with post-acute discharge support interventions, in four of these studies comparison groups were patients discharged from hospital receiving usual care comprising outpatient or community nursing care. The remaining two studies were before-and-after studies, hence intervention patients acted as their own controls, with little to no detail provided about care before the intervention. In these two studies, patients receiving usual care before the intervention were "not formally risk stratified and often had multiple service providers involved" in one study (Lewis et al., 2017) and no details of care prior to the intervention were provided in the other study (Lin et al., 2015).

5.4.4.8.1 Matching

Three studies used a matching strategy to select a comparison group that was similar in baseline characteristics to the intervention group. One study used propensity score matching, in which each subject in the sample is assigned a probability (propensity score) of receiving treatment based on observed baseline characteristics and using this score, control subjects are matched to intervention subjects. Two studies used direct matching on selected covariates, with one study selecting one control for each intervention subject, and the other study, an RCBA, making selections of ED admissions rather than patients of all eligible admissions matching the selected characteristics. The details of the studies that used matching and the details of their matching strategy can be seen in Table 5.8 below.

Table 5.8 – Studies using matching to select control groups and details of their matchings strategy

Study code	Study design (classified)	Matching strategy
Closa2017	Concurrently controlled prospective cohort study (PCS)	One-to-one propensity score matching including age, gender, Charlson index score, baseline Barthel index score, Barthel index score at admission to rehabilitation, number of geriatric syndromes, prevalence of delirium at admission, cognitive impairment, and main clinical diagnosis.
Leung2015	Nonrandomized controlled trial (NRCT)	One-to-one direct matching on age (±5 years), gender, patient disease diagnosis (COPD, chronic heart failure, cancer, other), Clinical Frailty index, carer relationship with patient.
Wright2013	Retrospective controlled before-and-after study (RCBA)	All matching ED admissions directly on HRG, treatment function and patient classification of ED admissions used to find TREAT-matching admissions as comparison group

Of the 19 studies that did not use matching to select a control group, two were before-and-after studies hence intervention patients acted as their own controls and seven reported no significant differences in baseline characteristics between intervention and control groups (these were all either RCTs or Q-RCTs). Of those remaining 10 studies that did not use matching and reported some differences between groups, seven used statistical adjustment for confounding covariates in

their analysis while in the remaining three, no adjustment was reported. Statistical adjustment will be further discussed in the analysis section.

5.4.5 Quality of included studies

As previously described, information was collected for each of the studies on items relating to study quality included in the Downs and Black checklist for assessing study quality of studies evaluating healthcare interventions (Downs and Black, 1998). The study quality scoring was then used to identify a quality grading for each study according to Hooper et al.'s grading (2008).

Of the 22 included studies, none were identified as being of excellent quality, six were identified as being of good quality, 15 were identified as being of fair quality and one was identified as poor quality. The good quality studies mostly included RCT designs, however one prospectively cohort study (PCS) and one non-randomised controlled trial (NRCT) was graded as being of good quality. The poor quality study was of a before-and-after (BA) study.

These quality gradings were considered in the summary of individual study findings.

Table 5.9 – Results of quality assessment using the Down's and Black quality assessment tool for randomised and non-randomised studies (modified version (Korakakis et al., 2018)*)*

Study code	*Aimonino2008*	*Isaia2009*	*Tibaldi2009*	*Caplan2005*	*Caplan2006*	*Mas2016*	*Closa2017*	*Mas2017*	*DiPollina2017*	*Kwok2004*	*Kwok2008*
Study design code	**RCT**	**PCS**	**RCT**	**RCT**	**RCT**	**PCS**	**PCS**	**PCS**	**Q-RCT**	**RCT**	**RCT**
Q1: Aim clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
Q2: Outcomes clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q3: Patients characteristics clearly described (inclusion/exclusion criteria)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q4: Interventions clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Q5: Principal confounders clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Partially
Q6: Main findings clearly described?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q7: Random variability for main outcome provided?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q8: Adverse events reported?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q9: Loss-to-follow up reported?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q10: Actual p-value reported?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q11: Sample asked to participate representative of the population?	Yes	Yes	Unable to determine	Unable to determine	Yes	Yes	Unable to determine	Unable to determine	Yes	Unable to determine	Unable to determine
Q12: Sample agreed to participate representative of the population?	Unable to determine	Yes	Yes	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine
Q13: Staff participating representative of the patients' environment?	Yes	Yes	Yes	Unable to determine	Yes	Yes	Yes	Yes	Yes	Unable to determine	Unable to determine
Q14: Attempt to blind participants?	No	No	No	No	No	No	No	No	No	No	No
Q15: Attempt to blind assessors?	Yes	No	Yes	No	No	No	No	No	No	No	Unable to determine
Q16: Data dredging based results stated clearly?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q17: Analysis adjusted for length of follow up?	Yes	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes
Q18: Appropriate statistics?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q19: Reliable compliance?	Unable to determine	Unable to determine	Unable to determine	Yes	Unable to determine	Yes	Yes	Yes	Unable to determine	No	Unable to determine
Q20: Accurate outcome measures?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q21: Same population?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q22: Participants recruited at the same time?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q23: Randomised?	Yes	No	Yes	Yes	Yes	No	No	No	No	Yes	Yes
Q24: Adequate allocation concealment?	No	No	No	No	No	No	No	No	No	No	No
Q25: Adequate adjustment for confounders?	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
Q26: Loss of follow up taken into account?	Unable to determine	Unable to determine	Yes	Unable to determine	Yes	Yes	Yes	Yes	Yes	Unable to determine	Unable to determine
Q27: Power calculation?	Yes	No	Yes	Yes	Yes	No	No	No	Yes	Yes	Yes
Total score/28	**22**	**19**	**19**	**18**	**22**	**20**	**19**	**19**	**21**	**17**	**15**

26-28 Excellent 20-25 Good 15-19 Fair <14 Poor

Study code	*Leff2005*	*Leff2006*	*Leung2015*	*Lewis2017*	*Lin2015*	*Mendoza2009*	*Parsons2018*	*Senior2014*	*Shyu2013*	*Wright2013*	*Ziden2008*
Study design code	**HCS**	**PCS**	**NRCT**	**BA**	**BA**	**RCT**	**RCT**	**RCT**	**RCT**	**RCBA**	**RCT**
Q1: Aim clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes
Q2: Outcomes clearly described?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q3: Patients characteristics clearly described (inclusion/exclusion criteria)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Q4: Interventions clearly described?	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes
Q5: Principal confounders clearly described?	Yes	Yes	Partially	No	Yes	Yes	Partially	Partially	Yes	No	Yes
Q6: Main findings clearly described?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q7: Random variability for main outcome provided?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q8: Adverse events reported?	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes
Q9: Loss-to-follow up reported?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Q10: Actual p-value reported?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes
Q11: Sample asked to participate representative of the population?	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Yes	Unable to determine	Yes	Yes
Q12: Sample agreed to participate representative of the population?	Unable to determine	Unable to determine	Unable to determine	No	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Yes
Q13: Staff participating representative of the patients' environment?	Unable to determine	Unable to determine	Unable to determine	Yes	Unable to determine	Yes	Unable to determine	Unable to determine	Unable to determine	Yes	Yes
Q14: Attempt to blind participants?	No	No	No	No	No	No	No	No	Yes	No	No
Q15: Attempt to blind assessors?	Unable to determine	Unable to determine	No	No	No	No	Yes	No	No	No	No
Q16: Data dredging based results stated clearly?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q17: Analysis adjusted for length of follow up?	Yes	Yes	No	No	No	Yes	Yes	Yes	Unable to determine	Yes	Yes
Q18: Appropriate statistics?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q19: Reliable compliance?	Unable to determine	Unable to determine	Yes	Yes	Yes	Unable to determine	Unable to determine	Yes	Unable to determine	Yes	No
Q20: Accurate outcome measures?	Yes	Yes	Yes	Unable to determine	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q21: Same population?	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Q22: Participants recruited at the same time?	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Q23: Randomised?	No	No	No	No	No	Yes	Yes	Yes	Yes	No	Yes
Q24: Adequate allocation concealment?	No	No	No	No	No	No	No	No	No	No	No
Q25: Adequate adjustment for confounders?	Yes	Yes	No	No	No	Yes	No	Yes	Yes	No	Yes
Q26: Loss of follow up taken into account?	Unable to determine	Unable to determine	Unable to determine	Unable to determine	Yes	Yes	Unable to determine	Unable to determine	Yes	Yes	Yes
Q27: Power calculation?	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Total score/28	**16**	**16**	**15**	**12**	**15**	**21**	**18**	**19**	**17**	**17**	**22**

26-28 Excellent 20-25 Good 15-19 Fair <14 Poor

5.4.6 Study outcomes

The included studies included several outcome measures used to evaluate intervention effectiveness, covering a range of domains. The four main domains identified were functional, physical, and mental health outcomes in addition to mortality outcomes, quality of life (QoL) outcomes, satisfaction with care outcomes and use or cost of health care services outcomes. This section aims to describe the outcome measures identified within each of these domains.

5.4.6.1 Functional, physical and mental health outcomes

Functional, physical and mental health outcomes were used as measures of intervention effectiveness in 16 of the included studies (10 RCTs, 5 PCSs and 1 HCS). These outcomes included differences or changes in functional ability or independence (ADL, IADL BI, IAM, FAI, FIM) (Aimonino2008, Tibaldi2009, Caplan2006, Caplan2005, Mas2016, Closa2017, Mas2017, Leff2005, Lin2015, Mendoza2009, Parsons2018, Ziden2008) (one of these studies reported the change in BI as a proportion of length of rehabilitation (Mas2016) and another as achieving functional resolution or not i.e. recovering at least a third of functional loss (Mas2017), level of functional handicap (LHS) (across mobility, independence, occupation and orientation domains) (Kwok2004, Kwok2008), physical mobility [exercise capacity (6-min walking test) (Kwok2004, Kwok2008), proportion walking outdoors/indoors, basic mobility (TUG), lower muscle strength (STS) and balance confidence (FES) (Ziden2008) and walking ability (MFAC) (Lin2015)], cognitive status (MMSE, MSQ, AMT, InterRAI-HC CPS) (Aimonino2008, Tibaldi2009, Caplan2006, Caplan2005, Lin2015, Senior2014), depression (GDS, InterRAI-HC DRS) (Aimonino2008, Tibaldi2009, Caplan2006, Senior2014), psychological health (GHQ) (Kwok2004), incidence, risk, severity and duration of delirium (Isaia2009, Tibaldi2009, Caplan2006, Leff2005), incidence of medical complications (including infections and falls) (Tibaldi2009, Leff2005), nutrition (MNA) (Aimonino2008, Tibaldi2009) and instability in health (InterRAI-HC CHESS) (Senior2014). For a chronic lung disease specific intervention study, respiratory function was used as an outcome measure (peak expiratory flow rate and oxygen saturation at rest) (Kwok2004). In addition, the use of psychoactive drugs (Isaia2009) was reported in one study, while prescription of sedative

medication and use of chemical restraints (Leff2005) were reported as adverse events another study.

5.4.6.2 Mortality

Mortality was used as an outcome measure in nine of the included studies. Mortality was assessed over two weeks in one study (Leff2005), 3-months in one study (Leung2015), six months in four studies (Aimonino2008, Isaia2009, Tibaldi2009, Caplan2006), 12-months in two studies (Mendoza2009, Senior2014), and two years in one study (DiPollina2017). All these studies compared mortality rates between groups, with three of these also measuring cumulative proportion mortality (Aimonino2008, Tibaldi2009, DiPollina2017) and one measuring absolute risk reduction of mortality (Senior 2014), over the given time periods.

5.4.6.3 Quality of life

Measures of quality of life (QoL) for either patients or caregivers were reported in 12 of the included studies. Eight of these studies used validated patient or caregiver QoL instruments (Aimonino2008, Isaia2009, Kwok2004, Leung2015, Mendoza2009, Senior2014, Shyu2013, Tibaldi2009), while nine included other measures relating to quality of life (Closa2017, DiPollina2017, Mas2016, Mas2017, Senior2014, Shyu2013, Aimonino2008, Tibaldi2009, Kwok2004). The validated patient QoL outcomes included were the NHP QoL measure (emotional, social and physical health) (Aimonino2008, Tibaldi2009), the mQOLC-E QoL measure (emotional, physical discomfort, value of life, existential distress, care and support, and food-related concerns) (Leung2015), and the SF-36 health-related QoL measure (mental and physical component summaries in addition to general health, general mental health, physical functioning, disability due to emotional problems, disability due to physical health problems, bodily pain, social functioning and vitality) (Mendoza2009, Shyu2013). The validated caregiver QoL measures used were caregiver stress (RSS) (Aimonino2008, Isaia2009, Tibaldi2009), caregiver health-related QoL (SF-36) (Senior2014) and caregiver burden (CRA, CCI) (Senior2014, Kwok2004).

The measures relating to quality of life were the proportion of patients discharged home (Mas2016, Closa2017), proportion achieving health crisis resolution (recovered at least a third of functional loss and discharged to community/primary care) (Mas2017), incidence of home death (DiPollina2017), pain (InterRAI-HC

Pain scale) (Senior2014, Shyu2013), time to first readmission (Aimonino2008, Tibaldi2009), perceived control of health (HLC) and level of social handicap (LHS) (Kwok2004).

5.4.6.4 Satisfaction with care

Measures of patient, caregiver or GP satisfaction with care received were assessed in four of the included studies. Two of the included studies used ad-hoc questionnaires to rate patient, caregiver or GP satisfaction (Aimonino2008, Caplan2006), while the other two used a modified Picker Hospital Survey covering several domains (physician, nurse, staff, comfort and convenience, safety, pain management, admission procedures, discharge procedures and overall) in addition to measuring the proportion reporting they would choose to receive care again in the same setting and the proportion reporting that they would recommend the type of care they received to other family members or friends (Leff2005, Leff2006).

5.4.6.5 Use or cost of health services

The use or cost of health care services was included as an outcome measure in 20 of the included studies. Outcomes for use of health care services included numbers of inpatient hospital admissions (6 studies: Tibaldi2009, DiPollina2017, Leff2005, Leung2015, Lewis2017, Lin2015), numbers or incidence rate of at least one readmission (6 studies: Aimonino2008, Caplan2006, Kwok2004, Kwok2008, Leff2005, Mendoza2009) and numbers of ED attendances (4 studies: Kwok2004, Leff2005, Lewis2017, Lin2015) or incidence rate of at least one ED attendance (1 study: DiPollina2017), incidences of nursing home admissions (including institutionalisation, admission to skilled nursing facilities) (4 studies: Isaia2009, Tibaldi2009, DiPollina2017, Leff2005) or absolute risk of permanent residential care placement (1 study: Senior2014), cumulative incidence of the first hospitalisation or ED attendance and cumulative incidence of unnecessary hospitalisations (1 study) (DiPollina2017) and numbers of home health visits (1 study: Leff2005), Length of stay (LOS) outcomes included hospital bed days or LOS over a given time period [7 studies: one over 3-month follow-up (Leung2015), four over 6-month follow-up (Kwok2004, Parsons2018, Lewis2017, Lin2015), one over 12-month follow-up (Wright2013) and one over 3-year follow-up (DiPollina2017)], LOS of the index acute care episode and/or rehabilitation

episode provided in the intervention or usual care setting (10 studies: Aimonino2008, Isaia2009, Tibaldi2009, Caplan2006, Mas2016, Closa2017, Mas2017, Leff2005, Parsons2018, Ziden2008), LOS of the first readmission (1 study: Tibaldi2009) and time spent in the ED before transfer (2 studies: Caplan2005, Leff2005).

Outcomes for the cost of health care services were reported in 10 studies and included total costs of care per patient or per patient per day or per visit (and cost of rehabilitation or acute episode only) (Aimonino2008, Isaia2009, Tibaldi2009, Caplan2006, Closa2017, Leff2005, Lin2015, Mendoza2009, Parsons2018) and total public health costs per patient, total health and social care costs per patient and total personal costs per patient (1 study: Kwok2008). Additional outcomes related to the use of health care included the primary cause of the first readmission (2 studies: Kwok2004, Kwok2008) and the proportion of same-day discharges (1 study: Wright2013).

5.4.7 Analysis

This section aims to describe the analysis of outcome measures described in the included studies. Full details of each of the study analyses can be found in Appendix B Table B-3.

5.4.7.1 Statistical techniques employed by the included studies

It was observed within the included studies that clarity in the description of analyses was variable. There were several studies that did not explicitly state their selected statistical analyses in sufficient detail to understand what statistical tests were carried out.

Generally, the included studies carried out unadjusted analyses with about half of the studies additionally carrying out adjusted analyses and/or survival analyses.

In order to compare outcome measures without adjustment, twenty-one of the included studies reported using specific parametric and non-parametric tests, while one study did not report the specific hypothesis testing used and reported only p-values of their unadjusted analysis (Mas2017). Sixteen studies reported using paired or unpaired t-tests for comparing continuous normally distributed outcomes.

The non-parametric tests used for comparing ordinal or continuous outcomes included the Kruskal-Wallis test (Mas2016, Closa2017), Mann-Whitney U-test (Kwok2004, Kwok2008, Mendoza2009, Wright2013, Ziden2008), the Wilcoxon signed-rank test (for paired data) (Leung2015, Lewis2017, Lin2015, Ziden2008).
The non-parametric tests used for comparing categorical outcomes and proportions included Fisher's exact test (for dichotomous outcomes) (Tibaldi2009, Caplan2005, DiPollina2017, Leff2005, Leff2006, Ziden2008), Chi-square test (Aimonino2008, Isaia2009, Tibaldi2009, Caplan2006, Mas2016, Closa2017, DiPollina2017, Kwok2008, Leff2006, Mendoza2009, Parsons2018, Shyu2013, Ziden2008), Mann-Whitney U-test (Caplan2006 Kwok2004, Kwok2008, Mendoza2009, Wright2013, Ziden2008), Mantel-Haenszel Chi-squre (Ziden 2008), McNemar's test for multiple observations, logistic regression (for dichotomous outcomes) (Leff2005) and ANOVA (Senior2014, Shyu2013).
The statistical techniques used for analysis of outcomes adjusting for residual differences between treatment groups were multivariable linear regression (Mas2016, Closa2017, Mas2017, Leff2005), multivariable logistic regression (Isaia2009, Mas2017, Leff2005, Leff2006) reporting odds ratios (ORs) or risk ratios (RRs), multiple regression analysis (Caplan2005), analysis of variance (Parsons2018), analysis of covariance (Mendoza2009) and a mixed model (Senior2014). There were two studies that reported ORs but did not describe any adjusted or regression analyses (Caplan2006, Wright2013). The adjustment factors reported in the included studies are described in the next section.
Six of the included studies carried out survival analyses (Aimonino2008, Isaia2009, Tibaldi2009, DiPollina2017, Leff2005, Senior2014). Five of these studies employed Kaplan-Meier survival analysis for analysing cumulative proportion survival for mortality or institutionalisation (Aimonino2008, Isaia2009, Tibaldi2009, DiPollina2017, Leff2005) with three of these reporting the use of a log-rank test to compare survival curves (Isaia2009, DiPollina2017, Leff2005). Three studies employed Cox proportional hazards regression for mortality (DiPollina2017), cumulative incidence of delirium (Leff2005) and 'institution-free survival' (Senior2014), with one reporting the use of a Wald test to compare cumulative incidences (DiPollina2017).

5.4.7.2 Adjustment factors

Twelve of the reviewed studies carried out statistical adjustment for different factors in their analysis. The adjustment factors selected included age (7 studies: Caplan2005, Mas2016, Closa2017, Mas2017, Leff2005, Parsons2018, Senior2014), gender (8 studies: Isaia2009, Caplan2005, Mas2016, Closa2017, Mas2017, Leff2005, Leff2006, Senior2014), functional status at admission or pre-admission (5 studies: Mas2016, Closa2017, Mas2017, Leff2005, Shyu2013), history or current status of delirium or confusion (4 studies: Isaia2009, Mas2016, Mas2017, Caplan2005), comorbidity (3 studies Charlson index: Mas2016, Closa2017, Mas2017, 1 study APACHE II: Leff2005), number of geriatric syndromes (3 studies: Mas2016, Closa2017, Mas2017), cognitive impairment or cognitive status (3 studies: Mas2017, Leff2005, Leff2006), mood disorder or depression (3 studies: Mas2017, Leff2005, Leff2006), living alone or living arrangements (3 studies: Caplan2005, Leff2006, Senior2014), length of acute stay or rehabilitation stay (2 studies: Caplan2005, Mas2017), and primary diagnosis or diagnostic group (2 studies: Mas2017, Leff2005). In the majority of these studies, these adjustment factors were added into multivariable models analysing intervention effect directly, but in one study (Mas2017), these were added into a propensity score model from which a propensity score was used as an adjustment factor in the multivariable analysis of intervention effect.

Additional patient factors selected were poverty and number of medications (Leff2005), "basal levels" (e.g. oxygen saturation) (Mendoza2009), health and disability needs level (Senior2014) and attrition (deaths and dropouts) (Shyu2013). Caregiver factors were selected including caregiver health (Leff2006), caregiver functional status (Leff2005, Leff2006) and having a child as a caregiver (Leff2005). Finally, additional adjustment factors relating to the intervention were selected by three studies including treatment strategy (Mas2017), treatment site (Leff2005) and allocated nursing team for an intervention where multiple nursing teams were involved (DiPollina2017).

5.4.8 Findings of included studies

This section aims to describe the findings of the included studies with regards to the evaluated outcome measures. The findings were included if they were statistically significant and can be seen in detail in Appendix B Table B-4.

5.4.8.1 Functional, physical and mental health outcomes

All the included studies assessing the functional, physical and mental health outcomes outlined reported either no difference or a positive impact of the intervention on these outcomes (of statistical significance).

There is conflicting evidence (category 4: disagreement between the findings of at least 2 RCTs) among the 12 studies evaluating functional ability or independence with four studies reporting a statistically significant improvement in one or more aspects of functional ability (1 good quality and 3 fair quality studies including 3 RCTs) (Caplan2005, Lin2015, Ziden2008, Parsons2018) and the remaining eight studies reporting no statistically significant difference (4 good quality and 4 fair quality studies including 4 RCTs) (Aimonino2008, Tibaldi2009, Caplan2006, Mas2016, Closa2017, Mas2017, Leff2005, Mendoza2009), though one of these seven studies showed an improvement in an adjusted analysis. The two studies evaluating functional handicap (across mobility, independence, occupation and orientation domains) also show conflicting evidence with one study showing an improvement (Kwok2008) and one study showing no difference (Kwok2004) (both fair quality RCTs).

There is also conflicting evidence (category 4: disagreement between the findings of at least 2 RCTs) among the four studies evaluating physical mobility. Two studies (1 good quality and 1 fair quality study including 1 RCT) reporting a statistically significant improvement in walking ability before and after the intervention (Lin2015) and a statistically significant increase in the proportion walking outdoors/indoors and an improvement in basic mobility (TUG), lower muscle strength (STS) and balance confidence (FES) compared to a control group (Ziden2008). Two studies (2 fair quality, both RCTs) showed no statistically significant difference in the 6-minute walking test indicating exercise capacity (Kwok2004, Kwok2008).

There is moderately strong evidence (category 2a: the findings are supported by 2 or more studies of at least good quality) that there was no significant effect of the interventions on cognitive status with all six studies reporting no statistically significant difference between comparison groups (2 good quality and 4 fair quality studies, including 5 RCTs) (Aimonino2008, Tibaldi2009, Caplan2006, Caplan2005, Lin2015, Senior2014).

There is conflicting evidence (category 4) among the five studies evaluating depression or psychological health, with two studies indicating an improvement in depression (1 good quality and 1 fair quality study, both RCTs) (Aimonino2008, Tibaldi2009) and three studies indicating no difference in depression or psychological health (1 good quality and 2 fair quality studies, all RCTs) (Caplan2006, Senior2014, Kwok2004).

There is conflicting evidence (category 4) among four studies evaluating the incidence or risk of delirium. Three studies found a statistically significant lowered incidence or risk of delirium (3 fair quality studies including 1 RCT) (Isaia2009, Tibaldi2009, Caplan2006) and one study found no significant difference (1 good quality RCT) (Leff2005). One of these studies also investigated duration, onset, and severity of delirium and it found a statistically significant lowered duration, slower onset and lower severity of delirium (1 fair quality study) (Isaia2009), hence there is weak evidence of these results.

There is weak evidence (category 2c: the findings are supported by at least 1 study of fair or poor quality) among the two studies evaluating complications that the interventions made no statistically significant difference to the incidence of medical complications including infections and falls (2 fair quality studies including 1 RCT). One study evaluated the intervention effect on infections and found no difference (Tibaldi 2009) and the other evaluated the intervention effect on bowel complications, urinary infections, emergency situations, falls, physical restraints and nosocomial infections, and again found no significant effect (Leff2005). The latter study however, did a find lower incidence of critical complications, hence there is also weak evidence of lowered critical complications.

With regards to additional adverse events in terms of the use of adverse drugs, there is weak evidence from two fair quality studies (no RCTs) of significant reductions in their use, one finding a reduction in the use of psychoactive drugs (Isaia2009) and the other finding a reduction in prescription of sedative medication and use of chemical restraints (Leff2005).

There is conflicting evidence (category 4) between two studies evaluating the intervention effect on nutrition with one study finding an improvement in nutrition (1 fair quality RCT) (Tibaldi2009), and the other finding no difference (1 good quality RCT) (Aimonino2008).

There is weak evidence from one study evaluating general instability in health (InterRAI-HC CHESS) that there is no significant difference between intervention and control groups (1 fair RCT) (Senior2014).

Finally, for a chronic lung disease specific intervention study, there weak evidence that there is no significant difference in respiratory function (peak expiratory flow rate and oxygen saturation at rest) (1 fair RCT) (Kwok2004).

5.4.8.2 Mortality

Overall, seven of the studies found no statistically significant difference in mortality rates while two of the studies found a statistically significant reduction (DiPollina2017, Leff2005). There is moderately strong evidence (category 2a: the findings are supported by 2 or more studies of at least good quality) from four studies that there is no significant difference in six-month mortality rates between intervention and control groups (2 good quality and 2 fair quality studies including 3 RCTs) (Aimonino2008, Isaia2009, Tibaldi2009, Caplan2006). There is also limited evidence (category 2b: the findings are supported by at least 1 study of good quality) from two of these studies of no difference in six-month cumulative proportion survival (1 good and 1 fair quality RCT – limited evidence) (Aimonino2008, Tibaldi2009).

There is limited evidence (category 2b) from two studies that there is no significant difference in 12-month mortality rates between intervention and control groups (1 good quality RCT - Mendoza2009, 1 fair quality RCT - Senior2014) and in addition, weak evidence (category 2c) of no difference in 12-month absolute risk reduction from one of these studies (Senior2014). There is weak evidence (category 2c) of no difference in 3-month mortality rate from one fair quality study (Leff2005-HCS).

Two studies found a reduction in mortality rates. There is weak evidence of a statistically significant reduction in two-week mortality rate from one fair quality study (Leung2015-QRCT). There is limited evidence of a statistically significant reduction in two-year mortality rate and no difference in two-year cumulative proportion survival from one good quality study (DiPollina2017-NRCT).

5.4.8.3 Quality of life

There is conflicting evidence (category 4) among the five studies reporting the intervention effect on patient QoL scores. Three studies reported a statistically

significant improvement in overall patient QoL (1 good quality and 2 fair quality studies including 2 RCTs) (Aimonino2008, Tibaldi2009, Leung2015) while one study reported no significant difference in overall mental and physical QoL (Mendoza2009 – good quality RCT) and another study found no difference in the mental component but an improvement in the physical component of QoL (Shyu2013 – fair quality RCT).

There is also conflicting evidence (category 4) among the five studies reporting the intervention effect on caregiver QoL, including health-related QoL, caregiver stress and caregiver burden. Two studies observed no statistically significant difference between comparison groups in caregiver stress (1 good and 1 fair quality RCT) (Aimonino2008, Tibaldi2009), while one study observed an increase in caregiver stress in the control group with no change in the intervention group (Isaia2009 – fair quality PCS) and another study observed no difference in the change in caregiver burden (Kwok2004 – fair quality RCT). The last study observed a slower decline in caregiver physical health-related QoL but no difference in other health-related QoL components or in caregiver burden (Senior2014 – fair quality RCT).

There is limited evidence (category 2b) among two studies indicating no statistically significant difference between comparison groups in the proportion who are discharged home (1 good quality and 1 fair quality study not RCTs) (Mas2016, Closa2017). There is weak evidence (category 2c) from one fair quality study indicating a statistically significant improvement in health crisis resolution (recovering at least a third of functional loss and discharged to community/primary care) (no difference in unadjusted analysis) (Mas2017 – PCS). There is limited evidence (category 2b) of a statistically significant increase in the incidence of home death in one good quality study (DiPollina2017 – Q-RCT). There is weak evidence (category 2b) indicating no statistically significant difference in pain among two fair quality RCTs (Senior2014, Shyu2013). There is limited evidence (category 2b) of a statistically significant increase in the time to readmission in the intervention group among two RCTs (1 good quality and 1 fair quality) (Aimonino2008, Tibaldi2009). Finally, there is weak evidence (category 2c) from one fair quality RCT indicating no difference in perceived control of health and stability observed in the level of social handicap of the intervention group while worsening in the control group (Kwok2004).

5.4.8.4 Satisfaction with care

There was conflicting evidence (category 4) of the intervention effect on patient satisfaction with their care. Three studies reported statistically significant improvements in patient satisfaction in the intervention group compared to the control group (1 good quality and 2 fair quality studies including 1 RCT) (Caplan2006, Leff2005, Leff2006), while one study reported no statistically significant difference (Aimonino2008 – good quality RCT).

There is limited evidence (category 2b) among three studies indicating a statistically significant increase in caregiver satisfaction in the intervention compared to the control group (1 good quality and 2 fair quality studies including 1 RCT) (Caplan2006, Leff2005, Leff2006).

There is limited evidence from a good quality study indicating no difference in GP satisfaction with care (Caplan2006).

One of these studies (fair quality, indicating weak evidence) also measuring the proportion reporting they would choose to receive care again in the same setting and the proportion reporting that they would recommend the type of care they received to other family members or friends found no significant difference in these measures (Leff2006).

5.4.8.5 Use or cost of health services

5.4.8.5.1 Use of health services

There is limited evidence (category 2b) among six studies indicating no statistically significant difference in the number of inpatient admissions between comparison groups (1 good quality, 4 fair quality and 1 poor quality study including 1 RCT) (Tibaldi2009, DiPollina2017, Leff2005, Leung2015, Lewis2017, Lin2015)

There is conflicting evidence (category 4) among four studies evaluating the intervention effect on the number of readmissions with three studies finding no statistically significant difference in the number of readmissions (2 fair quality studies, including 1 RCTs) (Kwok2004, Leff2005) and one study finding a statistically significant reduction in the number of readmissions (1 fair quality RCT) (Kwok2008). There is conflicting evidence (category 4) among five studies evaluating the intervention effect on the incidence rate of at least one readmission, with four studies finding no statistically significant difference (2

good quality and 2 fair quality RCTs) (Caplan2006, Kwok2004, Kwok2008, Mendoza2009) and one good quality RCT finding a lower incidence of readmission in the intervention group (Aimonino2008)

There is weak evidence (category 2c) among two studies finding no statistically significant difference in the number ED attendances between comparison groups (2 fair quality studies, including 1 RCT) (Kwok2004, Leff2005), although two before and after studies (of fair and poor quality) indicate lowered ED attendances (Lewis2017, Lin2015). There is limited evidence (category 2b) of a lower incidence rate of at least one ED attendance found in the intervention group from one good quality Q-RCT (DiPollina2017).

There is conflicting evidence (category 4) among four studies evaluating institutionalisation, with two studies finding a statistically significant reduction in institutionalisation rate in the intervention group (2 fair studies including 1 RCT) (Isaia2009, Tibaldi2009) and two studies finding no statistically significant difference (1 good and 1 fair quality study including 1 Q-RCT) (DiPollina2017).

There is weak evidence (category 2c) of no statistically significant difference in absolute risk reduction of permanent residential care placement from one fair quality RCT (Senior2014).

There is limited evidence (category 2b) from one good quality Q-RCT finding a statistically significant reduction in cumulative incidence of the first hospitalisation or ED attendance and cumulative incidence of unnecessary hospitalisations (DiPollina2017).

There is weak evidence (category 2c) from one fair quality study finding no statistically significant difference in the number of home health visits between comparison groups (Leff2005).

There is conflicting evidence (category 4) among seven studies evaluating hospital bed days or LOS over a given time period with three studies finding no statistically significant difference (DiPollina2017 – 3-year follow-up, Kwok2004 – 6-month follow-up, Leung2015 – 3-month follow-up) (1 good quality and 2 fair quality studies, including 1 RCT) and four studies finding a statistically significant reduction (1 poor and 3 fair quality, including 1 RCT) (Lewis2017 – 6-months before and after, Lin2015 – 6-month follow-up, Parsons2018 – 6-month follow-up, Wright2013 – 12-month follow-up).

There is conflicting evidence (category 4) from ten studies on the intervention effect on the length of the index acute episode and/or rehabilitation. Three studies found an increase (1 good and 2 fair quality studies including 1 RCT) (Aimonino2008, Isaia2009, Tibaldi2009), six studies found a reduction (2 good and 4 fair quality studies including 2 RCTs) (Caplan 2006, Mas2016, Closa2017, Mas2017, Leff2005, Parsons2018) and one study found no difference (1 good quality RCT) (Ziden2008).

There was weak evidence (category 2c) among one fair quality RCT finding no statistically significant difference in the length of stay of the first readmission (Tibaldi2009). There was also weak evidence (category 2c) among one fair quality RCT finding a shorter time spent in ED before transfer home or hospital of statistical significance (Caplan2005).

5.4.8.5.2 Cost of health services

Although ten studies reported cost outcomes, one of them did not appear to have tested the differences statistically and describes the result as "potential cost savings" hence the result of this study is excluded from this summary. Within the nine studies that tested cost differences statistically, all of them found a statistically significant reduction in at least some costs for the intervention group compared to the control group. There is moderately strong evidence among eight studies indicating a statistically significant reduction in patient care provision costs with the intervention compared to the control groups (in terms of total cost of episode per patient, or total costs of episode per patient per day) (3 good quality studies and 5 fair quality studies including 3 RCTs) (Aimonino2008, Isaia2009, Tibaldi2009, Caplan2006, Closa2017, Kwok2008, Leff2005, Mendoza2009). There is conflicting evidence (category 4) of the effect of the interventions on longer term costs with one good quality RCT finding no difference in the costs per patient over one year (Mendoza2009) and one fair quality RCT finding a greater reduction of health-related costs in the intervention group over a six-month follow-up period (Parsons2018). There is weak evidence (category 2c) from a fair quality study of a statistically significant reduction of total health and social care and personal costs per patient (Kwok2008).

There is weak evidence from two fair quality RCTs indicating no difference in primary cause of readmissions (Kwok2004, Kwok2008). There is weak evidence

from one fair quality RCBA indicating an increased proportion of same-day discharges (Wright2013).

5.5 Summary of findings

This scoping review aimed to

1) Document and identify themes, categories and classifications across the range of interventions
2) Identify methods and measures of effectiveness being used to evaluate the effectiveness of such interventions
3) Review the existing evidence on the effectiveness of these interventions

The findings of this review are summarised according to these aims.

5.5.1 What categories and classifications can be identified across the range of interventions?

A range of classifications and configurations of interventions were identified among the included studies, even within the relatively narrow focus interventions providing home treatment of acute medical conditions in elderly patients, at risk of unscheduled hospital admission. They were also identified as having multiple components which was as expected, given this is a defining characteristic of complex interventions (Campbell et al., 2007).

Eighteen unique interventions were identified across the 22 included studies. The following models of care were identified among the range of interventions in these studies:

- **Admission avoidance (or substitutive) Hospital at Home (HaH):** provides medical and nursing care that substitutes entirely for inpatient acute hospital care, characterised by "rapid response" teams and which cannot be provided by usual community-based home care services
- **Early discharge Hospital at Home (HaH):** substitutes the remainder of a patient's hospital stay after a patient's medical condition has stabilised following initial hospitalisation, which involves rehabilitation, usually provided in a hospital
- **Combined early discharge HaH and admission avoidance HaH:** combination of the above two models

- **Post-acute discharge support (or restorative care):** rather than substituting for a hospital stay or providing early discharge, patients recovery following a hospital stay is supported at home for where patients are identified as being at risk of further hospitalisation following discharge, aiming to restore or enhance functional ability at home

Across these interventions with varying models of care, there was some consistency in the types of healthcare professional roles involved in care delivery (see Table 5.10). Nurses were involved in care delivery in all 18 of the unique interventions identified across the 22 included studies. Geriatricians, physicians (also known as General Practitioners), physiotherapists and occupational therapists were involved in care delivery in at least half of the interventions. About a third of the interventions involved social care workers. Nine of the interventions involved other health professionals including other types of doctors or specialists and pharmacists.

Table 5.10 – Frequency of healthcare professional roles involved in care, observed among the unique interventions in the included studies

Healthcare professional role	Number of unique interventions among included studies (% of total studies)
Geriatrician	11 (61.1%)
Physician	11 (61.1%)
Nurse	18 (100.0%)
Physiotherapist	12 (66.6%)
Occupational therapist	10 (55.6%)
Social care worker	5 (27.8%)
Other	9 (50.0%)

5.5.2 What methods and measures of effectiveness are being used to evaluate the effectiveness of such interventions?

5.5.2.1 Methods

The specific methods employed for assessing the effectiveness of interventions were reviewed in this scoping review. Specifically, this included the study designs being employed including selection of comparison groups and the specific statistical analysis methods including any statistical adjustment of observed differences between groups.

Identifying study designs outside of experimental designs was challenging due to a lack of standardisation in literature around describing observational designs and variation among research fields in how different designs are understood

(Reeves, Wells and Waddington, 2017). This is an interesting observation because it highlights the complexity and ambiguity around observational designs, and the need for greater clarity in reporting observational study design in literature.

Six main study designs were identified among the included studies, three experimental designs and four observational designs. As indicated in Table 5.11, experimental designs included 11 RCTs where intervention and comparison groups were randomly allocated, a Q-RCT where groups were allocated in a quasi-random manner (sequentially allocated) and a NRCT (also called a natural experiment), where allocation was not random but was determined by researchers. Observational designs included six studies employing a cohort study design (most of them using concurrent comparison groups and one using historic control groups) and three before and after studies (two of which were self-controlled and one of which included a separate comparison group identified retrospectively).

Table 5.11 – Classified study designs identified among included studies

Study group selection	Study design	Number of studies (% of total studies)
Experimental (groups allocated by researchers)	Randomised controlled trials (RCTs)	11 (50.0%)
	Quasi-randomised controlled trial (Q-RCT)	1 (4.5%)
	Nonrandomised controlled trial (NRCT)	1 (4.5%)
Observational (groups identified based on existing information)	Concurrently controlled prospective cohort studies (PCS)	5 (22.7%)
	Historically controlled cohort study (HCS)	1 (4.5%)
	Retrospective controlled before-and-after study (CBA)	1 (4.5%)
	Before-and-after studies (BA) (self-controlled)	2 (9.1%)

Comparison groups are summarised in Table 5.12. As previously noted, they were not often well described as noted in other reviews of similar interventions (Shepperd and Iliffe, 2005a). However, comparison groups were often described as those receiving usual care, which depended on which model of care the intervention employed.

Table 5.12 – Comparison groups used among included studies

Study group selection	Comparison group	Number of studies (% of total studies)
Admission avoidance Hospital at Home (HaH)	Usual hospital inpatient care	8 (36.4%)
	Usual community home visiting and home hospitalisation (intervention added integrated care, formal coordination of services with a community geriatric unit and home CGA)	1 (4.5%)

Early discharge Hospital at Home (HaH)	Usual hospital inpatient rehabilitation care	6 (27.3%)
Combined admission avoidance and early discharge HaH	Usual hospital inpatient care followed by intermediate care in a rehabilitation unit	1 (4.5%)
Post-acute discharge support (restorative care)	Usual post-discharge outpatient or community nursing care	4 (18.2%)
	Self-controlled (intervention patients acted as own controls in before-and-after studies, little information provided about care prior to intervention)	2 (9.0%)

To account for confounding due to differences between groups, included studies most frequently used statistical adjustment in their analyses. However in three studies, matching methods were used to identify comparison groups to minimise the differences between groups (the three studies were an NRCT, a PCS and a RCBA). Two of these used direct matching (matching directly on specified covariates) and one used propensity score matching (matching based on a propensity score generated through a multivariable model developed to predict the likelihood of forming part of the intervention group).

Covariates used for matching and for statistical adjustment were of interest, as these are informative of the potential confounders one may face in the analysis of effect of admission avoidance interventions. Table 5.13 summarises the confounders used in matching or adjustment among the included studies.

Table 5.13 – Confounders identified by studies included in this scoping review

Risk factor	Matching	Statistical adjustment
Socio-demographic factors		
Age	✓ N=2	✓ N=7
Sex	✓ N=2	✓ N=8
Living alone or living arrangements		✓ N=3
Socioeconomic group		✓ N=1
Caregiver factors including health	✓ N=1	✓ N=2
Healthcare utilisation factors		
Prior length of hospital or rehabilitation stay		✓ N=2
Medical and health related factors		
Overall diagnosis group (e.g. HRG)	✓ N=2	✓ N=2
Specific medical diagnoses **Delirium or confusion** **Mood disorder or depression** **Cancer**	 ✓ N=1 ✓ N=1	 ✓ N=4 ✓ N=3
Comorbidity (Charlson index, APACHE II, number of geriatric syndromes)	✓ N=1	✓ N=3
Frailty index	✓ N=1	
Cognitive issues	✓ N=1	✓ N=3

Functional dependency	✓ N=1	✓ N=6
Clinical measurements (oxygen saturation)		✓ N=1
Number of medications		✓ N=1

In terms of statistical analysis methods for measuring effect, it was quickly recognised that analyses were poorly described in the included studies. Descriptions of analyses and statistical tests used were often ambiguous and in a few cases the specific analysis used could not be well determined from the studies' descriptions. Generally, the investigation of the analyses conducted in these studies included the reporting of unadjusted (specific parametric and non-parametric test according to type of outcome and data distributions, unadjusted survival analyses) and adjusted analyses (including multivariable linear regression, multivariable logistic regression reporting odds ratios or risk ratios, multiple regression analysis, analysis of variance or covariance, mixed models and adjusted survival analyses such as Cox proportional hazards regression), with specific methods and statistical tests being appropriate to the specific distributions of data and study designs, as is expected. It also highlighted a need for reporting clearly and in detail the analyses being conducted and why.

5.5.2.2 Measures of effect

Studies used a variety of measures of to evaluate the effect of interventions. They could broadly be categorised into:

- Functional, physical and mental health outcomes (16 studies)
- Mortality outcomes (9 studies)
- Quality of life outcomes (12 studies)
- Satisfaction with care outcomes (4 studies)
- Use or cost of health service outcomes (20 studies)

The variety of these measures is summarised in Table 5.14 below.

Table 5.14 – Outcome measures used in studies included in this scoping review

Domain	Outcome	Number of studies (% of total studies)
Functional, physical and mental health outcomes (N=16)	Functional ability, independence or handicap	14 (63.6%)
	Physical mobility (walking ability, balance confidence)	4 (18.2%)
	Cognitive status	6 (27.3%)
	Depression or psychological health	5 (22.7%)
	Delirium	4 (18.2%)

	Incidence of medical complications (including infections and falls)	2 (9.1%)
	Nutrition	2 (9.1%)
	Instability in health	1 (4.5%)
	Respiratory function	1 (4.5%)
	Adverse events (use of psychoactive drugs, sedatives or chemical restraints)	2 (9.1%)
Mortality outcomes (N=9)	Two-week mortality	1 (4.5%)
	Three-month mortality	1 (4.5%)
	Six-month mortality	4 (18.2%)
	Twelve-month mortality	2 (9.1%)
	Two-year mortality	1 (4.5%)
Quality of life (QoL) outcomes (N=12)	Validated patient QoL assessment measures or instruments	5 (22.7%)
	Validated caregiver QoL assessment measures or instruments	5 (22.7%)
	Other QoL measures (proportion discharged home, proportion achieving crisis resolution, incidence of home death, time to first readmission, pain, social handicap)	9 (40.9%)
Satisfaction with care (N=4)	Various measures of patient, caregiver or GP satisfaction with care	4 (18.2%)
Use or cost of health services (N=20)	Number of inpatient hospital admissions	6 (27.3%)
	Number or incidence rate of readmission	6 (27.3%)
	Number or incidence rate of ED attendance	5 (22.7%)
	Incidence of nursing home admission or placement	5 (22.7%)
	Cumulative incidence of hospitalisation or ED attendance	1 (4.5%)
	Number of home health visits	1 (4.5%)
	Length of stay outcomes (hospital bed days or LOS over a time period, LOS of index admission/episode, LOS of first readmission, time in ED before transfer)	17 (77.3%)
	Proportion of same day discharges	1 (4.5%)
	Cost of health services (total cost of care per patient, total public health cost per patient, total health and social care costs, total personal costs)	10 (45.5%)

5.5.3 What does the existing evidence tell us about the effectiveness of these interventions?

A summary of the study findings is presented in Table 5.15, including the overall evidence grading for the findings presented against each outcome. The evidence reviewed indicates that overall there are several areas of conflicting findings across the outcomes investigated. Where evidence has not been conflicting, findings are mostly classified as weak or limited evidence, given quality and design of the reviewed studies. However, some generalisations can be made. It

appears that the impact of home- and community- based interventions for treating acute conditions on functional, physical and mental health outcomes is overall either positive or there is no significant impact on these outcomes. While most findings were conflicting or of weak evidence grading, here is moderately strong evidence that these interventions have no impact on cognitive status. These findings highlight that for these physical outcomes, home- and community-based treatment is at least as effective as hospital treatment and that there is no detrimental impact.

When it comes to mortality, there is moderately strong evidence that there is no significant impact of these interventions on six-month mortality. Across other follow-up times, evidence was weak or limited, but indicated either no difference or an improvement in mortality rates hence overall the evidence points to these interventions being at least as effective as hospital treatment with no detrimental impact on mortality.

Across the nine studies reviewing either patient or caregiver quality of life, there was conflicting evidence as to whether these interventions are associated with an improvement or have no significant impact. There was weak or limited evidence across the studies evaluating a variety of other quality of life indicators overall finding either no difference or an improvement across groups. The studies finding a positive impact on these other quality of life indicators found an improvement in health crisis resolution (weak evidence, 1 study), an increase in time to readmission (limited evidence, 2 studies), an increase in incidence of home death (limited evidence, 1 study). Those finding no difference included no significant difference in proportion discharged home (limited evidence, 2 studies), no difference in perceived control of health (weak evidence, 1 study) and no difference in pain (weak, 2 studies). Hence, again, overall across quality of life indicators, the evidence points to these interventions being at least as effective as hospital treatment with no detrimental effect on quality of life.

The reviewed evidence indicates conflicting evidence across the four studies measuring patient satisfaction with care, finding either no difference or an improvement. There was limited evidence from three studies finding an improvement in caregiver satisfaction. There was weak evidence (1 study) of no difference in GP satisfaction and limited evidence (1 study) of no difference in recommender rates. Hence overall, again, satisfaction with care is at least as good

as usual care satisfaction across the various satisfaction measures, with some indication that caregiver satisfaction may be significantly improved.

As with other outcomes, use or cost of health services included a variety of outcomes, across which there were mixed results and conflicting evidence. In particular there were several areas of conflicting evidence across the number and incidence of hospital admission or attendance outcomes, finding either no difference or a reduction in these outcomes (see Table 5.15 for details). Where evidence was not conflicting, there was limited evidence from six studies indicating that there is no difference in the number of inpatient hospital admissions and there were some areas of limited evidence indicating a reduction in outcomes including ED attendance incidence rate and cumulative incidence of hospitalisation or ED attendance. Hence, these results around number and incidence of hospitalisation are very mixed.

Length of stay outcomes also pointed to conflicting results. Studies found either no difference or a reduction in length of stay over a given follow-up time period. Among studies assessing length of stay of the index acute care episode and/or rehabilitation (provided in either intervention or usual care settings), results were more conflicting finding either no difference, an improvement or an increase in length of stay. There is some weak evidence of an association with shorter time in the ED before transfer.

In terms of cost outcomes, there is moderately strong evidence of a reduction in patient care provision costs of the acute episode from eight studies as well as weak evidence of a reduction in total health and social care and personal costs per patient from one study. However, results on longer term costs seem to be conflicting with one study indicating a reduction and another indicating no difference. Hence, of all the outcomes reviewed, evidence appears strongest for an effect on costs, particularly in reducing patient care provision costs of the acute episode.

Table 5.15 – Summary of evidence across outcomes and evidence grading identified among studies included in this scoping review

Outcome	Evidence grading[1]	Summary of study findings ◉ *no difference* ◉ *positive effect* ◉ *negative effect*
Functional, physical and mental health outcomes (N=16)		
Functional ability, independence or handicap (N=14)	(4) Conflicting evidence	◉ Either no difference (N=9) ◉ or an improvement (N=5)

Physical mobility (exercise and walking ability, balance confidence) (N=4)	(4) Conflicting evidence	◉ Either no difference (N=2) ◉ or an improvement (N=2)
Cognitive status (N=6)	(2a) Moderately strong evidence	◉ No difference (N=6)
Depression or psychological health (N=5)	(4) Conflicting evidence	◉ Either no difference (N=3) ◉ or an improvement (N=2)
Incidence or risk of delirium (N=4)	(4) Conflicting evidence	◉ Either no difference (N=1) ◉ or an improvement (N=3)
Duration, onset and severity of delirium (N=1)	(2c) Weak evidence	◉ Improvement (N=1)
Incidence of medical complications (including infections and falls) (N=2)	(2c) Weak evidence	◉ No difference (N=2)
Nutrition (N=2)	(4) Conflicting evidence	◉ Either no difference (N=1) ◉ or an improvement (N=1)
Instability in health (N=1)	(2c) Weak evidence	◉ No difference (N=1)
Respiratory function (N=1)	(2c) Weak evidence	◉ No difference (N=1)
Adverse events (use of psychoactive drugs, sedatives or chemical restraints) (N=2)	(2c) Weak evidence	◉ Improvement (N=2)
Mortality outcomes (N=9)		
Two-week mortality (N=1)	(2c) Weak evidence	◉ Reduction (N=1)
Three-month mortality (N=1)	(2c) Weak evidence	◉ No difference (N=1)
Six-month mortality (N=4)	(2a) Moderately strong evidence	◉ No difference (N=4)
Twelve-month mortality (N=2)	(2b) Limited Evidence	◉ No difference (N=2)
Two-year mortality (N=1)	(2b) Limited Evidence	◉ Reduction (N=1)
Quality of life (QoL) measures (N=12)		
Validated patient QoL assessment measures or instruments (N=5)	(4) Conflicting evidence	◉ No difference (N=1), ◉ an improvement (N=3) or ◉ improvement in physical QoL component but ◉ no difference in mental QoL component (N=1)
Validated caregiver QoL assessment measures or instruments (N=5)	(4) Conflicting evidence	◉ No difference (N=3), ◉ no deterioration compared to control group (N=1) or slower deterioration compared to control group (N=1)
Other QoL measures (proportion discharged home, proportion achieving crisis resolution, incidence of home death, time to first readmission, pain, social handicap) (N=9)	(2b) Limited or (2c) weak evidence across these measures	◉ Improvement (N=4) or no deterioration compared to control group (N=5)
Patient, caregiver or GP satisfaction with care (N=4)		
Various measures of patient satisfaction with care (N=4)	(4) Conflicting evidence	◉ Either no difference (N=1) ◉ or an improvement (N=3)
Various measures caregiver satisfaction with care (N=3)	(2b) Limited evidence	◉ Improvement (N=3)
GP satisfaction with care (N=1)	(2b) Limited evidence	◉ No difference (N=1)
Proportion recommending care to family or friends (N=1)	(2c) Weak evidence	◉ No difference (N=1)
Use or cost of health services (N=20)		
Number and incidence of hospital admission or attendance outcomes		

Number of inpatient hospital admissions (N=6)	(2b) Limited evidence	◉ No difference (N=6)
Number of readmissions (N=4)	(4) Conflicting evidence	◉ Either no difference (N=3) ◉ or a reduction (N=1)
Incidence rate of readmission (N=5)	(4) Conflicting evidence	◉ Either no difference (N=4) ◉ or a reduction (N=1)
Number of ED attendances (N=4)	(2c) Weak evidence	◉ No difference (N=2) (◉though two before-and-after studies of poor and fair quality found a reduction)
Incidence rate of ED attendance (N=1)	(2b) Limited evidence	◉ Reduction (N=1)
Incidence of nursing home admission or placement (N=5)	(4) Conflicting evidence	◉ Either no difference (N=3) ◉ or a reduction (N=2)
Cumulative incidence of hospitalisation or ED attendance (N=1)	(2b) Limited evidence	◉ Reduction (N=1)
Number of home health visits (N=1)	(2c) Weak evidence	◉ No difference (N=1)
Length of stay outcomes (N=17)		
Hospital bed days or LOS over a time period (N=7)	(4) Conflicting evidence	◉ Either no difference (N=3) ◉ or a reduction (N=4)
LOS of index acute episode and/or rehabilitation (N=10)	(4) Conflicting evidence	◉ No difference (N=1), ◉ a reduction (N=6) ◉ or an increase (N=3)
LOS of first readmission (N=1)	(2c) Weak evidence	◉ No difference (N=1)
Time in ED before transfer (N=2)	(2c) Weak evidence	◉ Reduction (N=1)
Cost outcomes (N=10)		
Patient care provision costs (total costs per episode per patient or per patient per day) (N=8)	(2a) Moderately strong evidence	◉ Reduction (N=8)
Longer term costs (total costs per patient over a year) (N=1)	(4) Conflicting evidence	◉ Either no difference (N=1) ◉ or reduction (N=1)
Total health and social care and personal costs per patient (N=1)	(2c) Weak evidence	◉ Reduction (N=1)
Other outcomes		
Primary cause of readmissions (N=1)	(2c) Weak evidence	◉ No difference (N=1)
Proportion of same day discharges (N=1)	(2c) Weak evidence	◉ Increase (N=1)

[1]Note Hooper et al.'s (2008) evidence grading was used:

- 1a (very strong): the findings are supported by the results of 2 or more studies of at least excellent quality
- 1b (strong): the findings are supported by at least 1 study of excellent quality
- 2a (moderately strong): the findings are supported by 2 or more studies of at least good quality
- 2b (limited): the findings are supported by at least 1 study of good quality
- 2c (weak): the findings are supported by at least 1 study of fair or poor quality
- 3 (consensus): in the absence of evidence, there is agreement by a group of experts on the appropriate treatment course
- 4 (conflicting): there is disagreement between the findings of at least 2 randomized controlled trials.

5.6 Discussion and conclusion

This scoping review of literature forms part of Phase II of this research where the aim was to review existing literature to obtain guidance on the selection of a robust study design and identification of outcome measures. The scoping review not only enabled identification of the main study designs and outcomes being used in the assessment of effectiveness of home- and community-based interventions aiming to reduce avoidable hospital admissions for elderly patients, but also provided a better understanding of key features of these interventions and current evidence on their effect. The following main observations arise from this scoping literature review, which directly inform and influence the study design for this research.

- Though such interventions are varied with multiple features, some categories and key features can be identified, enabling categorisation into admission avoidance (or substitutive) Hospital at Home (HaH), early discharge Hospital at Home (HaH), combined early discharge HaH and admission avoidance HaH and post-acute discharge support (or restorative care). It is clear however that these interventions are complex and involve several interconnecting parts, and that making distinctions in terms of the processes involved and particularities of a given intervention of such kind is important towards identifying appropriate control groups and comparative methods.
- Observational study designs and methods were used in only a small proportion of the existing literature included in this scoping review. It was highlighted that the description of study design lacked consistency and clarity among the included studies and that particularly for observational methods, the study designs and methods can be highly complex. Hence, there is a requirement for further study of these designs and analytical methods, which resulted in the narrative review of quantitative evaluation approaches in observational research also conducted as part of Phase II of this research (presented in the chapter that follows – 0).
- A variety of measures of effect are being used across studies evaluating home- and community-based interventions aiming to reduce avoidable hospital admissions among elderly patients. These could be broadly categorised as functional, physical and mental health outcomes, mortality outcomes, quality of life outcomes, satisfaction with care outcomes and use or cost of health service outcomes. The most frequently used outcomes are use or cost of health services indicating that evaluation of such interventions is heavily focused on such outcomes. The next most frequently used outcomes were functional, physical and mental health outcomes; however, these outcomes were widely limited to studies employing experimental designs, which is

expected as these types of functional measures require physical assessment and are not routinely collected in electronic healthcare systems hence often need to be prospectively collected.

- Analyses were often not well described in detail and difficult to determine, however, analyses usually included both unadjusted and adjusted methods with the specific statistical tests and methods selected according to data distributions and study designs, which highlights the requirement for thorough consideration of the appropriate statistical methods to be employed for this research. This was also considered in the narrative review of quantitative evaluation approaches in observational research taking place as part of Phase II of this research (presented in the chapter that follows - 0).

The following observations can be made about the evidence reviewed across the included studies in terms of the effectiveness of these interventions against the study outcomes.

- In reviewing the evidence on the effectiveness of these interventions against the identified outcomes, overall, it was clear that there are conflicting results across all outcomes, primarily as to whether the interventions lead to an improvement or make no difference to the range of outcomes. However, it appears that for the most part, these interventions do not have a detrimental impact on study outcomes, except in the case of length of stay of the acute care or rehabilitation episode where several studies found an increased length of stay, however, again, there were conflicting results with other studies indicating no difference or an improvement on this outcome. It did appear that overall, the strongest evidence for an improvement in a given outcome was in cost outcomes, where there was evidence of reductions in costs of care of the acute or rehabilitation episode in at least eight studies, though results for longer term costs were conflicting as to whether there was a reduction or no difference.

These observations align with the findings of other reviews investigating the effectiveness of similar interventions. A Cochrane review of RCTs evaluating admission avoidance hospital at home programmes found little to no difference on mortality, little to no difference on readmission, low-certainty evidence that satisfaction with care may be improved, low-certainty evidence that cost of care may be reduced and conflicting results on the impact on length of stay (Shepperd et al., 2016). A Cochrane review of RCTs evaluating early discharge hospital at home programmes found insufficient evidence of a difference in mortality, increased readmission rates, increased satisfaction with care and mixed evidence on cost savings (Shepperd et al., 2009a). Overall, systematic reviews and meta-

analyses have identified mixed results across these types of interventions in terms of their effectiveness (Shepperd et al., 2009a, 2016; Caplan et al., 2012; Huntley et al., 2017; Low, Yap and Brodaty, 2011).

As Shepperd et al. (2009b) have highlighted, lack of agreed definition of complex interventions across studies makes it difficult to reach conclusions on their effectiveness due to the complexity and variation across the interventions. Alternative approaches such as the 'realist review' and theory-based analysis have been proposed, focusing more on "trying to explain as opposed to judge complex health interventions" (Shepperd et al., 2009b, p.5). The following excerpt highlights this issue well and expands on this proposal:

> *"The upshot of all of this is that systematic reviews of complex health interventions can and should be done, but if they are to shed more light than darkness, the systematic reviewers need explicitly to consider doing two things. First, they should search for and include relevant theoretical and qualitative work. Second, where relevant, they should include data from a broader range of experimental study designs than is currently normally the case in most Cochrane systematic reviews. Such an approach will in turn necessitate development of better search strategies to locate this non-trial literature and also the availability of techniques for the quality assessment of such studies. Theory-driven analysis, wherever possible, should also accompany the more conventional quantitative syntheses, the emphasis on the latter being down- played." (Shepperd et al., 2009b, p.6)*

These issues highlight confirm the need for the use of mixed methods in evaluating the effectiveness of complex interventions, and the results of this scoping review highlight that the effectiveness of home- and community-based interventions aiming to reduce avoidable hospital admissions for elderly patients is mixed, hence justifying the need for continued research in this area, in particular mixed methods research considering not only 'if' these interventions are effective against specified outcomes but also 'how,' 'why,' 'in what circumstances,' 'for whom,' and 'to what extent.'

It should be noted that this was a review of studies assessing comparative effectiveness where comparison groups were used to assess a variety of outcomes, some of which were qualitative (e.g. satisfaction with care), however, exclusively qualitative studies (e.g. participant interviews and thematic analyses) were not included in this review. This was outside the scope of this review as one of the main aims was towards informing the methods for comparative quantitative evaluation, which required a narrower focus on such studies. However, it is noted

as a limitation of this review, for example, in informing all possible types of evaluation such as qualitative approaches. An area of future work which would expand on this scoping review, is to review qualitative evaluative studies of integrated care interventions such as those included here, which has also been recommended by other researchers as noted previously.

Chapter 6 Narrative Review of Quantitative Evaluation Approaches in Observational Research

6.1 Introduction

As described in Chapter 5, the complexity and variety of available quantitative observational study designs and methods required further review in order to identify a suitable approach for this research. This chapter provides a narrative review of the methods available for comparing the effect of an exposure on an outcome in observational studies, identifying the methods suitable for the specific setting of this research and presenting those being employed for each of the comparative studies evaluating the comparative effect of the 'Closer to Home' programme.

Though the use of randomised controlled trials (RCTs) to evaluate the association between an exposure and an outcome is the gold standard, research in healthcare often requires alternatives for reasons such as ethical issues or due to an evaluation being conducted in hindsight, requiring retrospective methods as is the case here. In such settings, other study designs and analytical methods exist, with certain designs enabling the estimation of treatment effect despite the lack of randomisation. This can be done by eliminating factors that may confound estimation of treatment effects (due to the lack of random assignment) in the design and/or analysis in order to simulate an RCT. These types of studies are called observational studies, where there is some control (quasi-experimental studies, usually prospective) to no control (observational studies, usually retrospective) over the implementation/assignment of the treatment.

Inferring causality to any degree of certainty requires experimental research designs, however, well designed observational studies can be used to assess and evaluate causal hypotheses about the effects of exposure on outcome (Levin, 2006; Carlson and Morrison, 2009). This research was limited to the use of retrospective observational methods due to the retrospective nature of the evaluation, including

the lack of control over treatment assignment. Hence, only retrospective methods will be reviewed here.

6.2 Structure of this chapter

This chapter will comprehensively review the available methods for comparing the effectiveness of the 'Closer to Home' programme and subsequently describe the specific methods selected for each of the comparative studies, providing an in-depth description of the methods available and providing rationale for the selection of the specific methods employed (methodology).

The following four main areas of quantitative evaluation approaches were reviewed. This chapter is structured according to these four areas, describing the available methods in detail and concluding with the rationale for the selected approach for each of the four areas within this research.

- Retrospective observational study designs for evaluating associations between exposures and outcomes
- Matching methods for observational research
- Statistical analysis for observational comparative effectiveness studies (multivariable regression models)
- Confounder identification and covariate selection
- Handling of missing data in observational research

6.3 Retrospective observational study designs for evaluating associations between exposures and outcomes

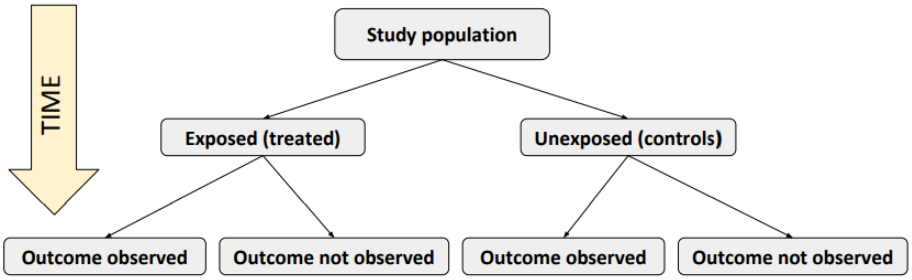
Retrospective methods that take advantage of large administrative healthcare databases have had increasing interest in the past decade, due to enabling a comprehensive coverage of full populations, having a relatively low cost for acquiring data on covariates and outcomes, and due to the ability to observe exposures and outcomes in a natural environment rather than in a tightly controlled RCT environment (Austin et al., 2012). Retrospective cohort studies and case-control studies are the two main types of retrospective observational studies for evaluating associations between exposures and outcomes (Song and Chung, 2010; Salkind, 2012). In this section, these two designs are summarised,

followed by a review of different types of control groups and ending with a discussion of the control groups and study design selected for the quantitative evaluation conducted for this research.

6.3.1 Retrospective cohort and case-control studies

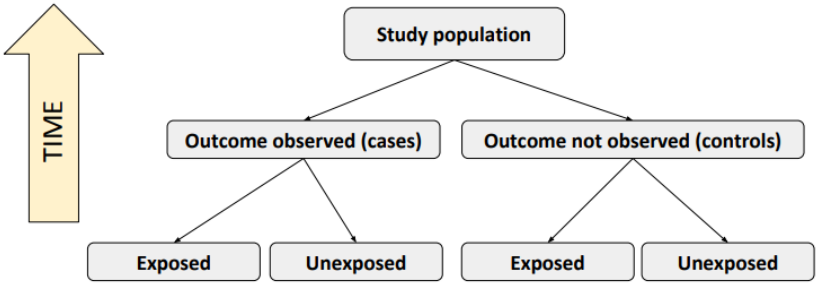
In cohort studies, the study population is selected based on their exposure status to some factor. In retrospective cohort studies (also known as historical cohort studies), longitudinal exposure and outcome data is collected retrospectively (Thiese, 2014). The following figure represents the general design of a cohort study.

Figure 6.1 – General design of a cohort study



In case-control studies, the study population is selected based on their outcome or event status where those with the outcome are known as 'cases' and those without the outcome are known as 'controls.' The outcome or event status is a characteristic that is developed in a participant, typically the presence or absence of a disease or condition but can also be other features such as quitting smoking or not (Hackshaw, 2014). Because case-control studies select the study population based on outcome, they are always retrospective by nature (Lewallen and Courtright, 1998). As with retrospective cohort studies, in case-control studies, exposure and outcome data is collected retrospectively. The following figure represents the general design of a case-control study.

Figure 6.2 – General design of a case-control study



There are two main types of case-control studies: the nested case-control and the case-cohort study (Ernster, 1994). Both types are based on the identification of cases and controls within a previously defined cohort. The nested case-control study selects all cases and then selects time-matched controls (for example matched on length of time in the cohort or date of entry) (Ernster, 1994). The case-cohort study selects all cases and then selects a random sample of controls from the entire sample. The main feature of case-control studies that contrasts them from cohort studies is that in all types of case-control studies, all cases are selected but only a selection of controls are included, without regard for the number of exposed and unexposed within these groups. This is why case-control studies are best for studying rare outcomes. This feature is the main argument in favour of case-control studies as they are associated with reduced costs in terms of burden of data collection, given covariates must be collected from all cases but only from a sample of controls (i.e. those where the outcome is not observed) (Austin et al., 2012).

Considerations of cost in terms of burden of data collection are not relevant to studies using administrative observational datasets however (Austin et al., 2012); hence, either cohort studies or case-control studies can be equally considered in this respect. The traditional approach to conducting a retrospective observational study using large observational datasets is the retrospective cohort study design, however, case-control studies have increasingly been used (Austin et al., 2012). Hence, some of the main further relevant advantages and disadvantages of retrospective cohort and case-control studies are highlighted in Table 6.1 below.

Table 6.1 – Advantages and disadvantages of retrospective cohort and case-control studies

	Retrospective cohort studies	Case-control studies
Advantages	• Good for investigating rare exposures (Song and Chung, 2010)	• Good for investigating rare outcomes (Song and Chung, 2010; Thiese, 2014)

	• Can assess multiple exposures and outcomes (Song and Chung, 2010)	• Can assess multiple exposures (Song and Chung, 2010)
Disadvantages	• Not good for investigating rare outcomes (Thiese, 2014)	• Not good for investigating rare exposures (Song and Chung, 2010) • Can only assess one outcome (Song and Chung, 2010)

Based on these highlighted advantages, the retrospective cohort study design appears most appropriate for the context of this research. In particular, the retrospective cohort study design works best for contexts such as that of this research where exposure is uncommon or rare (roughly 5% of the entire population aged 65 or over received treatment), and it allows for the assessment of more than one outcome which was desired for this research (several measures of hospital activity). Further to this, Austin and colleagues (Austin et al., 2012) found that retrospective cohort designs result in estimates with greater precision and lower mean squared error in a comparison of the retrospective cohort study design and the nested case-control design, using administrative datasets such as in the context of this research (Austin et al., 2012).

It is worth noting that it can be difficult to distinguish between these designs which is observed in literature, where studies have reported the use of case-control studies where they have actually employed a retrospective cohort design (Bredemeier, 2011).

6.3.2 Control group definition in retrospective observational studies

Retrospective observational studies that use administrative datasets lend themselves to some control over the choice of control group that will be selected as a comparison to the treatment group, due to having access to datasets covering full populations in these cases. In RCTs, for example, the choice of control group is not necessarily at the discretion of the researcher, as allocation is random (Malay and Chung, 2012). The criteria used to define control groups in observational studies contributes to their validity. In a review of control group selection in retrospective observational studies (namely case-control and retrospective cohort studies), Malay and Chung (2012) identified that many studies used poorly defined control groups, often containing specific inclusion and exclusion criteria, but having a lack of detail in describing how control groups

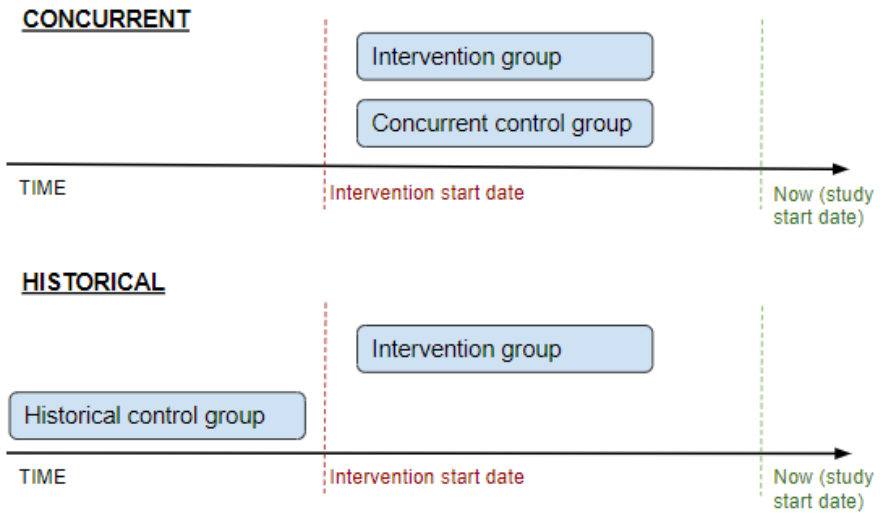
were selected. This may contribute to the previously highlighted difficulty in distinguishing observational study designs in literature. However, they were able to identify that retrospective observational studies usually employ two broad types of controls: concurrent and historical controls (ibid).

Concurrent controls are subjects who are from the same source population and are followed during the same time period as the intervention group. In the case of concurrent controls, a group is identified who did not receive the intervention or received an alternative or unrelated intervention at the time that the intervention group received the intervention (Malay and Chung, 2012). Concurrent controls who did not receive the intervention can be identified as subjects who segregate themselves into exposure status (e.g. voluntary enrolment into intervention such as use of a public advice line, use of a repeat-prescribing app available to the public) or are segregated into exposure status due to external factors (e.g. living outside region of eligibility for intervention, treated in a hospital not offering intervention) (Grimes and Schulz, 2002).

Historical controls are subjects who, at some specified period in the past, did not receive the intervention and are followed during a period in the past that may be parallel to the follow-up time period of the intervention patients. The use of historical controls is subject to chronology bias (i.e. the effect of differing time and place can confound the results), hence, it is advised that they should only be used in settings where the selection of a concurrent control group is not possible (Malay and Chung, 2012). These settings include those where it is unethical to use a concurrent control group or where there is such strong selection for the intervention that it is uncontrollable even with rigorous methods (Setoguchi and Gerhard, 2013).

Figure 6.3 graphically represents the selection of concurrent and historical control groups.

Figure 6.3 – Concurrent and historical control group selection in retrospective observational studies



Whether a concurrent or historical control group is chosen, how these are identified is important. Sometimes these can be identified retrospectively as a clearly defined group who received a different treatment or a group that was defined in advance as being eligible or being a target group for the intervention. However, there are times where a well-defined group is not available, hence the control group must be identified from a pool of potential controls in the full population.

It is important to identify whether the reasons for lack of exposure or selection to the intervention are associated with the outcomes being studied (Setoguchi and Gerhard, 2013). In the case of historical controls, the reasons for lack of exposure are often due to lack of availability of the intervention at the time or receipt of a different treatment. However, in the case of concurrent control groups, though reasons for lack of exposure include lack of availability (e.g. treated outside of region or hospital offering intervention) and receipt of a different treatment, there may be other reasons for lack of exposure as the intervention is known to have been available when selecting the concurrent control group.

For example, lack of exposure may be due to lack of eligibility or lack of need of the intervention, in which case there are likely to be observed differences between the exposed and unexposed groups. This is less likely to be the case where a well-defined control group has been identified in advance, however it can be difficult

to distinguish reasons for lack of exposure where the control group must be selected from a pool of potential controls in the full population.

Where observed differences between the exposed and unexposed groups are associated with the outcome of interest, these are a source of selection bias and need to be adequately adjusted for or controlled through the study design or analysis (Setoguchi and Gerhard, 2013). Incomparability of intervention and control subjects can lead to selection bias due to unaccounted differences in the characteristics between them (Malay and Chung, 2012).

One way of selecting a comparable control group, where a well-defined group of eligible or target patients has not been defined, is identifying control subjects from a pool of potential controls who match the characteristics of intervention subjects. This approach will be required within this research due to a lack of a well-defined control group for the ECT intervention.

While matched case-control studies are common and widely covered in literature, matched cohort studies are less common and not widely covered in literature (Sjölander et al., 2012; Sjölander and Greenland, 2013). Analysis of matched cohort studies is sparsely covered in literature (Cummings and Mcknight, 2004; Holford, Bracken and Eskenazp, 1989). It is hypothesised that the reason for this is due to availability of data sources as matched cohort studies require access to large population-based data sources including exposure information (Sjölander et al., 2012). Though less common, they are increasingly recommended (Sjölander and Greenland, 2013). The literature on general matching methods, however, is vast, hence these will be described in more detail in Section 6.4.

6.3.3 Control group definition for comparative evaluation of 'Closer to Home'

As previously described, retrospective observational studies require the selection of a carefully selected and well-defined cohort. As identified by Roland and colleagues (2005), this is particularly the case for evaluating admission avoidance schemes for elderly patients, as admissions for this age group fall in subsequent years after experiencing a crisis which means an inadequate control group could result in the misattribution of falling admission rates to a given intervention. The following excerpt by Roland and colleagues describes why this particular setting necessitates careful selection of a control group:

> *"To attribute reduced admission rates to a healthcare intervention it is essential to compare the intervention group with a carefully selected control population. If a randomised trial design is not feasible then, at the very least, admissions after the intervention should be compared with a control group who satisfy the 'high risk' criteria used to select the intervention group."* (Roland et al., 2005, p.291)

Hence, it is vital to carefully identify and define appropriate control groups that serve as a comparison to subjects who received the 'Closer to Home' interventions. As previously described, these should be groups who as much as possible, differ from 'Closer to Home' patients only by their exposure to the interventions. These control groups can be identified as those who were target patients or eligible patients for the interventions but did not receive them.

Retrospectively identifying a target population who did not receive treatment (i.e., a cohort of patients eligible for the intervention who did not receive the intervention), can be difficult. As previously described, it is important to identify whether the reasons for selection of the intervention are associated with the outcomes being studied as observed differences can be a source of selection bias.

In the context of this research, based on the proportion of recipients of the intervention being very small and based on the lack of mainstreaming of the services (which is explored in detail in Chapter 10), it is likely that many patients eligible for the intervention did not receive treatment due to reasons relating to lack of mainstreaming (e.g. lack of capacity, lack of awareness) rather than due to reasons related to their eligibility (unfortunately it was not possible to ascertain the specific reasons as this data was not collected). This reasoning provides a rationale for seeking a comparison cohort within the source population.

However, the results from Phase V (*'Retrospective cohort study assessing intervention effect on hospital activity outcomes'* which will be presented in Chapter 9) highlight that the intervention groups are significantly different from the remainder of the source population. Hence, it became apparent that well-defined, carefully selected comparison cohorts need to be identified out of the source population.

Specific study cohorts will be defined in detail in the presentation of the results in Chapter 9 Section 9.2, however, Table 6.2 gives an overview of the control groups identified for each of the studies evaluating the comparative effectiveness of each intervention. For two of the interventions (ALFY and GP Fellows), a well-defined pre-determined comparison target population was available for use as the

unexposed group in their corresponding retrospective cohort studies. However, for the ECT intervention, no clear or well-defined target population could be identified, as no pre-determined comparison target group was specified, and the referral criteria are loosely defined (further explored in the Qualitative Results chapter). Hence, to identify a comparison group for the ECT intervention, matching methods were used. Matching methods are varied and extensive, hence will be described in the next section, providing the rationale for the choice of matching methods employed for the selection of a control group for the ECT intervention.

Table 6.2 – Comparison group definition for each of the 'Closer to Home' interventions

Intervention	Well-defined comparison target group available?	Concurrent or historical	Target group who did not receive the intervention (potential control group)
Enhanced Community Team (ECT)	No	Concurrent	Matched control group to be identified (loosely defined referral criteria)
GP Fellows	Yes	Historical	Patients receiving ECT before GP Fellows was available
Advice Line for You (ALFY)	Yes	Concurrent	Patients identified as high risk (SPARRA ≥40) who were sent ALFY promotional materials (ALFY mailing list)

6.4 Matching methods for observational research

This section provides an overview of matching methods and approaches informing the selection of matching methods for the analysis of the Enhanced Community Team intervention within the 'Closer to Home' programme. As will be discussed, literature indicates that variations in matching methods and approaches lead to differing levels of bias of treatment effect estimates. Hence, these variations are carefully investigated in this section, concluding with the selected methods to be employed for the analysis based on the literature discussed.

6.4.1 Matching vs adjustment

There are several methods in existence for reducing bias due to lack of randomisation such that causal effects can be estimated from observational data. These include stratification methods such as matching, regression adjustment, instrumental variables, structural equation models and selection models (Stuart,

2010). Three key advantages of matching methods over other methods have been highlighted (Stuart, 2010):

1. Matching methods are complimentary to regression
2. Matching methods highlight areas of covariate imbalance between treatment and control groups, where treatment effect estimates would rely heavily on extrapolation. Regression and selection models perform poorly where there is insufficient overlap.
3. Matching methods have straightforward diagnostics to assess their performance

Given these advantages and given that within the setting of this study the pool of potential comparison group subjects have significantly different baseline characteristics to the treatment group (as will be presented in Chapter 9), matching methods aiming to identify similar groups with the potential to be combined with regression adjustment will be considered for the evaluation of the Enhanced Community Team (ECT). Hence, this section will briefly discuss the relative advantages of matching and regression adjustment methods. Matching methods are those where control subjects are selected to have similar covariate distributions as treated subjects, aiming to eliminate confounding on those covariates and replicate a randomised experiment. Regression adjustment methods refer to the statistical procedure of adjusting the estimated treatment effects by estimating the relationship between the outcome and covariates in each treatment group (Rubin, 1979).

Covariate adjustment is the traditional approach to correcting potential confounding, covariate imbalance and selection bias (Elze et al., 2017). However, statistical adjustment through multivariable regression has been criticised in that models may be over-fitted where the number of outcome events is low compared to the number of covariates, hence only a restricted number of confounders can be included in the model before overfitting (Benedetto et al., 2018; Elze et al., 2017). Matching on its own or as a precursor to covariate adjustment provides a potential solution to this issue. However, some studies have found that covariate adjustment and matching perform similarly (Elze et al., 2017; Posner et al., 2001).

Nevertheless, as highlighted previously, an advantage of matching is that it can be combined with regression. Rubin has found that covariate adjustment in matched samples is more robust (provides least biased treatment effect estimates) than covariate adjustment in unmatched samples, hence matching increases the robustness of statistical adjustments (Rubin, 1979, 1973). Hence the retrospective cohort study comparing the effectiveness of ECT aims to use matching methods combined with covariate adjustment. Covariate adjustment will be discussed separately in Section 6.5.3.1. Matching methods will be discussed in detail in the following sections, as there is a wide range of matching methods and configurations available.

6.4.2 Matching methods for rolling entry interventions

As is the case with 'Closer to Home' services, it is common among healthcare interventions for treated subjects to enter the intervention on a rolling basis rather than at a fixed time point. It has been noted that this is particularly common among home-based healthcare services, as these patients often experience sudden deterioration from acute events leading to their receipt of such services (i.e. entry into intervention is based on surrounding events) (Pimentel et al., 2019). In these cases, the main challenge of comparison group selection is defining a baseline period for the potential control group so that they can be matched on time-dependent covariates (Witman et al., 2019). Observational studies with rolling entry (also called time-dependent treatment or longitudinal entry) require special methods (Thomas et al., 2020). These methods include matching on time-dependent covariates to generate comparable groups (longitudinal matching) and including time-dependent covariates (including treatment) in a Cox model (Thomas et al., 2020).

Several longitudinal matching methods have been identified, including exact matching, balanced risk set matching, sequential cohort matching, rolling entry matching (REM) and a more newly developed method 'GroupMatch' based on the notion of time agnosticism (i.e. two subjects with similar outcome trajectories but different enrolment periods are compared) (Thomas et al., 2020; Pimentel et al., 2019). These methods are very recently being reviewed in literature (Thomas et al., 2020; Pimentel et al., 2019) and statistical packages for conducting these

methods readily are only recently being produced (Jones et al., 2019; Pimentel et al., 2019)

Hence, the relative advantages and direct comparisons between these identified longitudinal matching methods have not been widely studied (Thomas et al., 2020). In one study, comparing REM and sequential cohort matching, overall REM was found to achieve a better covariate balance between treatment and control groups in three out of four case studies (Witman et al., 2019). In another study comparing REM, exact matching, sequential cohort matching and 'GroupMatch,' the latter three outperformed REM in terms of covariate balance in a simulated setting but perform similarly in the empirical setting (case study) (Pimentel et al., 2019). Sequential matching has been noted to be laborious and time consuming, especially in large datasets (Pimentel et al., 2019). 'GroupMatch' has been noted to be more simple and easier to implement, but at the time of writing has not yet been made readily available through software, though the authors note a statistical package is in development to make this method readily available (Pimentel et al., 2019). REM, however, has been identified as a method that can be readily implemented through existing statistical packages, making this method computationally feasible for this study (Jones et al., 2019).

6.4.3 Matching strategy

Further to deciding on a method for matching which accounts for patterns over time, several other considerations are required in defining a specific matching strategy. The main considerations in developing a matching strategy can be defined by four factors: defining a measure of closeness, matching ratio, caliper selection (maximum difference allowed within a matched pair) and with or without replacement (Xie, 2011). These will be described in the following sections.

6.4.3.1 Defining closeness in matching

A wide range of approaches for determining distance measures in matching exist. They can be widely classified as stratification and modelling approaches (Sizemore and Alkurdi, 2019).

Stratification approaches match directly on covariates. These methods include exact matching where subjects are matched exactly on confounding covariates (e.g. if matched on sex, a female treated subject is matched to a female untreated subject) and coarsened exact matching (CEM) where treated subjects are matched

on stratified versions of covariates (i.e. continues variables are placed into bins) (e.g. 60-70 year old's are matched to 60-70 year old's).

Modelling approaches include matching on distance scores generated by models representing the distance between covariates of treated and untreated subjects. Two widely used approaches for matching using modelling are Mahalanobis Distance Matching (MDM) and Propensity Score Matching (PSM). The Mahalanobis distance measures the multi-dimensional distance between a point and a distribution. In MDM, treated subjects are matched to the nearest untreated subject, based on the Mahalanobis distance meaning that the subjects are matched on the distribution of their covariates. The Propensity Score represents the probability of treatment based on a multivariable model of the covariates predictive of receiving treatment. In PSM treated subjects are matched to untreated subjects with the smallest difference in propensity scores.

The relative advantages of the above-mentioned matching approaches have been highlighted in literature. The difficulty with exact matching is that it often leads to many unmatched subjects, leading to bias if they are kept in the analysis as the matched subjects will be inexact to the whole sample (Stuart, 2010) and also leading to bias if they are dropped, as the full treated sample becomes less representative of the whole. This is also the case with CEM and MDM as the number of covariates increases, as an attempt is made to identify untreated subjects that match all the included covariates of the treated subjects to some extent. MDM has been identified to work well when there are relatively few covariates (less than eight) but not so well with many covariates or when they are not normally distributed (Stuart, 2010). Similarly, CEM has been found to work well when there are relatively few covariates (less than ten) (Ripollone et al., 2020). PSM does not have these issues as the covariates are summarised in a single score. Sizemore and Alkurdi (2019) describe the how PSM differs to CEM and MDM:

> *'With exact matching, CEM and MDM the inability to find good counterfactual "twins" in the dataset becomes increasingly difficult in higher dimensions and necessitates some way to reduce the dimensionality of the data. PSM does exactly this: instead of matching units on all X, it collapses the covariate space into one variable defined as the probability of being treated, conditioned on X. After calculating the propensity score, instead of trying to fill n-bins we can simply match*

units within strata of the propensity score, and instead of finding nearest neighbours in a sparse n-dimensional space we need only to find nearest neighbours on a unidimensional plane.'

Hence, PSM solves the matching problem for high-dimensional data, however, because it uses a summarised score, matched pairs may not necessarily be similar across all their covariates (Sizemore and Alkurdi, 2019). PSM has been further criticised as paradoxically exacerbating covariate imbalance and bias, as first identified by King and Nielsen (2018). This is because PSM is based on scores representing the probability of treatment across the whole sample, hence, as matching is made more strict (e.g. using narrower calipers), more treated subjects are pruned because they do not have a close enough match so the overall matched sample may become more imbalanced as the distance between treated and untreated subjects was determined by the distribution of covariates of the whole sample (King et al., 2011). PSM prunes observations in a manner of independence of the covariates (and thus approximately randomly) which has been shown to cause imbalance (King and Nielsen, 2018). Hence, this so-called 'PSM Paradox' kicks in at some point, particularly quickly for datasets where treated and untreated subjects are relatively well balanced to begin with (King and Nielsen, 2018). This does not occur with CEM and MDM because matches are based on distributions of covariates for individuals rather than for the full sample.

However, other research has shown that in empirical settings, "although covariate imbalance sometimes increased after progressive pruning of matched sets, the application of commonly used propensity score calipers for defining an acceptable match stopped pruning near the lowest region of the imbalance trend and resulted in an improvement over the imbalance in the prematched data set" (Ripollone et al., 2018, p.1951). In addition, Jann highlights that "the arguments brought forward by King and Nielsen against Propensity Score Matching are valid, but they mostly apply to one specific form of PSM: pair matching (one-to-one matching without replacement). Other PSM matching algorithms perform much better because they are less affected by the random pruning problem" (2017, p.65).

6.4.3.2 Number of matches and caliper selection

In selecting the both the optimum number of matches to be included and the optimum caliper width (maximum difference allowed within a matched pair) in

studies matching treated subjects to untreated subjects, the trade-off between maximising sample size and minimising bias is of important consideration. This reflects the variance-bias trade-off: a higher untreated to treated ratio increases matched sample size which may increase the precision of treatment estimates thereby reducing variance, however, it may increase covariate imbalance between the groups as each additional control may be less comparable to the treated subject, thereby increasing bias (Austin, 2010; Linden and Samuels, 2013). Using lower untreated to treated ratios should have the opposite effect. There is a similar trade-off with using narrower caliper widths: using narrower caliper widths should reduce covariate imbalance between groups, thereby reducing bias, however, it may reduce the matched sample size, which reduces the precision of treatment estimates, thereby increasing variance (Austin, 2011). Using wider caliper widths should have the opposite effect.

Several studies have investigated the optimum numbers of matches and optimum caliper widths.

Ratios of 20 controls to treated subjects or even higher have been used (Rubin and Thomas, 1996). The rule of thumb however, is to choose at most ten controls to treated subjects so that the proportion of treated subjects in the full sample is not lower than 10% (Baser, 2006). Linden and Samuels have identified that generally a matching ratio of at most four control subjects to treated subjects elicits lowest bias in matching studies (2013). Selecting between one to up to four or five matches is common practice in matching studies (Austin, 2010; Rassen et al., 2012). Austin (2010) recommend that for PSM, in most settings, researchers should match one or two controls to each treated subject, based on finding that the mean squared error of the estimated treatment effect was minimised by approximately 84%. Linden and Samuels (2013) advocate undertaking a methodological approach to deciding on the optimum number of matches in matching studies, assessing the performance of several matching ratios in terms of covariate balance to identify and optimum ratio.

It has been identified that certain caliper widths (maximum difference allowed within a matched pair) can reduce varying levels of bias. Cochran and Rubin (1973) determined that using a caliper width defined as some proportion α of the standard deviation of the confounding variable reduces bias ($\alpha * \sigma$).

When matching directly on covariates, the caliper width is specified directly based on the maximum distance sought for based on values of the covariate. For example, when matching on age, if matches are sought within two years of the age of the treated subjects, $\alpha * \sigma$ is set to be equal to two, where σ is the standard deviation of the covariate (and α would be typically be calculated for use in matching algorithms). Defining these widths will be determined by the requirements of the researcher and significance of varying values of the covariates.

When matching on propensity scores, given Cochran and Rubin's (1973) above observation, Austin (2011b) conclude there is rationale for using caliper widths that are dependent on the distribution of propensity scores, such as some proportion α of the standard deviation of the propensity score. The caliper for propensity scores can be defined as $\alpha * \sigma$, where

$$\sigma = \sqrt{(\sigma_T^2 + \sigma_C^2)/2}$$

where σ_T^2 and σ_C^2 are the variances of the propensity scores or logit of the propensity scores of the treatment and potential control groups respectively (Jones et al., 2019; Cochran and Rubin, 1973). The table below indicates the change in bias identified by Cochran and Rubin (1973) and Austin (2011b), according to varying values of α and varying ratios of treatment to control group variance.

Table 6.3 – Effect of varying values of some proportion α of the standard deviation of the propensity score and varying ratios of treatment to control group variance

	Cochran and Rubin 1973			**Austin 2011**
$\boldsymbol{\alpha}$	$\sigma_T^2/\sigma_C^2 = 1/2$	$\sigma_T^2/\sigma_C^2 = 1$	$\sigma_T^2/\sigma_C^2 = 2$	$\sigma_T^2/\sigma_C^2 = 1$
0.2	99%	99%	98%	At least 99.3%
0.4	96%	95%	93%	-
0.6	91%	89%	86%	95.2%-99.6%
0.8	86%	82%	77%	-
1.0	79%	74%	69%	-

As the ratio of the variance in the treatment to control group (σ_T^2/σ_C^2) increases, the performance is somewhat poorer, hence as the ratio increases, smaller calipers are recommended (Stuart, 2010) however overall, the ratio has a minor effect

(Cochran and Rubin, 1973). Hence, regardless of this ratio, caliper widths equal to 0.2 (Austin, 2011b) or 0.25 (Rosenbaum and Rubin, 1985) of the standard deviation of the propensity score or logit of the propensity score have been recommended.

However, in practice, a wide variety of calipers are used (Austin, 2008), ranging between 0.001-0.06 standard deviations of the logit of the propensity score, with 0.2 being most common, as identified in a systematic review (Ali et al., 2015). One study comparing the use of calipers between 0.002-0.06 standard deviations found that bias was reduced by approximately 50-99% and numbers of matched pairs were reduced by approximately 1-10%, identifying that wider calipers were needed where initial imbalance between groups was greater or where fewer untreated subjects were available to match (Lunt, 2014). This suggests that the specific context and requirements of the matching setting should be considered when selecting a caliper for PSM and that the performance of several caliper widths should be assessed to identify an optimum caliper.

6.4.3.3 Matching with or without replacement

Particularly in scenarios where there are few comparable controls, re-using controls for more than one treated subject (i.e. with replacement) can be helpful. Doing so also involves a bias-variance trade-off, as the average quality of matching will increase thus reducing bias, but there will be an increase in variance (Baser, 2006). In addition, it has been highlighted that inference becomes more complex because matched controls are no longer independent, hence the analysis would need to account for this (Stuart, 2010). Matching with replacement has been discouraged when using PSM, as matching with replacement has not been found to have superior performance compared with better performing caliper matching approaches without replacement (Austin, 2014a). Hence, matching will be conducted without replacement.

6.5 Statistical analysis for observational comparative effectiveness studies: multivariable regression models

The primary threat to the validity of observational research is confounding, given the lack of random allocation. Confounders can distort the measured effect of an intervention if not managed appropriately. As previously described, adjustment

for confounders is necessary in observational research as observed differences between treatment groups are expected – introducing bias – due to lack of randomisation. As briefly described in section 6.4.1, regression adjustment for covariates is the traditional method for controlling for potential confounding (Elze et al., 2017). Traditional analyses in observational comparative effectiveness research estimate effect sizes by using multivariable regression models, which enable such adjustment for confounding covariates (Arbogast and VanderWeele, 2013; Morshed, Tornetta and Bhandari, 2009).

The main multivariable regression models appropriate for observational comparative effectiveness studies are logistic regression, linear regression, Poisson regression and Cox proportional-hazards regression (Morshed, Tornetta and Bhandari, 2009). Table 6.4 outlines these models according to their appropriate type of outcome and resulting effect estimate.

Table 6.4 – Appropriate multivariable adjustment models for common types of outcomes, adapted from Table III in Morshed, Tornetta and Bhandari's 'Analysis of Observational Studies: A Guide to Understanding Statistical Methods' (2009)

Type of outcome	Example	Model	Estimate of effect
Binary	Prevalence of postoperative infection	Logistic regression	Odds ratio
Continuous	Range of motion or functional outcome score	Linear regression	Mean difference
Rate	National rates of total joint replacement	Poisson regression	Rate ratio (Relative risk)
Survival-time (time-to-event)	Time to reoperation following hip replacement, risk of death (outcomes which may occur at any time over a given time period)	Cox proportional hazards	Hazard ratio

These models are based on the generalised linear model:

$$E[Y] = A + B_1 X_1 + B_2 X_2 + \ldots B_p X_p$$

where the expected value of Y is the sum of an intercept (A) and explanatory variables (X) multiplied by their respective coefficients (B) and where each coefficient represents the effect estimate or risk depending on the type of model (e.g. mean difference for linear regression, log odds ratio for logistic regression, log hazard ratio for Cox proportional-hazards regression) (Morshed, Tornetta and Bhandari, 2009).

Given that the outcome of interest to this research is discrete hospital activity, linear regression (used for continuous outcomes) will not be considered here. In addition, Poisson regression is not generally appropriate in cases where a large proportion of subjects do not experience the outcome (e.g. are never hospitalised) or there is too much variability (Weaver et al., 2015). This was expected to be the case in this research and was later confirmed, hence Poisson models were not a focus in this research and rather binary outcomes were primarily explored, particularly given that in the case of rare outcomes, the odds ratio and relative risk are almost the same (Hoffmann and Lim, 2007). However, the remaining models – namely logistic and Cox proportional-hazards regression models – are relevant and are discussed here.

6.5.1 Logistic regression

Logistic regression models are used for estimating effects of an exposure on an outcome where the outcome is binary (e.g. having a hospital admission or not, presence or absence of disease). The effect estimate in logistic regression is the odds ratio (OR), given by

$$OR = \frac{Odds\ of\ outcome\ in\ exposed\ subjects}{Odds\ of\ outcome\ in\ unexposed\ subjects}$$

(Hoffmann and Lim, 2007).

Though logistic regression models are helpful, they are primarily useful for evaluating the effect of events in a single time frame (e.g. a hospital admission in 30-day follow-up, or number of admissions in year follow-up) and they require index dates (or 'time zero') for both untreated and treated subjects, which can be difficult to identify in studies with staggered/rolling entry interventions. As briefly described in Section 6.4.2, it is common among healthcare interventions for subjects to enrol in the intervention on a rolling basis based on surrounding events rather than at a fixed time point and for exposure to occur more than once over time (time-dependent exposure).

It is also common in observational research for confounding covariates such as comorbidity to change over time (time-dependent covariates) (Arbogast and VanderWeele, 2013). Longitudinal matching was described in Section 6.4.2 as one way to counter time-dependent confounding in baseline covariates. However,

whether matching has been used or not, if subjects are followed through time, covariates may change during follow-up, and exposure may occur more than once, requiring adjustment for these time-dependent covariates in the multivariable regression models themselves. In addition, it is common for the outcome of interest to occur more than once, where the researcher may be interested in not only the first but also subsequent events. Logistic regression is not able to factor in these particularities.

Cox proportional-hazards models (also known as Cox models) are a helpful alternative. Cox models can be used to assess the effect of an exposures on outcome within single time frames as with logistic regression models, however extensions of the Cox model have the flexibility of assessing effects of exposures on outcomes over longitudinal time frames with time-varying coefficients and time-varying treatments. In addition, time-varying extensions of Cox models do not require analyses to be based on index dates (dates of exposure to treatment or 'time zero'), hence provide advantages for observational comparative effectiveness studies, where there may be no index dates within a comparison group.

6.5.2 Cox proportional-hazards models

The primary type of analysis for multivariable regression with time-dependent covariates is the time-dependent Cox proportional-hazards model. Because of how the Cox model works, it is well suited to the incorporation of time-dependent covariates. At each time period, the Cox model compares the covariate values of the subject who had the event to those of all others who were at risk at that time and tries to assign a risk score to each subject that best predicts the outcome at each time period, based on the risk set (subjects present for each event e.g. the set of those still at risk at each time point) and the covariate values of each subject just prior to the event (Therneau, Crowson and Atkinson, 2020).

The effect estimate in Cox proportional-hazards regression is the hazard ratio (HR), given by

$$HR = \frac{Hazard\ of\ outcome\ in\ exposed\ subjects}{Hazard\ of\ outcome\ in\ unexposed\ subjects}$$

where the hazard represents the instantaneous event rate at time t among survivors to t (Gail et al., 2019). Though very similar to risk ratios (or relative risk), hazard ratios are differentiated by their accounting for timing of events.

The standard Cox proportional-hazards model is appropriate for analysing survival data where time to first event is captured. The standard model cannot analyse repeated events because multiple events from the same individual are likely to be correlated, violating the assumption of independent observations required for the standard Cox model (Westbury et al., 2016; Amorim and Cai, 2015). Where subjects have multiple events, statistical models should account for correlated data, as rows for the events are correlated within subject (Therneau, Crowson and Atkinson, 2020). Extensions of the Cox model enable analysis of such recurrent events.

There are several methods for factoring in within-subject correlation in survival models, which these extensions of the Cox model employ. Two main multiple-failure Cox models that are widely used and are easily implemented using routine statistical software are the Andersen and Gill (AG) model and the Prentice, Williams and Peterson (PWP) model, which employ variance correction to factor in within-subject correlation in recurrent events (Westbury et al., 2016). These multiple-failure Cox extension models are outlined in Table 6.5 below.

Table 6.5 – Extended Cox models for recurrent events and their mechanisms

Cox model extension	Mechanism	Comment
Andersen and Gill (AG)	Assumes correlation between events within subject can be explained by past events, captured by appropriate specification of time-dependent covariates (e.g. number of previous events). Baseline hazard (underlying risk) is the same for each event. (Amorim and Cai, 2015)	Suitable when correlations between events within subject are induced by measured covariates (Amorim and Cai, 2015)
Prentice, Williams and Peterson (PWP)	Stratifies analysis by event, allowing the baseline hazard (underlying risk) to vary for each event. (Amorim and Cai, 2015)	Suitable when effects of covariates expected to be different in subsequent events (Amorim and Cai, 2015)

Of these two multiple-failure Cox extension models, the Andersen and Gill (AG) model (also known as the counting process model) has been highlighted as the most frequently applied and is recommended for settings where "dependence between subsequent events is mediated through time-varying covariates and the interest is in the overall effect on the intensity of the occurrence of a recurrent event" (Amorim and Cai, 2015, p.326). Prentice, Williams and Peterson (PWP) models (also known as conditional models) have been recommended for settings where there are few recurrent events per subject, where risk of recurrence varies

between recurrences because there is a strong biological relationship between events (e.g. risk of viral infection may be reduced in subsequent occurrences due to the development of immunity) and where interest is in separate risk of events rather than overall risk (Amorim and Cai, 2015; Guo, Gill and Allore, 2008).

Because the underlying mechanism of the PWP models is stratification by event, as the recurrence of events increases, the number at risk becomes very small for later strata leading to strata-specific effect estimates with low precision (Ozga, Kieser and Rauch, 2018; Amorim and Cai, 2015). This is why PWP models are more suitable for settings where there are few recurrent events per subject and why when using these models, data usually needs to be truncated, omitting events beyond the fourth occurrence for example (Amorim and Cai, 2015).

Westbury et al. (2016) suggest that in the context of hospital admission among older people, it is reasonable to expect that recurrent risk of admission increases based on previous admission (suggesting a biological relationship between events), hence PWP models may be better suited because they allow the underlying risk to vary between events through stratification. However, they do not address the issue of many recurrent events leading to many strata. Given that within setting of this research, the interest is primarily in treatment effect considering overall effect of recurrent events rather than in the separate risk of events and given that there are many recurrent events per patient which would require the use of many strata potentially leading to estimates with low precision in the case of PWP models, the AG model appears more appropriate for this research.

It seems reasonable to suggest that the use of time-varying covariates in an AG model may mediate dependence between events as there are many other factors that contribute to the recurrence of a hospital admission for an older person, especially if the number of previous admissions is included as a time-varying covariate as this relaxes the assumption that the underlying risk for all events is the same (Smedinga et al., 2017). It should be noted however, that because PWP models account for underlying increase in risk of admission based on number of accumulated previous admissions, they have been found to lead to more

conservative effect estimates, while failure to account for increase in underlying risk may lead to exaggerated effect estimates (Westbury et al., 2016).

Alternative models including the Wei, Lin and Weissfeld (WLW) model, frailty models and multi-state models, however, these are less widely used. An in depth comparison of these less widely used models is outwith the scope of this research, however, Table C-1 in Appendix C provides a brief description of these models with a summary of their suitability or lack thereof.

6.5.3 Analytical considerations for matched studies

Because matching, on average, generates samples of subjects that have more similar baseline covariates than randomly selected subjects would have and because baseline covariates are related to the outcome, matching implies within-matched-set association (exemplified by the fact that matched subjects will display more similarity in outcomes than randomly sampled subjects would) (Austin, 2014b). Though it is widely agreed that matching needs to be accounted for in the analysis of case-control studies, there is no universal agreement on whether matching needs to be accounted for to estimate significant levels in matched cohort studies (Austin, 2014b; Cummings and Mcknight, 2004), however, studies have found that ignoring matching can lead to incorrect significance levels and confidence intervals (Austin, 2014b). Hence it is recommended that matching be accounted for in the analysis to avoid bias due to within-matched-set association.

Matching can be accounted for in logistic regression through conditional models. Conditioning on matched-set allows these models to account for within-matched-set dependence, similar to stratifying with matched sets as strata (Xu et al., 2010). Two widely used approaches that account for matching in Cox proportional-hazards models are stratification for matched sets and the use of a robust variance estimator that accounts for clustering within matched sets (Austin, 2014b). The stratification approach stratifies the analysis by matched set, allowing the baseline hazard (underlying risk) to vary across matched sets (Brazauskas and Logan, 2016). Research indicates that this approach appears to give conditional effect estimates because the analysis is conditioned on the matched pairs (gives within-matched-set treatment effects), leading to biased marginal hazard ratio

estimates (overall effect estimates). Hence the use of a robust variance estimator is a preferred method as this approach averages the within-pair treatment effects to obtain the marginal/overall hazard ratio which is equivalent to that obtained in a conventional Cox proportional-hazards model, while within-matched-set correlation is accounted for in p-values and confidence intervals (unlike conventional Cox models) (Austin, 2014b; Brazauskas and Logan, 2016).

6.5.3.1 Covariate adjustment in matched and unmatched analyses

Covariate adjustment works by comparing exposed and unexposed subjects within levels of the potential confounders in the regression analysis (Sjölander and Greenland, 2013). To perform the adjustment using regression models, the potential confounding variables are included as covariates in the multivariable models assessing the effect of exposure on outcome.

Where matching has been used as a method for controlling for confounding, regression adjustment for further controlling confounding has been debated (Sjölander and Greenland, 2013). In matched case-control studies, because subjects are selected based on outcome rather than exposure, regression adjustment for confounding covariates is often required, including the matching variables, given there may be confounding through observed differences associated with exposure (Sjölander and Greenland, 2013; Mansournia, Hernán and Greenland, 2013). In matched cohort studies, however, because subjects are selected based on exposure, thus balancing baseline confounding covariates through the matching process, regression adjustment for matching variables may not be required as the they will no longer be associated with exposure – a condition for confounders (Sjölander and Greenland, 2013). Nguyen and colleagues (2017) show that where propensity scores have been used for matching to balance covariates across treatment groups, adjustment for residual differences in covariates (residual confounders) is advised. They showed that regression adjustment could drastically reduce residual confounding bias where covariates with a standardised mean difference greater than 0.1 were included.

Hence, in the retrospective matched cohort study of the ECT intervention, where both covariate matching and PSM will be conducted, only covariates identified as residual confounders will be included in adjustment for PSM, whereas for direct

covariate matching, the matching variables will be included in adjustment in addition to residual confounders.

Whichever method is used for controlling for confounding – namely regression adjustment, matching with regression adjustment or matching alone – the potential confounding variables to be included need to be carefully identified, considering their association with exposure and outcome. The process selected for identifying potential confounders and selecting covariates for adjustment is described in Section 6.6 below.

6.6 Confounder identification and covariate selection

As previously described, comparative studies should always consider potential confounders and should take them into account if possible, as confounders can distort the measured effect if not appropriately managed. A confounder influences both the dependent and independent variables in a study, introducing this type bias, where if removed, results would change in a clinically significant way. Confounding factors can either mask or falsely demonstrate an effect of an exposure on an outcome, making it difficult to establish causality (Skelly, Dettori and Brodt, 2012). Skelly et al. (2012) propose three steps towards dealing with confounding.

1. Measure and report all potential confounders
2. Routinely assess the role of confounding factors and adjust for them in the analysis
3. Report crude and adjusted estimates of association and discuss limitations of the study that may be due to confounding and the magnitude of the influence

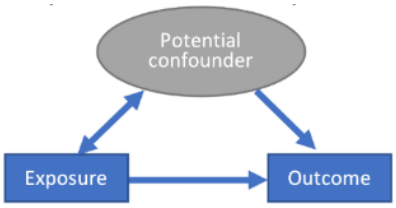
Performing these steps are particularly important to this study due to its observational nature, meaning there are many confounders involved and there has been no adjustment made at the outset (e.g. randomisation or quasi-experiment with pre-established similar groups).

Skelly et al. (2012) propose three main criteria for identifying true potential confounders. They establish that true potential confounders must be:

- Predictive of the outcome even in absence of the exposure
- Associated with the exposure
- Cannot be an intermediate between exposure and outcome (i.e. a confounding factor is not a consequence of exposure)

A representation of a true potential confounder can be seen in the figure below.

Figure 6.4 – Representation of a true potential confounder



Once potential confounders have been identified. There are several strategies for selecting which confounders (covariates) will be adjusted or controlled for, generally falling under two broad approaches: 1) selecting variables on the basis of background knowledge on the relationship of the variable to treatment and outcome and 2) selecting variables based on statistical associations using automatic variable selection methods (empirical variable selection) (Sauer et al., 2013). Both approaches will be described as defined by Sauer et al. (2013).

The first approach includes using causal graph theory to select covariates (which specifies causal assumptions using causal graph criteria so that a sufficient set of covariates can be identified), selecting all observed pre-treatment covariates, selecting all possible risk factors for the outcome and selection of all observed variables that are associated to treatment, outcome or both (disjunctive cause criterion). Using causal graph theory requires knowledge of the true causal network representing all cause pathways, however it is rarely known. The other approaches require partial knowledge of the causal structures which is more common, however they also have their limitations (Sauer et al., 2013).

The second approach, empirical variable selection, include identifying a subset of variables with statistical associations with the treatment and/or outcome from the original set. These methods can factor in background knowledge of the relationships or can be fully automated and include forward and backward selection procedures, best subset selection, sophisticated approaches such as machine learning algorithms and automatic high-dimensional 'proxy' adjustment in which large sets of variables are included in propensity score models (Sauer et al., 2013).

As Sauer and colleagues (2013) highlight, unmeasured confounding is likely to remain in observational comparative effectiveness research, hence every variable selection approach will result in bias. However, the focus can be placed on minimising bias, taking consideration of over- and under-adjustment. Sauer and

colleagues (2013) suggest that a practical approach may involve combining these two above-mentioned approaches. This involves initially selecting a set of a priori variables based on the researcher's knowledge of causal relationships and to then ultimately select those to be included in the analysis by empirical selection methods (Sauer et al., 2013). Hence, this is the approach that will be taken here.

6.7 Handling missing data in observational research

Missing data is a problem which affects most real-world datasets and which needs to be appropriately handled when using statistical models because they are mostly designed to be utilised on complete observations (Salgado et al., 2016). Inadequate handling of missing data can lead to potentially weak or invalid results and conclusions (Pedersen et al., 2017). Particularly within observational research, where the use of data from electronic health records and record linkage is prevalent, the issue of missing data is common, as data from electronic health records often contain missing data (Groenwold et al., 2012; Salgado et al., 2016; Pedersen et al., 2017). The data from this research is no exception, hence handling methods need to be considered for this research.

Salgado et al. (2016) suggest three general steps for handling missing data (adapted):

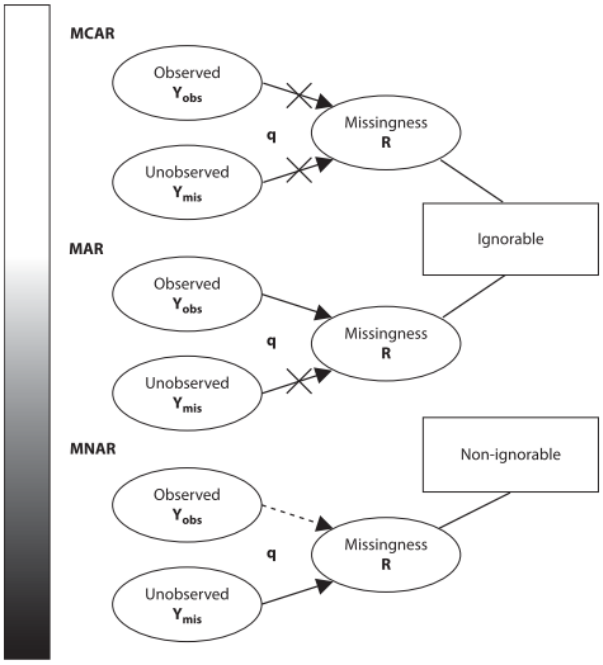
1. Identify patterns and reasons for missing data;
2. Analyse the proportion of missing data;
3. Choose the best method for handling missing data

6.7.1 Patterns and reasons for missing data

Determining the reasons for missing data and identifying any underlying patters is important towards determining the best handling method for missing data. In particular, different approaches should be taken for data that is missing at random (MAR), missing completely at random (MCAR) and for data that is missing not at random (MNAR). In settings where data is MCAR, the probability of being missing is equivalent for all observations, for example where there is an accidental reason for the missing data such as equipment malfunction. The MAR term is counterintuitive, as it refers to situations where the probability of being missing is related to some of the observed data but not unobserved data, for example if the likelihood of completion of a data field is related to age or gender

(which are fully observed). In contrast, with data that are MNAR, the probability of being missing is related to unobserved or unmeasured data. In healthcare research, missing data are mostly MAR rather than MCAR or MNAR (Pedersen et al., 2017).

Figure 6.5 Mechanisms of missing data and their ignorability from (Nakagawa, 2015)



Though identifying if data are MCAR can be relatively straightforward, distinguishing between MAR and MNAR is less simple, and there is no prescriptive way of determining whether data are MAR or MNAR. The only way to make the distinction is through the investigator's detailed knowledge of the mechanisms and data collection processes. However, Nakagawa (2015) highlights that no pure forms of MCAR, MAR and MNAR exist but that all missingness can be considered to be on a continuum between these forms.

It is clear that the missing data pertaining to this research are not MCAR, as the probability of missing values is not equivalent across observations and is not accidental. It is expected that for most if not all variables with missing data, the data are less likely to be recorded for individuals will lower levels of comorbidity and complexity (and therefore, hospital activity), because they do not attend healthcare facilities as frequently as those with high comorbidity and complexity. Because the reasons for missing data are most likely related to other observed data, they could be considered MAR, however, it is also likely that missing data are related to other unobserved data in addition to the observed data. For

example, several variables with missing data regarding functional ability are related to the lack of receiving a functional assessment, which is completed based on need, indicating that the missing values are related to the values themselves (e.g. those with no functional assessment more likely to be those with high functional ability), which would indicate the data are MNAR. However, those with lower comorbidity levels (a separately observed variable) are expected to be less likely to have a functional assessment, and hence have missing values for functional ability, which would indicate the data are MAR. Hence, it is expected that the missing data are somewhere on the continuum between MAR and MNAR, but given that where there has been no functional assessment, there are no complete values of any variables on functional ability, and that there are few other variables that directly inform functional ability, it seems unlikely that the missing values could be adequately recovered from the observed data. Hence, it seems more likely that data are MNAR, given that missing data are considered MCAR or MAR where missing values are recoverable from observed data (Choi, Dekkers and le Cessie, 2019).

6.7.2 Analysing the proportion of missing data

Model selection is concerned with identifying a subset of useful variables often from a large pool of variables. Large proportions of missing values can limit the usefulness of variables hence, measuring the proportion of missing values can help guide appropriate model selection. Salgado et al. (2016) suggest that a good rule of thumb is to remove variables with excessive amounts of missing data (>50%) from consideration, but highlight that rejecting variables can lead to bias and loss of predictive power; hence, variable selection should be tailored to the missing data mechanisms observed.

6.7.3 Choosing the best method for handling missing data

There are several, well-documented methods for handling missing data (Pedersen et al., 2017; Raghunathan, 2004). The most widely used is complete-case-analysis (where only individuals with complete observations are included), however, it requires data to be MCAR to produce unbiased estimates (Pedersen et al., 2017). Two popular alternatives are imputation methods and missing indicator methods which will be discussed here.

6.7.3.1 Imputation methods

Imputation methods are an alternative and very popular method for handling missing data. Imputation methods include replacing the missing values with the mean, using the last observation carried forward (in longitudinal data), or by generating a predictive model from observed variables (Salgado et al., 2016).

Imputation methods however, rely on the ability to recover missing values from other observed values, hence, they are suitable for data that are MCAR and MAR but not MNAR (Stavseth, Clausen and Røislien, 2019). The following excerpt summarises the main issues with imputation:

> *"The idea of imputation is both seductive and dangerous. It is seductive because it can lull the user into the pleasurable state of believing the data are complete after all, and it is dangerous because it lumps together situations where the problem is sufficiently minor that it can be legitimately handled in this way and situations where standard estimators applied to the real and imputed data have substantial biases" (Dempster, A.P and Rubin, 1983, p.8)*

Stavseth, Clausen and Røislien (2019, p.10) importantly highlight that "no matter how fancy the statistical method, and no matter how robust the results, no imputation method can truly compensate for the fact that data are indeed missing. Statistics is information handling, but it is not information." In addition, analyses based on data generated using imputation methods (particularly multiple imputation) can be difficult to interpret (Pedersen et al., 2017; Zhuchkova and Rotmistrov, 2019).

6.7.3.2 Missing-indicator method

Another popular method of handling missing data is to use missing indicators. Little (1976) proposed that datasets (and consequently variables) with missing data can be divided into the observed and the missing parts. The missing-indicator method adds a dummy indicator variable to the statistical model when a continuous variable has missing values or for categorical variables missing values are grouped into a separate level ("missing" category) (the two are mathematically equivalent) (Pedersen et al., 2017; Center for Behavioral Health Statistics and Quality, 2018). Missing indicator methods are a useful alternative to imputation, where missing data are MNAR. The reasoning is that "when missingness is associated with some hidden reason and regarded as just

additional substantive value of a variable, it is expected to produce unbiased results" (Zhuchkova and Rotmistrov, 2019, p.6).

The use of missing indicators has been debated in literature, though several studies point towards these methods as producing greatest levels of bias in comparison to other methods of handling missing data, other results in literature indicate that they do not produce bias (ibid).

Zhuchkova and Rotmistrov highlight that missing-indicator methods are not appropriate where the objective of the analysis is developing predictive models, as they cannot estimate the real predictive power of chosen variables, greatly deteriorating a model's predictive ability (ibid). However, they suggest that where the key objective is to investigate and detect relationships between variables, missing-indicator methods can be appropriate for handling missing data as they found estimates to be unbiased in most cases (ibid). In addition, other researchers have found that the missing indicator can lead to smaller bias than a model without it when data are MNAR and the covariate with missing values is strongly associated to its missing indicator (Choi, Dekkers and le Cessie, 2019).

6.8 Summary of methodological approach selected based on this review

Statistical methods and study designs for comparing the effectiveness of interventions within observational research are vast and can be complex, particularly due to the need to appropriately manage confounding factors resulting from a lack of randomisation. Hence, this review of methodological approaches of quantitative evaluation in observational research was required to inform a robust approach for the quantitative evaluation of the 'Closer to Home' programme.

The following four main areas of quantitative evaluation approaches were reviewed within this chapter.

- Retrospective observational study designs for evaluating associations between exposures and outcomes
- Matching methods for observational research
- Statistical analysis for observational comparative effectiveness studies (multivariable regression models)
- Confounder identification and covariate selection

- Handling of missing data in observational research

Available methods in each area were described in detail and the suitability to this research of the various approaches was discussed. This section will conclude this chapter by presenting and summarising the rationale for the selected approach for each of the four areas within this research.

6.8.1 Retrospective observational study designs for evaluating associations between exposures and outcomes

This chapter began by discussing the methodology for selecting the overall design for the comparative studies conducted for the quantitative evaluation of 'Closer to Home,' including selection of control groups. Based on the highlighted aspects of retrospective cohort studies, this design was identified most appropriate for the comparative studies conducted for this research, particularly due to their selection of the study population by exposure, making them advantageous for settings where exposure is rare as is the case in this context. Different types of control groups were discussed, particularly highlighting that control groups need to be carefully selected, with great consideration for the reasons for lack of exposure to the intervention. Well-defined target groups who did not receive the intervention could be identified for two of the 'Closer to Home' interventions (including both concurrent and historical control groups). However, a well-defined target group as a comparator to the ECT intervention could not be identified, necessitating matching methods to identify a concurrent, comparable group. Matching methods are varied and extensive, hence, were reviewed separately.

6.8.2 Matching methods for observational research

An overview of existing methods for reducing bias in observational data so that causal effects can be estimated was provided. Matching methods with the potential for regression adjustment were highlighted as methods appropriate for the evaluation of 'Closer to Home' interventions (particularly the Enhanced Community Team intervention), highlighting their advantages over other methods.

Given that there is a wide range of matching methods and their configurations, these were also reviewed. The setting of this study was highlighted to require longitudinal matching methods, as participants enter the intervention on a rolling basis, and their entry into the intervention is sensitive to the events and

characteristics surrounding their entry, which is typical of healthcare interventions. Though these methods and comparisons between them have not been widely studied, rolling entry matching (REM) was highlighted as a method for which there is some evidence that it outperforms its alternatives in an empirical setting and for which a statistical software package exists, making it computationally feasible for this study. Hence, REM, which finds untreated subjects matching the covariates of the treated subjects in the time preceding treatment, is selected as the longitudinal matching method of choice for the quantitative evaluation within this research.

Further to identifying an appropriate longitudinal matching approach, the specific matching strategy to be used needed consideration. Comparisons studying the differences in results between different matching strategies have been made, including comparisons across different measures of closeness used for matching (e.g. CEM, MDM or PSM) (Austin, 2014a; Ripollone et al., 2020; Thompson, 2014; Gu and Rosenbaum, 1993), specific matching strategy (e.g. nearest neighbour or optimal matching) (Baser, 2006; Gu and Rosenbaum, 1993), matching ratio (Rassen et al., 2012; Austin, 2010; Linden and Samuels, 2013), caliper selection (Austin, 2011b; Cochran and Rubin, 1973) and with or without replacement (Austin, 2014a). Some of the advantages and trade-offs involved in these different configurations have been discussed here, however, Fullerton and colleagues (2016) highlight that the abundance of matching methods and their variations is too great to be compared in one study.

King and Nielsen advise that "the key to the productive use of modern matching methods is that many matching solutions be compared" (2011, p.21). King and Nielsen advise particularly that if PSM is used, it should be used very carefully (King and Nielsen, 2018), and that it should not be used without comparing its results to other methods (King et al., 2011).

Hence, the matched analysis planned for this research will take into account some of the specific previously discussed guidance around these different approaches and configurations but will also consider more than one approach in its matching strategy and configuration. Table 6.6 below summarises the approaches selected for each matching element and the main rationale for the choice, thus concluding this section.

Table 6.6 – Matching approach selected for selection of control group in comparative analysis of Enhanced Community Team

Matching element	*Approach selected*	*Main rationale*
Longitudinal matching (LM) approach	Rolling entry matching (REM)	• Though comparisons in LM have not been widely studied, there is some evidence REM performs better than alternatives in empirical settings • Readily available through existing statistical software package, making it computationally feasible for this study
Matching strategy – Measure of closeness	• Propensity Score matching (PSM) • Direct covariate matching with calipers	• PSM was selected as it works well where there are many covariates as is the case in this study, whereas other approaches (e.g. MDM and CEM) work well where there are fewer covariates (less than 10). The logit of the propensity scores will be used for matching as it is more likely to be normally distributed that the propensity score itself (Austin, 2011b). • Based on the discussed issues and advice surrounding PSM, an additional matching approach, will be taken. Direct covariate matching with calipers was identified to have advantages to other alternatives such as CEM and MDM in that it can distinguish between closer matches rather than those in each category (e.g. If matching on age groups, CEM would for example find matches within age brackets such as those aged 60-70 matched with 60-70-year-olds, without regard for how close they are within the 60-70 range. Direct covariate matching with calipers would for example find matches within 10 years, enabling the selection of closest matches in the range), hence it seemed favourable, while having the advantages of other alternatives.
Matching strategy – Number of matched controls	Between 1 up to 5 controls per treated subject, assessing performance of each option	• As advised in the discussed literature, a methodological approach will be taken assessing performance of matching between 1 up to 5 controls per treated subject
Matching strategy – Caliper selection	PSM: Caliper widths of 0.2, 0.02 and 0.002 of the standard deviation of the logit of the propensity scores, assessing performance of each option Covariate matching: Caliper widths as appropriate for each covariate	• As described, though literature advises caliper widths of 0.2 or 0.25 of the standard deviation of the propensity score or logit of the propensity score in PSM, it also suggests that wide ranges of caliper widths are used in practice and that different calipers lead to varying levels of bias reduction. Hence a methodological approach will be taken assessing performance of three levels of calipers: the recommended 0.2 of the logit of the propensity score in addition to a 10- and 100-fold decrease in the caliper (0.02 and 0.002

Matching element	*Approach selected*	*Main rationale*
		standard deviations of the logit of the propensity scores). Ten-fold decreases have been used in literature to assess sensitivity (Wyss et al., 2015). • For direct covariate matching, caliper widths will be defined in the analysis for each covariate using a caliper, based on the researcher's knowledge of the significance of unit changes in each covariate
Matching strategy – With or without replacement	Without replacement	• Based on the direct discouragement of using matching with replacement in PSM as discussed, PSM will be conducted without replacement. In addition, despite the potential increase in sample size, matching with replacement will not be used for direct covariate matching either based on the fact that inference becomes more complex, as discussed.

6.8.3 Statistical analysis for observational comparative effectiveness studies (multivariable regression models)

As described, statistical analysis for evaluating comparative effects in observational studies requires methods that account for factors that may influence outcomes, other than the exposure being studied (confounders). These methods generally include the previously described matching methods and multivariable adjustment models. Such models discussed here included multivariable logistic and Cox proportional-hazards regression models. These regression models in particular offer advantages to matched studies, due to their ability to account for dependence within matched sets, which can be achieved through conditional logistic models and through stratification or robust variance estimators in Cox models.

Hence, logistic regression models will be used to compare binary outcomes within single time frames for the comparative evaluation of 'Closer to Home,' making use of conditional models where matched comparison groups are used. Further, a multiple-failure Cox extension model (specifically the Anderson and Gill model, whose advantages were previously outlined) will be used to assess recurrent events and to be able to adjust for time-varying covariates which are advantages of this model over logistic models.

6.8.4 Confounder identification and covariate selection

In terms of adjusting for confounding, as described, a combined approach to selection of covariates for adjustment is recommended, hence will be taken within this research. Causal diagrams will be used in combination with empirical covariate selection in each analysis. This process was applied to the analysis in this research and is described in Chapter 9 Section 9.2.3 (*'Confounder identification and multivariable model selection*). The main benefit of using a causal diagram is to avoid over-adjusting for confounders (e.g. including covariates strongly associated with exposure but unrelated with the outcome can increase bias) and identifying unobserved confounders (Fullerton et al., 2016; Sauer et al., 2013).

6.8.5 Handling missing data in observational research

As discussed, missing data are common within healthcare research, particularly with observational research which often makes use of existing electronic health record data. Several approaches were presented for handling missing data, of which imputation and missing data indicators were discussed. Imputation does not appear appropriate as an approach for handling missing data within this research given that most if not all missing values are related to observed data, but the observed data is not sufficient to be able to appropriately impute values. Though the use of missing indicators is not optimum and has been criticised in literature, literature also indicates that their use can lead to smaller bias that models without them in scenarios where data are missing not at random (Choi, Dekkers and le Cessie, 2019). Hence, missing data indicators appear likely to be a suitable approach within this research. Ultimately, the use of missing indicators comes with the limitation of only partial adjustment for confounding covariates (Ibrahim, Chu and Chen, 2012; Choi, Dekkers and le Cessie, 2019). However, to ensure an optimum handling method suited to the data used within this research, Salgado et al.'s (2016) approach will be followed by first identifying patterns and reasons for missing data and the proportions of missing data, which will be presented as part of the quantitative results.

6.9 Chapter summary

This chapter has provided the necessary review of quantitative observational methods available for selection, given their wide variety and complexity as identified by the scoping literature review presented in the previous chapter (Chapter 5). This review meets the Phase II aim to review existing literature to obtain guidance on the selection of a robust study design. It has laid out the rationale for the selected approaches in each element of study design, appropriate handling of confounding and statistical analysis among other elements pertaining to conducting a quantitative study evaluating the effect of the 'Closer to Home' services.

Chapter 7 Quantitative Data Collection

The data pertinent to this research had not previously been used in the context of research hence research-ready datasets needed to be compiled from existing routinely collected data sources. It is recognised in literature that "in knowledge discovery in databases, data preparation is the most crucial and time consuming task, that strongly influences the success of the research" (Salgado et al., 2016, p.144). Hence, understanding the local landscape of data including the information systems used and identifying any data quality issues was necessary towards ensuring accurate analyses. In Scotland, the information system landscape varies across health board as systems can be implemented nationally – being mandatory or elective – or locally (Bouamrane and Mair, 2011), making this requirement especially pertinent. This chapter will begin by describing the consultation processes involved in the data collection stage and will then proceed to describe the information systems and pertaining datasets relevant to this study along with their limitations. The chapter will finish by describing the final datasets compiled for analysis.

7.1 Consultation process

One major aspect and undertaking of this PhD and the data collection process was continuous consultation with healthcare staff including information services analysts, community service managers and individual system users including nurses and GPs. The main aims of this consultation process were to 1) ensure a high standard of data quality and correct data linkage, 2) identify the interpretation of individual data fields, and 3) identify opportunities for the use of additional valuable data sources.

7.1.1 Data quality assurance and ensuring correct data linkage

Data quality has been noted to be a multi-dimensional concept. Batini et al. (2009) have outlined three main steps involved in data quality assessment common to all methodologies they reviewed:

1. *State reconstruction:* Collecting contextual information on organisational processes, services, data collections and associated management procedures and quality issues

2. *Assessment/measurement*: Measurement of data quality issues including identifying and determining root causes of discrepancies by comparing results to reference values
3. *Improvement:* Determining and taking necessary steps, strategies and actions for data quality improvement

The data collection process for this research followed these steps in a cyclic fashion. An initial stage of data familiarisation and collecting contextual information (Step 1), was necessary prior to data collection to facilitate the process, to ensure data quality and ensure correct data linkage. This required extensive consultation initially with information services followed by consultations with services managers and clinicians to make clarifications on what was being observed both in relation to data quality and to interpretation of data discussed in the next section.

A key output of collecting contextual information was a conceptual map of NHS Forth Valley's data and information systems displayed in Figure 7.2. During the data familiarisation stages, several data quality issues were identified requiring continuous measurement and assessment (Step 2) alongside consultations with information systems, service managers and clinicians. These were all followed-up by an improvement stage (Step 3) considering options for improving data quality and taking action where possible, usually involving making adjustments in data collection scripts. These data quality assurance steps took place continually and cyclically during the data collection stage of this research and are illustrated by Figure 1 below.

Figure 7.1 – Process for data quality assurance of data used in this research, adapted from Pipino, Lee and Wang (2002)

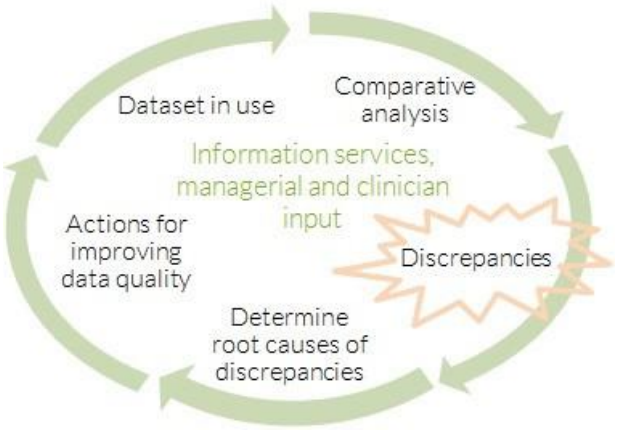
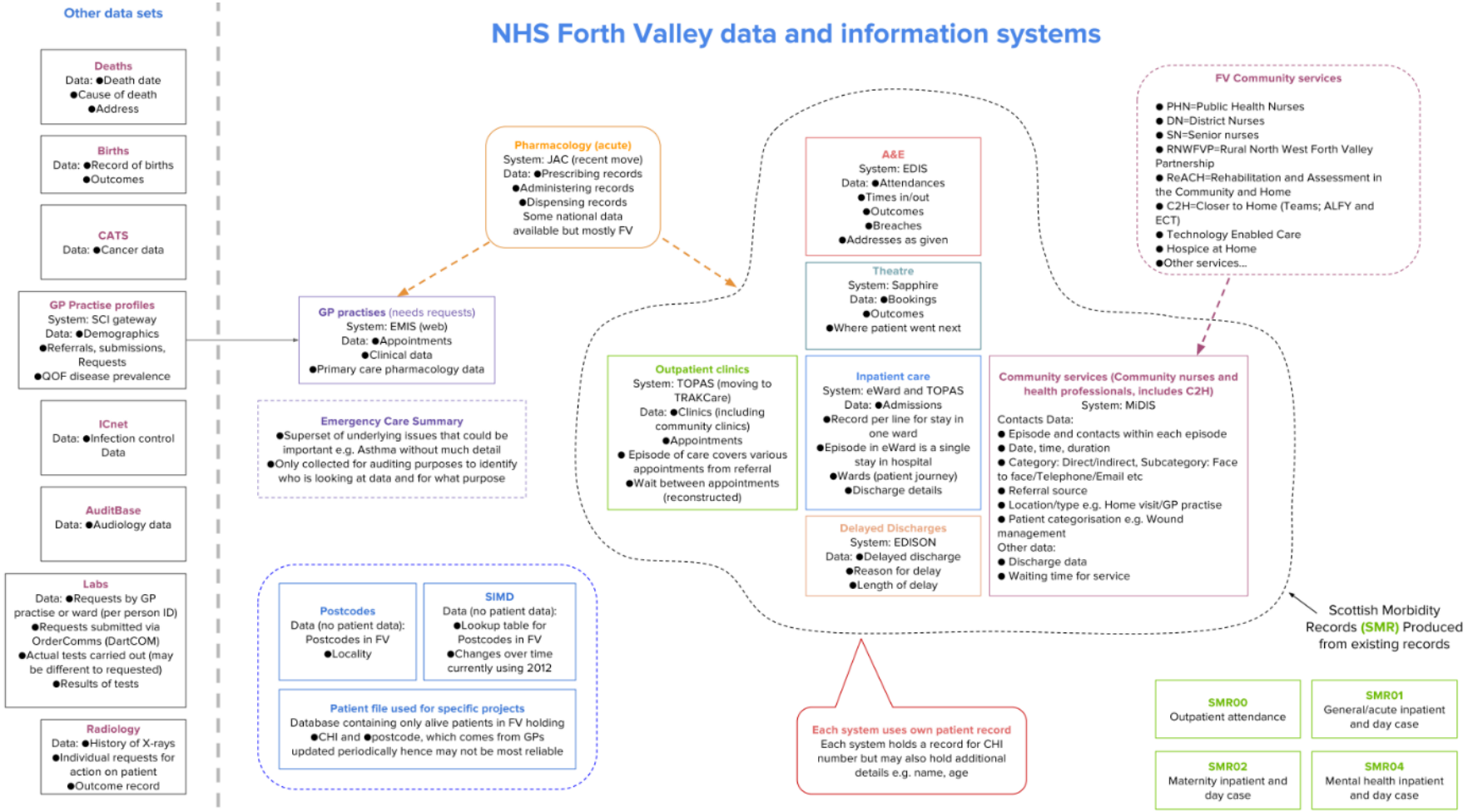


Figure 7.2 – Concept map of NHS Forth Valley data and information systems



7.1.2 Interpreting individual data fields

Due to lack of documentation, several data fields would have been impossible to interpret, and data linkages could not have taken place correctly without consultation. Correct interpretation was especially crucial for date fields in order to understand which fields should be used in filtering. This was the case with defining start dates of ECT episodes as there are referral received dates, episode registration dates and timestamps for when users created an episode, hence consultations took place with nurses to understand that the last of these was not appropriate to use as data may be entered retrospectively. This is one example among several other required consultations.

7.1.3 Opportunities for use of additional valuable data sources

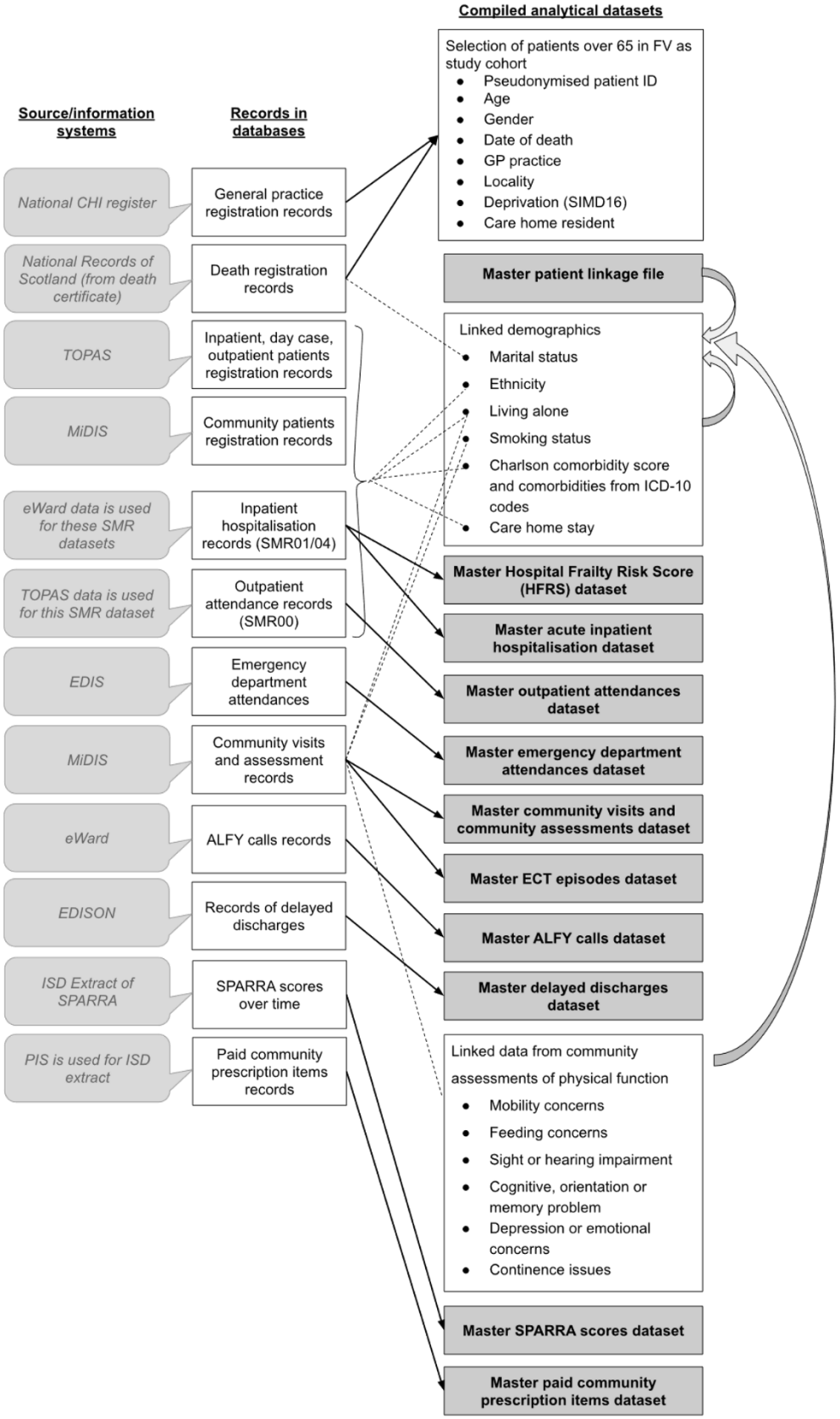
Due to the expertise, willingness and connections of NHS Forth Valley health board's information services (such as Information Services Division Scotland), opportunities arose to expand the wealth of data for the study population. Two valuable datasets obtained through this consultation process were prescription data and Scottish Patients at Risk of Admission and Readmission (SPARRA) scores. An initial enquiry within information services led onto several discussions with both NHS Forth Valley's local Prescribing Support Team and Information Services Division Prescribing (national) which resulted in the request and obtaining of prescribing records for the cohort of this study (further details in Section 7.2.6). A similar enquiry within information services about the SPARRA datasets led onto discussions with the Information Services Division SPARRA team which resulted in the request and obtaining of monthly SPARRA scores for the study cohort. This process is described in more detail in Section 7.2.9 of this chapter.

7.2 Relevant data, information systems and data quality issues

This section will follow a structure of 1) introducing the relevant data to this study, 2) describing the information system or data entry system and 3) discussing any data quality issues applicable along with how these were resolved.

As an aid in understanding the information presented, the reader is encouraged to refer to Figure 7.3 below throughout this chapter. This
figure displays the linkages that occurred for compiling analytical datasets, which will be described at the end of this chapter.

Figure 7.3 – Analytical datasets compiled for this research, with source records in databases and including source locations and information systems



7.2.1 Patient registration records (CHI and Deaths)

Patient registration records were required to identify the population of interest to this research and to obtain basic registration information such as the patient's unique identifier (Community Health Index number) (required to enable linkage with other datasets), date of birth (required to calculate age), date of death if applicable (required for mortality), gender, registered GP practice, address and postcode (the latter two were required to derive deprivation and nursing home residency). This section describes the two main patient registration databases that were used – the local Community Health Index (CHI) database and the local database for the deaths register of Scotland – and how they were used to compile the population of interest to this research. The local CHI database contains a table of an extract of the national CHI registry of patients who are alive and are or have previously been registered with a Forth Valley GP practise (referred to as the 'CHI table'). The local deaths database contains a table of an extract of the Deaths Register of Scotland for Forth Valley residents (referred to as the 'Deaths table'). The compilation of patient demographics and data sources for these will be described in a later section.

7.2.1.1 CHI table of living patients in Forth Valley

The national Community Health Index (CHI) registry is a national population register uniquely identifying all patients in NHS Scotland and is used for health care purposes (ISD Scotland, 2019). The CHI table in NHS Forth Valley is an extract of the national CHI registry and is updated on a quarterly basis. It contains details of patients who are alive and are currently or have previously been registered with a Forth Valley GP.

7.2.1.1.1 Data quality issues and resolution

The table contains an indicator for patients who have transferred from the health board, along with the reason for the transfer (for example 'Transferred out of health board area'). There is also a column indicating the date on which each patient was accepted at the registered GP practice that is recorded for them. The original CHI registry includes also a column indicating whether a patient is a new transfer from another health board. This way, on the original CHI registry, a distinction can be made between patients accepted to a Forth Valley GP practice from another health board, and patients who have transferred GP within the

health board. This is not the case, however on the local CHI table which is an extract of the national CHI registry, hence it was not originally possible to make this distinction. This distinction is significant because previous hospital admission records for patients joining a Forth Valley GP practice as a new patient to the health board, are held by their previous health board. Forth Valley information services holds only hospital admission records for patients hospitalised in Forth Valley or registered with a Forth Valley GP.

Due to an internal project within Forth Valley already requesting additional variables form the national CHI registry, the opportunity arose to make additions to the requested variables. Hence, the column of data indicating if a patient is a new transfer from another health board was obtained, resolving the above-mentioned issue. This request was made the 20th of July 2018 and the data was made available by the 8th of January 2019.

7.2.1.2 Deaths table of Forth Valley patients

The Deaths table contains an extract of the Deaths Register of Scotland for Forth Valley residents or patients who have died in Forth Valley and is updated on a weekly basis from files received from National Records of Scotland (previously known as the General Register Office for Scotland) who hold the deaths register.

7.2.1.2.1 Data quality issues and resolution

The weekly updates to the deaths table mean that data for patients who die at the weekend can be missed in the data collection, hence, on a yearly basis, these are retrospectively revised and added in. Despite being frequently updated and then checked on a yearly basis, there are still some deaths missing from this database, which was found when investigating ECT patients who did not appear on either the CHI or Deaths tables. Some of these patients were found to have a death date recorded on community and inpatient patient registration tables. It is possible that these patients transferred health board hence are not captured on the Deaths Register for Forth Valley. Alternatively, it is also possible that due to a patient dying in hospital, or a death occurring at a weekend as previously mentioned, the community and outpatient patient table contain more up to date information than the Deaths table because they retrieve patient demographics from the Scottish Care Information (SCI) Store and are subscribed to updates in demographics. Despite investigation, the reasons could not be identified with

certainty. Hence, in compiling the population (which will be described in more detail further on), these patients have not been included in the study cohort, both to ensure data quality and reduce uncertainty.

There are a few other minor data quality issues surrounding the Deaths table which are important to discuss as a limitation, however these have also been addressed where possible. The first issue is that there are several records in this table where the patient identifier is blank, hence, these were all excluded as it is not possible to link their characteristics or hospitalisations. Secondly, on occasion, some patient identifiers have been recorded incorrectly (for example, one digit is incorrect). This was identified when matching patients to CHI numbers in SMR01 which was previously described. It was identified at this stage that the same patient had one or more different CHI numbers recorded in SMR01 when compared to the CHI and Deaths table. At this point, the incorrect CHI numbers were identified within the Deaths table and were corrected on a case-by-case basis, so that the data linkage performed correctly (106 patients). This was important because without this step, hospitalisation records (and other data) for these patients would not be found.

7.2.2 Community visits and assessment records

Data relating to home visits and other activity from community services in Forth Valley was required in order to identify patients using the ECT and GP Fellows services. Community activity was also important when identifying time-dependent matching variables and confounders. Any contact with a patient such as home visits or about a patient including telephone calls or muldisciplinary meetings are recorded as 'contacts.' In addition, community services record a vast amount of data within their Multidisciplinary Information System (MiDIS), including a range of demographics and assessments that are carried out in patients' homes. The collection of demographics for the full population of interest will be discussed in Section 7.4.

The community assessments carried out to assess patients' functional disabilities were of interest as potential matching variables confounders. These assessments recorded aspects such as whether

- Concerns with a patients functional mobility
- Concerns with a patient's ability to feed themselves independently

- Cognitive, orientation or memory problems
- Sight or hearing impairment
- Depression or emotional concerns
- Continence issues

The assessments were recorded upon admission to certain community services including ECT, district nursing, continence advisory services, 'Rehab Care Group' (i.e. community rehabilitation services such as ReACH), or upon necessity once admitted to a service such as a continence or falls assessment. Despite some of these assessments being conducted over time, they were not found to be consistently completed and for some patients, assessment records were sparse over time (which is expected), hence rather than using these assessment variables over time, the worst recorded functional variables were extracted. For example, for a patient who had five assessments over time where only the first identified a mobility concern whereas the remaining assessments indicated no mobility conerns, the positive mobility concern was extracted.

MiDIS is a system that was designed for the purpose of community data collection, however there are still issues that have been observed in the data being collected. The issues with using MiDIS do not lie in the integral design of the system, but rather with user understanding and lack of system support. MiDIS was designed as a small scale project initially intended for local use by NHS Tayside, hence, large scale support had not been a focus.

7.2.2.1 Information system - MiDIS

MiDIS is an Oracle based information system designed for community care, developed and hosed by NHS Tayside and has been in place in their health board since 2010. NHS Forth Valley have used MiDIS to record community episodes since May 2011. The MiDIS system is based around episodes of care for each community service and contacts within those episodes.

7.2.2.2 Data quality issues and resolution

One issue that arises from lack of support is that NHS Forth Valley receives a view (snapshot) of the full data captured on MiDIS. This means that there are selected fields which Forth Valley can see and make use of which cover a vast range, however other fields exist which are not accessible to NHS Forth Valley.

Within MiDIS, contacts directly with a patient or contacts relating to a patient are recorded and stored. On occasion, a community staff member may have accidentally created a contact under the wrong episode of care, or may have unintentionally created a contact for whatever reason. When this happens, the member of staff cannot delete the contact but instead can mark it as an invalid contact and the contact will visually have a strikethrough. The first data collection issue that exists within ECT data (and all other community services data stored on MiDIS at NHS Forth Valley), is that within NHS Forth Valley's view of data collected on MiDIS the column indicating invalid contacts is not available. Hence, it is impossible to identify invalid contacts without manually checking each contact within the system.

The inability to distinguish between invalid and valid contacts is a limitation of the contacts data from MiDIS, however where invalid contacts were identified these were marked to be excluded within the queries for extracting community visits data.

7.2.3 ALFY calls

Records of calls to the ALFY service were relevant to this study in order to identify patients using the service and any outcomes relating to the use of the service. When deciding on what system was to be used for recording information for the ALFY service, NHS Forth Valley were limited to using their existing systems. There were no systems within NHS Forth Valley designed for call handling, which is still currently the case. The decision to use eWard, a ward management system, to record information pertaining to ALFY, an advice line, was mainly based on the ability of the system to manage multiple cases in a single ward. ALFY uses a virtual ward in eWard which can handle multiple calls at one time.

The ALFY service used eWard to record data pertaining to calls until September 2018. At this point, the service changed over to the community information system MiDIS, however, ALFY data has been fragmented since then due to exploratory use. Hence, only data recorded prior to September 2018 was considered for this research. The eWard system and its use for ALFY will be described in depth due to the implications on data quality.

7.2.3.1 Information System - eWard

eWard is a ward management system currently used across NHS Forth Valley and was implemented in 2006. The system was developed by The Solution Works, a computer software company, who worked together with NHS Forth Valley to develop a replacement for their previous system, Delta, which was lacking in more modern tools and technologies. eWard was designed to assist the management of in-patient care and was configured to deliver NHS Forth Valley's needs. Hence, the system includes electronic medicine management and automatically generated documents such as Immediate Discharge Letters (IDLs). In 2006, eWard was implemented in Falkirk and District Royal Infirmary and Stirling Royal Infirmary (Savantech, 2017). These hospitals were both replaced by the £300m Forth Valley Royal Hospital in Larbert, which opened to its first patients in 2010, which now also uses eWard (BBC Scotland, 2010; Savantech, 2017).

7.2.3.2 Data quality issues and resolution

The use of eWard for ALFY has caused some issues in data collection, mainly because of incompatibility of ALFY operations to the eWard system. There are two main design limitations that are at the root of the data collection issues. The first design limitation is that eWard is designed for in-patient stays, hence, for each episode of care, there is one reason for admission (called 'presenting complaint' in eWard) and one outcome. Due to this limitation, ALFY nurses are unable to record more than one outcome, hence the service administrators decided to use a facility of eWard called 'signifiers' in a way it was not designed to be used. Signifiers in eWard are used as flags that can be added for patients during their in-patient stay to indicate important information to clinical staff such as the fact that a patient may be on oxygen or has low blood pressure. For the ALFY service, signifiers were added as outcomes of the calls including a referral to equipment support or social services, or to indicate that a patient needed advice and reassurance. These were also used to indicate who the caller was. Signifiers are in a picklist; hence multiple signifiers can be selected for an episode of care. This means that there is inconsistency in the availability of data for the caller and outcomes.

The second limitation is that eWard's design means that one episode of care may involve stays in multiple wards. The combination of these limitations cause the

observation of unusual data. For ALFY, a single episode of care is in theory equivalent to an individual telephone call, without expecting stays in other wards. However, in practise, a patient who makes a call is kept on the ALFY virtual ward for the full duration of their management by a nurse, which may extend to some time after the call due to a nurse making referrals or phoning social services for that patient. During this time, a patient who called ALFY may be admitted to a physical ward in a hospital. When this happens, a nurse or doctor in the physical ward sees that an episode of care is already open, and because a patient can have only one episode of care at a given time (due to the assumption of eWard that wards are physical), they use this episode of care for the patient's in-patient stay and overwrite fields such as reason for admission or signifiers. This limitation means that unusual reasons for admission and signifiers have been recorded for ALFY calls.

To resolve this identified issue, information services within Forth Valley limited the available linked signifiers to be within the subset of signifiers used for ALFY. This meant that no unusual signifiers were extracted. Additionally, any reasons for admission outwith the ALFY options were replaced with a 'data overwritten' tag. This way, for reasons for admission, a distinction was clearly made between ALFY data and data that had been overwritten.

7.2.4 Inpatient hospitalisation records

Acute inpatient hospitalisation records were relevant to this study as this is one of the primary outcomes being compared in the evaluation of 'Closer to Home.' In Scotland, the Scottish Morbidity Record (SMR) datasets are nationally held healthcare datasets for individual patients and are used for reporting national statistics. The four SMR datasets are outpatient attendance (SMR00), general/acute inpatient and day case (SMR01), maternity inpatient and day Case (SMR02) and mental health inpatient and day case (SMR04). SMR datasets are obtained for each health board by processing the data held in each local information system to be standardised into the SMR format. In NHS Forth Valley, inpatient hospitalisations are recorded on their ward management system eWard. For the purpose of this research, SMR01 was used as the source of data for acute inpatient hospitalisations as it has undergone several data quality checks, has

undergone professional clinical coding and is used nationally. SMR datasets also contain various patient demographics to be discussed in a later section.

SMR01 contains information on the primary and secondary medical conditions pertaining to the hospitalisation, in the form of International Classification of Diseases (ICD) codes.

7.2.4.1 Data quality issues and resolution

Despite thorough data quality checks and despite being designed for national use, SMR datasets data quality issues are still observed in these datasets. Ensuring that patient identifiers (CHI numbers) were included in hospitalisation records was not always part of the processing of SMR datasets, possibly due to the fact these are used on an aggregate rather than individual basis. In consultation with Information Services in NHS Forth Valley, it was identified that a major push was made around 2014 to ensure CHI numbers were included. Hence after this date the number of records without CHI numbers should be reduced.

A second issue identified was that during a patient's hospitalisation they may change consultant, significant facility, specialty and/or hospital (ISD Scotland, 2009). Each of these movements are recorded in SMR01 as individual rows of data, with the whole patient stay termed a 'continuous inpatient stay' (CIS). After receiving SMR01, each healthboard adds their own indicator of CIS using an algorithm that identifies and groups together rows that should be part of the same CIS. From consultation with Information Services, this algorithm has been used as standard across most health boards. Upon thorough inspection, the algorithm is problematic in certain situations making one stay appear as several stays, and vice versa.

To resolve the issues of missing CHI numbers, record linkage was conducted to assign CHI numbers where these were missing by matching on patient characteristics. The matching was conducted on name and date of birth. To resolve the issue of incorrect identification of a CIS, an algorithm included in the data extraction process to group CIS correctly.

7.2.5 Emergency department attendances

Emergency department attendances were relevant to this study as a secondary outcome in the evaluation of 'Closer to Home' and in identifying time-dependent matching variables and confounders. In NHS Forth Valley, these are collected

through their Emergency Department Information System (EDIS). One row of data is collected for each attendance at the ED.

EDIS was developed by a healthcare sofware application provider known as iSOFT. The first implementation of EDIS in Scotland as part of a national A&E system roll-out was in NHS Grampian in 2005 (Digital Health Intelligence Limited, 2005). EDIS includes records of all emergency department attendances for patients in NHS Forth Valley.

There were no relevant data quality issues identified with EDIS data.

7.2.6 Delayed discharges

Delayed discharges were of relevance to this research as a potential covariate in multivariable analyses, as experiencing a delay may indicate of complex needs and potentially a lack of home or family support and/or functional disability. Delayed discharges are collected in the Scottish national system EDISON (Electronic Discharge Information System Online Nationally). The dataset includes details about delays including reasons for and length of delays of discharge from hospital.

There were no relevant data quality issues identified in EDISON data.

7.2.7 Outpatient attendance records

Outpatient activity in addition to emergency hospital activity was of relevance to this research as relevant patient history that may need to be factored in the analyses. Outpatient waiting lists and appointments within NHS Forth Valley are managed in the TOPAS patient management system, developed by Cambric Systems. The dataset includes details about outpatient appointments including date and time, location, specialty and clinic type.

There were no relevant data quality issues identified in TOPAS data.

7.2.8 Paid community prescription items

Prescription records were relevant to this study in order to have a greater understanding of co-morbidities of the population of interest. Co-morbidities can be captured in a number of ways, including prescriptions, and the Charlson co-morbidity index. One study comparing these and other multiple measures of co-morbidity found that “the number of prescribed drugs is the most powerful measure for predicting future consultations and the second most powerful

measure for predicting mortality," after the Charlson index (Brilleman and Salisbury, 2013). Hence, there was the potential for data on prescriptions to be used as a proxy measure of multimorbidity in this research.

In Scotland, prescriptions are recorded separately for items dispensed in the community (e.g. pharmacy) and those dispensed in acute hospitals. Prescriptions dispensed in the community are of most interest to this research as they provide the most information for the full population and give a better picture of the population's regular medication requirements. Unlike the previously mentioned datasets in Sections 7.2.1 – 7.2.5 of this chapter, community prescriptions are not locally held by NHS Forth Valley's Information Services. Hence a request for this data for the population of interest was made from ISD Scotland prescribing.

The process involved an initial consultation (13th February 2018) followed by a formal application (28th March 2018) detailing the variables required, the population (about 65,000 elderly patients in Forth Valley) and timescales the data was required for. It also involved obtaining Caldicott approval within NHS Forth Valley for the release of non-anonymised information. The requested extract was received on the 4th May as a compressed file, and after obtaining the correct extraction software it was accessed and transferred to the local NHS Forth Valley databases the 11th of May, hence this process from consultation to access took four months. Following this time, investigation and further consultation with ISD took place. It was identified due to data quality issues of one of the patient registrations used to obtain unique patient identifiers (UPIs) for the request that 69 of the UPIs originally sent were incorrect, hence no data was found for them in the obtained extract. Hence, after consultation and investigation from ISD, a request was made for the same data for these 69 patients, which was obtained the 14th of January 2019.

An additional request was made for aggregate data for NHS Forth Valley of numbers of paid items by dispenser (community pharmacies, dispensing doctors etc.) and prescriber (GP, nurse, dentist etc.) as well as aggregate data for the percentage of paid items in NHS Forth Valley without CHI numbers. The purpose of this request for aggregate data was to have a greater understanding of the sources and quality of data.

The prescribing records obtained included the number of paid items and the number of British National Formulary (BNF) classes (paragraphs) covered by the

prescribed items (1,510,018 records). To reduce variation and the effect of exaggerated polypharmacy for patients with multiple medication under the same BNF class (paragraph), the average monthly number of BNF paragraphs was used as a proxy measure for multimorbidity, as repeated prescriptions of a drug may be more likely to relate to chronic conditions, and has been used by other researchers (Brilleman and Salisbury, 2013).

7.2.8.1 Information system – PIS

The national prescribing dataset held by ISD Scotland is known as the Prescribing Information System (PIS). PIS is "one of the few nationwide databases which include routinely collected data on prescribed items and whether they were dispensed and reimbursed or not" (Alvarez-Madrazo et al., 2016, p.715c). Before and after raw data are submitted for PIS they undergo 10 stages of quality checking and PIS has been used in multiple research publications (Alvarez-Madrazo et al., 2016). PIS is not without its limitations with its main weaknesses described elsewhere (Alvarez-Madrazo et al., 2016).

7.2.8.2 Data quality issues

Despite multiple quality checks, records without identifiers are still present in PIS, hence if there were any, these records would not be captured within the extract for the population of interest. Through the second request made to ISD prescribing, it was confirmed that in NHS Forth Valley unique patient identifiers (UPI) were captured correctly for 96.18% of paid prescription items between 2015-17.

Table 7.1 – Proportion of UPI capture among prescribing data

Paid Year	2015	2016	2017
Percentage of paid items with correctly captured UPI	96.21%	96.10%	96.23%

7.2.9 SPARRA scores

The Scottish Patients at Risk of Admission and Readmission (SPARRA) tool is a predictive algorithm developed in 2006 for identifying an individual's risk of emergency hospitalisation within the next year (Mahmoud, 2016). SPARRA is mainly used to for identifying cases or groups of patients at risk, for example patients with complex care needs who may identify from intervention such as

anticipatory care (NHS National Services Scotland, 2012). SPARRA scores range from 1-99%, with a score of 40% or above generally regarded as an increased risk. The SPARRA model has been reported to have a positive predicted value of 59.8% and a sensitivity of 10.5% (Mahmoud, 2016). The model was developed using logistic regression and considers a wide variety of patient-level history, combining information about an individual's hospital inpatient admissions, community dispensed prescriptions, Emergency Department (ED) attendances, new outpatient attendances and psychiatric inpatient admissions in addition (NHS National Services Scotland, 2012). Hence, the SPARRA cohort includes patients who have these records, which covers about 67% of the Scottish population (NHS National Services Scotland, 2012). The SPARRA model cohort is divided into three groups, namely 'Frail Elderly,' 'Long Term Conditions,' and 'Younger Emergency Department', each of which considers different additional factors in the predictive model. The 'Frail Elderly' cohort, which is the type of patient most relevant to this research, considers age, deprivation and prescriptions in specific British National Formulary (BNF) chapters as factors additional to patient-level history (NHS National Services Scotland, 2012).

SPARRA scores are calculated monthly by ISD, at the end of each month, however the data used to calculate scores comes from pre-prediction periods up to the start (1st) of the month, to allow a four-week lag in hospital and prescribing records so that they are sufficiently complete. As an example. SPARRA scores for February 2018 were calculated at the end of February 2018, using data up to the 31st January 2018, and the result is said to be the SPARRA score "as at 1st February 2018." The score represents the risk of emergency admission in the following 12 months (i.e. from the 1st February 2018 – 31st January 2019).

Similar to prescribing data, SPARRA scores are not routinely and locally held within NHS Forth Valley's Information Services, although access to query scores for living patients within Forth Valley is available. After initial queries were made for these scores accessible by NHS Forth Valley's Information Services, it was identified that a request would need to be made with ISD SPARRA team for a complete dataset of SPARRA scores for the study cohort, as the locally accessible database did not include scores for deceased patients.

As with the prescribing request the process involved an initial consultation with the ISD SPARRA team (18th July 2019) followed by a formal application (2nd

August 2019 after obtaining Caldicott approval within NHS Forth Valley for the release of non-anonymised information. The formal application detailed the variables required, the population (about 65,000 elderly patients in Forth Valley) and timescales the data was required for. The requested extract was received on the 24th of September 2019 and transferred to the local NHS Forth Valley databases the same day, hence this process from consultation to access took roughly three months. The obtained data was reviewed and clarifications were made through consultation with the ISD SPARRA team.

An update of the originally requested SPARRA data was required to match the timeframes of the final study data. A new request following the same process of obtaining local Caldicott approval (submitted 15th July 2020) and submission of a formal application to the ISD SPARRA team upon local approval (3rd August 2020) was made. The data update was obtained 11th August 2020.

7.2.9.1 Data quality issues and resolution

After a follow-up query about the received SPARRA data regarding some missing scores for patients where scores were expected, it was identified that there had been an error made in the initial data query by the ISD SPARRA team meaning that some of the scores were incorrect. One of the issues was caused by a syntax typo and another issue was caused by UPIs changing over time for a few patients, meaning they had missing scores for some months. The issue was first highlighted to the ISD SPARRA team on the 16th April 2020 and after consultation, a correct extract was sent on the 25th May 2020 and analyses were re-run with the correct extract.

7.2.10 Additional patient demographics

Some additional patient demographics were required for consideration as potential confounders or for any subgroup analysis required. In addition to patient registration records, some patient activity datasets record demographics. As briefly described in the preceding sections, some demographics were obtainable from the CHI and Deaths patient registration tables. Additional valuable demographics were available within other patient registration records, as these exist for most of the information systems previously described. The additional registration records used for demographics were the MiDIS community patient registration records and the TOPAS outpatient registration records. In addition,

patient activity datasets recorded demographics, of which outpatient attendance data (SMR00), hospital inpatient stay data (SMR01) and community visit data (MiDIS) contained demographics of interest to this research. For demographic variables that can change over time, a script was written in SQL that selected the most recent available information. The specific demographic variables and how they were collected will be described in more detail in the next section.

7.3 Derived data

Two main data items were derived from the existing data described in the preceding sections. These were a measure of comorbidity, the Charlson comorbidity score, and a measure of frailty, the Hospital Frailty Risk Score (HFRS). These were important measures considered likely to be potential confounders. Though they have some overlap and have previously been used interchangeably, it is now recognised in geriatric medicine that comorbidity and frailty are distinct presentations (Fried et al., 2004). Díez-Villanueva et al. describe the distinction as follows: "Frailty and comorbidity are clinical manifestations of two distinct aging-related processes, involving diminished functional reserve and accumulation of pathological processes" (2017, p.379). In addition the Charlson score and the HFRS have been found to be only weakly correlated (McAlister et al., 2020).

Both scores are based on the allocation of different weights to different medical conditions according to their prognostic ability, as defined by a specified algorithm that takes the sum of these weights to construct a prognostic score.

7.3.1 The Charlson comorbidity score

The Charlson comorbidity score (Charlson et al., 1987) (also known as the Charlson comorbidity index) was developed as a prognostic tool for predicting 1-year mortality, based on clinical conditions identified through hospital database or chart review (Sundararajan et al., 2004). A weighted score is assigned to each of 17 comorbid conditions, with their sum giving the Charlson comorbidity summary score (Sundararajan et al., 2004). A score of zero indicates no comorbidities were identified, and higher scores indicate higher disease burden and higher mortality risk. The comorbidities included in the Charlson score are as follows (Sundararajan et al., 2004):

- Acute myocardial infarction
- Congestive heart failure
- Peripheral vascular disease
- Cerebral vascular accident (stroke)
- Dementia
- Pulmonary disease
- Connective tissue disorder
- Peptic ulcer disease
- Liver disease and severe liver disease
- Diabetes and diabetes complications
- Paraplegia (paralysis)
- Renal disease
- Cancer and metastatic cancer
- HIV

The Charlson score is widely used and validated within healthcare research (Sundararajan et al., 2004). It can be generated by identifying the above mentioned conditions through hospital records or patient review, however it is frequently generated by identifying the comorbid conditions through the World Health Organisation's (WHO) International Classification of Diseases (ICD) codes in hospital or patient records in electronic health care records. The ICD codes corresponding to the defined comorbidities have been specified in literature, with coding algorithms defined by Deyo et al. (Deyo, Cherkin and Ciol, 1992) for the Ninth Revision of ICD (ICD-9) and by Quan et al. for the Tenth Revision (ICD-10) (Quan et al., 2005).

Given that ICD-10 codes were available in the SMR datasets previously mentioned, the Quan coding algorithm was used to identify the comorbidities for computing Charlson Scores. A readily available package exists within R statistical software ("icd") for computing Charlson scores from ICD-10 codes using the Quan coding algorithm (Wasey, 2018). This package was used to compute Charlson scores for the 65,188 patients in the study cohort, based on ICD-10 codes recorded in SMR datasets in the five years prior to the introduction of 'Closer to Home' services. A five-year period of records for constructing Charlson scores has been used by other researchers (Kavanagh et al., 2016). A "baseline" Charlson score was constructed for all patients in the study cohort, rather than capturing

scores over time, as the score measures comorbidity including long term conditions that are unlikely to change over the study time period.

7.3.2 The Hospital Frailty Risk Score

As with the Charlson score, the Hospital Frailty Risk Score (HFRS) (Gilbert et al., 2018) is based on the identification and weighting of medical conditions. However, unlike the Charlson score, it has been developed solely for capturing these conditions from ICD-10 codes and its development is much more recent (2018). The HFRS was developed to measure frailty using ICD-10 codes among older people in acute care settings. The ICD-10 codes included in the HFRS are frailty indicators and symptoms in the following categories: frailty (e.g. dementia, delirium, Alzheimer's disease, cellulitis), chronic heart problems, elective cataracts, acute heart problems and cancer and lung disease (Gilbert et al., 2018).

The HFRS has been internally validated and was found to perform at least as well as other manual measures of frailty such as the Rockwood Frailty Index at predicting hospital use and mortality (Gilbert et al., 2018). More recently, in the last two years since published, it has been externally validated by several studies (McAlister et al., 2020; McAlister and Van Walraven, 2019; Eckart et al., 2019; Shebeshi, Dolja-Gore and Byles, 2021). The main advantage of the HFRS is that it provides a low-cost, systematic way to measure frailty using routine data, as manual measures can be time-consuming and difficult to capture for large populations (Gilbert et al., 2018).

A two-year period of records is recommended for constructing the HFRS (Gilbert et al., 2018). Hence, the HFRS was calculated for each patient on a monthly basis, to capture changes in frailty, as the frailty conditions captured in the HFRS are likely to change over time. An R script was written to calculate these monthly scores based on the coding algorithm detailed in Gilbert et al.'s supplementary appendix (Gilbert et al., 2018).

7.3.3 Limitations of derived data

The use of the Charlson score and the HFRS in this research comes with the limitation of relying on ICD-10 codes for identification of the medical conditions and symptoms that form the scores. Within the context of this research, the only

source of reliable and accurate ICD-10 diagnostic coding is found within the SMR01 inpatient hospitalisation dataset, as these codes are assigned by clinical coders who undergo specialty training to ensure the accuracy of such codes. This reliance means that the Charlson score and the HFRS can only be calculated for patients with SMR01 records (i.e. those who have had an inpatient hospitalisation). This is an important limitation, as comorbidity and frailty will be unmeasured among patients without hospitalisations, however, the lack of measurement itself is a likely indicator of reduced comorbidity and frailty given the lack of hospitalisation (Gilbert et al., 2018). Hence, distinctions were made for both the Charlson score and the HFRS between patients with no inpatient hospitalisation records in the relevant periods, and patients with a score of zero, whose ICD-10 codes were not within the medical conditions and symptoms comprising the scores. This has been done by other researchers (Kavanagh et al., 2016).

In addition, the HFRS has been recently developed and although it has been validated by several studies as previously mentioned, research is still ongoing, hence its use is not widely established as with the Charlson score. It is recognised that the HFRS as a measure of frailty is limited, as it cannot capture complex patient characteristics important to frailty such as dynamic functional states or caregiver factors, hence automatic assessment of frailty through ICD-10 codes cannot replace clinical assessment (Bruno et al., 2019; O'Caoimh et al., 2018). The use of HFRS been recommended as being "primarily useful for estimating frailty prevalence for service-level planning" rather than being used to rationalise clinical assessment or for use in predicting clinical outcomes (O'Caoimh et al., 2018). Given that the use of HFRS in the context of this research is for identifying distinguishing characteristics and identifying potential confounders, this limitation seems acceptable.

7.4 Final master study datasets

The first step towards developing an analytical dataset for the full population of over 65s in Forth Valley was to compile a list of their unique identifiers. These could then be linked to the required patient characteristics for analysis. To compile this list, two main sources of data were used: the CHI table of living patients in Forth Valley and the Deaths table, as previously described. Both of

these tables are routinely updated, hence, due to their changing nature, a list of unique patient identifiers, found by combining these tables and setting a filter to select only patients aged over 65 by the time of data collection, was captured on the 20th of April, 2018 as the core list to be used as the cohort of elderly patients in Forth Valley and for compiling the population level analytical dataset. Prior to this, date, work was put into defining this dataset, and preliminary analyses were conducted, however, this date was set as the cut-off date for keeping the list of unique patient identifiers static.

This means that any patients who did not appear in neither the CHI or the Deaths tables as of the 20th of April, 2018, mainly due to having died, and not having appeared on the deaths register yet (as previously described), were excluded (50 ECT patients, 111 ALFY mailing list patients). Information for these patients could have been recovered from the TOPAS outpatient or MiDIS community patient registration records, however, there is no indication on these databases of whether these patients had been transferred from the health board, hence to ensure data quality and reduce uncertainty, these were excluded. The total number of patients in the final cohort including how they were identified is displayed in Table 7.2.

Table 7.2 – Total number of patients in full study population by their source location

Source	Number of patients in final study cohort
CHI registry of patients registered with a GP in Forth Valley or with a Forth Valley postcode	56,350
Deaths registered in Forth Valley	8,680
ECT patients in neither CHI nor deaths registries	72
ALFY patients in neither CHI nor deaths registries	86
Total patients in study population	**65,188**

Having identified this study population, a master patient linkage dataset was developed including their key demographics and features to be used in analysis. Separately, master datasets were developed for other features such as time-varying characteristics and healthcare activity including outcome measures. The reader is strongly encouraged to refer back to Figure 7.3 for a visualisation of the complex linkages involved in the development of the study datasets and for an overview of the final master datasets developed. However, these will be further described in Sections 7.4.1 and 7.4.2.

7.4.1 Master patient linkage dataset

The characteristics collected for each patient in the final analytical dataset and how they were obtained from the source datasets are listed in Table 7.3 below. In addition, an indicator for receipt of a 'Closer to Home' service (ECT, GP Fellows and ALFY in separate columns) and a binary cohort indicator of whether the patient belongs to the control or the intervention (any 'Closer to Home' service) population was added.

Table 7.3 – Final variables in master patient linkage dataset used in analysis and how variables were obtained

Source field	Source location	Transformation	Final variable
CHI number	Patient registration dataset (CHI/Deaths)	Search in pseudonymised lookup table after corrections	Anonymous identifier
Date of birth	Patient registration dataset (CHI/Deaths)	Subtract Date of birth from Date of data collection	Age
Gender	Patient registration dataset (CHI/Deaths)	Standardisation (e.g. Female to F)	Gender (m, f, uknown)
Postcode	Main patient registration dataset (CHI/Deaths), where null most recent record in TOPAS/MiDIS patient registration datasets or SMR01records	Search in lookup table for Datazone, Locality, HSC partnership and Health board name	Datazone (2011 version), Locality Name, HSC partnership, Health board name
		Search in lookup table for deprivation	SIMD quintile and decile (2016 version)
Address and Postcode	Patient registration dataset (CHI/Deaths) for address, postcode as above	Search address/postcode for names/postcodes of nursing homes in Forth Valley	Care home resident (indicator, 1=yes, 0=no)[a]
Discharge location	Hospitalisation records (SMR01)	Indicator where discharge location indicates discharged to care home (code 25)	Care home stay (indicator, 1=yes, 0=no)[a]
GP practice code	Patient registration (CHI and where null, most recent record in TOPAS)	Search in lookup table for GP practice health centre name (using GP practice postcode from Deaths and where null use GP practice code)	GP practice name, GP Cluster
GP practice postcode	Deaths patient registration		
Date of death	Patient registration (Deaths, where Deaths null TOPAS,where TOPAS also null MiIDS)	None	Date of death
Location of death	Deaths patient registration	Standardisation (Care home, At home or non-institution, NHS hospital or Other)	Location of death
Ethnicity	Most recent non-null/non- unspecified from MiDIS, TOPAS patient registration datasets and hospitalisation (SMR01) records	Standardisation (white, other, unknown, missing)	Ethnicity (white, other, unknown, missing)

Marital status	Most recent non-null/non- unspecified from Deaths, MiDIS, TOPAS patient registration datasets and SMR01 records	Standardisation (S=Single, M=Married / civil partnership, D=Divorced / separated, W=Widowed / surviving civil partner, missing)	Marital status (S, M, D, W, missing)[b]
Living alone	Most recent record from MiDIS assessment forms and SMR01 discharge location codes 11-12 (Private Residence - living alone/living with relatives or friends)	Standardisation (living alone=yes, no, missing)	Living alone (indicator, 1=yes, 0=no)[b]
Smoking status	Most recent MiDIS assessment forms record	Standardisation (smoking status=yes, ex-smoker, no, missing)	Smoking status
Recorded fall	Most recent MiDIS assessment forms record	Indicator (0=no falls recorded, 1=fall recorded)	Ever fall (1=yes, 0=no)
Community assessed • depression or emotional concerns • cognitive, orientation or memory problems • sight or hearing impairment • concerns with functional mobility • concerns with ability to feed themselves • continence issues	Most recent MiDIS assessment forms record	None	Depression or emotional concerns (yes, no, missing) Cognitive, orientation or memory problems (yes, no, missing) Sight or hearing impairment (yes, no, missing) Mobility concerns (yes, no, missing) Feeding concerns (yes, no, missing) Continence issues (yes, no, missing)
ICD-10 diagnostic codes	Hospitalisation records from past five years (SMR01)	Algorithm identifying and scoring selected comorbid conditions to calculate Charlson score. Indicators for individual conditions as defined in the Charlson algorithm were also added (0=no, 1=yes).	Charlson score, Charlson group (No ICD-10 codes, 0, 1-2 (Mild), 3-4 (Moderate), 5+ (Severe)) Comorbid conditions: • Myocardial or chronic heart failure (MI of CHF) (0=no, 1=yes) • Peripheral vascular disease (PVD) (0=no, 1=yes) • Stroke (0=no, 1=yes) • Pulmonary disease (0=no, 1=yes) • Rheumatic condition (0=no, 1=yes) • Peptic ulcer disease

			(PUD) (0=no, 1=yes) • Liver disease (0=no, 1=yes) • Diabetes mellitus (DM) (0=no, 1=yes) • Renal condition (0=no, 1=yes) • Dementia (0=no, 1=yes) • Cancer (0=no, 1=yes) • Paralysis (0=no, 1=yes)

a. Care home residency and care home stay were combined to develop a secondary variable indicating either a stay or residency in a care home

b. Marital status and living alone were combined to develop a secondary variable, indicating if the patient has been recorded as living alone or not at any point, with not married being classified as living alone and married/cohabiting as not living alone due to missing values for the primary variable living alone. This reduced the missing values by 34.0%.

7.4.2 Master linked datasets

The master patient linkage dataset was the backbone of the quantitative study design and analysis. It was then used to link time-variable characteristics, healthcare activity and outcome measures as required throughout the analysis. The final master linked datasets are described in Table 7.4

Table 7.4 – Final master linked datasets used in analysis

Source	**Master linked dataset**	**Time frame**
SMR01	Acute inpatient hospitalisation dataset	01/01/2014-18/09/2019
EDIS	Emergency department attendance dataset	01/01/2014-28/04/2019
EDISON	Delayed discharges dataset	03/01/2013-14/05/2018
MiDIS	Community episodes and community assessments dataset	31/12/2013-17/10/2019
MiDIS	ECT episodes dataset	14/12/2015-03/12/2019
eWard	ALFY calls dataset	01/12/2015-31/08/2018
ISD – SPARRA	SPARRA scores dataset	01/12/2014-01/04/2019
ISD – Prescribing (PIS)	Paid community prescription items dataset	01/01/2015-01/12/2017
Derived from ICD-10 codes in SMR01 records	Hospital Frailty Risk Score dataset	01/01/2015-01/04/2019

Note: See Sections 7.2 – 7.3 for detailed descriptions of each of the source systems and datasets

Abbreviations: SMR01=Scottish Morbidity Record of Inpatient Hospitalisations, EDIS=Emergency Department Information System, EDISON=Electronic Discharge Information System Online Nationally,

MiDIS=Multidisciplinary Information System, eWard=Electronic Ward Management System, ISD=Information Services Division, SPARRA=Scottish Patients at Risk of Readmission and Admission, PIS=Prescribing Information System, ICD-10=International Classification of Diseases (10th revision)

7.5 Chapter summary

This research was the first to make use of routinely collected, linked data describing the patient journey in NHS Forth Valley for the purpose of evaluating their 'Closer to Home' programme. Hence, research ready datasets were not readily available and had to be compiled. Phase III of this research was the construction of an analytical, research-ready dataset which could be used for the quantitative evaluation of the 'Closer to Home' services. The main aims of this phase were 1) to gain an in-depth understanding of the relevant datasets available and the linkages between them, 2) to identify any data quality issues and potential resolutions and 3) to construct an analytical dataset maximising use of available data pertaining to the general elderly population in Forth Valley.

This chapter has met these aims by documenting the relevant data sources, describing data quality issues and how these were resolved, describing the data linkages involved and describing how the analytical datasets were compiled. It should be highlighted that Phase III was one of the most time-consuming and complex aspects of this research, requiring a lengthy process of identifying data, conducting data quality checks, consulting with Information Services (often due to lack of documentation) and conducting complex data linkage.

This highlights one of the issues faced by services like 'Closer to Home,' where evaluation has been commissioned far down the line of implementation and the design of research-ready or 'evaluation-ready' datasets has not been considered at the outset. This chapter described how it was possible to use routinely collected electronic health record data to develop a dataset for analysis and evaluation of 'Closer to Home'. However, it was not without its challenges requiring complex data linkages, lengthy consultations and data quality checks. This chapter (and Phase III of this research) highlight the need for commissioners of evaluation to consider data collection processes early on (including data collection from existing systems), in order to identify the suitability of existing systems and data for the purpose of evaluation. Commissioners are encouraged to prioritise the implementation of data collection processes that are fit for the purpose of

evaluation in order to reduce the resource-intensive process of constructing evaluation datasets.

Chapter 8 Services Use and Activity

8.1 Introduction

Phase IV of this research involved a descriptive statistical analysis of the use and activity of the 'Closer to Home' services, using the research-ready datasets compiled in Phase III. The aim was to gain some insight into the level of reach of the services, which serves towards understanding and documenting the context (part of the evaluation framework developed for this research described in Chapter 2). This chapter will present the results of the descriptive analysis including summary statistics such as monthly referrals and activity, service use over time, types of conditions treated and referral sources among other relevant figures.

8.2 Enhanced Community Team

The ECT service was operational from December 2015 and continues to be operational. For the purpose of summarising activity, data was obtained for episodes beginning between the 14th December 2015, when the first episode was recorded, and discharged by the 1st October 2019. There were 2,165 referrals to the ECT, which met the service criteria, between these dates. On average the service received 47 new referrals per month.

Table 8.1 – Summary statistics of monthly ECT referrals

Statistic	Mean	SD	Median	Min	Max
Value	47.1	13.1	44.5	20	74

ECT episodes recorded in their Multidisciplinary Information System (MiDIS) included those that may be classed as "false" episodes (i.e. episodes that did not truly begin for several reasons). These episodes were usually cases where the ECT service received a referral but when they made an attempt to provide care, they could not do so for various reasons. These reasons include identifying that:

- the referral was inappropriate (i.e. did not meet the service criteria) upon investigation by the team
- the patient had been admitted to the hospital prior to any involvement from ECT

- the patient had been admitted to the hospital the same day the patient was referred before ECT completed any direct contact with the patient
- the patient had been transferred to another service, discipline or agency on the same day the patient was referred before ECT completed any direct contact with the patient
- a patient who was meant to be discharged from hospital and transferred to their care was not able to be discharged after all (failed facilitated discharge)
- the patient could not be contacted (non-attendance)
- the patient refused care (did not opt in)

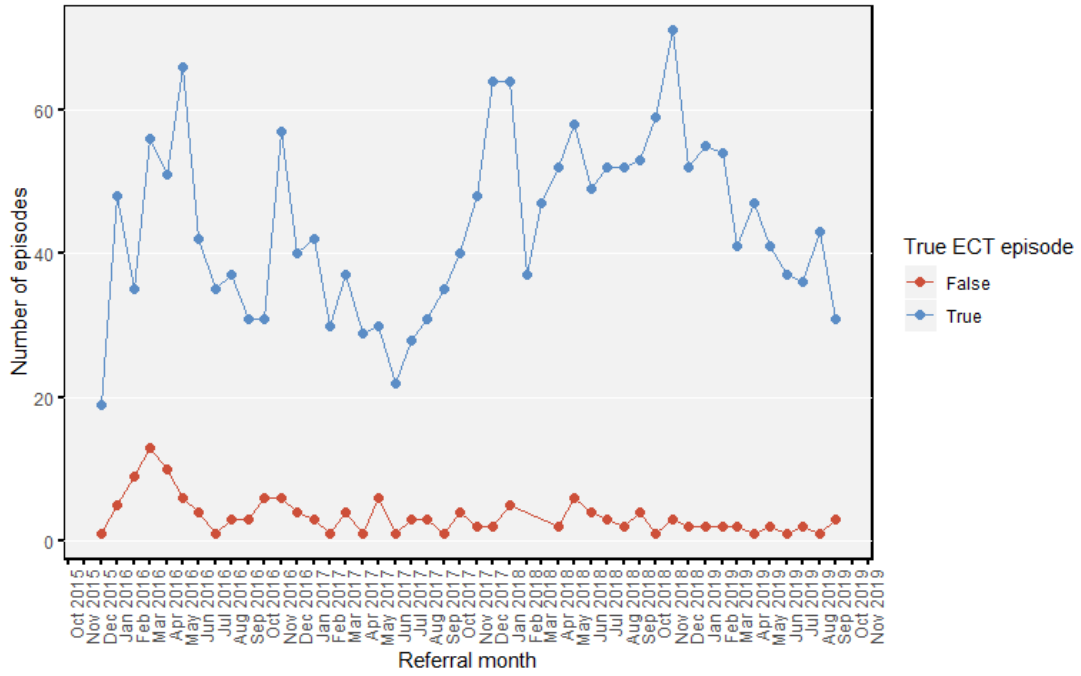
The total number of episodes by whether they were false or true episodes can be seen in Table 8.2 below.

Table 8.2 –Frequency of 'false' ECT episodes by reason

Episode	Reason for false episode	n
False episode	Admitted on referral date with no direct contact	6
	Admitted prior to ECT involvement	25
	Care transferred/no longer required on referral date with no direct contact	11
	Deceased with no direct contact	10
	Did not opt in	6
	Failed Facilitated Discharge	28
	Inappropriate referral	59
	Non attendance	5
True episode	-	2015
Total		2165

The following figure displays the total number of ECT episodes by month, separating out "true" and "false" episodes. It appears that the number of false episodes was higher towards the beginning of the service which is aligned with potential implementation issues near the beginning. Overall the peaks in activity roughly align with winter seasons, as expected.

Figure 8.1 – Total number of ECT episodes by month



From this point onward, only activity for "true" ECT episodes will be presented. This means activity for 150 episodes covering 147 patients will be excluded, leaving 2,015 true ECT episodes for 1,741 unique patients. The following table describes monthly activity for true ECT episodes.

Table 8.3 – Summary statistics of monthly true ECT episodes

Statistic	Mean	SD	Median	Min	Max
Value	43.8	12.2	42	19	71

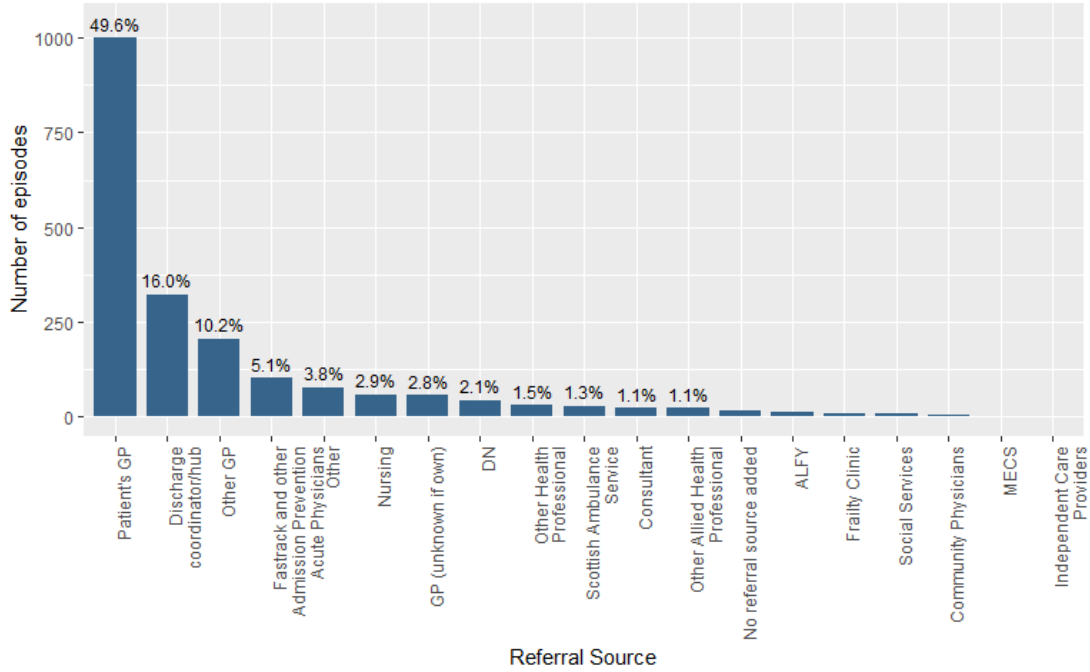
Table 8.4 displays the frequency of recurrent ECT episodes. It was most common for patients to only receive one ECT episode, however a small proportion received two or more episodes during the observation period.

Table 8.4 – ECT patients by number of episodes per patient

Number of ECT episodes	Number of patients	Percent
1	1504	86.4%
2	205	11.8%
3	27	1.6%
4	5	0.3%
Total	1741	100.0%

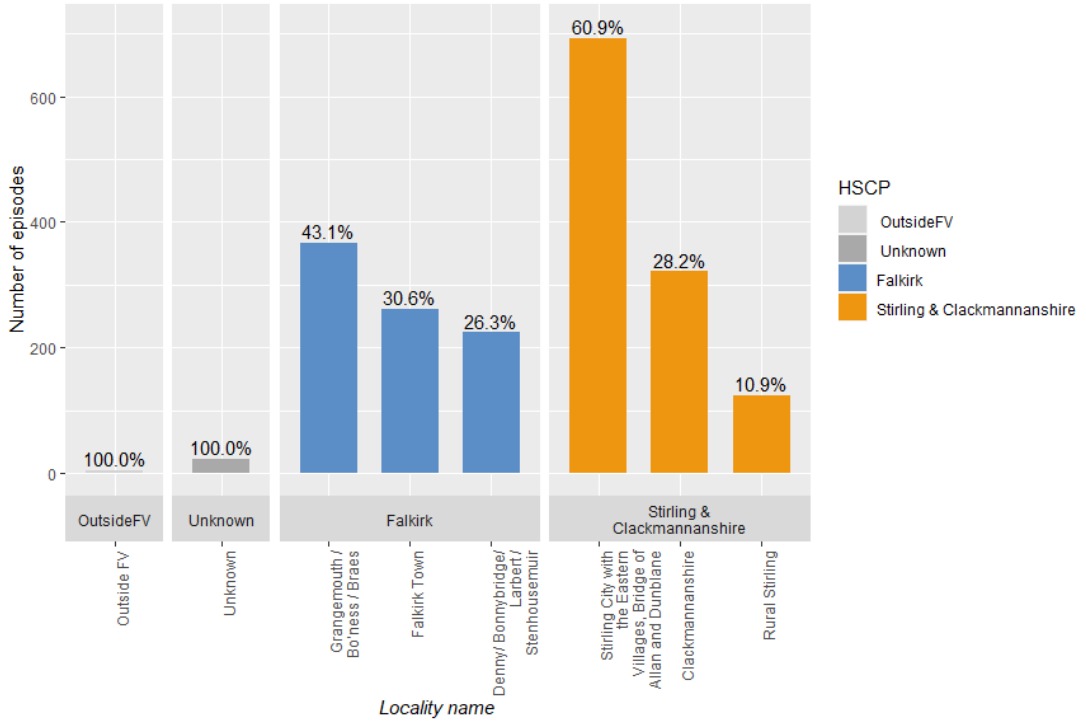
About half of referrals to the ECT service came from the patient's own GP. A wider range of referral sources covered the remaining half including discharge coordinators in hospitals or other GPs, which can be seen in Figure 8.2.

Figure 8.2 – Number of ECT episodes by referral source



Patient locality was known for the vast majority of episodes (98.9%). While, a few patients were seen in areas outside Forth Valley (likely due to being registered with a Forth Valley GP despite being outside the area) (n=4), just under half of episodes were for patients residing in the Falkirk area (42.8%) and just over half in the Stirling and Clackmannshire area (57.2%). Figure 8.3 displays the distribution of episodes by locality. Episodes in the Stirling City locality accounted for a third of all episodes (34.3%).

Figure 8.3 – ECT episodes by locality



Each ECT episode is assigned a patient categorisation which gives a general idea of the type of patient the episode was for. About half of episodes were categorised under the 'unwell adult' pathway, meaning a community-dwelling older patient who has become generally acutely unwell (49.7%). About a third of episodes were categorised as supporting a hospital discharge (29.0%), while the remainder were classified as 'acute disease management,' specifically managing a chronic condition (13.1%), those suffering a fall (with no injury) (6.8%) and a small proportion were classified as requiring care provision in the home (1.8%) or 'other' (0.2%). Episodes by patient categorisation over time can be seen in Figure 8.4. It be seen that the 'acute disease management' pathway was created from July 2017, hence these will have been categorised as 'unwell adult' prior to this date so cannot be distinguished.

Figure 8.4 – Total ECT episodes by patient categorisation over time

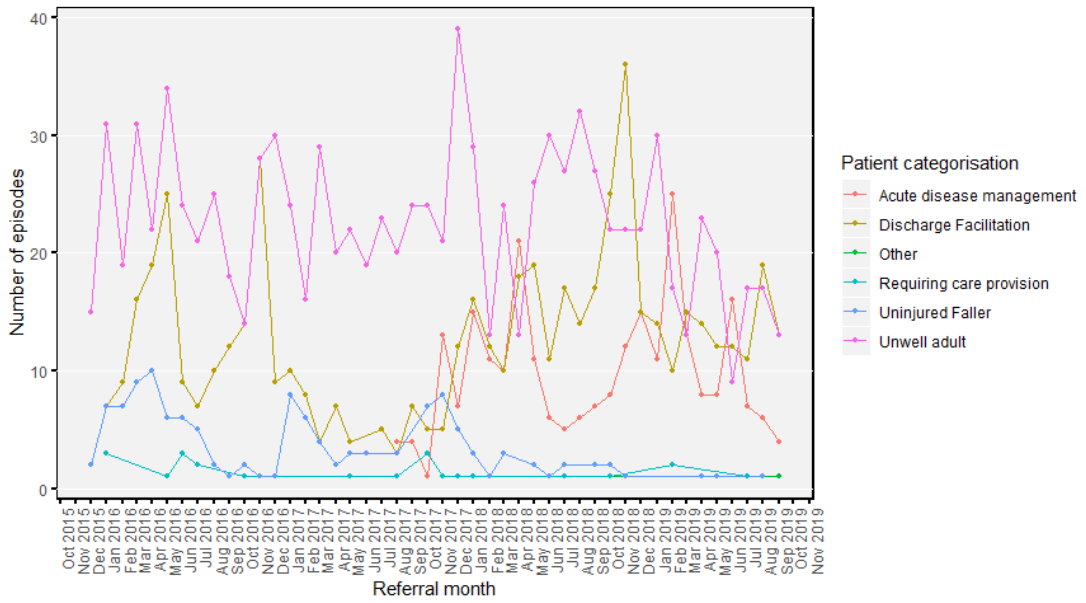


Table 8.5 displays the most frequent reasons for referral as recorded by ECT staff assessing the patients upon referral. A quarter of referrals indicated the facilitation of hospital discharge as the referral reason. The next most frequent reasons for referral were chest infection, urinary tract infection (UTI) and reduced mobility. These conditions help provide context for the types of patients and range of conditions that ECT treated.

Table 8.5 – List of observed ECT referral reasons ordered by frequency

Referral reason	Number of episodes	Percent of total episodes
Facilitate hospital discharge	489	24.3%
Chest infection	261	13.0%
UTI	239	11.9%
Reduced mobility	236	11.7%
Increased confusion	136	6.7%
Fall	118	5.9%
Increased falls	114	5.7%
Support early discharge	108	5.4%
Exacerbation of COPD	102	5.1%
Delirium	96	4.8%
Suspected UTI	92	4.6%
Requires POC / Crisis Care	81	4.0%
Increased shortness of breath	60	3.0%
Other infection	58	2.9%
Suspected chest infection	55	2.7%

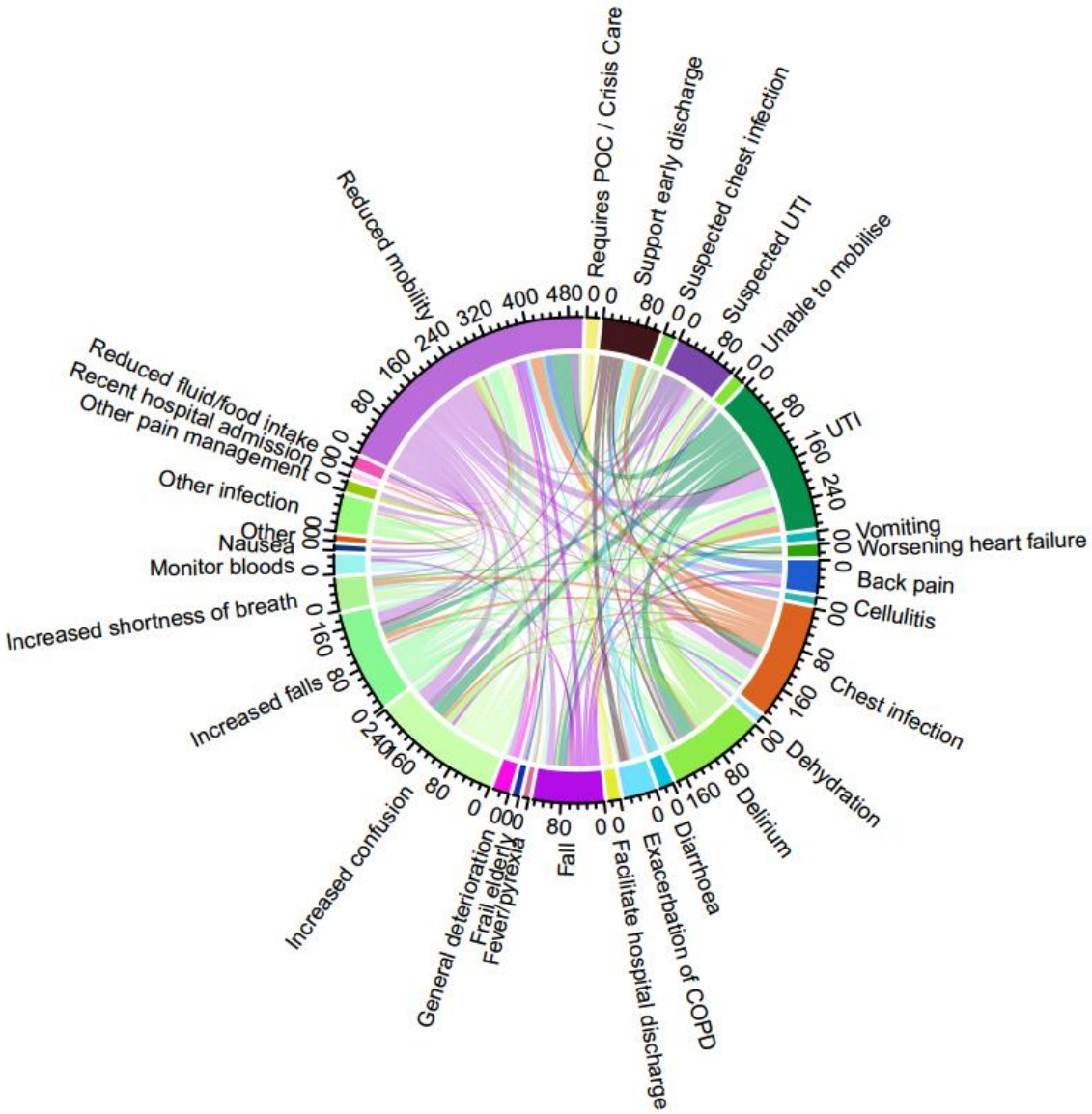
Referral reason	Number of episodes	Percent of total episodes
Worsening heart failure	49	2.4%
Other	48	2.4%
General deterioration	47	2.3%
Back pain	42	2.1%
Monitor bloods	33	1.6%
Vomiting	33	1.6%
Frail elderly	31	1.5%
Other pain management	30	1.5%
Diarrhoea	29	1.4%
Cellulitis	28	1.4%
Reduced fluid/food intake	28	1.4%
Unable to mobilise	26	1.3%
Dehydration	21	1.0%
Fever/pyrexia	21	1.0%
Dizziness/Lightheaded	19	0.9%
Assessment (ECT/REACH)	18	0.9%
Recent hospital admission	17	0.8%
Support/monitor fracture	17	0.8%
Nausea	16	0.8%
Exacerbation of other chronic illness	15	0.7%
Patient refusing/reluctant of hospital admission	15	0.7%
Acute Kidney Injury	13	0.6%
Monitor Atrial Fibrillation	12	0.6%
Pneumonia	11	0.5%
Constipated	10	0.5%
Cough	10	0.5%
Gastroenteritis	10	0.5%
Medications management	10	0.5%
Swollen limbs	10	0.5%
Unable to cope	10	0.5%
Palliative patient	9	0.4%
Decline in cognitive function	7	0.3%
Suspected TIA or stroke	7	0.3%
Carer stress	6	0.3%
Sepsis	6	0.3%
Continence care	5	0.2%
Flu	5	0.2%
Increased anxiety	5	0.2%

Referral reason	Number of episodes	Percent of total episodes
Self-neglect	3	0.1%
Depression	2	0.1%
Episode of unresponsiveness	2	0.1%
Falls risk	2	0.1%
Suspected pneumonia	2	0.1%
Tachycardia	2	0.1%
Assessment (Equipment)	1	0.0%

**ECT reason for referral was originally a free-text field. A standardised list of referral reasons was obtained through examination of the data and consultation with ECT members. Up to three referral reasons were extracted for each episode. Note that given each episode could have up to three referral reasons, the numbers indicate the number of individual episodes where each reason was observed. The sum of these numbers does not equate to the total number of episodes, and the percentages are the percent out of the total number of episodes hence do not add up.*

In order to better understand how these referral reasons interact, a chord diagram was created, displaying the frequency of referral reasons that appear together. The diagram can be seen in Figure 8.5. The diagram reveals, for example, that increased confusion, reduced mobility and delirium often present themselves alongside a UTI among ECT patients.

Figure 8.5 – Chord diagram indicating frequency of referral reasons appearing together within episodes



Note: This figure includes episodes with referral reasons that appear in conjunction with one or more other referral reasons. Episodes with only one referral reason are not included here. In addition, referral reasons appearing in conjunction with another referral reason for less than 5 episodes are excluded from this figure, to improve readability. The width of each chord indicates the number of episodes where the two referral reasons appear together. Note that each chord appears twice within the diagram, as the chords are one-directional (e.g. width of chord from 'Reduced mobility' to 'UTI' is equal to the width of the chord from 'UTI' to 'Reduced mobility'). The figure runs clockwise, hence, each tick mark indicates 20 episodes, as read clockwise.

The ECT service conducted 25,876 contacts between the 14th December 2015 to the 31st October 2019. On average, the ECT service conducted 19 contacts every day, including both direct and indirect contacts. Direct contacts are those where

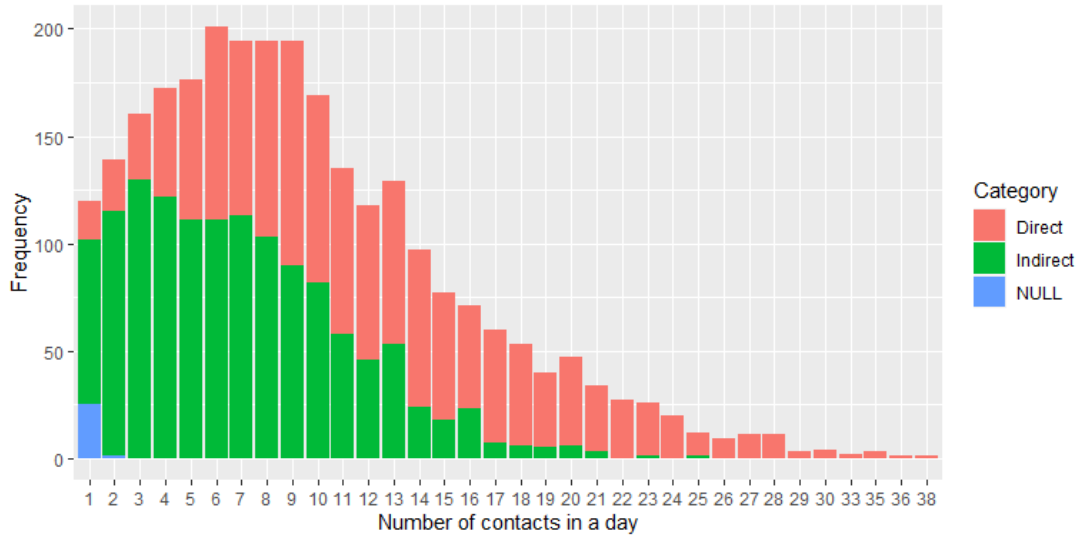
a direct contact was made with a patient whether by phone or in-person and indirect contacts are those where a contact was made about a patient or with a patient's relative but not directly with the patient. On average, the ECT service conducted 12 direct contacts and 7 indirect contacts per day. The following table displays summary statistics daily contacts conducted by ECT by category.

Table 8.6 – Summary statistics for daily ECT contacts by category

Statistic	Mean	Median	SD	Min	Max
Direct	12.2	11	6.4	1	38
Indirect	6.9	6	4.2	1	25
Unknown	1.0	1	0.2	1	2
All categories	18.7	18	9.0	1	51

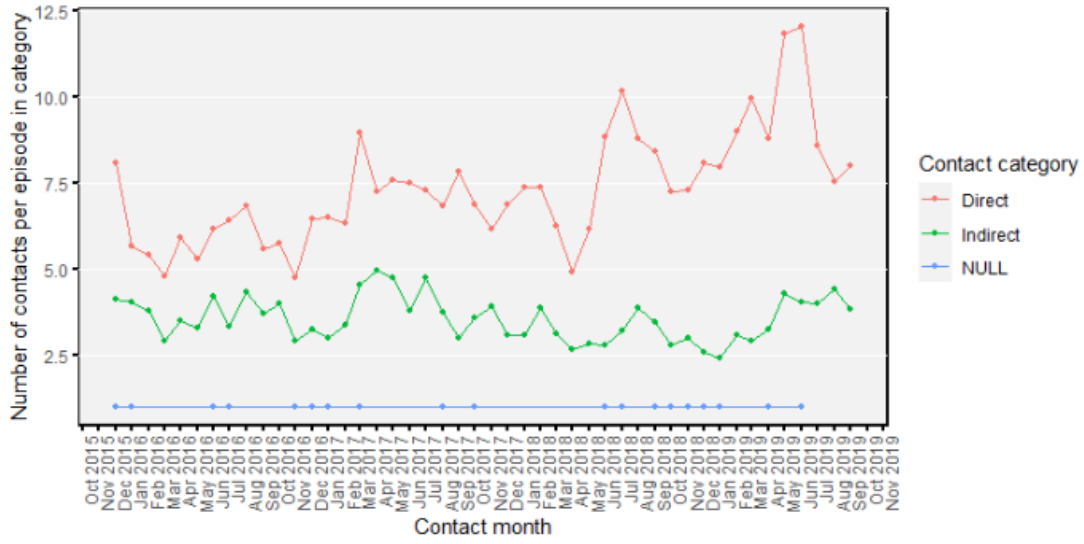
Figure 8.6 displays the frequency of numbers of contacts per day provided by the service. The most frequent number of contacts per day was six contacts per day for direct contacts and three indirect contacts per day.

Figure 8.6 – Histogram of daily ECT contacts by category



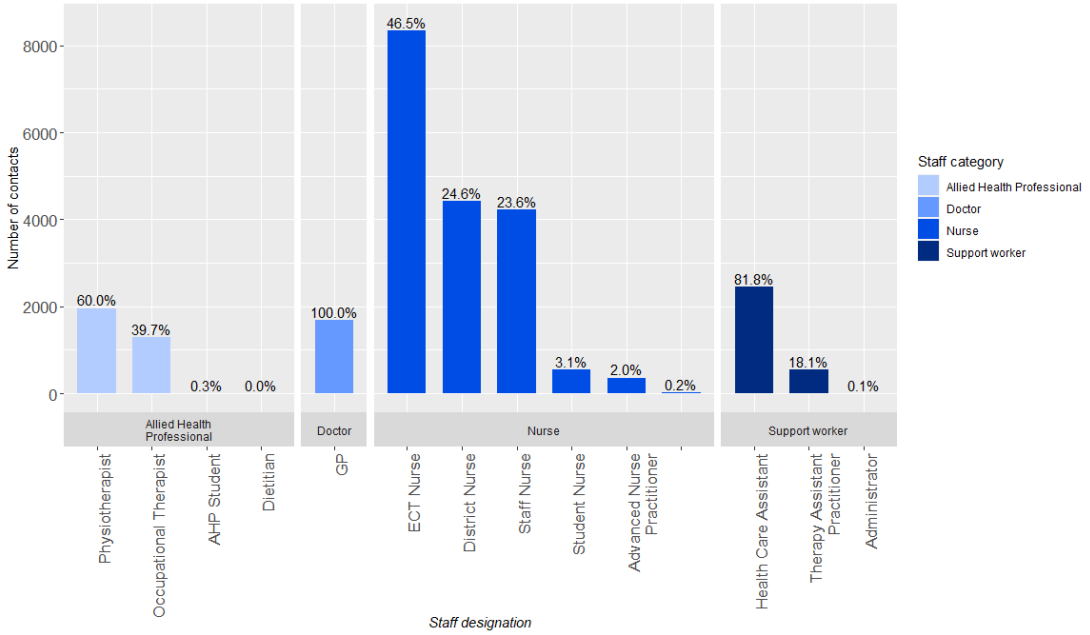
On average, patients received 9 direct contacts and 4 indirect contacts throughout their episode of care. Figure 8.7 displays the number of contacts per episode over time. It appears that the number of direct contacts per episode increased over time. This is most likely due to increased capacity and capability of the ECT team due to the introduction of the GP Fellows in January 2017 and introduction of dedicated health care assistants in early 2018.

Figure 8.7 – Number of contacts per episode by contact category over time



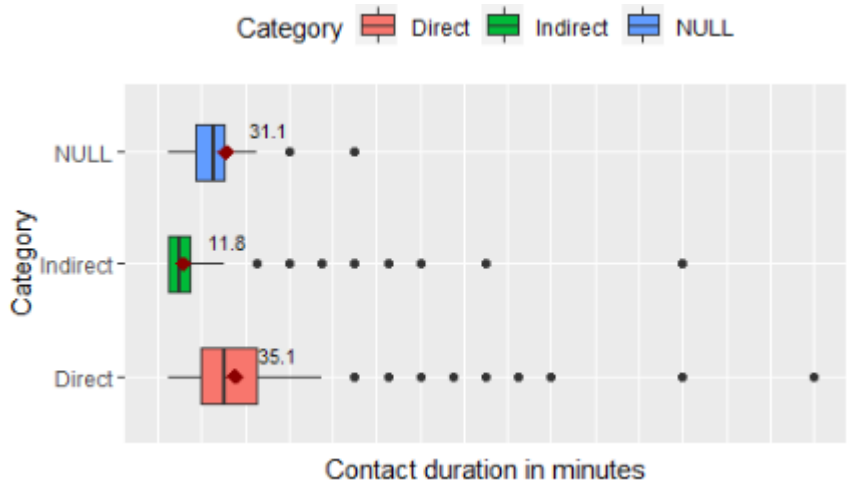
ECT contacts were primarily delivered by nurses (69.3%). Contacts were also delivered by allied health professionals (12.6%), support workers (11.6%) and GP fellows (6.5%). The figure below displays the numbers of contacts by staff designation in more detail.

Figure 8.8 – Number of ECT contacts by staff designation



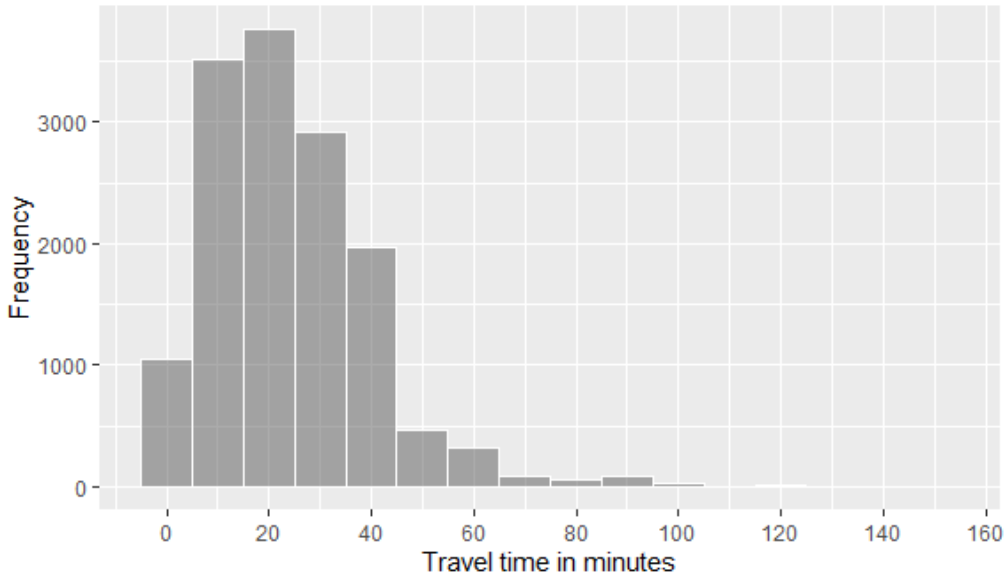
The average direct ECT contact took 35 minutes while indirect contacts took 12 minutes. A boxplot of the contact duration by category can be seen in the figure below.

Figure 8.9 - Boxplot of contact duration by category, displaying mean values



Of the total 25,876 contacts, 16,248 (i.e. 62.8%) were delivered face-to-face, where a travel time may have applied. Information about travel time was provided for 14,294 of these contacts (88.0%). Travel time was on average 26 minutes. However, ECT staff travelled up to two hours on several occasions to deliver care.

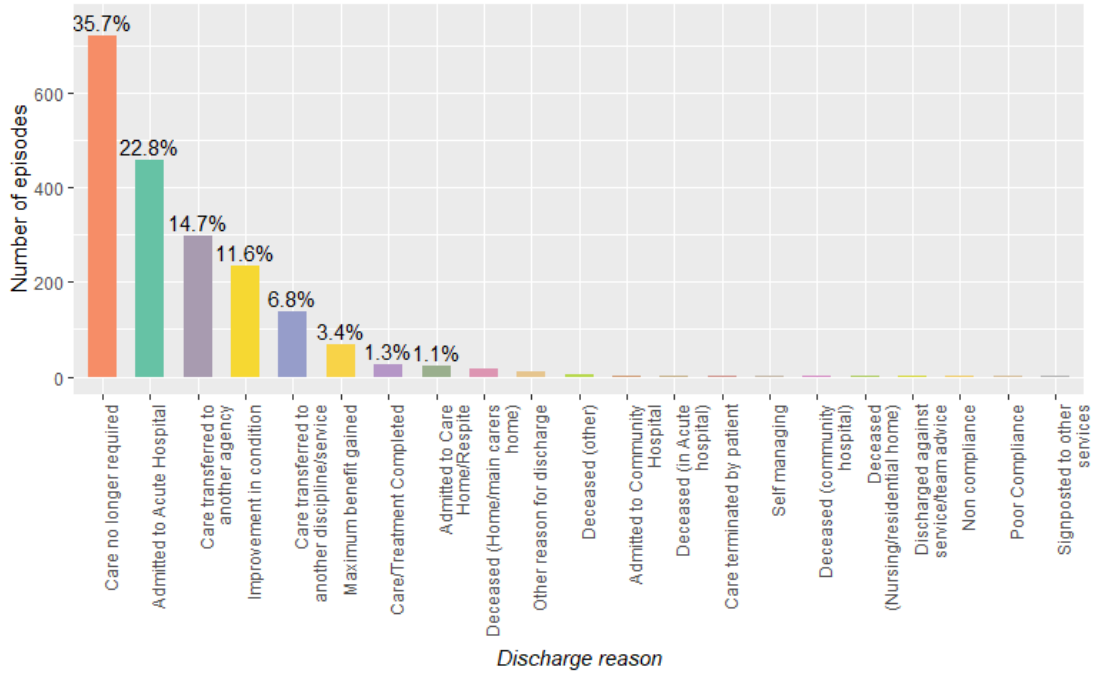
Figure 8.10 – Histogram of travel time to provide face-to-face direct contacts



Finally, to conclude the description of activity for the ECT service, a summary of the reason for discharge is presented. In about a third of ECT episodes, the discharge reason was provided as 'care no longer required,' meaning their input was successful allowing them to remain at home and the extra support is no longer required. However, in a significant proportion of episodes (22.8%), the patient was

admitted to the acute hospital following discharge from the ECT service. The figure below displays the number of episodes by discharge reason.

Figure 8.11 – Number of ECT episodes by discharge reason



8.3 'Advice Line for You' (ALFY)

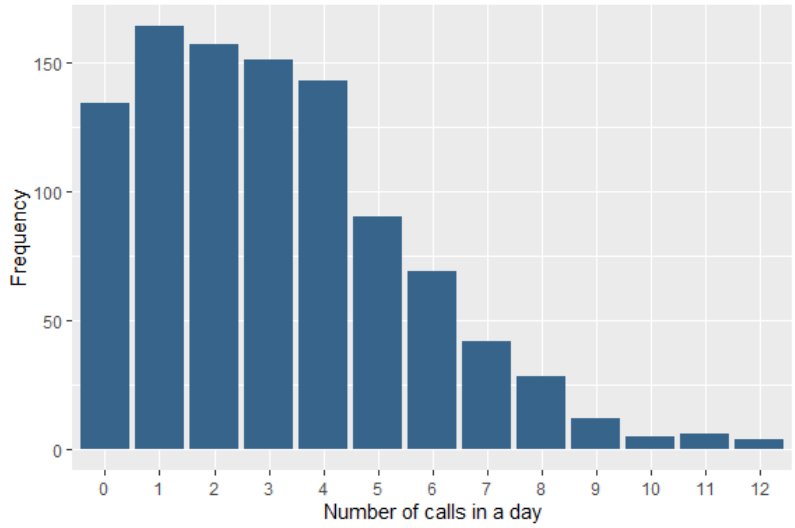
The ALFY service was operational from the 1st of December, 2015 until the 31st of August 2018. Service activity data was obtained and summarised for this period. There were 3,157 calls made to the ALFY line during its operational period. On average, the service received 96 monthly calls. This equated to about three calls daily on average.

Table 8.7 – Summary statistics of monthly and daily ALFY calls

Statistic	Mean	SD	Median	Min	Max
Monthly calls	95.67	23.03	88	67	146
Daily calls	3.14	2.42	3	0	12

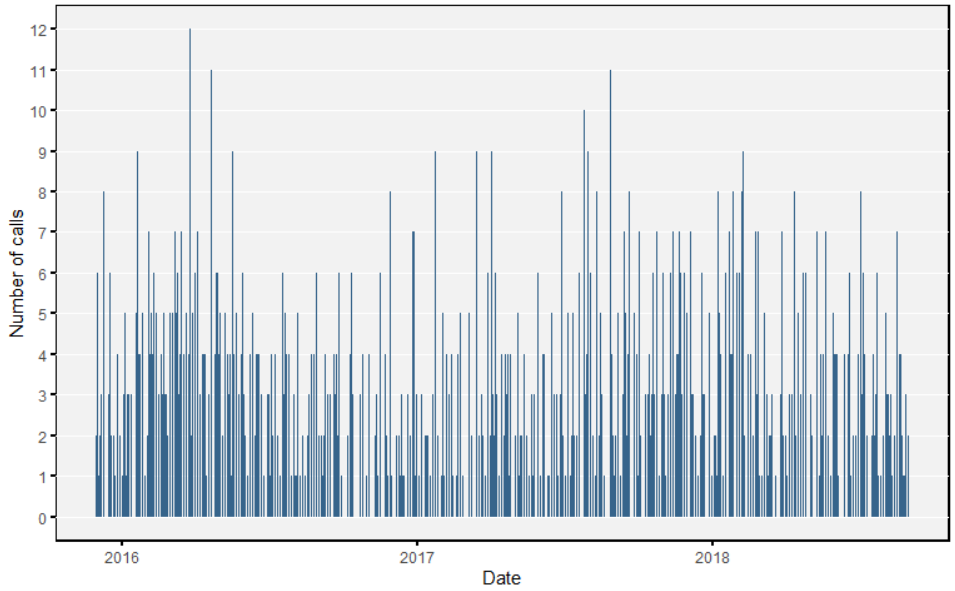
It was most common to receive between one to four calls daily, however there were more than 100 days of the service where no calls were received.

Figure 8.12 – Histogram of daily ALFY calls



The number of daily calls can be seen in the below figure.

Figure 8.13 – Total number of ALFY calls by day



Near the beginning of the ALFY service, a target group for the service was identified, comprising those aged 65 and over registered with a Forth Valley GP with a Scottish Patients at Risk of Admission or Readmission (SPARRA) score of at least 40% (i.e. are said to have a 2 in 5 chance of being admitted to hospital in the prediction year). The patients in the SPARRA list were targeted to be including in a mailing list to receive ALFY promotional materials (n=3,586 patients on the mailing list). It is helpful to view the activity of the service in light of the two categories of ALFY callers – those who were or were not on the mailing

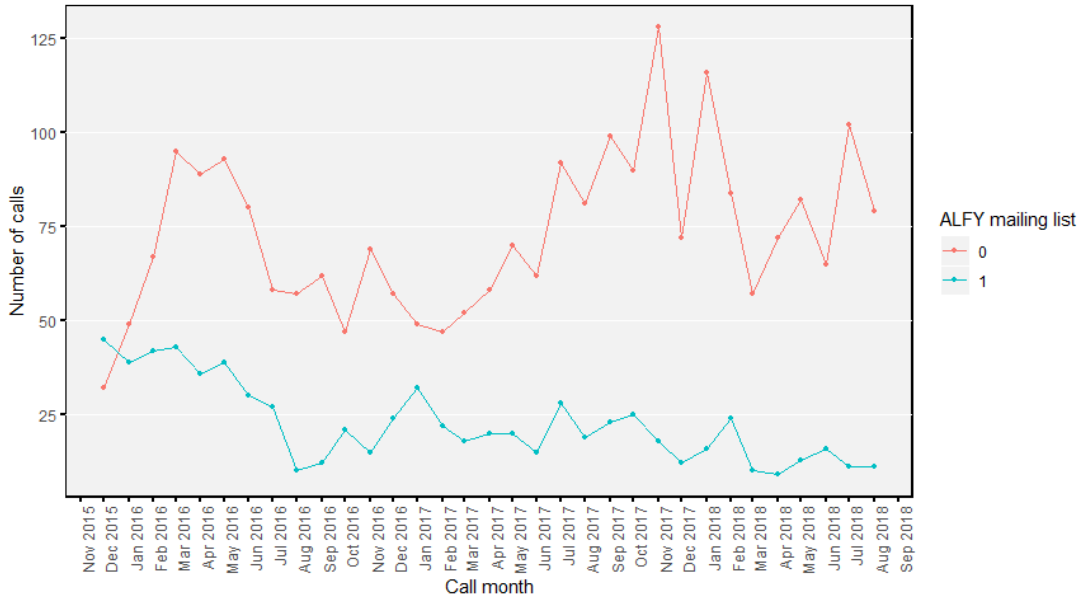
list. The vast majority of callers were not on the mailing list (N=1,536, 79.5%), indicating that the service may not have reached the target population to the extent they intended. In fact, of patients on the mailing list, just over 10% made a call to the service (n=396). Overall, patients on the mailing list (with higher SPARRA scores) made more calls on average than those not on the mailing list.

Figure 8.14 – Number of ALFY calls by whether the caller was or was not on the mailing list

Patient on mailing list	Number of calls	% of calls	Calls per patient
Yes (N=396)	745	23.6%	1.88
No (N=1536)	2412	76.4%	1.57

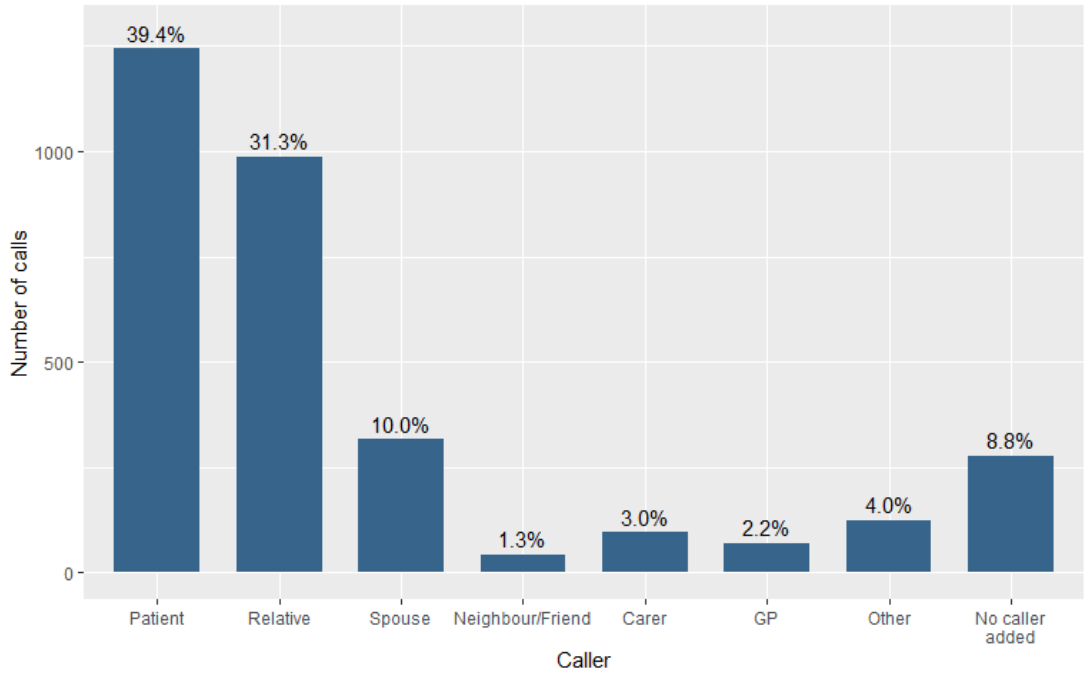
Viewing service activity in light of these two categories may be helpful. Figure 8.15 displays monthly ALFY calls by this categorisation, revealing increased activity for patients on the mailing list near the beginning of the service when the service was promoted to them. Further efforts were made to promote the service throughout its lifetime to the general public, for example, promotional materials on service vehicles, radio interviews and press releases in 2017, which is reflected in the increased activity around that time.

Figure 8.15 – Number of monthly ALFY calls by whether the caller was on the ALFY mailing list or not



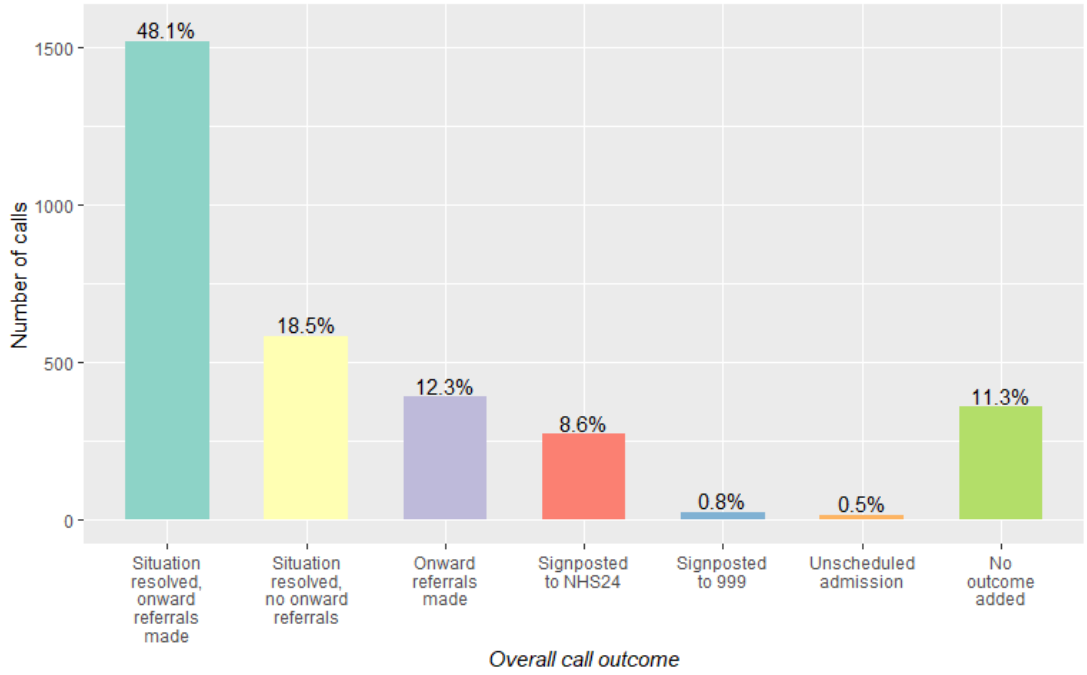
Just over a third of calls came from patients themselves, about a third came from relatives of patients and a tenth came from their spouse. The remaining callers included neighbours or friends, carers or GPs. The total numbers of calls by caller can be seen in the following figure.

Figure 8.16 – Total ALFY calls by caller



Calls to the ALFY service most often resulted in the situation being resolved and onward referrals to other services being made (48.1%). The full distribution of calls by overall call outcome can be seen in the below figure.

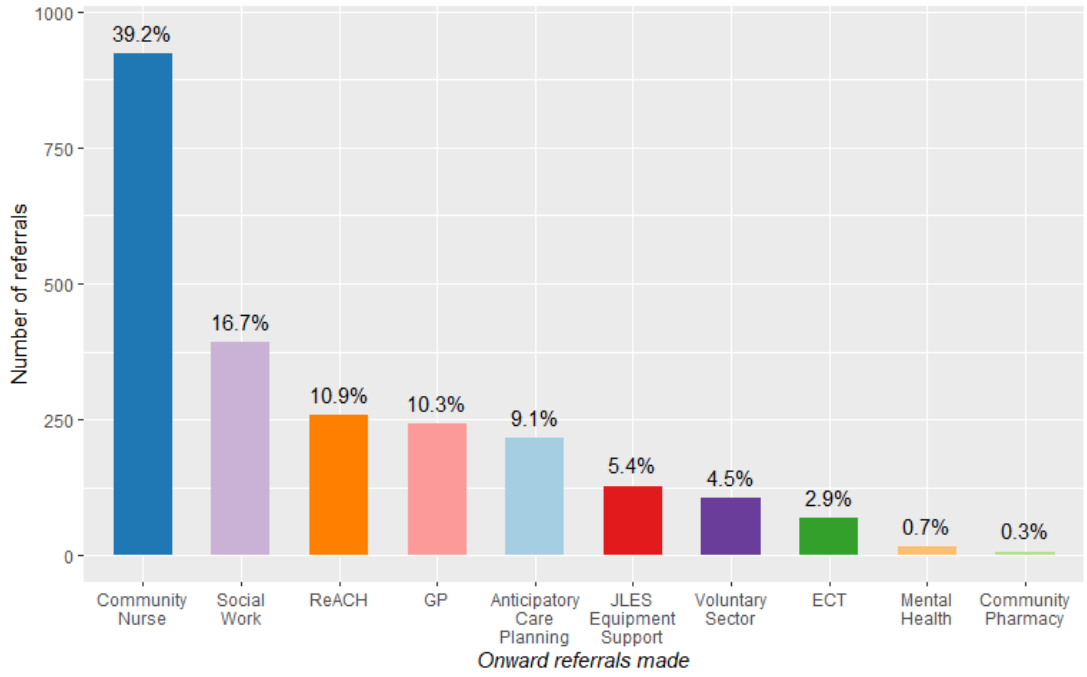
Figure 8.17 – Total ALFY calls by overall call outcome



Onward referrals were made to a variety of different services, the most common being community nursing. A small number of calls (N=68) resulted in referral to

the ECT. The total number of referrals made as a result of ALFY calls can be seen in the figure below.

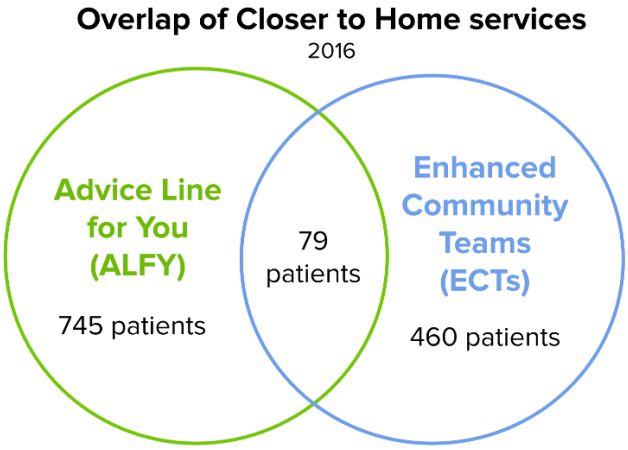
Figure 8.18 – Total numbers of referrals made as a result of ALFY calls

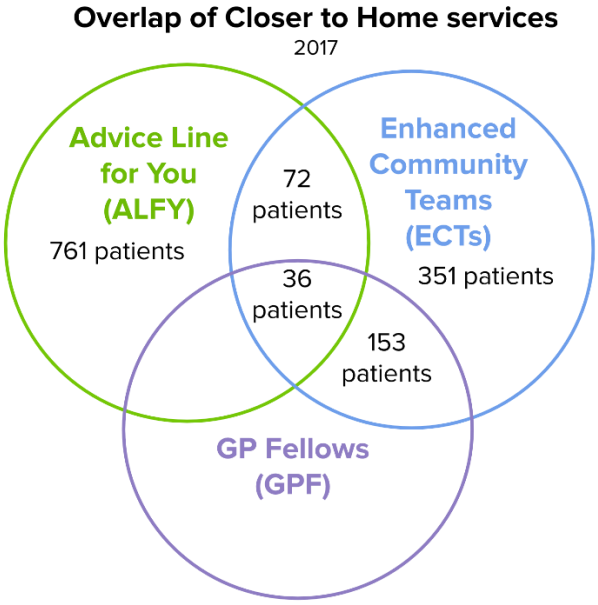


8.4 Overlap of these main services

Following the exploratory and process mapping phase of this research (presented in Chapter 4), it became clear that the three main services of 'Closer to Home' are interlinked. In 2016, the first year of the 'Closer to Home' services, 745 patients used the ALFY service and 460 patients used the ECT service. Of these, 79 patients used both the ALFY and ECT services. Figure 8.19 displays this overlap.

Figure 8.19 – Venn diagram showing overlap of 'Closer to Home' main components in 2016 and 2017





8.5 Discussion and conclusion

This chapter aimed to describe the service activity of the 'Closer to Home' programme. Describing its activity contributes towards gaining a greater understanding of the context of the programme.

It was not possible to determine the exact extent of the reach and adoption of the 'Closer to Home' programme, as the number of eligible patients who did not receive the services was not specifically tracked and cannot easily be determined. However, examining the routine levels of activity of the service can give us some idea of the level of reach of the services.

The ECT service received 47 referrals which met their criteria per month on average, 44 of which were considered true ECT episodes (i.e. those that were accepted, met the criteria upon investigation or visit, and continued on to be a part of the ECT caseload). On average, the ECT service conducted 12 contacts directly with patients and 7 indirect contacts every day. Given these levels of activity, and given that in Forth Valley, hospitalisation rates were around 1,069 admissions per month for patients over 65, it appears that the reach of the ECT was limited. Given the relatively small size of the service, limited capacity is expected, however, these figures give us some indication of its reach, which appears comparatively small.

The ALFY service received around 96 calls per month, equating to about three calls a day. These figures reveal a clearly underutilised service. This analysis of

activity also identified that though promotional materials about the service were sent to three and a half thousand patients over 65 at increased risk of admission (based on SPARRA score), only about 10% actually went on to use the service. Most of the callers to the service were not on the target mailing list, indicating the service did not particularly reach the intended patient group.

In summary, this chapter has provided a brief overview of the service activity, of the 'Closer to Home' programme, providing some context for its level of reach. Some insight into referral sources, types of conditions treated, and some of the outcomes achieved were also presented which serve as helpful context around the operational structures and processes of the services. The analysis presented in this chapter formed part of Phase IV of this research, to describe the service activity, contributing towards the first research question (*"RQ1. What were the structures and operational processes of the 'Closer to Home' programme?").*

Chapter 9 Quantitative Analysis and Results

9.1 Introduction

The fifth phase of this research involved a quantitative evaluation of the effects of 'Closer to Home' interventions on hospital activity outcomes. As described in Chapter 2 ('Methodological approach'), the quantitative evaluation involved three comparative studies of the effect on hospital activity of each of the three individual components of the 'Closer to Home' programme. The main aims of this phase were to:

1. Assess the effect of each 'Closer to Home' intervention on hospital activity outcomes – namely emergency inpatient hospitalisation, emergency department attendance and emergency inpatient length of stay – appropriately accounting for confounding
2. Examine the characteristics of the full study population, highlighting key differences
3. Identify potential confounders for consideration in any analysis

The results of the fifth phase of this research including the quantitative results of the analyses assessing the effects of each 'Closer to Home' intervention, each of which had differing designs and analysis, will be presented in this chapter.

9.2 Methods

9.2.1 Study design

As described in 0, the retrospective cohort study design was selected, where the cohort is selected based on exposure to some treatment or intervention. Here, patients were selected based on exposure or non-exposure to 'Closer to Home' interventions. Control group selection and definition for this research was discussed in 0, Section 6.3.3. Three separate studies were conducted for each of the 'Closer to Home' interventions and are presented in Section 9.5. The three studies are described as follows, including their study group definitions:

1. **Effect of the Enhanced Community Team (ECT) on hospital activity outcomes**

- *Intervention group:* Patients receiving ECT between 1st January 2016 - 31st March 2019
- *Comparator group:* Concurrent group of patients from the Forth Valley elderly population matched on selected characteristics determined by confounder identification (two matching approaches are used, rolling entry direct covariate matching and rolling entry propensity score matching, based on the narrative methodological review in 0)

2. **Effect of the GP Fellows as an enhancement to ECT on hospital activity outcomes**
    - *Intervention group:* Patients receiving ECT care between 1st January 2017 - 31st December 2017 (after GP Fellows were introduced)
    - *Comparator group:* Patients receiving ECT care between 1st January 2016 - 31st December 2016 (before GP Fellows were introduced)
3. **Effect of the Advice Line for You (ALFY) on hospital activity outcomes**
    - *Intervention group:* Patients calling ALFY between 1st January 2016 - 1st October 2018
    - *Comparator group:* Concurrent group of patients eligible for ALFY (identified as high risk with SPARRA ≥40 who were sent ALFY promotional materials at service launch) who did not call ALFY (ALFY mailing list patients)

9.2.1.1 Matching approach for comparison group selection in study of ECT

Given that there was no previously defined comparison group for patients receiving ECT, such as a previously identified target group or eligible group as there were in the GP Fellows and ALFY study designs, matching was considered a suitable alternative method to identify a comparison group. As described in 0 the rolling entry matching approach enables the selection of comparison groups that are matched on characteristics that change over time (time-dependent covariates) and is particularly suited to healthcare interventions where treated subjects enter on a rolling basis and where patients experience sudden

deterioration from acute events leading to their receipt of the interventions (Pimentel et al., 2019). In practice, this involved matching time periods in addition to covariates.

As previously described in 0, Section 6.4, a range of matching strategies and more than one matching approach should be employed when using matching for comparison group selection. Two matching approaches were used – direct covariate matching and propensity score matching.

9.2.1.1.1 Direct covariate matching

In the direct covariate matching cohort each intervention patient was matched to one comparison group patient on six variables – namely age, comorbidity (Charlson score), risk of admission (SPARRA), whether they had lived alone, whether they received a community physical function assessment and prior emergency hospitalisation. These variables were selected through empirical variable selection, presented in Section 9.5.1.2 (the variable selection methodology is described in Section 9.2.3).

A matching ratio of one control to one treated patient, using matching without replacement was employed. This was to reduce the numbers of intervention patients being dropped from the sample due to inability to find matches (for example if matching ratios are high). As described in 0, Section 6.4 having too many unmatched subjects leads to bias if they are kept in the analysis as the matched comparison group sample become less comparable to the intervention group but dropping them also leads to bias as the full treated sample becomes less representative of the whole.

9.2.1.1.2 Propensity score matching

For the propensity score matching cohort, 24 covariates were included in a model calculating a propensity score for each patient and a matching ratio of one intervention patient to three controls was selected. The matching variables were selected through empirical variable selection, presented in Section 9.5.1.2 (the variable selection methodology is described in Section 9.2.3). Propensity score matching provides more flexibility than direct covariate matching hence different matching ratios were explored and varying levels of calipers (*alpha* values determining the acceptable level of proximity in propensity scores, which are defined as some proportion of the standard deviation of the propensity score, see 0, Section 6.4.3.2 for more details) were used. The matching ratio and measure of

closeness (caliper) for propensity score matching was selected following a comparison of various matching ratios and calipers, described in Sections 9.5.1.2 and 9.5.1.3, with the aim of achieving an optimum balance of similarity of the groups and again, minimising the number of unmatched subjects.

9.2.2 Statistical models and outcome measures

Three main hospital activity measures were assessed in each of the three analyses: emergency inpatient hospitalisation, emergency department attendance and emergency inpatient length of stay. Table 9.1 summarises the specific outcome measures and statistical analysis conducted to assess each outcome measure for each of the three studies assessing the effect of 'Closer to Home' on hospital activity.

Table 9.1 – Specific outcome measures and statistical analysis for each study

Study	Outcome measure	Statistical analysis
1. Effect of the ECT intervention*	*Emergency inpatient hospitalisation (yes/no) within 30 days of referral to ECT (or assigned dummy referral date for matched patients)*	Multivariable conditional logistic regression (accounts for matching)
	Emergency department attendance (yes/no) within 30 days of referral to ECT (or assigned dummy referral date for matched patients)	
	Time-varying effect on emergency inpatient hospitalisation (yes/no) throughout follow-up	Multiple-failure, Cox multivariable proportional hazards regression (Cox extension Anderson and Gill model) with robust variance estimator to account for matching
	Time-varying effect on emergency department attendance (yes/no) throughout follow-up	
	Time to discharge from emergency inpatient hospitalisations (to assess length of stay) following referral to ECT (or assigned dummy referral date for matched patients)	
2. Effect of the enhanced ECT (GP Fellows addition)	*Emergency inpatient hospitalisation (yes/no) within 30 days of referral to ECT*	Multivariable logistic regression
	Emergency department attendance (yes/no) within 30 days of referral to ECT	
	Time-varying effect on emergency inpatient hospitalisation (yes/no) throughout follow-up	Multiple-failure Cox multivariable proportional hazards regression (Cox extension Anderson and Gill model
	Time-varying effect on emergency department attendance (yes/no) throughout follow-up	
	Time to discharge from emergency inpatient hospitalisations (to assess length of stay) following referral to ECT	

3. Effect of the ALFY intervention	*Time-varying effect on emergency inpatient hospitalisation (yes/no) throughout follow-up*	Multiple-failure Cox multivariable proportional hazards regression (Cox extension Anderson and Gill model
	Time-varying effect on emergency department attendance (yes/no) throughout follow-up	
	Time to discharge from emergency inpatient hospitalisations (to assess length of stay) following referral to ECT	

**Note: For the analyses assessing the effect of ECT intervention on outcomes measured within a set time frame (e.g. within 30 days of referral in logistic regression), the index date was the ECT referral date for intervention patients, which was assigned to matched comparison group patients as their dummy referral date*

Chapter 6 included a thorough review of statistical models that could be used to assess the intervention effect in this research. Multivariable logistic regression and multivariable Cox proportional hazards regression were identified as techniques that can suitably model the outcome and account for the effects of confounding as described in Chapter 6, Section 6.5. Multivariable logistic regression models for assessing the effect of binary events in single time frames (i.e. experiencing an emergency inpatient hospitalisation or emergency department attendance within 30 days of referral) and multiple-failure Cox extension models (specifically the Anderson and Gill model) to include time-varying effects both to assess recurrent events (i.e. assessing the hazard of emergency inpatient hospitalisation, emergency department attendance throughout follow-up) and to analyse survival (hazard of discharge from emergency inpatient admission following referral to ECT to assess length of stay throughout follow-up). Where matched cohorts were used, appropriate modifications were made to the respective models (e.g. conditional logistic regression and robust variance estimators in Cox models).

9.2.3 Confounder identification and multivariable model selection

A combined approach of determining an initial set of candidate variables followed by empirical variable selection was used to identify potential confounders which were either used as matching variables or used as variables for adjustment in statistical models. The process for determining a set of initial candidates and the results are presented in Section 9.3. The initial set of candidates was then used in empirical variable selection of confounders included as matching variables or

model adjustment variables, within each analysis, hence will be presented within the corresponding results (Section 9.5).

Empirical variable selection for identifying both matching variables and multivariable model adjustment variables was conducted using best subset exhaustive search (exhaustive selection uses a branch-and-bound algorithm, computing the residual sum of squares for all possible regressions based on Furnival and Wilson (Furnival and Wilson, 2000)). Although other perhaps simpler variable selection methods are available such as stepwise selection, these do not consider all combinations of potential predictors and their pitfalls have been discussed in literature (Smith, 2018). Best subset selection finds the best subset of predictors that produces the best fit in terms of squared error, considering all possible combinations, while stepwise selection iteratively adds or removes a variable that best improves the fit without considering all combinations. Best subset selection has been found to outperform or at least perform as well other variable selection methods in simulations (Hastie, Tibshirani and Tibshirani, 2020) and has been shown to outperform other methods specifically for variable selection in Cox proportional hazards models (Petersson and Sehlstedt, 2018). Most attractive is the ability to select a subset of the most predictive variables, including capability to limit the maximum variables included, for identifying the most significant confounders for adjustment or matching variables.

The Bayesian information criteria (BIC) was used as the metric for subset model selection, selecting the subset of variables that minimised the BIC. Other metrics are available (e.g. adjusted R-squared and Mallows CP), however BIC has a stronger penalty for additional variables which aligns with the aim of finding the main confounders for adjustment.

9.2.4 Assessment of covariate balance between treated and untreated subjects

The standardised mean difference (SMD) (also referred to as standardised bias in literature), is a preferred measure for assessing covariate balance, particularly used in matched studies (Austin, 2011a; Palesch, 2014). The SMD is generically defined as the difference in means of the covariate between treated and untreated groups divided by the standard deviation of one of the treatment groups or of the

full sample (Harder, Stuart and Anthony, 2010). Unlike p-values in significance testing, SMDs are not influenced by sample size and enable comparison of variables in different units (Austin, 2011a). SMDs will be reported here when assessing covariate balance between groups, which is defined as:

$$SMD = \frac{Difference\ in\ covariate\ means\ between\ groups}{Standard\ deviation\ of\ covariate\ among\ subjects}$$

The specific definition of the SMD for continuous and dichotomous variables can be found in Appendix D. A SMD of less than 0.1 is considered to indicate a negligible difference in mean or prevalence of covariates, hence an SMD greater than 0.1 indicates important covariate imbalance (Austin, 2011a).

Researchers have advised against using hypothesis testing in assessing baseline differences, partly due to the sample size dependency but also due to indicating statistical but not clinical significance or relevance (Palesch, 2014). Hence it is advised that the researcher's knowledge and judgement should be used rather than p-values in isolation to assess clinical significance of baseline differences and the same could be said about using SMDs, hence the researcher's knowledge and judgement will also be used in identifying covariates with important imbalances that require adjustment in the analysis.

9.2.5 Assessing model validity

As with all statistical models, it is important to test whether they are appropriate and suitable for modelling the study data and to test whether underlying assumptions are met so that correct interpretations can be made. The Cox proportional-hazards model has three main checks required to ensure the results from the model are valid and for correct interpretation (Xue and Schifano, 2017):

1. Is the proportional hazards assumption satisfied?
2. Are the functional forms of the variables appropriate?
3. Are there any outliers or influential observations?

The first check regards the fundamental assumption made by the Cox model that hazard ratios do not depend on time i.e. the ratio of the hazards for any two individuals remain constant over time (proportional). This should be true for each covariate, hence each covariate should have a multiplicative effect on the hazard function, which should be constant over time (Xue et al., 2013). Proportional hazards are considered the primary concern to analysts when fitting a Cox model

(Keele, 2010) and is seen as essential towards correct interpretation of hazard ratios generated from a Cox model (Barraclough, Simms and Govindan, 2011).

Though it was previously claimed that the proportional hazards assumption is very often reasonable (Tibshirani, 1982), it has been recently highlighted that in practice, hazard ratios are not constant over time for most medical interventions (Stensrud and Hernán, 2020). Hazards may not be proportional because treatment effect can change over time or because individuals with greater disease susceptibility are more likely to develop the disease earlier, for example (Stensrud and Hernán, 2020). This is likely to apply to healthcare interventions also. In addition, in practice, small sample sizes may mean tests of proportional hazards lack power to detect deviations from proportional hazards or large sample sizes can cause small deviations to appear statistically significant (Rulli et al., 2018).

The power of statistical tests for detecting violations of the proportional hazards assumption depends on the correct specification of the model (Keele, 2010).

The implications of a violation of the proportional hazards assumption in practice are primarily on the interpretation of the hazard ratio estimates. In a Cox model where hazards are proportional, the hazard ratio can be interpreted as a constant hazard at all times over the follow-up period, but where the proportional hazards assumption is not met, it needs to be interpreted as the weighted average of the true hazard ratio over the follow-up period (Stensrud and Hernán, 2020).

9.2.6 Statistical software used and important packages/functions

The software selected for statistical analysis in this research was R (version 4.0.1) (R Core Team, 2020). It is widely recognised as a powerful and versatile tool for statistical analysis and visualisation, in the form of a programming language. This section will highlights some of the important R packages and functions used for this research along with any specifications of note.

Both rolling entry matching (defined in 0, Section 6.4) and time-dependent multivariable regression models (defined in 0, Section 6.5) (specifically Cox models) rely on data that is in a 'counting process' format (Jones et al., 2019; Westbury et al., 2016). Rolling entry matching requires data divided into set time intervals and given that time-varying covariates were recorded monthly, and that activity surrounding exposure to the intervention changed significantly in each

month preceding exposure to the 'Closer to Home' interventions, the 'counting process' dataset was divided into monthly intervals. Cox models require data divided into one record-per-interval between each event time, per patient, with data on covariates and exposure available at each interval (Thomas and Reyes, 2014).

Figure 9.1 displays an example of dummy longitudinal data in the 'counting process' format of data that was used in the analysis. Each row represents an interval of time in an individual's follow-up, where a new row is generated where there is a change in time-dependent treatment. In this example, patients are followed for 100 days. Intervention patients have multiple rows corresponding in a change in their receipt of intervention (trt_status) corresponding to the time at which they received it. Covariates are included for each row including time-dependent covariates (age in this example) as well as an indicator of event of death or event of a hospitalisation ('event'). Patient #7, for example, received the intervention on day 18 until day 42 but they died on day 55.

Figure 9.1 – Example of 'counting process' format data

id	tstart	tstop	trt_status	time_id	group	gender	age	death	event
1	0	28	0	1	intervention	female	67	0	0
1	29	62	1	2	intervention	female	68	0	0
1	63	100	0	3	intervention	female	68	0	1
2	0	100	0	1	comparison	male	62	0	0
3	0	82	0	1	comparison	female	89	1	0
4	0	100	0	1	comparison	male	78	0	1
5	0	100	0	1	comparison	female	77	0	0
6	0	97	0	1	comparison	male	81	1	1
7	0	17	0	1	intervention	male	73	0	0
7	18	42	1	2	intervention	male	73	0	0
7	43	55	0	3	intervention	male	74	1	1
8	0	100	0	1	comparison	female	91	0	0

The R function 'sqldf()' within the 'sqldf' package (Grothendieck, 2017), which enables the use of SQL queries to select and structure data was used to structure the data in this way.

As previously discussed in 0, rolling entry matching is a relatively new development. The 'rollmatch' R package was developed specifically for rolling entry matching in the context of healthcare interventions with staggered/rolling entry (Jones et al., 2019). The 'rollmatch' package was used to process and prepare the data for rolling entry matching and to conduct PSM, while the 'Matching' package (Sekhon, 2011) was used to conduct direct covariate matching.

The R package 'survival' was used for the analysis (Therneau, 2020). The package is widely used in literature, with several papers detailing specific commands used for specific analyses. One such paper that details R commands for different types of time-dependent Cox models which aided this analysis is a paper by Westbury and colleagues (2016). For empirical variable selection of confounders, the R function 'regsubsets()' in the 'leaps' package was used (Lumley, 2020).

9.3 Confounder identification

As described in 0, Section 6.6, a combined approach to covariate adjustment involving the selection of a set of a priori variables based on the researcher's knowledge of causal relationships followed by empirical selection methods for the final selection of adjustment variables. To obtain a set of a priori variables, potential confounders are identified from literature and a causal diagram is presented based on partial knowledge of the causal pathways for use in this combined approach.

9.3.1 Identifying potential confounders from literature

In identifying potential confounders, previous literature can provide a good starting point and help to ensure all confounders are considered and not just those for which data is available. Three main systematic reviews were identified for identifying potential confounders predictive of the outcome:

- a systematic review of 23 studies investigating the association between geriatric syndromes and hospitalisation (including ED visit or readmission) (Wang et al., 2013) (note the original review included a total of 47 studies, also considering nursing home admission, hence the 23 studies considering hospitalisation were considered here) (aged ≥65)
- a systematic review of 12 validated instruments for identifying community-dwelling older adults at risk of hospitalisation, ED visit or readmission (aged ≥50) (O'Caoimh et al., 2015)
- a systematic review of 12 studies identifying risk factors for hospital readmissions in elderly patients (aged ≥75)

In addition, the scoping review for this research reviewed methods employed by similar studies measuring the effect of admission avoidance home visiting programmes. Matching strategies and statistical adjustment are both ways to reduce the effect of potential confounders on the analysis. The scoping review took note of variables that were used for these purposes in the included studies, indicative that they were considered to be potential confounders. These may also

offer guidance towards identifying potential confounders in this analysis, hence these have been included for consideration.

Based on these systematic reviews and scoping review conducted for this research, the following potential confounding factors presented in Table 9.2 were identified, providing guidance towards identifying potential confounders for this research. These factors will be initially used to develop a causal diagram of the causal relationship between potential confounders and exposure and outcome.

Table 9.2 – Potential confounding factors identified from systematic reviews identifying predictors of hospitalisation, ED visits or readmissions in elderly patients and from the scoping review conducted for this research

Risk factor	**Systematic review of the association between geriatric syndromes and hospitalisation (including ED visit or readmission) (≥65)** (Wang et al., 2013) **(n=23)**	**Systematic review of validated instruments for identifying community-dwelling older adults at risk of hospitalisation (including ED visit or readmission) (≥50)** (O'Caoimh et al., 2015) **(n=12)**	**Systematic review of risk factors for hospital readmission among elderly patients (≥75)** (García-Pérez et al., 2011) **(n=12)**	**Confounders identified by studies measuring effect of admission avoidance home visiting included in scoping review conducted for this research (n=22)**
Socio-demographic factors				
Age	✓ N=8*	✓ N=2	✓ N=1	✓ N=2[M],7[A]
Sex	✓ N=7*	✓ N=2	✓ N=1	✓ N=2[M],8[A]
Marital status	✓ N=1*	✓ N=1	✓ N=2	
Home or family support including living alone	✓ N=2*	✓ N=4	✓ N=3	✓ N=3[A]
Patient or caregiver quality of life		✓ N=2	✓ N=2	
Socioeconomic group or proxy measure	✓ N=1*	✓ N=1	✓ N=1	✓ N=1[A]
Lives in rural area	✓ N=1*			
Smoking			✓ N=1	
Ethnicity	✓ N=3*			
Caregiver factors including health				✓ N=2[A]
Healthcare utilisation factors				
Prior hospitalisation	✓ N=9*	✓ N=7	✓ N=4	
Prior length of hospital or rehabilitation stay				✓ N=2[A]
Prior ED visits	✓ N=1*	✓ N=2		
Prior primary care visits	✓ N=4*	✓ N=1		
Prior use of home care services		✓ N=1		
Nursing home residency	✓ N=1*			
Undergoing treatment	✓ N=1*	✓ N=1		
Medical and health related factors				
Self-reported health	✓ N=7*	✓ N=7		
Overall diagnosis group (e.g. HRG)				✓ N=2[M],2[A]

Specific medical diagnoses[1,2,3] (excluding dementia)	✓ N=4*	✓ N=9	✓ N=5	
Multimorbidity (including chronic disease or geriatric syndrome counts, Charlson index and APACHE II) or disease severity	✓ N=4		✓ N=4	✓ N=2[A]
Frailty	✓ N=6			✓ N=1[M]
Cognitive issues or impairment (including dementia)	✓ N=4	✓ N=6		✓ N=1[M],3[A]
Functional disability or dependency	✓ N=10	✓ N=8	✓ N=5	✓ N=1[M],6[A]
Malnutrition	✓ N=1*			
Weight loss	✓ N=1	✓ N=2		
Continence		✓ N=2	✓ N=1	
Prior falls		✓ N=1		
Polypharmacy (multiple measures used)	✓ N=2	✓ N=1	✓ N=2	✓ N=1
Prescribed specific medications		✓ N=1		
Laboratory findings		✓ N=2		
Clinical measurements (oxygen saturation)				✓ N=1

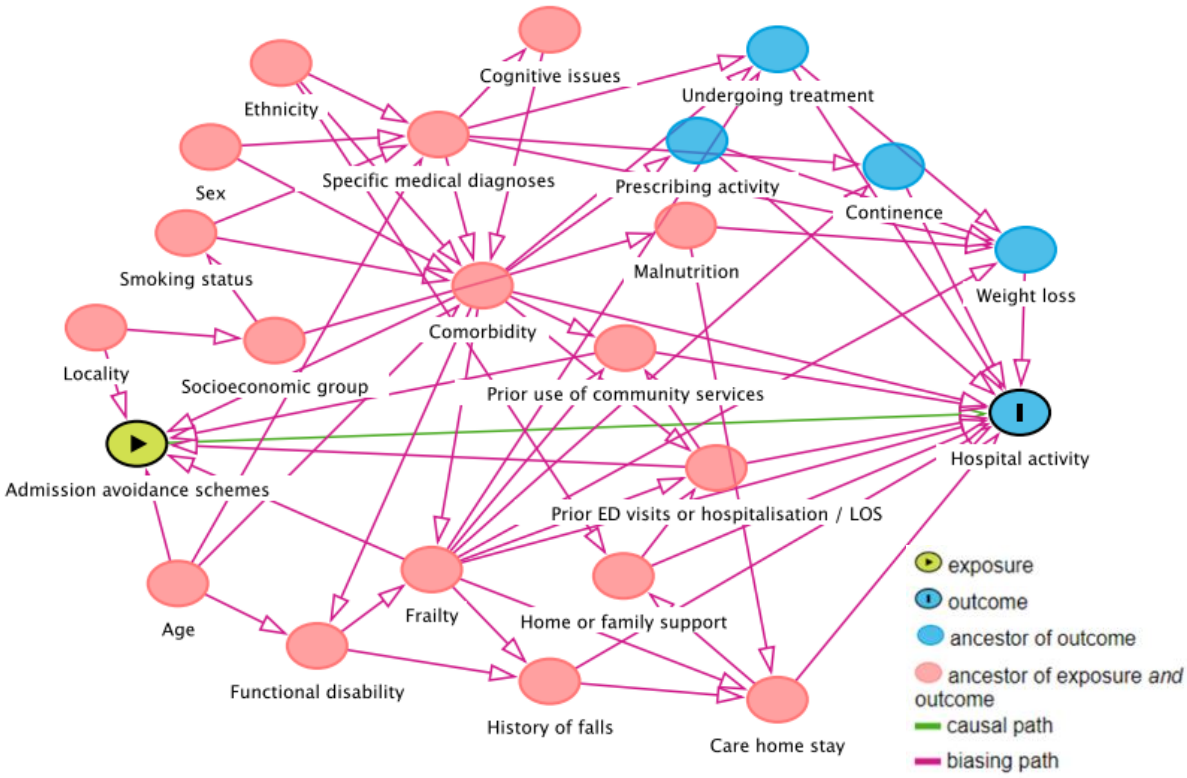
**Note these risk factors were not included in the systematic review as the focus was on geriatric syndromes, hence these risk factors were identified within each of the included studies*
1 In Wang et al.'s (2013) review, the following specific diagnoses were included: heart disease, cancer, diabetes, circulatory system, asthma, recurrent pneumonia, renal failure, peptic ulcers, digestive system and medication allergies.
2 In O'Caoimh et al.'s (2015) review the following specific diagnoses were included: arthritis, diabetes, chest, coronary artery disease, diabetes, heart disease, congestive heart failure, MI, stroke, COPD, cancer, leg ulcers and impaired vision or hearing.
3 In García-Pérez et al.'s (2011) review the following specific diagnoses were included: respiratory system, genito-urinary system, circulatory system, sight, cancer, pressure sores and neurological.
4 In the scoping review conducted for this research, the following specific diagnoses were included as confounders: delirium, confusion, mood disorder, depression and cancer.

9.3.2 Causal diagram of potential confounders

Based on these potential confounders identified above from literature, a causal diagram was developed, indicating potential confounders that may confound the effect of admission avoidance schemes on hospital activity. As described previously in Section 6.6, causal graph theory requires knowledge of the true causal network representing pathways between treatment and outcome and it is quite technical, so a full causal graph analysis is not appropriate here. Rather, causal diagrams, which are a component of causal graph theory, are used here. Causal diagrams are helpful for visualising confounders, with their main practical use being to ensure adjustment for confounders and avoid adjustment for known colliders (factors that are caused by both an exposure and an outcome

independently) (Sauer et al., 2013). They can be particularly useful for matching studies (Mansournia, Hernán and Greenland, 2013). The causal diagram developed to identify confounders on the pathway between receiving an admission avoidance intervention for elderly patients and hospital activity can be seen in Figure 9.2 below.

Figure 9.2 – Causal diagram of potential confounders of the effect of admission avoidance schemes on hospital activity



Note: *Clinical measurements including laboratory results, self-reported health, patient quality of life and caregiver factors including health and quality of life were not included in this causal diagram as they have many associations which would make the diagram very difficult to read. Note also that home or family support includes marital status and living alone.*

At the outset, we can identify confounders for which we have no data. Hence these are immediately noted as limitations of the quantitative analysis conducted for this research. These unmeasured confounders include:

- Clinical measurements (e.g. oxygen saturation, laboratory results)
- Self-reported health
- Weight loss
- Quality of life
- Caregiver factors (e.g. health and quality of life)

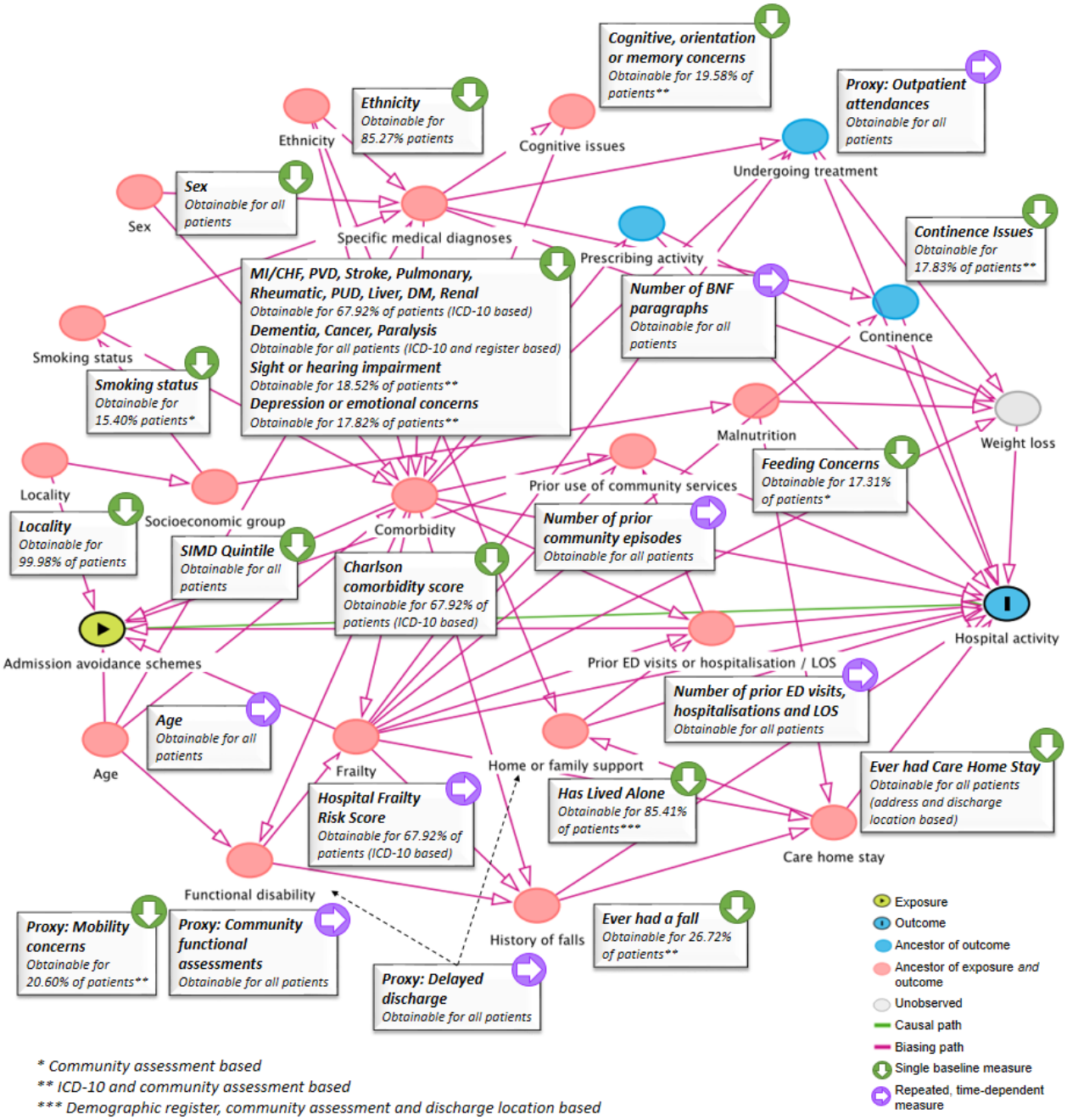
In addition, we have only partial data for several other potential confounders (there is missing data for smoking status, ethnicity, living alone, functional mobility, self-feeding ability, sight or hearing impairments, history of falls,

cognitive issues, depression and continence) and limited data for other potential confounders (frailty score, comorbidity score and specific medical diagnoses are based on hospital records, which means we have no data on frailty and comorbidity of patients who have not been hospitalised which was noted in Chapter 7). These will be noted as limitations of the quantitative analysis conducted for this research.

The causal diagram indicates no clear colliders (factors caused by both the exposure and outcome independently), hence there are no clear concerns about adjustment for colliders which would result in collider bias.

The causal diagram displayed in Figure 9.2 will be used when considering the empirical selection of matching variables and/or adjustment in each of the analyses, as per Sauer and colleagues (2013) suggestion of initially selecting a set of a priori variables and ultimately selecting those to be included through empirical covariate selection. To make this clearer and to highlight the actual available variables for consideration in the empirical variable selection within the study data, Figure 9.3 was developed, overlaying the available data variables over the previously presented causal diagram based on the expected causal relationships between variables from literature. The figure indicates the completeness of the variables and whether they are recorded as a single baseline measurement, or as a repeated measurement recorded over time, for inclusion as time-dependent covariates.

Figure 9.3 – Data variables for consideration in empirical covariate selection, overlaid on causal diagram



As the figure indicates, some variables directly relating to the expected confounders were not available, however, indicative proxy variables were available for use. These include an indicator of whether mobility concerns were present and the number of functional assessments conducting in the community, which are conducted based on need of functional assessment, hence these are proxy indicators of functional disability. Another variable – delayed discharge –

was identified as being indicative of complex needs hence was selected as an additional proxy measure of lack of home or family support and/or functional disability. A delay in a patient's discharge is recorded and tracked within NHS Forth Valley, with the majority of delays being due to the patient awaiting adequate home support or care home placement as they are require complex care or functional support. In addition, outpatient attendance was considered a proxy indicator of undergoing medical treatment.

The variables outlined in Figure 9.3, identified through the causal diagram of relationships between variables based on literature (Figure 9.2), will be used as the set of a priori variables for consideration in the empirical covariate selection for each of the analyses.

9.4 Study population

The initial study population prior to any sub-setting or exclusions comprised of elderly residents of Forth Valley, defined as being aged 65 or over by the start of the observation period (1st January 2015) and either registered with a Forth Valley GP, received treatment within the Forth Valley area or with a registered death within the Forth Valley area (Martin et al., 2019). Table 9.3 presents summary statistics for the baseline characteristics of the full 'Closer to Home' study cohort, including averages of measures that changed over time at a baseline period (2015).

Table 9.3 – Baseline characteristics of full study cohort prior to sub-setting or exclusions

	General elderly population (n=61800)	'Closer to Home' patients (n=3388)	P-Value	SMD
Age (mean (SD))	73.13 (7.76)	79.06 (8.34)	<0.001	0.736
Sex = Male (%)	28216 (45.7)	1390 (41.0)	<0.001	0.094
Ethnicity (%)			<0.001	0.449
White	52001 (84.1)	3275 (96.7)		
Other	297 (0.5)	16 (0.5)		
Not specified	8403 (13.6)	96 (2.8)		
MISSING	1099 (1.8)	1 (0.0)		
Smoking status (%)			<0.001	0.984
Yes	1346 (2.2)	256 (7.6)		
Ex-smoker	2450 (4.0)	550 (16.2)		

	General elderly population (n=61800)	'Closer to Home' patients (n=3388)	P-Value	SMD
No	4376 (7.1)	1060 (31.3)		
MISSING	53628 (86.8)	1522 (44.9)		
Health and Social Care Partnership				
Stirling & Clackmannanshire (%)	29747 (48.1)	1737 (51.4)	<0.001	0.064
Falkirk (%)	32053 (51.9)	1651 (48.6)		
Locality (%)			<0.001	0.200
Clackmannanshire	10855 (17.6)	582 (17.2)		
Denny/ Bonnybridge/ Larbert / Stenhousemuir	9190 (14.9)	422 (12.5)		
Falkirk Town	9272 (15.0)	536 (15.8)		
Grangemouth / Bo'ness / Braes	13582 (22.0)	687 (20.3)		
Rural Stirling	9 (0.0)	6 (0.2)		
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	6053 (9.8)	225 (6.6)		
SIMD16 Quintile ǂ (%)			<0.001	0.133
1	8186 (13.2)	566 (16.7)		
2	14506 (23.5)	846 (25.0)		
3	12495 (20.2)	714 (21.1)		
4	13651 (22.1)	649 (19.2)		
5	12962 (21.0)	613 (18.1)		
Living alone ever recorded (%)			<0.001	0.749
Yes	7188 (11.6)	1199 (35.4)		
No	45143 (73.0)	2146 (63.3)		
MISSING	9469 (15.3)	43 (1.3)		
Care Home Stay = Yes (%)	3832 (6.2)	409 (12.1)	<0.001	0.205
Fall ever recorded (%)			<0.001	1.270
Yes	10366 (16.8)	1985 (58.6)		
No	4431 (7.2)	639 (18.9)		
MISSING	47003 (76.1)	764 (22.6)		
Functional Assessment ever conducted = Yes (%)	12525 (20.3)	2637 (77.8)	<0.001	1.408
Mobility concerns (%)			<0.001	1.325
Yes	7797 (12.6)	2029 (59.9)		

	General elderly population (n=61800)	'Closer to Home' patients (n=3388)	P-Value	SMD
No	3180 (5.1)	423 (12.5)		
MISSING	50823 (82.2)	936 (27.6)		
Sight or hearing impairment (%)			<0.001	1.226
Yes	5978 (9.7)	1639 (48.4)		
No	3819 (6.2)	635 (18.7)		
MISSING	52003 (84.1)	1114 (32.9)		
Cognitive, orientation or memory problem (%)			<0.001	1.249
Yes	4330 (7.0)	1250 (36.9)		
No	6091 (9.9)	1090 (32.2)		
MISSING	51379 (83.1)	1048 (30.9)		
Feeding concerns (%)			<0.001	1.203
Yes	3550 (5.7)	1116 (32.9)		
No	5530 (8.9)	1085 (32.0)		
MISSING	52720 (85.3)	1187 (35.0)		
Depression or emotional concern (%)			<0.001	1.186
Yes	2629 (4.3)	787 (23.2)		
No	6778 (11.0)	1420 (41.9)		
MISSING	52393 (84.8)	1181 (34.9)		
Continence issues (%)			<0.001	0.954
Yes	5734 (9.3)	1306 (38.5)		
No	3960 (6.4)	623 (18.4)		
MISSING	52106 (84.3)	1459 (43.1)		
Charlson Score group (%)			<0.001	0.995
No ICD-10 codes recorded in past 5 years	20719 (33.5)	195 (5.8)		
No comorbidities identified (0)	19359 (31.3)	621 (18.3)		
Mild (1-2)	13645 (22.1)	1249 (36.9)		
Moderate (3-4)	4770 (7.7)	755 (22.3)		
Severe (5+)	3307 (5.4)	568 (16.8)		
Comorbidities (ICD-10 based)				
MI or CHF (%)	5718 (9.3)	866 (25.6)	<0.001	0.440
PVD (%)	2166 (3.5)	316 (9.3)	<0.001	0.239
Stroke (%)	4360 (7.1)	659 (19.5)	<0.001	0.372

	General elderly population (n=61800)	'Closer to Home' patients (n=3388)	P-Value	SMD
Pulmonary (%)	5375 (8.7)	883 (26.1)	<0.001	0.471
Rheumatic (%)	631 (1.0)	106 (3.1)	<0.001	0.148
PUD (%)	425 (0.7)	53 (1.6)	<0.001	0.083
Liver (%)	745 (1.2)	116 (3.4)	<0.001	0.148
DM (%)	5074 (8.2)	699 (20.6)	<0.001	0.359
Renal (%)	3526 (5.7)	688 (20.3)	<0.001	0.445
Dementia (%)	3027 (4.9)	549 (16.2)	<0.001	0.374
Cancer (%)	7211 (11.7)	659 (19.5)	<0.001	0.216
Paralysis (%)	239 (0.4)	34 (1.0)	<0.001	0.074
Had SPARRA score in 2015 = Yes (%)	58425 (94.5)	3349 (98.8)	<0.001	0.243
Average SPARRA score 2015 (mean (SD))	14.03 (13.31)	26.32 (16.34)	<0.001	0.825
Had HFRS in 2015 = Yes (%)	23558 (38.1)	2038 (60.2)	<0.001	0.452
Average HFRS 2015 (mean (SD))	2.22 (3.86)	3.07 (4.03)	<0.001	0.214
Average monthly prescriptions (BNF paragraphs)** 2015 (mean (SD))	3.85 (2.79)	5.73 (3.12)	<0.001	0.635
Admitted as inpatient 2015 = Yes (%)	12508 (20.2)	1264 (37.3)	<0.001	0.384
Inpatient hospitalisations 2015 (mean (SD))	0.33 (0.86)	0.69 (1.31)	<0.001	0.328
Emergency inpatient hospitalisations 2015 (mean (SD))	0.19 (0.63)	0.51 (1.08)	<0.001	0.362
Non-emergency inpatient hospitalisations 2015 (mean (SD))	0.14 (0.52)	0.18 (0.65)	<0.001	0.077
Emergency inpatient length of stay in days 2015 (mean (SD))*	14.04 (26.55)	16.85 (24.20)	<0.001	0.111
Admitted at ED in 2015 = Yes (%)	9889 (16.0)	1029 (30.4)	<0.001	0.346
ED Attendances 2015 (mean (SD))	0.22 (0.64)	0.52 (1.20)	<0.001	0.306
Outpatient attendances 2015 (mean (SD))	2.37 (2.67)	2.60 (2.42)	<0.001	0.092
Community episodes 2015 (mean (SD))	0.36 (1.16)	0.98 (1.85)	<0.001	0.404
Community functional assessments 2015 (mean(SD))	0.26 (1.70)	0.82 (2.61)	<0.001	0.252

	General elderly population (n=61800)	'Closer to Home' patients (n=3388)	P-Value	SMD
Delayed discharges 2015 (mean (SD))	0.01 (0.12)	0.02 (0.18)	<0.001	0.075

† SIMD16 Quintile indicates level of deprivation (1=within most deprived fifth of population, 5=within least deprived fifth)

**Note length of stay includes only length of stay for patients admitted*

*** Average monthly number of BNF classes was used to reduce effect of exaggerated polypharmacy and variation for patients who have multiple medications in the class as described in Section 7.2.8.*

Abbreviations: ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure), PVD (Peripheral Vascular Disease), PUD (Peptic Ulcer Disease), DM (Diabetes Mellitus), SPARRA (Scottish Patients at Risk of Readmission and Admission), HFRS (Hospital Frailty Risk Score), ED (Emergency Department), BNF (British National Formulary)

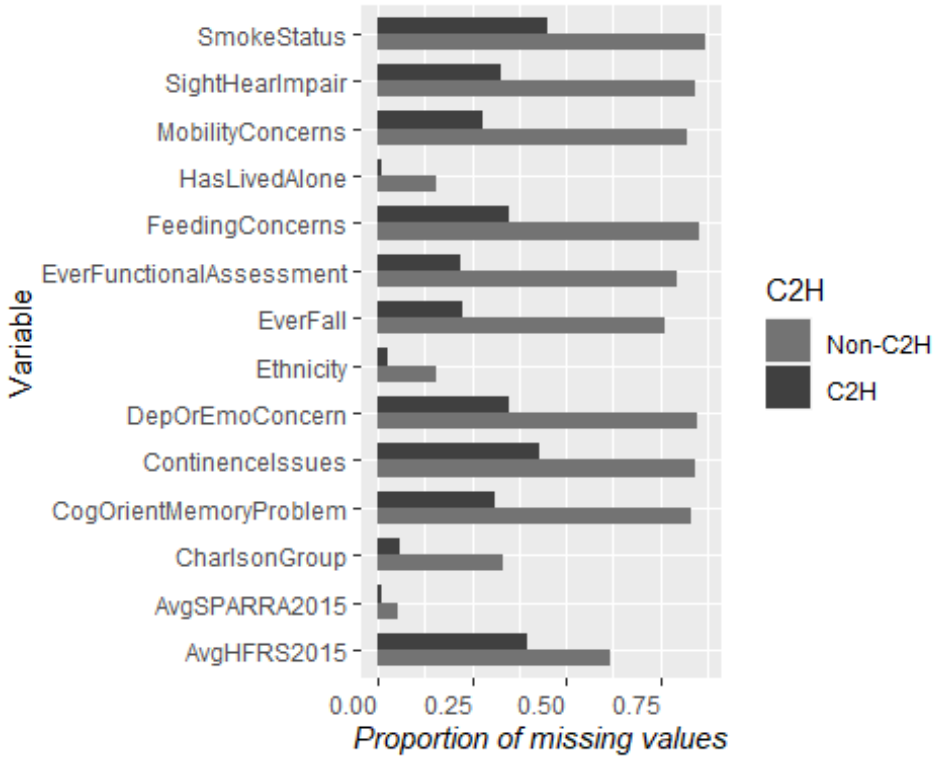
It is clear that the 'Closer to Home' population is significantly different to the remaining general elderly population, as expected. 'Closer to Home' patients are generally older, have higher levels of comorbidity and polypharmacy, higher levels of hospital activity and overall at higher risk of hospital admission. Specific differences between study groups will be assessed and discussed in more detail for each of the selected study samples within each of the analyses.

9.4.1 Missing data

A discussed in 0 Section 6.7, there are several methods of handling data depending on the patterns and type of missingness. The first step is to identify the proportions of missingness and the patterns observed in the missing data.

The following plot presents the proportions of missingness across 'Closer to Home' patients and the general elderly population. Clearly, 'Closer to Home' patients have much lower proportions of missing data which is expected given their increased interaction with the healthcare system.

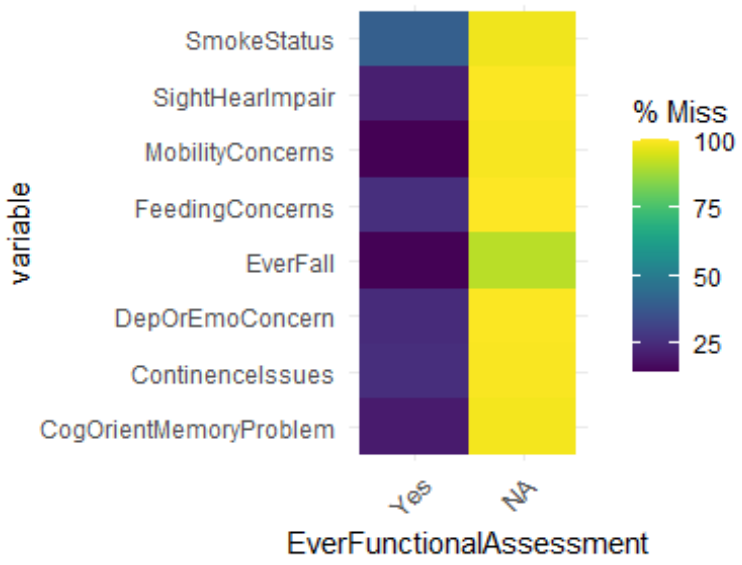
Figure 9.4 – Proportions of missing values across covariates among full study cohort



C2H = 'Closer to Home,' SPARRA=Scottish Patients at Risk of Admission and Readmission, HFRS=Hospital Frailty Risk Score

The next step is to identify any patterns in the missing data. We expect to see that the missing values across variables recorded on community heath assessments are directly linked to whether an assessment was conducted or not. This is confirmed in the following plot, where high proportions of missingness are observed among variables where a functional assessment has not been conducted.

Figure 9.5 – Proportions of missing values among variables recorded on community assessments, by whether a functional assessment has been conducted or not



9.4.1.1 Handling missing data

As expected, and as highlighted above, the variables relating to functional activity are likely to be missing due to reasons relating to their values, as functional assessments are carried out based on need, hence it appears likely that Their missingness could be partially explained through other observed variables such as comorbidity or living alone. However, given these observations, it is likely the data are somewhere between missing-at-random (MAR) and missing-not-at-random (MNAR). Because the observed variables are not sufficient to make appropriate predictions of what the missing values might be, imputation is not appropriate for these variables. Hence, the missing-indicator method in the form of a separate category, will be employed for these variables.

As described in detail in 0 (Section 6.7.3.2) – though the use of missing indicators is not optimum and has been criticised in literature – where the missingness of the variables adds substantive value (i.e. missingness is associated with some hidden reason and there is knowledge in the missingness) and where the objective is to investigate relationships between variables rather than develop predictive models, the use of missing-indicators can be appropriate (Zhuchkova and Rotmistrov, 2019). Ultimately, using missing indicators limits the analysis to only partially adjusting for confounding covariates (Ibrahim, Chu and Chen, 2012; Choi, Dekkers and le Cessie, 2019).

For calculated scores, patients without a score do not have missing data but rather are given a separate category indicating no score has been calculated. Hence, for Charlson scores, a lack of score is assigned a separate level. Similarly, for patients who begin with no HFRS and SPARRA scores, they are given a separate level for any initial periods without a score, however, as they are recorded over time, if there is a period of no score after having a score, the last observation is carried forward as once a patient is at risk, it is unlikely they will be completely risk free afterwards. Hence, it is more appropriate to carry forward their last observation that to assign them a 'no score' category. To maintain scores as numerical variables, the separate 'no score' level was assigned the value of zero, while adding one to recorded scores to ensure they are differentiated (e.g. no HFRS score was treated as 0.0 and HFRS calculated scores of 0.0 and 5.5 are treated as 1.0 and 6.5 respectively)

In addition, Salgado et al. (2016) advise that variables with more than 50% of values missing should be removed from analysis. Upon selection of the study samples for each analysis, the proportions of missing values were reviewed, considering the exclusion from analysis of variables with more than 50% of values missing. This was only the case in the ALFY study cohort with one variable (smoking status), hence the variable was not included in any statistical analyses for assessing the effect of ALFY.

9.5 Results of the retrospective comparative cohort study assessing the effect of 'Closer to Home'

This section will present the results of each of the retrospective cohort studies investigating the effects on hospital activity of each of the three components of the 'Closer to Home' programme.

The results for each comparative study are structured in the following way:

1. Description of study population and exclusions
2. Characteristics of included population and differences between 'Closer to Home' intervention patients and comparison groups
3. Selection of covariates included for controlling for confounding (either through adjustment, matching or both) based on causal diagram and empirical covariate selection
4. Adjusted and unadjusted treatment effect estimates

9.5.1 Effect of the Enhanced Community Team on hospital activity outcomes

This section aims to provide the results of the comparative analysis of the Enhanced Community Team (ECT) service, evaluating its effect on hospital activity outcomes. The main aim of the service was to support older people to remain well at home by providing an alternative to hospitalisation through receiving equivalent medical care and support in their home. The three hospital outcomes investigated were emergency inpatient hospitalisation, emergency department attendance and emergency inpatient length of stay.

9.5.1.1 Study sample and exclusions

ECT patients were defined as those receiving ECT intervention between 1st January 2016 - 31st March 2019, while the potential control population was defined as the general elderly population (aged 65 and over) residing in Forth Valley. Several exclusions were made in selecting the study cohort. The following table describes the exclusions made and frequencies in each study group. Exclusions were made in the listed order.

Table 9.4 – Exclusions for ECT study cohort by exclusion reason

Exclusion reason	General elderly	ECT patients
1. *Registered with the prison service GP practice code (code 31391)*	28	0
2. *Not registered with a Forth Valley GP*	194	1
3. *Not resident in Forth Valley, based on postcode*	20	7
4. *Aged under 65 during the observation period (i.e. must have been aged 65 or over between 1st January 2016 - 31st March 2019)*	5	50
5. *Were registered with a Forth Valley GP after the 1st January 2015*	3440	82
6. *Transferred out of the Forth Valley health board during the data collection period (1st January 2015 - 31st March 2019)*	285	18
7. *Had died before the start of the observation period (1st January 2016)*	2531	0
8. *Death date before date of ECT episode, indicating recording error*	0	71
9. *Not in study cohort for which all demographics were collected*	0	11
10. *For ECT patients, all their ECT episodes began before the observation period (before 1st January 2016)*	0	36
Total excluded	**6503**	**276**
No exclusion reason (included)	**57177**	**1303**

Some of these exclusions (5-6) were required due to not being able to collect any prior hospital activity records as their data is likely to be held with other health boards, skewing the results. The final exclusion (10) was required as it was expected that the implementation phase in the first month it was expected the service would not be running as designed due to teething problems or other issues, which may skew the results.

Among the patients who were not excluded, several included ECT patients were considered to be part of the general population rather than the intervention group, in certain select circumstances, in order that they could be part of the control pool of potential matches. These included patients who did not truly receive the service ('false' episodes, as described in Chapter 8, Section 8.2) and patients whose ECT activity began after the end of the observation period. These are described in Table 9.5 below.

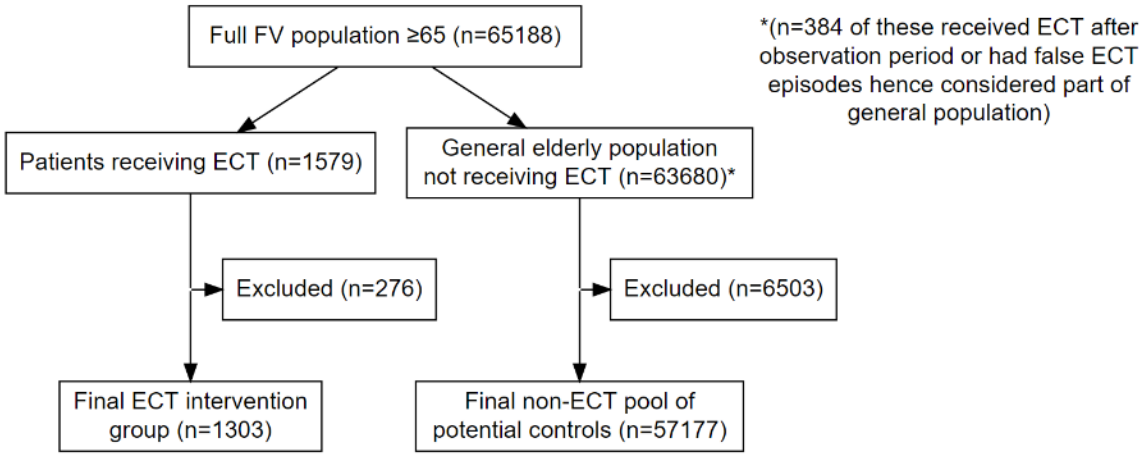
Table 9.5 – Count and reasons for ECT patients considered as part of potential control pool

Reason selected ECT patients considered as part of general population	ECT patients
1. *All their ECT episodes were 'false' episodes**	117
2. *All their ECT episodes ended (were discharged) after the observation period (after 31st March 2019)*	267
Total	**384**

**'False' ECT episodes were those where upon assessment by ECT, were not suitable for the service or could not be seen (e.g. had been admitted) (see Chapter 8, Section 8.2 for more detail)*

The following diagram describes the total numbers of patients in the original population along with how many were considered ECT patients or potential control patients and how many were excluded.

Figure 9.6 – Flowchart outlining ECT study cohort and exclusions



9.5.1.1.1 Baseline characteristics of full ECT study groups before matching

This section will describe the characteristics of the full ECT study cohort including the pool of potential controls, highlighting those that differ between groups. Table 9.6 presents summary statistics for the baseline characteristics of the full ECT study cohort prior to any matching, including averages of measures that changed over time at a baseline period (2015).

Table 9.6 – Baseline characteristics of ECT study population prior to matching

	Pool of potential controls (n=57177)	ECT (n=1303)	P-Value	SMD
Age (mean (SD))	72.93 (7.53)	80.73 (7.45)	<0.001	1.041
Sex = Male (%)	25992 (45.5)	524 (40.2)	<0.001	0.106
Ethnicity (%)			<0.001	0.460
White	48564 (84.9)	1267 (97.2)		
Other	267 (0.5)	7 (0.5)		
Not specified	7537 (13.2)	29 (2.2)		
MISSING	809 (1.4)	0 (0.0)		
Smoking status (%)			<0.001	1.375
Yes	1227 (2.1)	134 (10.3)		
Ex-smoker	2321 (4.1)	268 (20.6)		
No	4175 (7.3)	501 (38.4)		
MISSING	49454 (86.5)	400 (30.7)		
Health and Social Care Partnership			<0.001	0.151

	Pool of potential controls (n=57177)	ECT (n=1303)	P-Value	SMD
Stirling & Clackmannanshire (%)	27508 (48.1)	725 (55.6)		
Falkirk (%)	29669 (51.9)	578 (44.4)		
Locality (%)			<0.001	0.310
Clackmannanshire	10103 (17.7)	214 (16.4)		
Denny/ Bonnybridge/ Larbert / Stenhousemuir	8682 (15.2)	144 (11.1)		
Falkirk Town	8331 (14.6)	175 (13.4)		
Grangemouth / Bo'ness / Braes	12656 (22.1)	259 (19.9)		
Rural Stirling	5442 (9.5)	75 (5.8)		
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	11963 (20.9)	436 (33.5)		
SIMD16 Quintile † (%)			<0.001	0.132
1	7548 (13.2)	215 (16.5)		
2	13406 (23.4)	335 (25.7)		
3	11677 (20.4)	267 (20.5)		
4	12499 (21.9)	246 (18.9)		
5	12047 (21.1)	240 (18.4)		
Living alone ever recorded (%)			<0.001	0.935
Yes	6531 (11.4)	581 (44.6)		
No	42323 (74.0)	717 (55.0)		
MISSING	8323 (14.6)	5 (0.4)		
Care Home Stay = Yes (%)	2814 (4.9)	207 (15.9)	<0.001	0.365
Fall ever recorded (%)			<0.001	1.858
Yes	9645 (16.9)	922 (70.8)		
No	4046 (7.1)	265 (20.3)		
MISSING	43486 (76.1)	116 (8.9)		
Functional Assessment ever conducted = Yes (%)	11760 (20.6)	1216 (93.3)	<0.001	2.166
Mobility concerns (%)			<0.001	2.143
Yes	7255 (12.7)	978 (75.1)		
No	2920 (5.1)	200 (15.3)		
MISSING	47002 (82.2)	125 (9.6)		
Sight or hearing impairment (%)			<0.001	1.789

	Pool of potential controls (n=57177)	ECT (n=1303)	P-Value	SMD
Yes	5724 (10.0)	791 (60.7)		
No	3525 (6.2)	286 (21.9)		
MISSING	47928 (83.8)	226 (17.3)		
Cognitive, orientation or memory problem (%)			<0.001	1.870
Yes	3961 (6.9)	650 (49.9)		
No	5745 (10.0)	456 (35.0)		
MISSING	47471 (83.0)	197 (15.1)		
Feeding concerns (%)			<0.001	1.815
Yes	3320 (5.8)	590 (45.3)		
No	5204 (9.1)	476 (36.5)		
MISSING	48653 (85.1)	237 (18.2)		
Depression or emotional concern (%)			<0.001	1.700
Yes	2536 (4.4)	356 (27.3)		
No	6350 (11.1)	689 (52.9)		
MISSING	48291 (84.5)	258 (19.8)		
Continence issues (%)			<0.001	1.177
Yes	5357 (9.4)	585 (44.9)		
No	3643 (6.4)	267 (20.5)		
MISSING	48177 (84.3)	451 (34.6)		
Charlson Score group (%)			<0.001	1.234
No ICD-10 codes recorded in past 5 years	18887 (33.0)	32 (2.5)		
No comorbidities identified (0)	18443 (32.3)	197 (15.1)		
Mild (1-2)	12639 (22.1)	473 (36.3)		
Moderate (3-4)	4349 (7.6)	341 (26.2)		
Severe (5+)	2859 (5.0)	260 (20.0)		
Comorbidities (ICD-10 based)				
MI or CHF (%)	5342 (9.3)	360 (27.6)	<0.001	0.485
PVD (%)	2037 (3.6)	126 (9.7)	<0.001	0.248
Stroke (%)	4020 (7.0)	274 (21.0)	<0.001	0.411
Pulmonary (%)	5039 (8.8)	379 (29.1)	<0.001	0.536
Rheumatic (%)	617 (1.1)	46 (3.5)	<0.001	0.164
PUD (%)	400 (0.7)	24 (1.8)	<0.001	0.102
Liver (%)	692 (1.2)	50 (3.8)	<0.001	0.168

	Pool of potential controls (n=57177)	ECT (n=1303)	P-Value	SMD
DM (%)	4691 (8.2)	277 (21.3)	<0.001	0.375
Renal (%)	3224 (5.6)	337 (25.9)	<0.001	0.578
Dementia (%)	2490 (4.4)	270 (20.7)	<0.001	0.510
Cancer (%)	6417 (11.2)	292 (22.4)	<0.001	0.306
Paralysis (%)	229 (0.4)	8 (0.6)	0.230	0.030
Had SPARRA score in 2015 = Yes (%)	54590 (95.5)	1295 (99.4)	<0.001	0.249
Average SPARRA score 2015 (mean (SD))	13.51 (12.59)	28.31 (15.96)	<0.001	1.030
Had HFRS in 2015 = Yes (%)	21649 (37.9)	829 (63.6)	<0.001	0.533
Average HFRS 2015 (mean (SD))	1.89 (3.45)	3.38 (4.10)	<0.001	0.393
Average monthly prescriptions (BNF paragraphs)* 2015 (mean (SD))	3.85 (2.73)	5.95 (3.02)	<0.001	0.732
Admitted as inpatient 2015 = Yes (%)	10968 (19.2)	500 (38.4)	<0.001	0.434
Inpatient hospitalisations 2015 (mean (SD))	0.31 (0.82)	0.72 (1.43)	<0.001	0.357
Emergency inpatient hospitalisations 2015 (mean (SD))	0.17 (0.59)	0.54 (1.07)	<0.001	0.437
Non-emergency inpatient hospitalisations 2015 (mean (SD))	0.14 (0.51)	0.18 (0.81)	0.005	0.060
Emergency inpatient length of stay in days 2015 (mean (SD))*	12.02 (25.28)	19.35 (24.75)	<0.001	0.293
Admitted at ED in 2015 = Yes (%)	8837 (15.5)	395 (30.3)	<0.001	0.359
ED Attendances 2015 (mean (SD))	0.22 (0.64)	0.48 (1.03)	<0.001	0.308
Outpatient attendances 2015 (mean (SD))	2.39 (2.66)	2.54 (2.20)	0.132	0.062
Community episodes 2015 (mean (SD))	0.31 (1.07)	1.17 (2.02)	<0.001	0.533
Community functional assessments 2015 (mean (SD))	0.21 (1.50)	1.10 (3.08)	<0.001	0.367
Delayed discharges 2015 (mean (SD))	0.01 (0.10)	0.04 (0.23)	<0.001	0.171

† SIMD16 Quintile indicates level of deprivation (1=within most deprived fifth of population, 5=within least deprived fifth)

**Average monthly number of BNF classes was used to reduce effect of exaggerated polypharmacy and variation for patients who have multiple medications in the class as described in Section 7.2.8.*

***Note length of stay includes only length of stay for patients admitted*

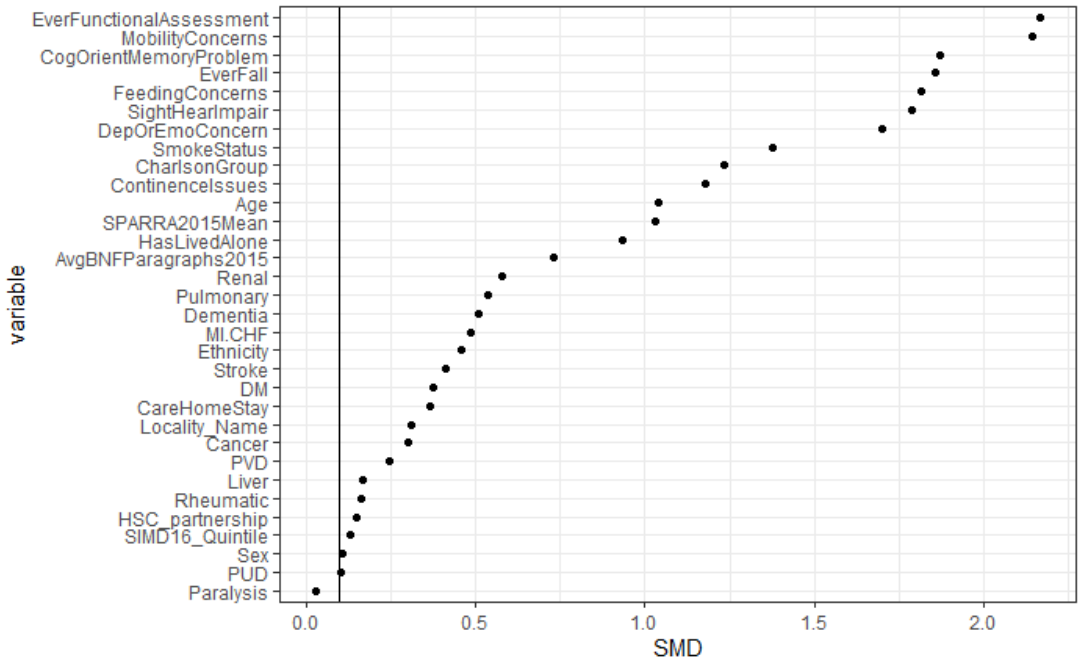
Abbreviations: SIMD16 (Scottish Index of Multiple Deprivation 2016 version), ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure), PVD (Peripheral Vascular Disease), PUD (Peptic Ulcer Disease), DM (Diabetes Mellitus), SPARRA (Scottish Patients at Risk of Readmission and Admission), HFRS (Hospital Frailty Risk Score), BNF (British National Formulary), ED (Emergency Department)

There are clear differences in the demographics of the ECT intervention patients compared to those in the general elderly population, displaying statistically significant differences in every demographic characteristic. Of note are higher comorbidity in terms of Charlson comorbidity grouping and higher proportions who have had a care home stay. Of most note are the significantly lower numbers of missing values in demographics such as smoking status, living alone and measures of functional status. In particular, ECT patients are much more likely to have had a functional assessment conducted (therefore much more likely to have required one) (20.6% compared to 93.3% of ECT patients). Among non-missing values, ECT patients appear to have higher levels of functional impairments in the various functional status areas.

There are also clear differences in the study cohorts in terms of their 2015 risk scores and activity. Roughly twice the proportion of patients who received ECT were admitted to the hospital as inpatients or attended the ED in 2015 as were in the general elderly population. Of those admitted, ECT patients experiences nearly twice the length of hospital stay. Similarly, ECT patients experienced an average SPARRA score more than twice as high as the general elderly population's average score. ECT patients received roughly double the number of average monthly prescriptions (BNF paragraphs) as the general elderly population. ECT patients also experienced more delayed discharges, with a rate of 40 per 1,000 in 2015 compared to 10 per 1,000 in the general elderly population. In addition, they experienced higher community activity and slightly higher outpatient activity.

The standardised mean differences (SMDs) across the baseline variables are displayed visually in Figure 9.7, highlighting variables with the greatest differences (an SMD>0.1 indicates an important difference).

Figure 9.7 – Standardised Mean Differences (SMDs) across baseline variables between ECT intervention patients and the general elderly population (pool of potential controls)



9.5.1.2 Empirical variable selection of matching variables

Prior to any matching, a selection of matching variables should be determined. Confounders should always be included as matching variables if possible. These are variables that are associated with the exposure and the outcome as described in 0, Section 6.6.

A list of potential confounders, expected to be associated with the outcome, was identified in Section 9.3 which is used here as the initial candidate set for consideration. This uses the combined approach described in Section 9.3, using a set of a priori variables followed by empirical variable selection. Here, empirical variable selection constitutes identifying variables most predictive of exposure amongst the initial candidates in several logistic regression models (best subset selection).

For propensity score matching, all initial candidates are considered for a best subset of all variables to be included in the propensity score model. As previously discussed in 0 (Section 6.4.3.1), stratification approaches to matching work best with a limited number of covariates, hence for the direct covariate matching, a subset of up to seven predictors will be considered. This was determined by testing with a range of numbers of predictors, where seven predictors resulted in a good

balance of predictors that approximately characterise intervention patients (based on researcher's knowledge) but not having too many such that there were too many unmatched subjects (the difficulty with unmatched subjects was described in Section 9.2.1.1).

In the limited model, count predictors were included as binary predictors (e.g. number of admissions as binary admission indicator), to allow for greater ease of direct matching with these predictors (e.g. directly matching on binary admission will enable more matches to be found than matching on number of admissions).

Table 9.7 displays the full initial candidate set of potential predictors of receiving ECT and indicates whether they were included in the best subset models (both the full and limited models). Figures displaying the selected predictors at varying values of the BIC are included in Appendix E.

Table 9.7 – Predictors of receiving ECT highlighting those included in best subset models

	Logistic regression model				Best subsets models	
Predictor	OR	95% CI	P-value	SMD >0.1	Best Full Model	Best Limited Model
Age	1.04	1.04,1.05	<0.001***	X	X	X
Sex	1.05	0.93,1.18	0.431	X		
Ethnicity	1.01	0.84,1.21	0.951	X		
Smoking status	1.15	1.08,1.23	<0.001***	X	X	
Locality	1.08	1.05,1.12	<0.001***		X	
SIMD16 Quintile	0.98	0.93,1.02	0.251			
Functional Assessment ever conducted	6.51	4.8,8.83	<0.001***	X	X	X
Living alone ever recorded	1.90	1.7,2.13	<0.001***	X	X	X
Care home stay	0.83	0.64,1.09	0.176	X		
Fall ever recorded	1.36	1.22,1.52	<0.001***	X	X	
Mobility concerns	1.43	1.25,1.63	<0.001***	X	X	
Sight or hearing impairment	0.82	0.73,0.92	<0.001***	X	X	
Cognitive, orientation or memory problem	1.42	1.27,1.59	<0.001***	X	X	
Feeding concerns	1.63	1.46,1.82	<0.001***	X	X	
Depression or emotional concern	0.94	0.84,1.06	0.331	X		

	Logistic regression model				Best subsets models	
Predictor	OR	95% CI	P-value	SMD >0.1	Best Full Model	Best Limited Model
Continence issues	0.64	0.59,0.7	<0.001***	X	X	
Average monthly prescriptions (BNF paragraphs) 2015	1.01	0.99,1.03	0.555			
SPARRA score	1.01	1,1.01	<0.01**		X	
Charlson Score	1.04	0.98,1.1	0.189		X	
MI or CHF	1.08	0.93,1.26	0.297	X		
PVD	0.90	0.74,1.1	0.312	X		
Stroke	0.98	0.84,1.14	0.775	X		
Pulmonary	1.47	1.27,1.7	<0.001***	X	X	
Rheumatic	1.19	0.87,1.61	0.274	X		
PUD	0.88	0.58,1.34	0.565	X		
Liver	1.36	1.01,1.84	<0.05*	X		
DM	1.04	0.89,1.22	0.624	X		
Renal	1.22	1.02,1.46	<0.05*	X		
Dementia	1.27	1.08,1.49	<0.01**	X		
Cancer	1.03	0.83,1.29	0.776	X		
Paralysis	0.70	0.35,1.43	0.331			
HFRS	0.99	0.98,1	<0.05*			
Emergency inpatient admissions†	2.26	1.93,2.64	<0.001***	X	X	X†
Non-emergency inpatient admissions†	1.43	1.13,1.8	<0.01**	X	X	
ED attendances†	0.92	0.78,1.09	0.313			
Outpatient attendances†	1.14	1.07,1.2	<0.001***		X	
Community episodes†	1.27	1.18,1.38	<0.001***		X	
Functional Assessments ††	0.96	0.89,1.03	0.208			
Delayed discharges†	2.53	1.94,3.31	<0.001***		X	
Inpatient length of stay ††	1.03	1.02,1.04	<0.001***		X	

† These variables were included in the limited subset model as binary indicators rather than as a count

†† These variables were not included in the limited subset model as binary forms were already present

Abbreviations: SIMD16 (Scottish Index of Multiple Deprivation 2016 version), ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure), PVD (Peripheral Vascular Disease), PUD (Peptic Ulcer Disease), DM (Diabetes Mellitus), SPARRA (Scottish Patients at Risk of Readmission and Admission), HFRS (Hospital Frailty Risk Score), BNF (British National Formulary), ED (Emergency Department)

9.5.1.2.1 Matching variables for direct covariate matching

Four variables were included in the best subsets model limited to seven total predictors (age, whether a functional assessment was ever conducted, whether records show have ever been living alone and whether they experienced an emergency inpatient hospital admission as seen in Table 9.7). This selection was used as a guide to select matching variables in combination with the researcher's knowledge and judgement. Though Charlson comorbidity score and SPARRA score were not included in the best subset model, they are both considered to be important predictors encompassing a range of factors, hence they were included as matching variables. Hence, the following variables were included for rolling entry direct covariate matching, based on variables identified in the best subset models of limited size and based on the researcher's knowledge and judgement:

- Age within five years
- Charlson score within two points (not included in best predictor subset however considered to be an important predictor encompassing a range of health conditions)
- SPARRA score within ten points (within 10% risk of admission) (not included in best predictor subset however considered to be an important predictor encompassing a range of factors)
- Living alone ever recorded
- Functional assessment ever conducted
- Emergency admission in the month prior to entry month (entry month is month of first ECT episode for ECT patients)

9.5.1.2.2 Matching variables for propensity score matching

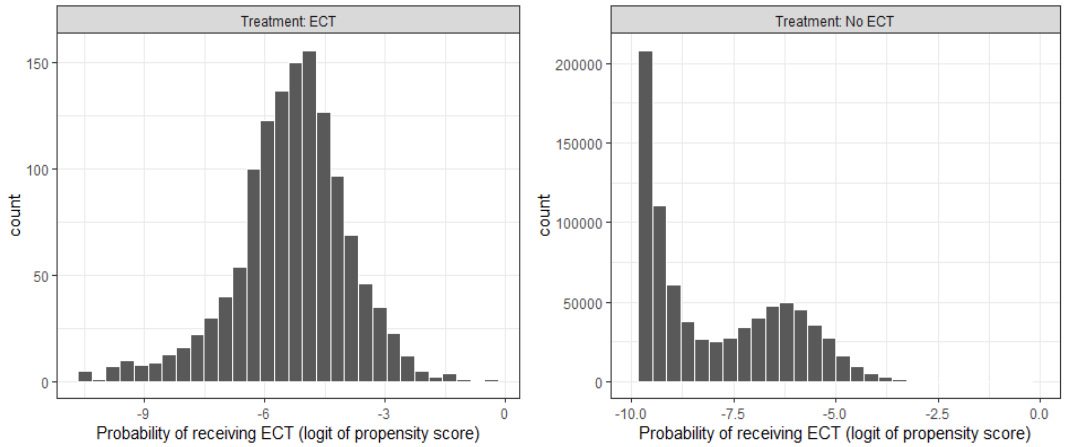
All variables identified in the best subset model of any size (20 predictors as seen in Table 9.7) and those identified as statistically significant predictors in the full logistic regression model (an additional four variables) were included in the propensity score model for rolling entry propensity score matching. This is based on the recommendation that any variable critical for selection into treatment should be included in propensity score models, as failing to include them means the propensity scores will not be able to eliminate selection bias (Olmos and Govindasamy, 2015).

Hence, the following model for propensity scores was used:

$$
\begin{aligned}
ECT \sim Age + Smoking\ status + Locality + Functional\ assessment\ ever\ recorded \\
+ Has\ lived\ alone + Fall\ ever\ recorded + Mobility\ concerns \\
+ Sight\ or\ hearing\ impairment \\
+ Cognitive, orientation\ or\ memory\ problem + Feeding\ concerns \\
+ Continence\ issues + \ SPARRA\ score + Charlson\ score \\
+ Pulmonary + Liver + Renal + Dementia \\
+ Hospital\ frailty\ risk\ score \\
+ Number\ of\ prior\ emergency\ admissions \\
+ Number\ of\ prior\ nonemergency\ admissions \\
+ Number\ of\ prior\ outpatient\ attendances \\
+ Number\ of\ prior\ community\ episodes \\
+ Number\ of\ prior\ delayed\ discharges \\
+ Prior\ inpatient\ length\ of\ stay\ in\ days
\end{aligned}
$$

The distribution of the resulting propensity scores for the full study sample in displayed in Figure 9.8. The ECT intervention group have a normal distribution of propensity scores as expected, whereas the general elderly population includes a substantial number of patients with very low probability of receiving ECT based on the propensity score model. The aim of matching here will be to find a group closely matching the ECT group's propensity scores, hence achieving the same distribution of scores in both intervention and comparison groups.

Figure 9.8 – Probability of receiving ECT (logit of propensity scores) by group for full study sample (before matching) based on selected propensity score model



9.5.1.3 Results of matching

As previously described, two types of rolling entry matching were used to obtain two matched cohorts – direct covariate matching and propensity score matching. The results of both types of matching will be presented here.

9.5.1.3.1 Direct covariate matching

For rolling entry direct covariate matching, a total of 1289 ECT patients were successfully matched to 1289 control patients (meaning 14 patients were removed from the analysis due to inability to find a match within the specified criteria).

9.5.1.3.2 Propensity score matching

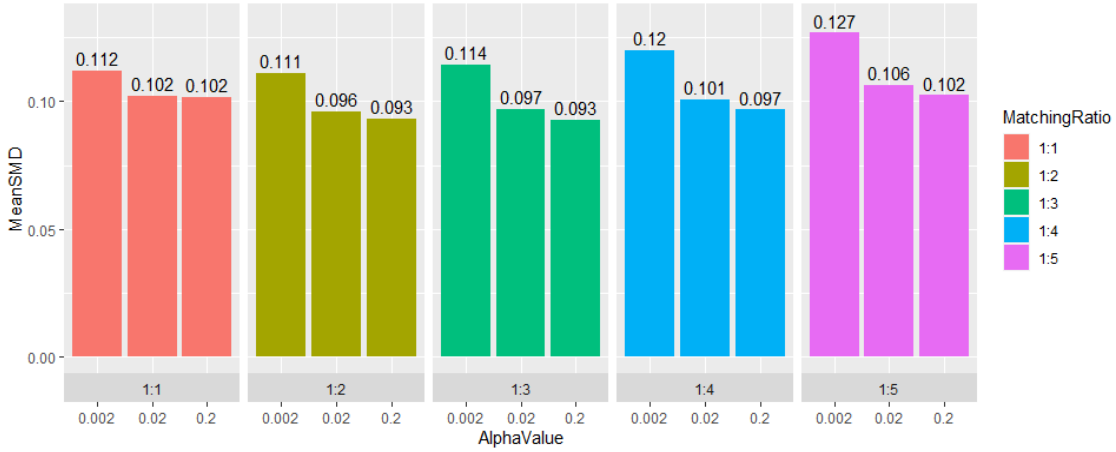
For rolling entry propensity score matching, Table 9.8 describes the number of successful matches at varying matching ratios and varying caliper widths (i.e. *alpha* values representing some proportion of the standard deviation of the propensity score).

Table 9.8 – Results of propensity score matching at varying matching ratios and alpha values

Matching Type	Comparison group	Intervention group	Unmatched intervention patients
1 to 1 alpha=0.2	1299	1299	4
1 to 1 alpha=0.02	1282	1282	21
1 to 1 alpha=0.002	1172	1172	131
1 to 2 alpha=0.2	2590	1299	4
1 to 2 alpha=0.02	2516	1280	23
1 to 2 alpha=0.002	2208	1170	133
1 to 3 alpha=0.2	3853	1296	7
1 to 3 alpha=0.02	3690	1275	28
1 to 3 alpha=0.002	3156	1170	133
1 to 4 alpha=0.2	5067	1294	9
1 to 4 alpha=0.02	4787	1275	28
1 to 4 alpha=0.002	3971	1169	134
1 to 5 alpha=0.2	6175	1293	10
1 to 5 alpha=0.02	5757	1275	28
1 to 5 alpha=0.002	4671	1169	134

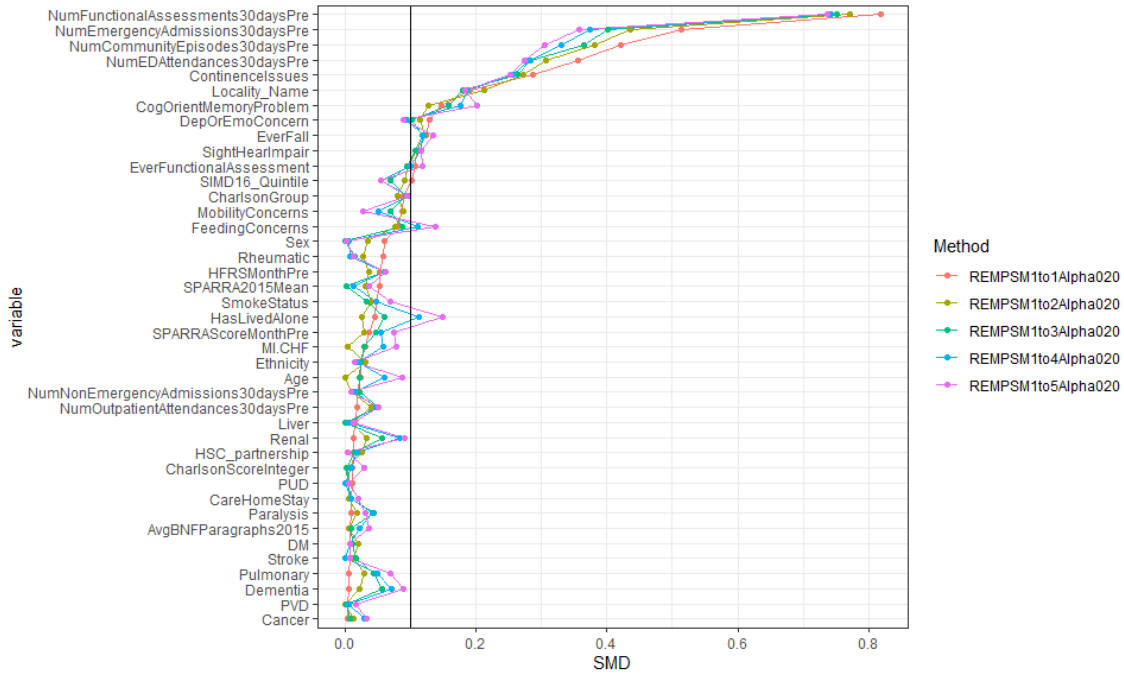
Based on these results, higher matching ratios of course lead to a maximised overall sample size, however, examining the associated SMDs across all variables can help in identifying the best strategy. Based on Figure 9.9, an alpha value of 0.2 appears to minimise the overall SMD across all matching ratios.

Figure 9.9 – Overall standardised mean differences (SMDs) across covariates between different matching ratios and alpha values in rolling entry propensity score matching



To compare the results in SMDs between matching ratios within the alpha value selected (0.2), examining the SMDs across all covariates provides a helpful guide. Based on the following figure, matching ratios of 1:2 or 1:3 appear to minimise SMDs across covariates the most.

Figure 9.10 – Standardised mean differences (SMDs) for each covariate between different matching ratios and alpha values in rolling entry propensity score matching



Hence, based on these figures and the above findings, matching ratios of either two or three untreated to one treated subject, with an alpha value of 0.2 minimise the overall SMD across covariates. A ratio of three to one was thus chosen to maximise the overall sample size while minimising SMD.

Hence, for rolling entry propensity score matching, a total of 1296 ECT patients were successfully matched to 3853 control patients (meaning seven ECT patients were removed from the analysis due to inability to find a match within the specified criteria).

9.5.1.4 Baseline characteristics of matched ECT study cohorts

Having identified matched samples, the characteristics of the samples are described here.

Table 9.9 describes the baseline characteristics of the study sample, including SMDs which highlight key differences. Figure 9.11 displays the SMDs across baseline covariates between ECT intervention patients and non-ECT patients for each covariate among both matched cohorts and the full cohort prior to matching. It is clear that the matching in both matched cohorts has been successful at finding subgroups of patients that are much more comparable to the ECT intervention patients than the general elderly population. Direct covariate matching has been very successful at finding matches that are close to the ECT intervention patients, even on characteristics that have not been directly matched. However, it appears that the propensity score matched sample was able to identify even closer matches, as SMDs are overall less, particularly for characteristics relating to physical function which were evaluated at community assessments (these were included in the PS algorithm, but not included in direct covariate matching).

Figure 9.11 – Standardised mean differences (SMDs) for each matching strategy and unmatched cohort (i.e. prior to matching) (REMDirectMatched= direct covariate matching cohort, REMPSMatched= propensity score matched cohort)

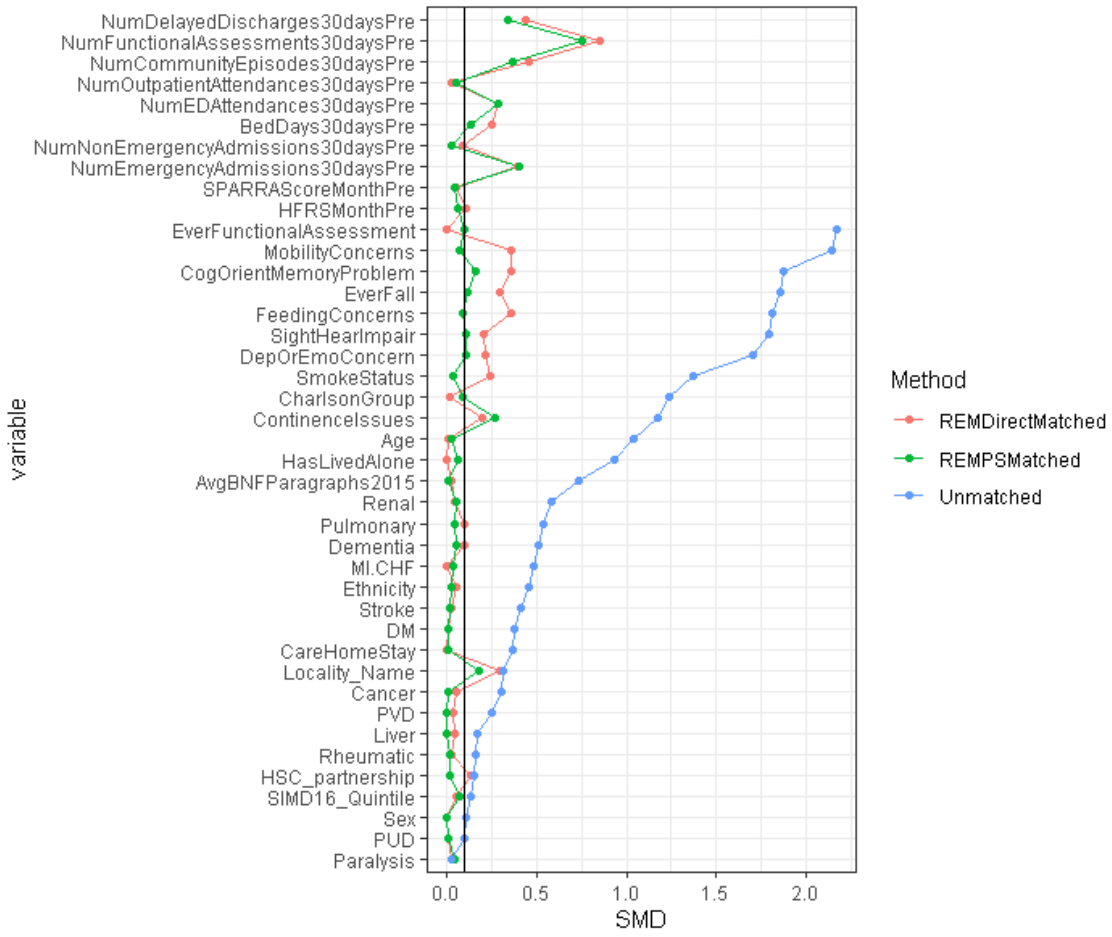


Table 9.9 – Baseline characteristics of direct covariate and propensity score matched study samples

	Rolling entry direct matched sample				Rolling entry propensity score matched sample			
Characteristic	Comparison group (n=1289)	ECT (n=1289)	p-value	SMD	Comparison group (n=3853)	ECT (n=1296)	p-value	SMD
Age (mean (SD))	82.74 (7.34)	82.78 (7.41)	0.881	0.006	82.58 (7.91)	82.76 (7.47)	0.491	0.022
Sex = Male (%)	518 (40.2)	517 (40.1)	1.000	0.002	1546 (40.1)	521 (40.2)	0.988	0.002
Ethnicity (%)			0.574	0.056			0.733	0.025
White	1258 (97.6)	1253 (97.2)			3760 (97.6)	1260 (97.2)		
Other	4 (0.3)	7 (0.5)			16 (0.4)	7 (0.5)		
Not specified	26 (2.0)	29 (2.2)			77 (2.0)	29 (2.2)		
MISSING	1 (0.1)	0 (0.0)			0 (0.0)	0 (0.0)		
Smoking status (%)			<0.001	0.238			0.778	0.034
Yes	86 (6.7)	132 (10.2)			417 (10.8)	133 (10.3)		
Ex-smoker	247 (19.2)	265 (20.6)			779 (20.2)	267 (20.6)		
No	423 (32.8)	495 (38.4)			1430 (37.1)	497 (38.3)		
MISSING	533 (41.3)	397 (30.8)			1227 (31.8)	399 (30.8)		
Health and Social Care Partnership			0.001	0.131			0.667	0.015
Stirling & Clackmannanshire (%)	635 (49.3)	719 (55.8)			2166 (56.2)	719 (55.5)		
Falkirk (%)	654 (50.7)	570 (44.2)			1687 (43.8)	577 (44.5)		
Locality (%)			<0.001	0.293			<0.001	0.181
Clackmannanshire	262 (20.3)	211 (16.4)			673 (17.5)	213 (16.4)		

	Rolling entry direct matched sample				Rolling entry propensity score matched sample			
Characteristic	Comparison group (n=1289)	ECT (n=1289)	p-value	SMD	Comparison group (n=3853)	ECT (n=1296)	p-value	SMD
Denny/ Bonnybridge/ Larbert / Stenhousemuir	164 (12.7)	142 (11.0)			377 (9.8)	144 (11.1)		
Falkirk Town	194 (15.1)	171 (13.3)			539 (14.0)	175 (13.5)		
Grangemouth / Bo'ness / Braes	296 (23.0)	257 (19.9)			771 (20.0)	258 (19.9)		
Rural Stirling	103 (8.0)	74 (5.7)			388 (10.1)	75 (5.8)		
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	270 (20.9)	434 (33.7)			1105 (28.7)	431 (33.3)		
SIMD16 Quintile †(%)			0.757	0.054			0.319	0.070
1	202 (15.7)	211 (16.4)			595 (15.4)	214 (16.5)		
2	347 (26.9)	333 (25.8)			985 (25.6)	334 (25.8)		
3	269 (20.9)	264 (20.5)			743 (19.3)	264 (20.4)		
4	254 (19.7)	242 (18.8)			835 (21.7)	246 (19.0)		
5	217 (16.8)	239 (18.5)			695 (18.0)	238 (18.4)		
Living alone ever recorded (%)			1.000	<0.001			0.168	0.061
Yes	574 (44.5)	574 (44.5)			1601 (41.6)	576 (44.4)		
No	710 (55.1)	710 (55.1)			2240 (58.1)	715 (55.2)		
MISSING	5 (0.4)	5 (0.4)			12 (0.3)	5 (0.4)		
Care Home Stay = Yes (%)	202 (15.7)	202 (15.7)	1.000	<0.001	622 (16.1)	205 (15.8)	0.816	0.009
Fall ever recorded (%)			<0.001	0.294			0.001	0.119

	Rolling entry direct matched sample				Rolling entry propensity score matched sample			
Characteristic	Comparison group (n=1289)	ECT (n=1289)	p-value	SMD	Comparison group (n=3853)	ECT (n=1296)	p-value	SMD
Yes	737 (57.2)	910 (70.6)			2735 (71.0)	916 (70.7)		
No	350 (27.2)	265 (20.6)			884 (22.9)	264 (20.4)		
MISSING	202 (15.7)	114 (8.8)			234 (6.1)	116 (9.0)		
Functional Assessment ever conducted = Yes (%)	1204 (93.4)	1204 (93.4)	1.000	<0.001	3495 (90.7)	1209 (93.3)	0.005	0.095
Mobility concerns (%)			<0.001	0.358			0.083	0.070
Yes	768 (59.6)	969 (75.2)			2988 (77.5)	972 (75.0)		
No	264 (20.5)	197 (15.3)			499 (13.0)	199 (15.4)		
MISSING	257 (19.9)	123 (9.5)			366 (9.5)	125 (9.6)		
Sight or hearing impairment (%)			<0.001	0.207			0.004	0.107
Yes	674 (52.3)	782 (60.7)			2272 (59.0)	785 (60.6)		
No	290 (22.5)	285 (22.1)			1006 (26.1)	285 (22.0)		
MISSING	325 (25.2)	222 (17.2)			575 (14.9)	226 (17.4)		
Cognitive, orientation or memory problem (%)			<0.001	0.359			<0.001	0.158
Yes	426 (33.0)	643 (49.9)			1758 (45.6)	647 (49.9)		
No	555 (43.1)	452 (35.1)			1627 (42.2)	452 (34.9)		
MISSING	308 (23.9)	194 (15.1)			468 (12.1)	197 (15.2)		
Feeding concerns (%)			<0.001	0.355			0.024	0.088
Yes	382 (29.6)	584 (45.3)			1630 (42.3)	586 (45.2)		

	Rolling entry direct matched sample				Rolling entry propensity score matched sample			
Characteristic	Comparison group (n=1289)	ECT (n=1289)	p-value	SMD	Comparison group (n=3853)	ECT (n=1296)	p-value	SMD
No	532 (41.3)	471 (36.5)			1571 (40.8)	473 (36.5)		
MISSING	375 (29.1)	234 (18.2)			652 (16.9)	237 (18.3)		
Depression or emotional concerns (%)			<0.001	0.218			0.006	0.102
Yes	259 (20.1)	351 (27.2)			992 (25.7)	355 (27.4)		
No	676 (52.4)	684 (53.1)			2214 (57.5)	683 (52.7)		
MISSING	354 (27.5)	254 (19.7)			647 (16.8)	258 (19.9)		
Continence issues (%)			<0.001	0.193			<0.001	0.264
Yes	605 (46.9)	579 (44.9)			1863 (48.4)	580 (44.8)		
No	342 (26.5)	265 (20.6)			1078 (28.0)	265 (20.4)		
MISSING	342 (26.5)	445 (34.5)			912 (23.7)	451 (34.8)		
Charlson Score group (%)			0.993	0.019			0.101	0.093
No ICD-10 codes recorded in past 5 years	33 (2.6)	32 (2.5)			149 (3.9)	32 (2.5)		
No comorbidities identified (0)	192 (14.9)	197 (15.3)			637 (16.5)	197 (15.2)		
Mild (1-2)	482 (37.4)	473 (36.7)			1337 (34.7)	469 (36.2)		
Moderate (3-4)	339 (26.3)	338 (26.2)			959 (24.9)	340 (26.2)		
Severe (5+)	243 (18.9)	249 (19.3)			771 (20.0)	258 (19.9)		
Comorbidities (ICD-10 based)								
MI or CHF (%)	352 (27.3)	354 (27.5)	0.965	0.003	1012 (26.3)	358 (27.6)	0.357	0.031

	Rolling entry direct matched sample				Rolling entry propensity score matched sample			
Characteristic	Comparison group (n=1289)	ECT (n=1289)	p-value	SMD	Comparison group (n=3853)	ECT (n=1296)	p-value	SMD
PVD (%)	136 (10.6)	122 (9.5)	0.394	0.036	377 (9.8)	126 (9.7)	0.991	0.002
Stroke (%)	284 (22.0)	268 (20.8)	0.471	0.030	841 (21.8)	274 (21.1)	0.632	0.017
Pulmonary (%)	312 (24.2)	369 (28.6)	0.012	0.100	1039 (27.0)	375 (28.9)	0.181	0.044
Rheumatic (%)	41 (3.2)	46 (3.6)	0.663	0.021	126 (3.3)	46 (3.5)	0.693	0.015
PUD (%)	20 (1.6)	22 (1.7)	0.876	0.012	74 (1.9)	24 (1.9)	0.969	0.005
Liver (%)	39 (3.0)	50 (3.9)	0.281	0.047	145 (3.8)	49 (3.8)	1.000	0.001
DM (%)	275 (21.3)	272 (21.1)	0.923	0.006	806 (20.9)	277 (21.4)	0.758	0.011
Renal (%)	308 (23.9)	331 (25.7)	0.316	0.041	901 (23.4)	335 (25.8)	0.079	0.057
Dementia (%)	218 (16.9)	267 (20.7)	0.016	0.097	710 (18.4)	268 (20.7)	0.081	0.057
Cancer (%)	311 (24.1)	282 (21.9)	0.190	0.053	874 (22.7)	290 (22.4)	0.849	0.007
Paralysis (%)	11 (0.9)	8 (0.6)	0.645	0.027	39 (1.0)	8 (0.6)	0.261	0.044
Average monthly prescriptions (BNF paragraphs)[a] 2015 (mean (SD))	5.84 (2.98)	5.93 (3.01)	0.463	0.029	5.92 (3.20)	5.95 (3.03)	0.755	0.010
Average SPARRA score in month prior* (mean (SD))	36.38 (16.74)	37.25 (17.01)	0.200	0.051	36.60 (18.07)	37.45 (17.28)	0.142	0.048
Average HFRS in month prior* (mean (SD))	4.34 (6.21)	4.97 (6.17)	0.009	0.102	4.61 (6.39)	4.99 (6.19)	0.063	0.060
Admitted as inpatient in 30 days prior*= Yes (%)	225 (17.5)	474 (36.8)	<0.001	0.445	671 (17.4)	479 (37.0)	<0.001	0.450
Emergency inpatient hospitalisations in 30 days prior* (mean (SD))	0.18 (0.43)	0.38 (0.56)	<0.001	0.394	0.18 (0.45)	0.38 (0.57)	<0.001	0.402

	Rolling entry direct matched sample				Rolling entry propensity score matched sample			
Characteristic	Comparison group (n=1289)	ECT (n=1289)	p-value	SMD	Comparison group (n=3853)	ECT (n=1296)	p-value	SMD
Non-emergency inpatient hospitalisations in 30 days prior* (mean (SD))	0.02 (0.16)	0.04 (0.20)	0.029	0.086	0.03 (0.23)	0.04 (0.20)	0.490	0.023
Emergency inpatient length of stay in days in 30 days prior* (mean (SD))**	11.46 (9.20)	13.85 (9.99)	0.002	0.249	12.46 (9.66)	13.75 (9.93)	0.023	0.131
Admitted at ED in 30 days prior*= Yes (%)	146 (11.3)	291 (22.6)	<0.001	0.303	431 (11.2)	294 (22.7)	<0.001	0.310
ED Attendances in 30 days prior* (mean (SD))	0.13 (0.38)	0.25 (0.50)	<0.001	0.282	0.13 (0.40)	0.26 (0.51)	<0.001	0.284
Outpatient attendances in 30 days prior* (mean (SD))	0.21 (0.60)	0.23 (0.64)	0.485	0.028	0.28 (0.99)	0.23 (0.64)	0.145	0.051
Community episodes in 30 days prior* (mean (SD))	0.30 (0.82)	0.76 (1.15)	<0.001	0.459	0.38 (0.90)	0.75 (1.14)	<0.001	0.365
Community functional assessments in 30 days prior* (mean(SD))	0.20 (0.80)	1.10 (1.26)	<0.001	0.850	0.27 (0.90)	1.09 (1.26)	<0.001	0.752
Delayed discharge in 30 days prior*= Yes (%)	10 (0.8)	151 (11.7)	<0.001	0.464	96 (2.5)	148 (11.4)	<0.001	0.356

[a]*Average monthly number of BNF classes was used to reduce effect of exaggerated polypharmacy and variation for patients who have multiple medications in the class as described in Section 7.2.8.*

**30 days prior to ECT intervention or prior to assigned dummy ECT date*

***Note length of stay includes only length of stay for patients admitted*

† SIMD16 Quintile indicates level of deprivation (1=within most deprived fifth of population, 5=within least deprived fifth)

Abbreviations: SIMD16 (Scottish Index of Multiple Deprivation 2016 version), ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure), PVD (Peripheral Vascular Disease), PUD (Peptic Ulcer Disease), DM (Diabetes Mellitus), SPARRA (Scottish Patients at Risk of Readmission and Admission), HFRS (Hospital Frailty Risk Score), BNF (British National Formulary), ED (Emergency Department)

Key differences between the groups, however, still exist in both the matched samples, particularly in their time-dependent covariates, 30 days prior to ECT intervention (or dummy intervention date for comparison group patients). The differences are most notable in their emergency hospital activity and community activity. While around 37% of ECT patients were admitted as inpatients in the 30 days prior to referral, about half the proportion of comparison group patients were admitted, in both matched samples. In both matched samples, emergency inpatient admission rates were about twice as high among ECT patients compared to their matched counterparts, in the 30 days prior to referral (380 admissions per 1000 ECT patients compared to 180 admissions per 1000 comparison group patients). Emergency department activity differed in the same way. About 11% of ECT patients experienced a delayed discharge from hospital in the 30 days prior to referral while in the comparison groups, less than 1% experienced a delay among the direct covariate matched sample and 2.5% in the propensity score matched sample.

Though outpatient activity was similar between groups in both matched samples, ECT patients experienced roughly double the community activity than comparison group patients (760 community episodes per 1000 ECT patients in direct covariate matched sample and 750 in the propensity score matched sample, compared to 300 per 1000 comparison group patients in direct covariate matched sample and 380 in the propensity score matched sample).

It may seem unexpected that emergency hospital activity in the 30 days prior to referral differs so greatly given this was included as a covariate in matching in both matching strategies at least to some extent. However, this is because the rolling entry obtained based on time-dependent covariates at monthly intervals, where the month of receipt of ECT was included as a reference point for finding matches, regardless of what point within the month it took place. Hence, upon using actual dates of referral and assigned dummy dates of referral, the activity in the 30 days prior to this has differed between the groups, highlighting the time sensitive nature of receipt of ECT (this is further explored in the discussion of this chapter).

In summary, residual differences between the groups in both matched samples remained, which is expected. However, multivariate adjustment will be made for residual differences in the statistical analysis.

9.5.1.5 Visual comparison of trends over time in outcome measures

Two of the main outcome measures (namely emergency inpatient hospitalisations and emergency department attendance), are explored visually over time across groups, relative to the date of ECT intervention (or assigned dummy date for control patients). Monthly admission rates for each group were calculated by dividing the total number of admissions each month by the number of patients who were alive at the start of each month. This was done to factor in the different group sizes and to factor in mortality.

Figure 9.12Figure 9.13 highlight the success of matching in both matching strategies for achieving control groups displaying similar patterns in emergency inpatient hospitalisations during their baseline periods. For rolling entry direct covariate matching it is clear that patients have been matched on their emergency inpatient hospitalisations in the month prior to intervention (though it appears more effective than expected, as patients were matched on whether they experienced a hospitalisation but appear very closely matched in actual number of hospitalisations). Such close matching is not observed with the rolling entry propensity score matched sample, as expected, though similar patterns are observed.

Figure 9.12 – Emergency admission rate relative to index date (ECT date or matched dummy ECT date) for rolling entry direct covariate matching cohort

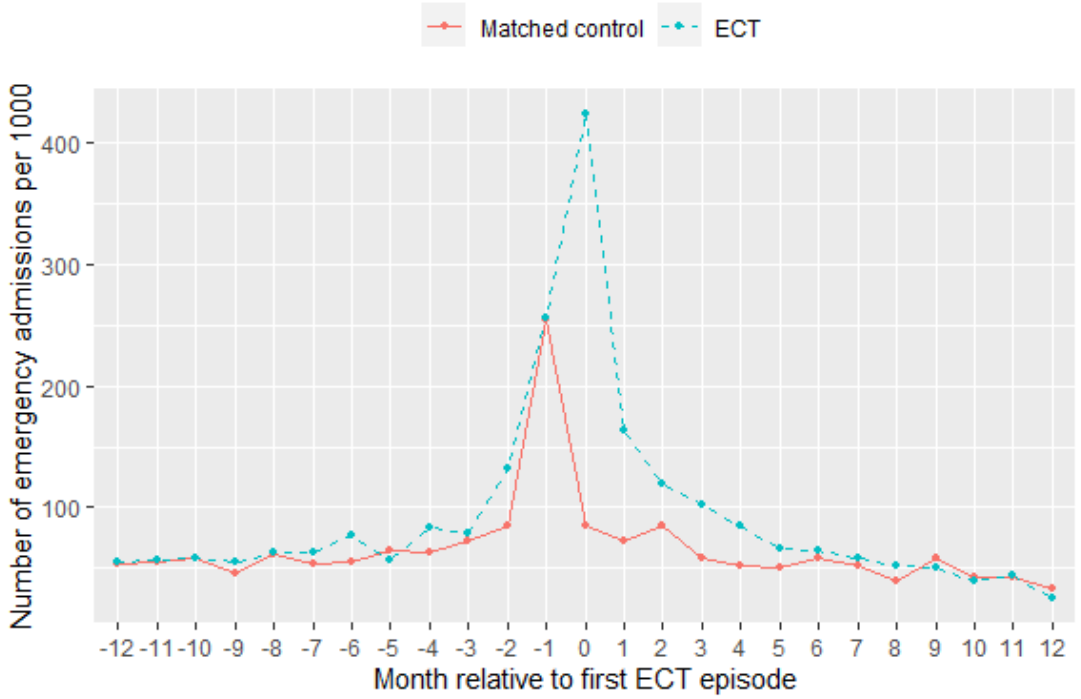
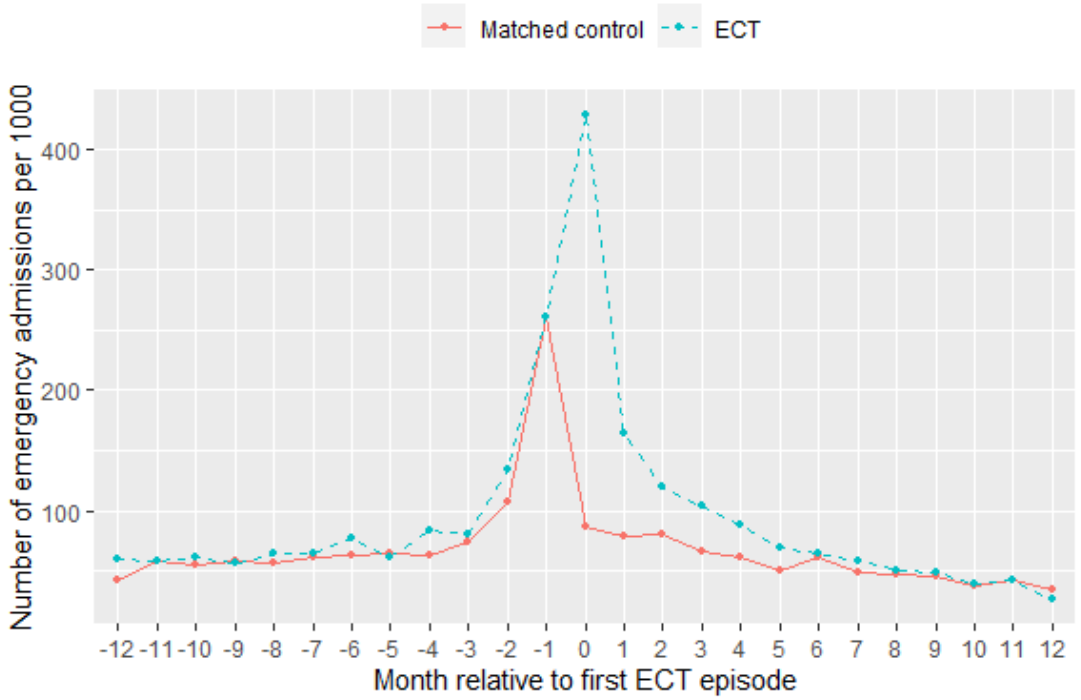


Figure 9.13 – Emergency admission rate relative to index date (ECT date or matched dummy ECT date) for rolling entry Propensity Score matching cohort



With both matching strategies, a drastic increase in activity is observed in the month of intervention where ECT patients experience their peak followed by a drastic drop in hospitalisations. Amongst both control groups, the peak is seen in the prior month with a similar subsequent drop, as is expected amongst elderly patients (Roland et al., 2005). The patterns were very similar amongst emergency department attendances, as seen in Figure 9.13 andFigure 9.14.

Figure 9.14 – ED attendance rate relative to index date (ECT date or matched dummy ECT date) for rolling entry direct covariate matching cohort

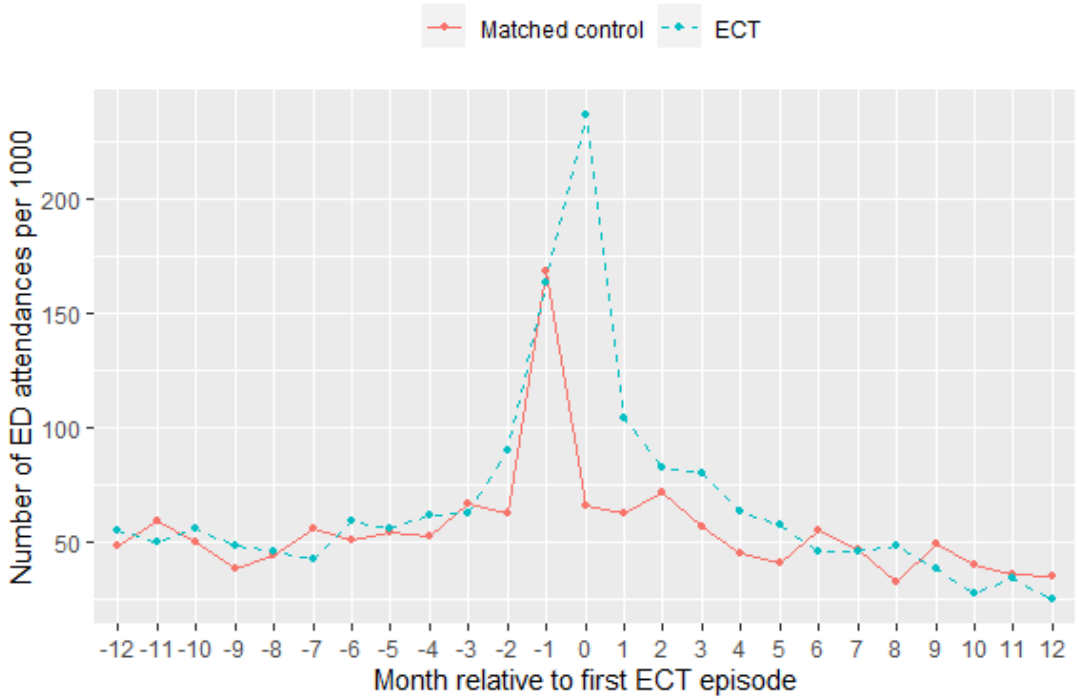
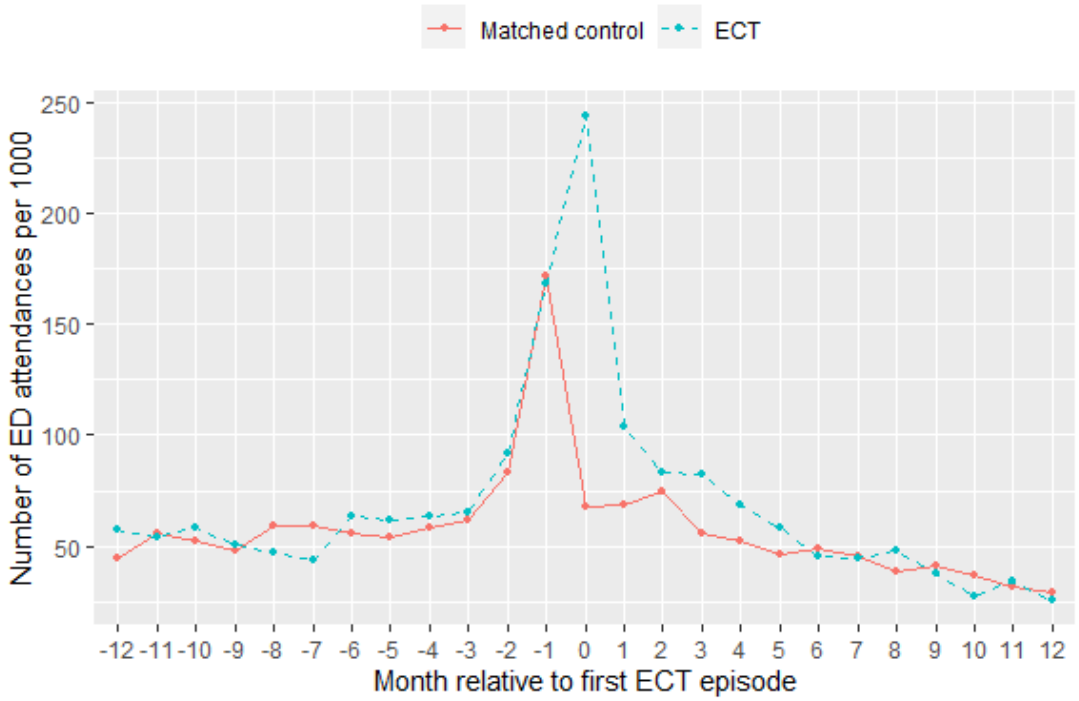


Figure 9.15 – ED attendance rate relative to index date (ECT date or matched dummy ECT date) for rolling entry Propensity Score matching cohort



9.5.1.6 Results of statistical models assessing the effect of ECT on hospital activity outcomes

As described in Section 9.2.2, conditional logistic regression and Cox proportional-hazards models were used to assess the effect of ECT on hospital activity outcomes, both of which are able to make appropriate allowances for the use of matched samples. The conditional logistic regression models were used to compare the effect of ECT on experiencing hospital activity outcomes within 30 days of first ECT referral (or allocated dummy ECT referral date for control patients). Cox proportional-hazards models enable assessment of the effect of multiple treatment episodes (time-variable effect), where the effect estimate is the daily hazard of experiencing an event, hence they enabled the inclusion of the effect of subsequent ECT episodes. Cox models also enable the inclusion of time-dependent covariates for multivariate adjustment of characteristics that change over time.

9.5.1.6.1 Effect on emergency inpatient hospitalisation

Among both matched cohorts, rates of emergency inpatient admissions within 30 days of referral (or allocated dummy ECT referral date for control patients) were much higher in ECT intervention patients than their matched counterparts (32.9% ECT patients admitted vs 7.4% non-ECT in direct matched cohort and 33.3% ECT patients admitted vs 7.5% in propensity score matched cohort). When comparing the effect of ECT on experiencing an emergency inpatient hospitalisation within 30 days in a conditional logistic regression model, using the rolling entry direct matched sample, ECT was associated with increased odds of hospitalisation in the unadjusted model (OR 6.29, 95% CI [4.81, 8.22] see Table 9.10). Similar results were observed among the propensity score matched sample (OR 6.37, 95% CI [5.32, 7.63]). Associated event rates are displayed in Table 9.10.

Table 9.10 – Event rates for emergency inpatient hospitalisation within 30 days of referral for each matched sample

	Rolling entry direct matched sample			**Rolling entry propensity score matched sample**		
Intervention	Events	Patients	Event rate	Events	Patients	Event rate
ECT	424	1289	0.33	432	1296	0.33
Non-ECT	96	1289	0.07	290	3853	0.08

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Intervention	Events	Patients	Event rate	Events	Patients	Event rate

**Events represent emergency hospitalisation and event rates are calculated as the ratio of events per person*

The odds ratios were slightly reduced in the adjusted models for both matched samples (OR 5.51, 95% CI [3.77, 8.06] for direct covariate matched sample and OR 6.19, 95% CI [4.97, 7.72] for propensity score matched sample). Overall, ECT was associated with significantly higher odds of emergency inpatient hospitalisation, with ECT patients having roughly six times higher odds of being admitted, among both matched samples.

The adjusted intervention effect estimates are displayed in Table 9.11 along with estimates for included adjustment variables.

Table 9.11 – Adjusted effect estimates of ECT on 30-day emergency hospitalisation in conditional logistic regression for each matching strategy, including estimates for adjustment variables

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Treatment						
No ECT	—	—		—	—	
ECT	5.51	3.77, 8.06	<0.001	6.19	4.97, 7.72	<0.001
Smoking status*						
No	—	—				
Yes	0.69	0.33, 1.47	0.3			
Ex-smoker	0.68	0.37, 1.25	0.2			
MISSING	0.87	0.48, 1.60	0.7			
Locality						
Clackmannanshire	—	—		—	—	
Denny/ Bonnybridge/ Larbert / Stenhousemuir	0.61	0.29, 1.26	0.2	0.95	0.61, 1.47	0.8
Falkirk Town	0.98	0.46, 2.11	>0.9	0.88	0.59, 1.31	0.5
Grangemouth / Bo'ness / Braes	1.35	0.70, 2.59	0.4	0.94	0.65, 1.36	0.7
Rural Stirling	0.56	0.22, 1.44	0.2	0.92	0.57, 1.48	0.7
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	0.89	0.47, 1.71	0.7	0.54	0.38, 0.77	<0.001

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Fall ever recorded*						
No	—	—				
Yes	0.89	0.52, 1.50	0.6			
MISSING	1.16	0.38, 3.52	0.8			
Mobility concerns*						
No	—	—				
Yes	0.68	0.36, 1.28	0.2			
MISSING	0.44	0.12, 1.57	0.2			
Cognition, orientation or memory problem						
No	—	—		—	—	
Yes	1.49	0.92, 2.42	0.11	1.08	0.84, 1.39	0.5
MISSING	0.91	0.26, 3.23	0.9	1.30	0.77, 2.21	0.3
Continence issues						
No	—	—		—	—	
Yes	0.73	0.42, 1.28	0.3	1.06	0.80, 1.40	0.7
MISSING	1.17	0.57, 2.40	0.7	0.97	0.68, 1.40	0.9
Sight or hearing impairment*						
No	—	—				
Yes	1.02	0.57, 1.84	>0.9			
MISSING	2.16	0.50, 9.32	0.3			
Depression or emotional concerns*						
No	—	—				
Yes	0.78	0.45, 1.36	0.4			
MISSING	0.10	0.02, 0.43	0.002			
Feeding concerns						
No	—	—				
Yes	1.03	0.61, 1.74	>0.9			
MISSING	2.83	0.86, 9.32	0.086			
Number of emergency inpatient hospitalisations in 30 days prior	1.30	0.79, 2.14	0.3	2.32	1.74, 3.10	<0.001
Number of ED attendances in 30 days prior	2.02	1.19, 3.42	0.009	1.03	0.77, 1.40	0.8
Number of community episodes in 30 days prior	0.94	0.74, 1.19	0.6	0.84	0.73, 0.96	0.010

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Number of community functional assessments in 30 days prior	1.17	0.95, 1.45	0.13	1.11	1.01, 1.24	0.040
Delayed discharge in 30 days prior=Yes**				0.69	0.41, 1.14	0.15

[1]OR = Odds Ratio, CI = Confidence Interval

**Variable only included for adjustment in direct matched sample*

***Variable only included for adjustment in propensity score matched sample*

Note: Adjustment variables for all of the analyses assessing the comparative effect of ECT intervention were selected by reviewing residual differences between intervention and control patients in each matched cohort, particularly those with SMD>0.1, however the researcher's knowledge and judgement was employed when reviewing and selecting these. For example, although the differences in having a sight or hearing impairment appeared statistically significant between groups with an SMD slightly above 0.1, the proportions do not appear relevant especially as the main differences are among the 'No' or 'Missing' categories. Additionally, though there were some differences in whether the patients experienced a delayed discharge in the 30 days prior in the direct matched cohort, the frequencies were very low (e.g. n=10 experiencing a delay in one group) and no events were experienced in some of the low frequency groups so it would be inappropriate to include this as a covariate.

When comparing the time-variable effect of ECT on the daily hazard of experiencing an emergency inpatient hospitalisation Cox proportional hazards regression model (takes into account subsequent ECT episodes), ECT was associated with increased daily hazard of hospitalisation in the unadjusted model among both matched samples (HR 3.89, 95% CI [3.31,4.57] for direct covariate matched sample and HR 3.92, 95% CI [3.51,4.38] for propensity score matched sample). The associated event rates are displayed in Table 9.12.

Table 9.12 – Emergency hospitalisation event rates and person-years for each matched sample

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Treatment	Events	Person-years	Event rate	Events	Person-years	Event rate
ECT	501.00	119.12	4.21	525.00	122.29	4.29
Non-ECT	5869.00	6995.62	0.84	11505.00	14097.12	0.85

**Events represent emergency hospitalisation and event rates are calculated as the ratio of events over exposure time (person years)*

The hazard ratio was marginally lower in the adjusted model (time-dependent covariates) among the direct covariate matched sample and marginally higher among the propensity score matched sample. Table 9.13 below displays the results of the adjusted Cox proportional-hazards models, comparing the effect of ECT on emergency inpatient hospitalisation. The results indicate that after adjustment, having an ECT episode increased the daily hazard of having a hospital admission by a factor of 3.69 (95% CI [3.14, 4.32]) among the direct matched sample, and by a factor of 4.19 (95% CI [3.74, 4.69]) among the propensity score matched sample.

Table 9.13 – Adjusted effect estimates of ECT on daily hazard of emergency hospitalisation in Cox proportional hazards regression (including time-varying covariates) for each matching strategy, including estimates for adjustment variables

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
Treatment						
No ECT	—	—		—	—	
ECT	3.69	3.14, 4.32	<0.001	4.19	3.74, 4.69	<0.001
Smoking status*						
No	—	—				
Yes	1.00	0.90, 1.11	>0.9			
Ex-smoker	1.03	0.96, 1.12	0.4			
MISSING	0.96	0.89, 1.05	0.4			
Locality						
Clackmannanshire	—	—		—	—	
Denny/ Bonnybridge/ Larbert / Stenhousemuir	1.03	0.93, 1.14	0.6	1.19	1.09, 1.31	<0.001
Falkirk Town	0.96	0.87, 1.06	0.4	1.05	0.97, 1.15	0.2
Grangemouth / Bo'ness / Braes	0.99	0.91, 1.09	0.9	0.96	0.89, 1.04	0.3
Rural Stirling	0.98	0.87, 1.10	0.7	0.82	0.74, 0.91	<0.001
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	1.00	0.91, 1.09	>0.9	0.85	0.79, 0.92	<0.001
Fall ever recorded*						
No	—	—				
Yes	1.17	1.08, 1.27	<0.001			

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
MISSING	1.10	0.96, 1.27	0.2			
Mobility concerns*						
No	—	—				
Yes	1.02	0.94, 1.11	0.7			
MISSING	0.91	0.79, 1.05	0.2			
Cognition, orientation or memory problem						
No	—	—		—	—	
Yes	1.11	1.04, 1.18	<0.001	0.94	0.89, 0.99	0.029
MISSING	0.98	0.83, 1.15	0.8	1.47	1.32, 1.65	<0.001
Continence issues						
No	—	—		—	—	
Yes	1.00	0.92, 1.08	>0.9	1.04	0.98, 1.11	0.14
MISSING	1.03	0.94, 1.13	0.5	0.96	0.89, 1.04	0.3
Sight or hearing impairment*						
No	—	—				
Yes	1.02	0.95, 1.11	0.5			
MISSING	1.18	1.00, 1.40	0.049			
Depression or emotional concerns*						
No	—	—				
Yes	1.02	0.95, 1.11	0.5			
MISSING	1.18	1.00, 1.40	0.049			
Number of emergency inpatient hospitalisations in prior interval	1.22	1.10, 1.34	<0.001	1.68	1.58, 1.80	<0.001
Number of ED attendances in prior interval	1.24	1.13, 1.37	<0.001	1.17	1.10, 1.25	<0.001
Number of community episodes in prior interval	1.05	1.00, 1.11	0.031	1.05	1.01, 1.08	0.005
Number of community functional assessments in prior interval	1.06	1.02, 1.09	<0.001	1.06	1.04, 1.09	<0.001

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
Delayed discharge in prior interval=Yes**				1.12	0.93, 1.34	0.2

[1]HR = Hazard Ratio, CI = Confidence Interval

**Variable only included for adjustment in direct matched sample*

***Variable only included for adjustment in propensity score matched sample*

Note: See note on Table 9.11 for a description of how adjustment variables were selected.

9.5.1.6.2 Effect on emergency department attendance

Among both matched cohorts, rates of emergency department attendances within 30 days of referral (or allocated dummy ECT referral date for control patients) were also much higher in ECT intervention patients than their matched counterparts (14.9% ECT patients attended ED in direct matched cohort and 15.2% ECT patients attended ED in propensity score matched cohort vs 5.7% in the comparison group among both matched samples). When comparing the effect of ECT on experiencing an emergency department attendance within 30 days of referral in a conditional logistic regression model, ECT was associated with increased odds of ED attendance in the unadjusted model among both the direct covariate matched sample (OR 2.87, 95% CI [2.16, 3.83]) and the propensity score matched sample (OR 2.96, 95% CI [2.40, 3.64]). Associated event rates can be seen in Table 9.14.

Table 9.14 – Event rates for emergency department attendance within 30 days of referral for each matched sample

	Rolling entry direct matched sample			**Rolling entry propensity score matched sample**		
Intervention	Events	Patients	Event rate	Events	Patients	Event rate
ECT	192	1289	0.15	1097	1296	0.15
Non-ECT	74	1289	0.06	219	3853	0.06

**Events represent emergency department attendances and event rates are calculated as the ratio of events per person*

The odds ratios remained very similar in the adjusted models for both matched samples (OR 2.85, 95% CI [1.82, 4.46] for direct covariate matched sample and OR 2.90, 95% CI [2.24, 3.77] for propensity score matched sample). Overall, ECT

was also associated with significantly higher odds of emergency department attendance, with patients having roughly three times higher odds of attending the emergency department, among both matched samples.

The adjusted intervention effect estimates are displayed in Table 9.15 along with estimates for included adjustment variables.

Table 9.15 – Adjusted effect estimates of ECT on 30-day emergency department attendance in conditional logistic regression for each matching strategy, including estimates for adjustment variables

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Treatment						
No ECT	—	—		—	—	
ECT	2.85	1.82, 4.46	<0.001	2.90	2.24, 3.77	<0.001
Smoking status*						
No	—	—				
Yes	0.66	0.29, 1.46	0.3			
Ex-smoker	1.00	0.50, 2.01	>0.9			
MISSING	0.97	0.48, 1.97	>0.9			
Locality						
Clackmannanshire	—	—		—	—	
Denny/ Bonnybridge/ Larbert / Stenhousemuir	1.23	0.51, 2.96	0.6	0.94	0.58, 1.50	0.8
Falkirk Town	1.08	0.45, 2.58	0.9	0.87	0.56, 1.36	0.6
Grangemouth / Bo'ness / Braes	1.50	0.73, 3.09	0.3	0.75	0.50, 1.14	0.2
Rural Stirling	0.29	0.08, 1.07	0.063	0.39	0.21, 0.75	0.004
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	1.02	0.47, 2.22	>0.9	0.61	0.41, 0.90	0.012
Fall ever recorded*						
No	—	—				
Yes	1.32	0.74, 2.36	0.3			
MISSING	2.73	0.81, 9.19	0.10			
Mobility concerns*						
No	—	—				
Yes	0.88	0.45, 1.72	0.7			
MISSING	0.33	0.08, 1.31	0.11			

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Cognition, orientation or memory problem						
No	—	—		—	—	
Yes	1.28	0.74, 2.24	0.4	1.28	0.96, 1.71	0.10
MISSING	0.45	0.10, 2.02	0.3	1.13	0.62, 2.06	0.7
Continence issues						
No	—	—		—	—	
Yes	0.68	0.35, 1.30	0.2	0.97	0.71, 1.34	0.9
MISSING	0.77	0.33, 1.81	0.6	0.96	0.65, 1.43	0.8
Sight or hearing impairment*						
No	—	—				
Yes	0.99	0.52, 1.90	>0.9			
MISSING	2.88	0.62, 13.5	0.2			
Depression or emotional concerns*						
No	—	—				
Yes	0.70	0.38, 1.31	0.3			
MISSING	0.26	0.07, 1.06	0.061			
Feeding concerns						
No	—	—				
Yes	1.27	0.68, 2.37	0.5			
MISSING	2.83	0.82, 9.72	0.10			
Number of emergency inpatient hospitalisations in 30 days prior	1.02	0.52, 1.97	>0.9	1.07	0.77, 1.49	0.7
Number of ED attendances in 30 days prior	2.48	1.38, 4.48	0.003	2.07	1.47, 2.93	<0.001
Number of community episodes in 30 days prior	1.02	0.76, 1.38	0.9	0.89	0.76, 1.04	0.13
Number of community functional assessments in 30 days prior	0.94	0.73, 1.20	0.6	0.96	0.84, 1.09	0.5
Delayed discharge in 30 days prior**				0.79	0.44, 1.41	0.4

[1]OR = Odds Ratio, CI = Confidence Interval

**Variable only included for adjustment in direct matched sample*

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value

***Variable only included for adjustment propensity score matched sample*

Note: See note on Table 9.11 for a description of how adjustment variables were selected.

When comparing the effect of ECT on the daily hazard of experiencing an emergency department attendance, in a Cox proportional hazards regression model (takes into account subsequent ECT episodes), ECT was also associated with increased daily hazard of emergency department attendance in the unadjusted model among both matched samples (HR 2.13, 95% CI [1.78, 2.56] for rolling entry direct matched cohort and HR 2.08, 95% CI [1.81, 2.40] for rolling entry propensity score matched sample).

Associated event rates are displayed in Table 9.16 below.

Table 9.16 – Emergency department attendance event rates and person-years for each matched sample

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Treatment	Events	Person-years	Event rate	Events	Person-years	Event rate
ECT	225.00	119.12	1.89	235.00	122.29	1.92
Non-ECT	4919.00	6995.62	0.70	9785.00	14097.12	0.69

Table 9.17 displays the results of the adjusted Cox proportional-hazards model with time-dependent covariates, comparing the effect of ECT on emergency department attendance. These results indicate that after adjustment, having an ECT episode increases the daily hazard of attending the emergency department by a factor of 2.09 (95% CI [1.74, 2.50]) among the direct covariate matched sample or very similarly a factor of 2.03 (95% CI [1.75, 2.35]) among the propensity score matched sample. These hazard ratios are very similar to those in the unadjusted model.

Table 9.17 – Adjusted effect estimates of ECT on daily hazard of emergency department attendance in Cox proportional hazards regression (including time-varying covariates) for each matching strategy, including estimates for adjustment variables

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
Treatment						

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
No ECT	—	—		—	—	
ECT	2.09	1.74, 2.50	<0.001	2.03	1.75, 2.35	<0.001
Smoking status*						
No	—	—				
Yes	1.04	0.90, 1.20	0.6			
Ex-smoker	1.01	0.92, 1.11	0.8			
MISSING	1.02	0.92, 1.12	0.7			
Locality						
Clackmannanshire	—	—		—	—	
Denny/ Bonnybridge/ Larbert / Stenhousemuir	1.13	0.99, 1.29	0.068	1.34	1.21, 1.48	<0.001
Falkirk Town	1.11	0.97, 1.27	0.14	1.22	1.11, 1.35	<0.001
Grangemouth / Bo'ness / Braes	0.96	0.85, 1.09	0.6	1.07	0.98, 1.17	0.2
Rural Stirling	0.73	0.62, 0.86	<0.001	0.66	0.58, 0.75	<0.001
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	1.15	1.02, 1.29	0.022	1.05	0.97, 1.14	0.2
Fall ever recorded*						
No	—	—				
Yes	1.31	1.18, 1.45	<0.001			
MISSING	1.09	0.91, 1.30	0.4			
Mobility concerns*						
No	—	—				
Yes	0.92	0.83, 1.02	0.10			
MISSING	1.05	0.88, 1.25	0.6			
Cognition, orientation or memory problem						
No	—	—		—	—	
Yes	1.20	1.10, 1.30	<0.001	1.06	1.00, 1.13	0.052
MISSING	1.09	0.89, 1.33	0.4	1.53	1.36, 1.72	<0.001
Continence issues						
No	—	—		—	—	
Yes	1.06	0.96, 1.17	0.2	1.03	0.97, 1.10	0.4
MISSING	1.06	0.94, 1.19	0.4	1.02	0.93, 1.11	0.7
Sight or hearing impairment*						

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
No	—	—				
Yes	1.03	0.93, 1.14	0.5			
MISSING	0.87	0.71, 1.07	0.2			
Depression or emotional concerns*						
No	—	—				
Yes	0.95	0.87, 1.04	0.3			
MISSING	1.09	0.87, 1.36	0.5			
Feeding concerns*						
No	—	—				
Yes	0.94	0.86, 1.02	0.14			
MISSING	0.89	0.73, 1.10	0.3			
Number of emergency inpatient hospitalisations in prior interval	1.11	0.98, 1.24	0.090	1.20	1.11, 1.29	<0.001
Number of ED attendances in prior interval	1.49	1.33, 1.69	<0.001	1.61	1.49, 1.73	<0.001
Number of community episodes in prior interval	0.98	0.93, 1.04	0.5	1.05	1.01, 1.09	0.012
Number of community functional assessments in prior interval	1.00	0.98, 1.03	0.9	1.04	1.02, 1.06	<0.001
Delayed discharge in prior interval**				1.07	0.87, 1.31	0.5

[1]HR = Hazard Ratio, CI = Confidence Interval

**Variable only included for adjustment in direct matched sample*

***Variable only included for adjustment in propensity score matched sample*

9.5.1.6.3 Effect on emergency inpatient length of stay

A visual inspection of the distribution and cumulative distribution of length of stay in days for emergency inpatient hospitalisations indicates a small difference between the two groups (see Figure 9.16 – Figure 9.19). The median length of stay over follow-up for the ECT intervention patients was 9 days, whereas their matched counterparts had a median length of stay for 7 days in the direct matched cohort and 8 days in the propensity score matched cohort.

Figure 9.16 – Cumulative distribution of length of stay for emergency hospital stays over follow-up by group (rolling entry direct matched cohort) (0=no ECT intervention, 1=ECT intervention)

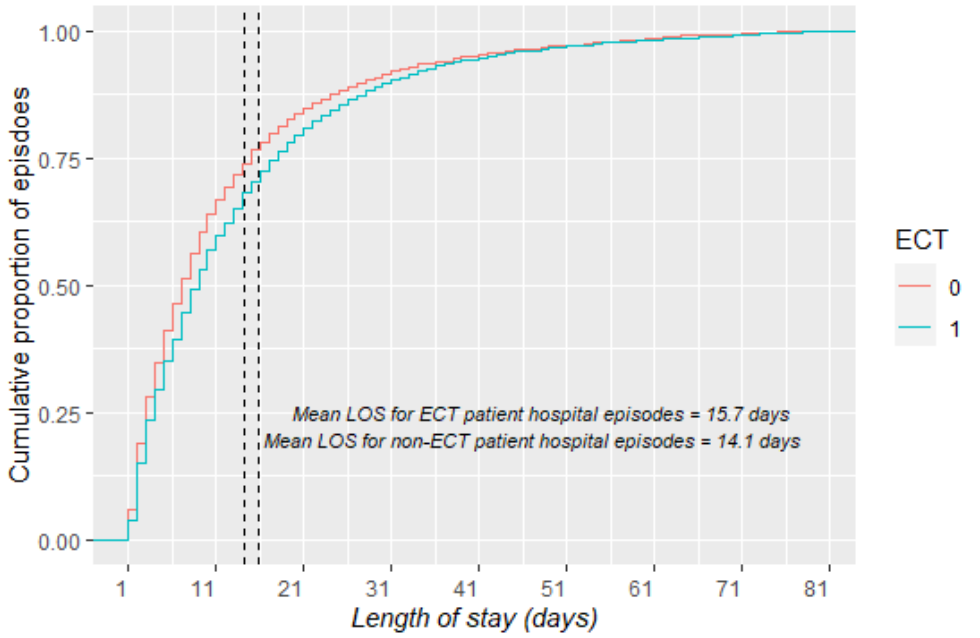


Figure 9.17 – Cumulative distribution of length of stay for emergency hospital stays over follow-up by group (rolling entry propensity score matched cohort) (0=no ECT intervention, 1=ECT intervention)

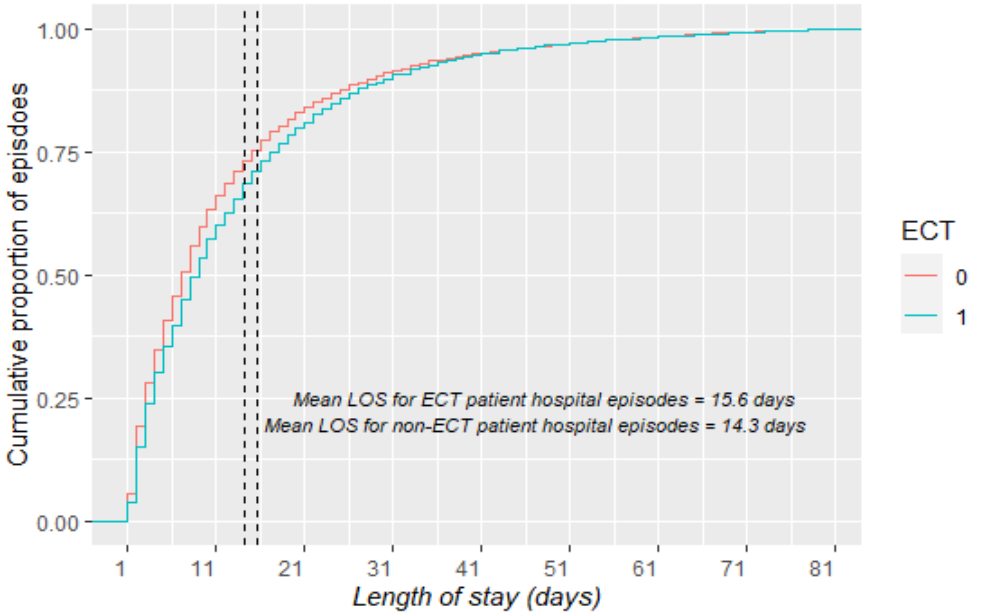


Figure 9.18 – Frequency of emergency admission episodes over follow-up period by length of stay by group (rolling entry direct matched cohort)

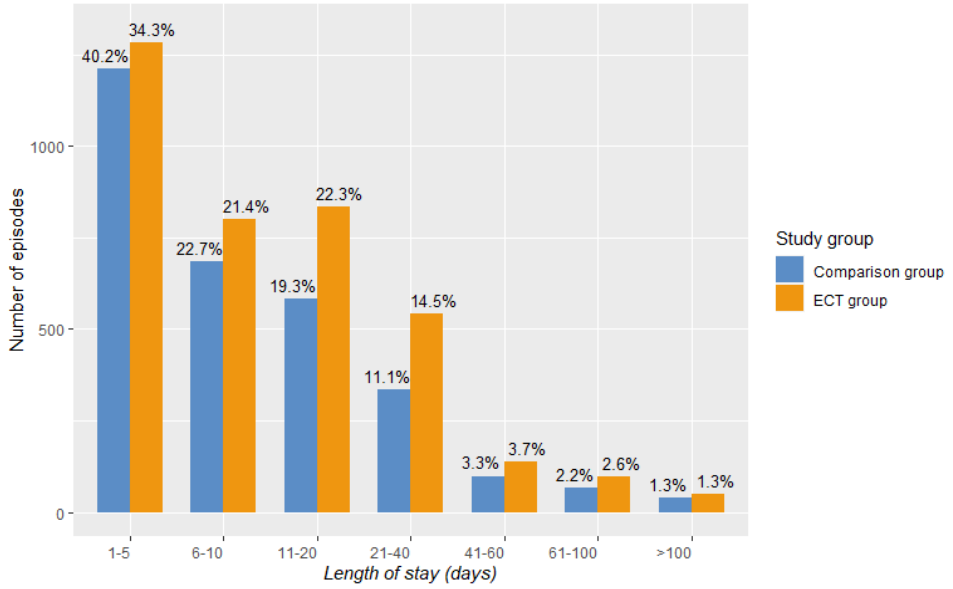
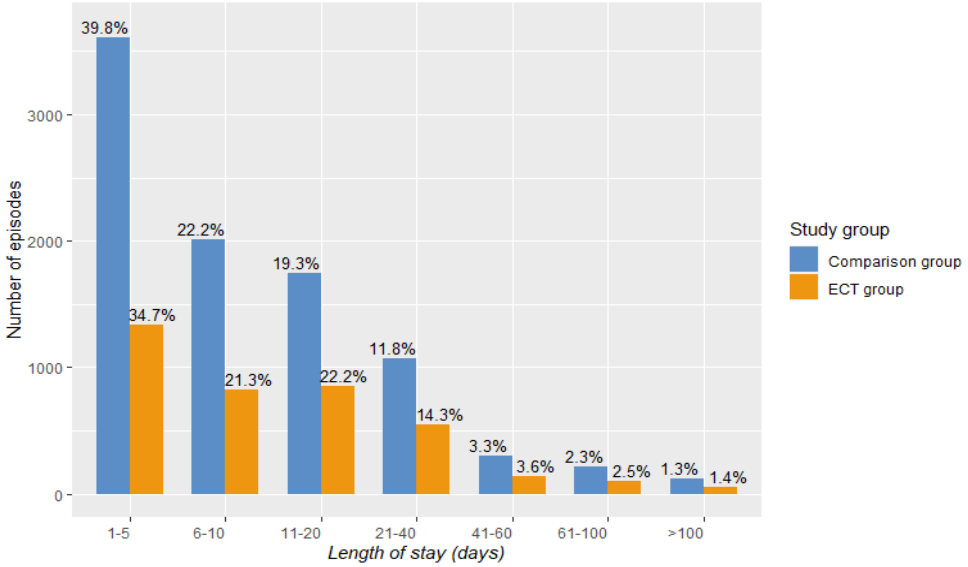


Figure 9.19 – Frequency of emergency admission episodes over follow-up period by length of stay by group (rolling entry propensity score matched cohort)



When comparing the effect of ECT on the hazard of discharge from emergency inpatient hospitalisation following referral to ECT (or dummy referral for matched patients) in Cox proportional hazards regression, ECT was associated with reduced hazard of discharge (i.e. prolonged length of stay) in the unadjusted model among both the direct covariate matched sample (HR 0.65, 95% CI [0.52, 0.81]) and the propensity score matched sample (HR 0.62, 95% CI [0.53, 0.71]).

The hazard ratios were marginally higher in the adjusted model for both matched samples. Table 9.18 below displays the results of the adjusted Cox proportional-hazards models, comparing the effect of ECT on hazard of discharge. The results indicate that after adjustment, having an ECT episode reduced hazard of discharge (i.e. prolonged length of stay) by a factor of 0.70 (95% CI [0.54, 0.91]) among the direct matched sample, and by a factor of 0.69 (95% CI [0.59, 0.80]) among the propensity score matched sample.

Table 9.18 – Adjusted effect estimates of ECT on time to discharge in Cox proportional hazards regression, including estimates for adjustment variables

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
Treatment						
No ECT	—	—		—	—	
ECT	0.70	0.54, 0.91	0.009	0.69	0.59, 0.80	<0.001
Smoking status*						
No	—	—				
Yes	0.78	0.63, 0.98	0.032			
Ex-smoker	0.98	0.84, 1.14	0.8			
MISSING	0.97	0.82, 1.15	0.7			
Locality						
Clackmannanshire	—	—		—	—	
Denny/ Bonnybridge/ Larbert / Stenhousemuir	0.87	0.70, 1.08	0.2	0.85	0.74, 0.96	0.010
Falkirk Town	0.83	0.68, 1.02	0.081	0.87	0.77, 0.98	0.017
Grangemouth / Bo'ness / Braes	0.95	0.79, 1.15	0.6	0.91	0.82, 1.01	0.087
Rural Stirling	0.68	0.52, 0.89	0.005	0.86	0.74, 0.98	0.030
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	0.88	0.73, 1.07	0.2	0.84	0.76, 0.94	0.001
Fall ever recorded*						
No	—	—				
Yes	0.81	0.70, 0.95	0.008			
MISSING	0.93	0.68, 1.26	0.6			
Mobility concerns*						
No	—	—				
Yes	0.95	0.78, 1.15	0.6			

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
MISSING	0.75	0.53, 1.08	0.12			
Cognition, orientation or memory problem						
No	—	—		—	—	
Yes	0.88	0.77, 1.00	0.049	0.95	0.88, 1.02	0.15
MISSING	1.16	0.83, 1.62	0.4	0.91	0.78, 1.06	0.2
Continence issues						
No	—	—		—	—	
Yes	0.74	0.62, 0.87	<0.001	0.89	0.83, 0.97	0.006
MISSING	0.82	0.67, 1.00	0.049	1.02	0.92, 1.13	0.7
Sight or hearing impairment*						
No	—	—				
Yes	0.80	0.68, 0.95	0.009			
MISSING	1.29	0.89, 1.86	0.2			
Depression or emotional concerns*						
No	—	—				
Yes	1.18	1.01, 1.37	0.031			
MISSING	0.60	0.40, 0.90	0.012			
Feeding concerns*						
No	—	—				
Yes	0.98	0.86, 1.12	0.8			
MISSING	1.23	0.88, 1.73	0.2			
Number of emergency inpatient hospitalisations in 30 days prior	1.19	0.95, 1.48	0.13	1.40	1.24, 1.57	<0.001
Number of ED attendances in 30 days prior	0.99	0.87, 1.12	0.9	1.11	1.03, 1.20	0.005
Number of community episodes in 30 days prior	0.94	0.85, 1.04	0.2	0.91	0.86, 0.96	0.001
Number of community functional assessments in 30 days prior	0.97	0.91, 1.03	0.3	0.94	0.91, 0.97	<0.001
Delayed discharge 30 days prior**				1.15	0.72, 1.84	0.6

	Rolling entry direct matched sample			Rolling entry propensity score matched sample		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value

[1]HR = Hazard Ratio (Note: A hazard ratio of less than one corresponds to an increased length of stay, whereas a hazard ratio of greater than one corresponds to a decreased length of stay), CI = Confidence Interval

**Variable only included for adjustment in direct matched sample*

***Variable only included for adjustment propensity score matched sample*

Note: See note on Table 9.11 for a description of how adjustment variables were selected.

9.5.2 Effect of the GP Fellows as an enhancement to ECT on hospital activity outcomes

This section aims to provide the results of the comparative analysis of the GP Fellows service, evaluating its effect on hospital activity outcomes in comparison to the ECT service without the GP Fellows (the added effect of GP Fellows). The main aim of the addition of GP Fellows was to provide enhanced medical advice and support to the ECT team, potentially preventing admissions due to lack of medical expertise in the existing team. The three hospital outcomes investigated were emergency inpatient hospitalisation, emergency department attendance and emergency inpatient length of stay.

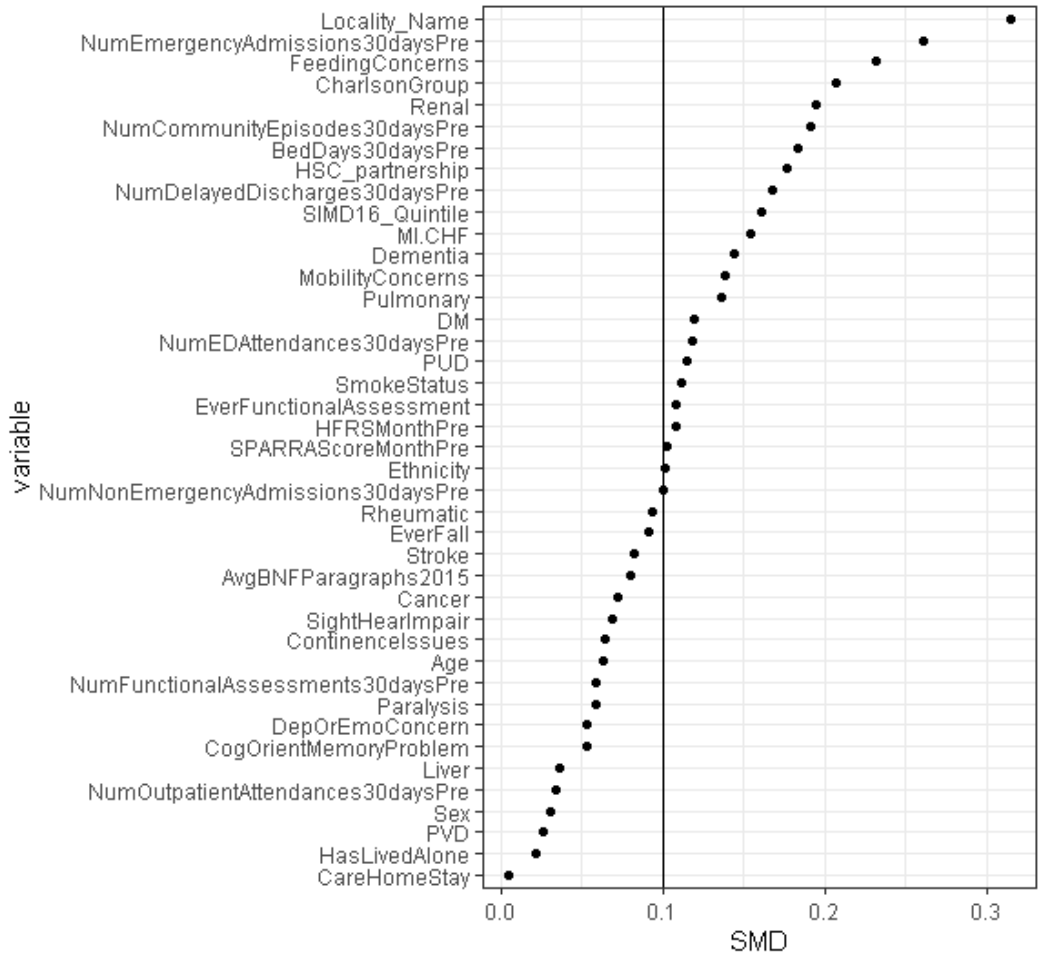
9.5.2.1 Study sample

GP Fellows patients were defined as those receiving ECT intervention in the ECT study cohort (see Section 9.5.1.1), between 1st January 2017 - 31st December 2017, while the comparison group was defined as patients receiving ECT intervention in the year before GP Fellows were introduced (1st January 2016 - 31st December 2016). There were 420 patients in the GP Fellows-enhanced ECT intervention group and 324 patients in the comparison group (ECT only).

9.5.2.2 Baseline characteristics of study sample

This section will describe the characteristics of the GP Fellows study sample, highlighting those that differ between groups. Table 9.19 presents summary statistics for the baseline characteristics of the GP Fellows study cohort, including averages of measures that changed over time at a baseline period (30 days prior to referral to ECT) and SMDs which highlight key differences. Figure 9.20 displays the SMDs in the baseline characteristics between the groups.

Figure 9.20 – Standardised Mean Differences (SMDs) across baseline variables between GP Fellows intervention and ECT comparison groups



It is clear that the two groups are similar however, there are residual differences which is expected. The localities from which patients originated differed between the two time periods which is expected. The profile of comorbidities also differed between the groups, which may be due to the change in expertise available or due to other service changes. There were lower proportions of patients with moderate to severe Charlson comorbidity and higher proportions of patients with mild comorbidity in the GP Fellows-enhanced ECT intervention group (52.4% moderate to severe, 33.1% mild) compared to ECT only (42.9% moderate to severe, 41.7%). There was a lower proportion of patients with renal conditions, myocardial infarction or chronic heart failure, diabetes or dementia but a higher proportion of patients with pulmonary conditions in the GP Fellows group (see Table 9.19). There was also a lower proportion of patients with functional

disabilities, particularly issues in their mobility or issues being able to feed themselves (see Table 9.19).

These changes in comorbidity and functional ability profile of patients receiving GP Fellows-enhanced ECT intervention are likely due to the changes in patient pathways as the service developed, for example, as the service developed a pathway was developed for chronic obstructive pulmonary disease (COPD) in conjunction with the ambulance service and as the service developed they received less referrals for discharge support where patients may have displayed higher levels of functional disability.

Finally, there were notable in their emergency hospital activity and community activity. While around 39% of GP Fellows-enhanced ECT intervention patients were admitted as inpatients in the 30 days prior to referral, 29% the proportion of comparison group patients were admitted. Emergency inpatient admission rates were notably higher among GP Fellows-enhanced ECT intervention patients compared to ECT only intervention, in the 30 days prior to referral (420 admissions per 1000 ECT patients compared to 280 admissions per 1000 comparison group patients). A lower proportion of GP Fellows-enhanced intervention patients experienced an emergency department attendance (25.5% vs 19.1%). A lower proportion also experienced a delayed discharge in the 30 days prior to referral (7.7% in GP Fellows group compared to 12.6%).

Though outpatient activity was similar between groups in both, GP Fellows-enhanced ECT intervention patients experienced lower community activity than ECT only comparison group patients (620 community episodes per 1000 GP Fellows-enhanced ECT intervention patients compared to 840 per 1000 comparison group).

Table 9.19 – Baseline characteristics of GP Fellows study sample

Characteristic	ECT intervention (2016) (n=420)	ECT enhanced with GP Fellows (2017) (n=324)	p-value	SMD
Age (mean (SD))	81.24 (7.61)	80.76 (7.70)	0.397	0.063

Sex = Male (%)	167 (39.8)	124 (38.3)	0.736	0.031
Ethnicity (%)			0.431	0.102
White	407 (96.9)	314 (96.9)		
Other	2 (0.5)	0 (0.0)		
Not specified	11 (2.6)	10 (3.1)		
MISSING	0 (0.0)	0 (0.0)		
Smoking status (%)			0.519	0.111
Yes	48 (11.4)	34 (10.5)		
Ex-smoker	73 (17.4)	70 (21.6)		
No	180 (42.9)	136 (42.0)		
MISSING	119 (28.3)	84 (25.9)		
Health and Social Care Partnership			0.021	0.177
Stirling & Clackmannanshire (%)	220 (52.4)	198 (61.1)		
Falkirk (%)	200 (47.6)	126 (38.9)		
Locality (%)			0.003	0.315
Clackmannanshire	81 (19.3)	46 (14.2)		
Denny/ Bonnybridge/ Larbert / Stenhousemuir	48 (11.4)	26 (8.0)		
Falkirk Town	58 (13.8)	45 (13.9)		
Grangemouth / Bo'ness / Braes	94 (22.4)	55 (17.0)		
Rural Stirling	23 (5.5)	18 (5.6)		
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	116 (27.6)	134 (41.4)		
SIMD16 Quintile † (%)			0.314	0.161
1	66 (15.7)	57 (17.6)		
2	115 (27.4)	83 (25.6)		
3	72 (17.1)	72 (22.2)		
4	87 (20.7)	54 (16.7)		
5	80 (19.0)	58 (17.9)		
Living alone ever recorded (%)			0.832	0.021
Yes	182 (43.3)	137 (42.3)		
No	238 (56.7)	187 (57.7)		
MISSING	0 (0.0)	0 (0.0)		
Care Home Stay = Yes (%)	72 (17.1)	55 (17.0)	1.000	0.004
Fall ever recorded (%)			0.465	0.091
Yes	309 (73.6)	235 (72.5)		

No	89 (21.2)	65 (20.1)		
MISSING	22 (5.2)	24 (7.4)		
Functional Assessment ever conducted = Yes (%)	405 (96.4)	305 (94.1)	0.191	0.108
Mobility concerns (%)			0.169	0.139
Yes	345 (82.1)	248 (76.5)		
No	51 (12.1)	51 (15.7)		
MISSING	24 (5.7)	25 (7.7)		
Sight or hearing impairment (%)			0.650	0.068
Yes	274 (65.2)	211 (65.1)		
No	91 (21.7)	64 (19.8)		
MISSING	55 (13.1)	49 (15.1)		
Cognitive, orientation or memory problem (%)			0.775	0.053
Yes	234 (55.7)	172 (53.1)		
No	141 (33.6)	115 (35.5)		
MISSING	45 (10.7)	37 (11.4)		
Feeding concerns (%)			0.008	0.231
Yes	239 (56.9)	152 (46.9)		
No	120 (28.6)	127 (39.2)		
MISSING	61 (14.5)	45 (13.9)		
Depression or emotional concerns (%)			0.769	0.053
Yes	132 (31.4)	102 (31.5)		
No	227 (54.0)	169 (52.2)		
MISSING	61 (14.5)	53 (16.4)		
Continence issues (%)			0.687	0.064
Yes	208 (49.5)	151 (46.6)		
No	82 (19.5)	70 (21.6)		
MISSING	130 (31.0)	103 (31.8)		
Charlson Score group (%)			0.103	0.207
No ICD-10 codes recorded in past 5 years	11 (2.6)	9 (2.8)		
No comorbidities identified (0)	50 (11.9)	41 (12.7)		
Mild (1-2)	139 (33.1)	135 (41.7)		
Moderate (3-4)	116 (27.6)	79 (24.4)		
Severe (5+)	104 (24.8)	60 (18.5)		
Comorbidities (ICD-10 based)				

MI or CHF (%)	130 (31.0)	78 (24.1)	0.047	0.154
PVD (%)	42 (10.0)	35 (10.8)	0.814	0.026
Stroke (%)	77 (18.3)	70 (21.6)	0.309	0.082
Pulmonary (%)	115 (27.4)	109 (33.6)	0.078	0.136
Rheumatic (%)	19 (4.5)	9 (2.8)	0.295	0.093
PUD (%)	12 (2.9)	4 (1.2)	0.208	0.115
Liver (%)	14 (3.3)	13 (4.0)	0.769	0.036
DM (%)	101 (24.0)	62 (19.1)	0.129	0.120
Renal (%)	125 (29.8)	69 (21.3)	0.012	0.195
Dementia (%)	104 (24.8)	61 (18.8)	0.065	0.144
Cancer (%)	109 (26.0)	74 (22.8)	0.373	0.073
Paralysis (%)	1 (0.2)	2 (0.6)	0.821	0.058
Average monthly prescriptions (BNF paragraphs)[a] 2015 (mean (SD))	6.26 (3.29)	6.00 (3.08)	0.280	0.080
Average SPARRA score in month prior* (mean (SD))	38.18 (17.63)	36.45 (16.25)	0.173	0.102
Average HFRS in 30 days prior* (mean (SD))	5.11 (6.12)	4.45 (6.04)	0.144	0.108
Admitted as inpatient in 30 days prior*= Yes (%)	163 (38.8)	94 (29.0)	0.007	0.208
Emergency inpatient hospitalisations in 30 days prior* (mean (SD))	0.42 (0.61)	0.28 (0.50)	0.001	0.261
Non-emergency inpatient hospitalisations in 30 days prior* (mean (SD))	0.03 (0.17)	0.05 (0.25)	0.166	0.100
Emergency inpatient length of stay in days in 30 days prior* (mean (SD))**	14.45 (9.89)	12.64 (9.82)	0.113	0.183
Admitted at ED in 30 days prior*= Yes (%)	107 (25.5)	62 (19.1)	0.050	0.153
ED Attendances in 30 days prior* (mean (SD))	0.28 (0.50)	0.22 (0.49)	0.112	0.118
Outpatient attendances in 30 days prior* (mean (SD))	0.21 (0.59)	0.19 (0.63)	0.648	0.034
Community episodes in 30 days prior* (mean (SD))	0.84 (1.17)	0.62 (1.08)	0.010	0.191
Community functional assessments in 30 days prior* (mean(SD))	1.13 (1.28)	1.20 (1.28)	0.431	0.058
Delayed discharge in 30 days prior* (mean (SD))	53 (12.6)	25 (7.7)	0.041	0.163

[a]*Average monthly number of BNF classes was used to reduce effect of exaggerated polypharmacy and variation for patients who have multiple medications in the class as described in Section 7.2.8.*

**30 days prior to ECT intervention*

***Note length of stay includes only length of stay for patients admitted*

† SIMD16 Quintile indicates level of deprivation (1=within most deprived fifth of population, 5=within least deprived fifth)

Abbreviations: SIMD16 (Scottish Index of Multiple Deprivation 2016 version), ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure), PVD (Peripheral Vascular Disease), PUD (Peptic Ulcer Disease), DM (Diabetes Mellitus), SPARRA (Scottish Patients at Risk of Readmission and Admission), HFRS (Hospital Frailty Risk Score), BNF (British National Formulary), ED (Emergency Department)

9.5.2.3 Visual comparison of trends over time in outcome measures

Two of the main outcome measures (namely emergency inpatient hospitalisations and emergency department attendance), are explored visually over time across groups, relative to the date of ECT intervention for both study groups. As before, monthly admission rates for each group were calculated by dividing the total number of admissions each month by the number of patients who were alive at the start of each month to factor in the different group sizes and mortality.

Figure 9.21 and Figure 9.22 display the patterns in activity over time for each of the two outcome measures. Both groups display very similar patterns, and though lower emergency inpatient admission rates and ED attendance rates are observed in the GP Fellows-enhanced ECT intervention group in the month immediately following ECT referral, their baseline values in the month before referral are also lower, as previously noted.

Figure 9.21 – Emergency inpatient admissions by month relative to ECT referral date for those receiving ECT intervention only (2016) compared to those receiving GP Fellows-enhanced ECT care (2017)

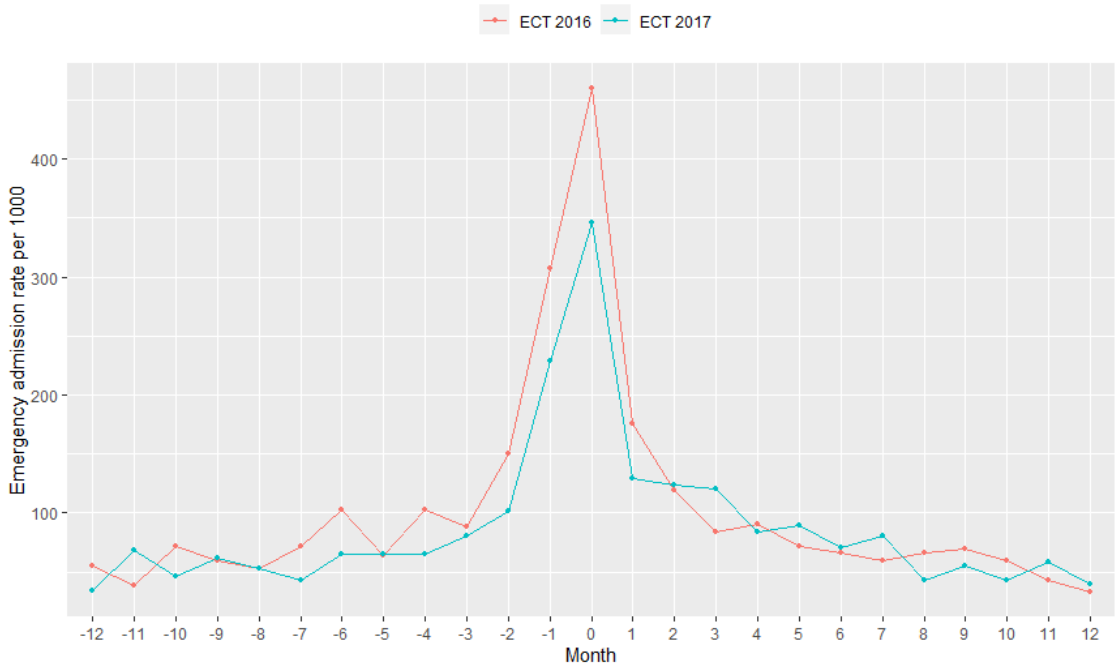
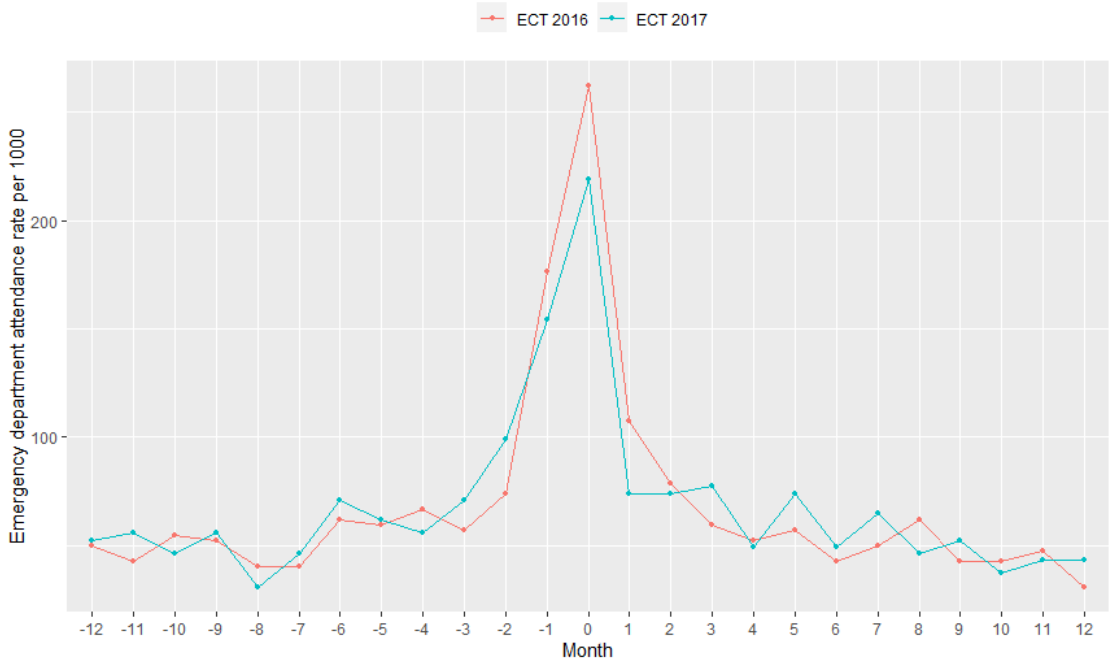


Figure 9.22 – Emergency department attendances by month relative to ECT referral date for those receiving ECT intervention only (2016) compared to those receiving GP Fellows-enhanced ECT care (2017)



9.5.2.4 Results of statistical models assessing the effect of the GP Fellows as an enhancement to the ECT on hospital activity outcomes

As described in, logistic regression was used to assess the effect of GP Fellows-enhanced ECT intervention on hospital activity outcomes. As described in Section 9.2.2, logistic regression and Cox proportional-hazards models were used to assess the effect of the GP Fellows as an enhancement to the ECT service on hospital activity outcomes. The logistic regression models were used to compare the effect of GP Fellows-enhanced ECT intervention on experiencing hospital activity outcomes within 30 days of first ECT referral. The Cox models were used to assess the time-variable effect on hazard of experiencing hospital activity outcomes and on length of stay (hazard of discharge).

9.5.2.4.1 Effect on emergency inpatient hospitalisation and emergency department attendance

When comparing the effect of GP Fellows-enhanced ECT intervention on experiencing an emergency inpatient hospitalisation within 30 days in a logistic regression model, receiving GP Fellows-enhanced ECT intervention was associated with reduced odds of emergency inpatient hospitalisation in the unadjusted model, however the result was not statistically significant (OR 0.76, 95% CI [0.56,1.04], p-value=0.085). Similar results were observed for emergency department attendance in the unadjusted logistic regression model, namely, a reduced risk which was not statistically significant (OR 0.79, 95% CI [0.53, 1.18], p-value=0.3). Associated event rates are displayed in Table 9.20.

Table 9.20 – Event rates for emergency hospitalisation and emergency department attendance within 30 days of ECT referral

	Emergency inpatient hospitalisation within 30 days			ED attendance within 30 days of referral		
Intervention	Events	Patients	Event rate	Events	Patients	Event rate
GP Fellows-enhanced ECT (2017)	97	324	0.30	45	324	0.14
ECT only (2016)	151	420	0.36	71	420	0.17

**Events represent emergency hospitalisation and event rates are calculated as the ratio of events per person*

The reduced odds were slightly less pronounced in the adjusted model for both outcomes and again were not statistically significant (OR 0.79, 95% CI [0.56, 1.12] for emergency inpatient hospitalisation and OR 0.79, 95% CI [0.50, 1.22] for emergency department attendance). Overall, GP Fellows as an enhancement to ECT was associated with lower odds of emergency inpatient hospitalisation and of emergency department attendance in the 30 days following referral, with patients having roughly 0.80 times the odds of experiencing an event across both outcomes, however the results were not statistically significant.

The adjusted intervention effect estimates are displayed in Table 9.21 along with estimates for included adjustment variables.

Table 9.21 – Adjusted effect estimates of GP Fellows as an enhancement to ECT on 30-day emergency hospitalisation and emergency department attendance in conditional logistic regression

	Treatment effect on 30-day emergency hospitalisation			Treatment effect on 30-day ED attendance		
Characteristic	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Treatment						
ECT (2016)	—	—		—	—	
ECT with GP Fellows (2017)	0.79	0.56, 1.12	0.2	0.79	0.50, 1.22	0.3
Locality						
Clackmannanshire	—	—		—	—	
Denny/ Bonnybridge/ Larbert / Stenhousemuir	0.69	0.34, 1.36	0.3	0.79	0.32, 1.90	0.6
Falkirk Town	1.03	0.57, 1.87	>0.9	0.81	0.36, 1.79	0.6
Grangemouth / Bo'ness / Braes	1.46	0.86, 2.50	0.2	1.72	0.89, 3.40	0.11
Rural Stirling	0.94	0.41, 2.07	0.9	0.50	0.11, 1.64	0.3
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	1.03	0.63, 1.69	>0.9	1.03	0.54, 2.02	>0.9
Mobility concerns						
Yes	—	—		—	—	
No	0.75	0.44, 1.26	0.3	1.16	0.61, 2.11	0.6
MISSING	1.28	0.51, 3.20	0.6	1.95	0.69, 5.64	0.2

	Treatment effect on 30-day emergency hospitalisation			Treatment effect on 30-day ED attendance		
Characteristic	OR[1]	95% CI[1]	p-value	OR[1]	95% CI[1]	p-value
Feeding concerns						
Yes	—	—		—	—	
No	1.10	0.75, 1.61	0.6	1.46	0.90, 2.36	0.13
MISSING	0.94	0.47, 1.81	0.9	1.13	0.47, 2.52	0.8
Charlson group						
No comorbidities identified (0)	—	—		—	—	
Mild (1-2)	2.18	1.21, 4.05	0.011	2.15	1.03, 4.83	0.050
Moderate (3-4)	2.24	1.14, 4.47	0.021	1.64	0.68, 4.09	0.3
Severe (5+)	4.77	2.35, 9.92	<0.001	2.35	0.93, 6.09	0.074
Comorbidities (ICD-10 based)						
MI or CHF	0.66	0.45, 0.98	0.041	0.94	0.57, 1.53	0.8
Renal	1.10	0.72, 1.68	0.6	0.84	0.48, 1.45	0.5
Pulmonary	0.81	0.56, 1.18	0.3	0.84	0.52, 1.35	0.5
Dementia	1.05	0.70, 1.56	0.8	1.00	0.60, 1.65	>0.9
DM	1.02	0.68, 1.52	>0.9	1.20	0.71, 1.97	0.5
Number of emergency inpatient hospitalisations in 30 days prior*	2.31	1.61, 3.35	<0.001	1.06	0.67, 1.65	0.8
ED attendance in 30 days prior*	0.77	0.48, 1.21	0.3	2.38	1.39, 4.07	0.001
Number of community episodes in 30 days prior*	0.74	0.61, 0.89	0.002	0.95	0.75, 1.18	0.6
Delayed discharge in 30 days prior*	0.39	0.19, 0.75	0.007	0.53	0.21, 1.17	0.14

[1]OR = Odds Ratio, CI = Confidence Interval

**30 days prior to ECT intervention*

Abbreviations: ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure, DM (Diabetes Mellitus), ED (Emergency Department)

Note: Adjustment variables for all of the analyses assessing the comparative effect of GP Fellows enhancement to ECT were selected by reviewing residual differences between intervention and comparison group patients, particularly those with SMD>0.1, however the researcher's knowledge and judgement was employed when reviewing and selecting these. For example, although the differences in deprivation quintiles appeared significant between groups with an SMD above 0.1, the differences are more pronounced in localities, which encompasses deprivation.

When comparing the time-variable effect of addition of GP Fellows to the ECT on the daily hazard of experiencing an emergency admission or an emergency attendance, in a Cox proportional hazards regression model (taking into account subsequent ECT episodes), the addition of GP Fellows was associated with a slightly reduced daily hazard of emergency hospitalisation and emergency department attendance in the unadjusted models (Emergency hospitalisation: HR 0.85, 95% CI [0.68, 1.07], p=0.2; Emergency department attendance: HR 0.70, 95% CI [0.50, 0.99], p=0.041). However, the result was not statistically significant for emergency hospitalisation. Associated event rates are displayed in Table 9.22.

Table 9.22 – Event rates for emergency hospitalisation and emergency department attendance and person-years throughout follow-up

	Emergency inpatient hospitalisation			Emergency department attendance		
Intervention	Events	Person-years	Event rate	Events	Person-years	Event rate
GP Fellows-enhanced ECT (2017)	121	30.72	3.94	51	30.72	1.66
ECT only (2016)	181	39.01	4.64	90	39.01	2.31
No intervention	1704	1679.82	1.01	1329	1679.82	0.79

**Events represent emergency hospitalisation and event rates are calculated as the ratio of events over exposure time (person years)*

Table 9.23 below displays the results of the Cox proportional-hazards model with time-dependent covariates, comparing the effect of GP Fellows on hospitalisation after adjustment for key differences between groups. These results indicate that after adjustment, the addition of GP Fellows to ECT does not appear to make a difference to the daily hazard of having a hospital admission (HR 0.98, 95% CI [0.77, 1.23]) and though there still appears to be a reduction in daily hazard of emergency department attendance in the adjusted model (HR 0.79, 95% CI [0.56, 1.12]), it is no longer statistically significant.

Table 9.23 – Adjusted effect estimates of GP Fellows on daily hazard of emergency hospitalisation in Cox proportional hazards regression (including time-varying covariates) including estimates for adjustment variables

	Emergency hospitalisation			Emergency department attendance		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
Treatment						
ECT (2016)	—	—		—	—	
ECT with GP Fellows (2017)	0.98	0.77, 1.23	0.8	0.79	0.56, 1.12	0.2
Locality						
Clackmannanshire	—	—		—	—	
Denny/ Bonnybridge/ Larbert / Stenhousemuir	1.20	0.92, 1.55	0.2	1.54	1.18, 2.00	0.001
Falkirk Town	1.10	0.94, 1.28	0.2	1.32	1.07, 1.64	0.011
Grangemouth / Bo'ness / Braes	1.12	0.94, 1.33	0.2	1.21	0.96, 1.53	0.11
Rural Stirling	0.94	0.72, 1.23	0.7	0.87	0.64, 1.19	0.4
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	1.07	0.92, 1.25	0.4	1.36	1.08, 1.71	0.008
Mobility concerns						
Yes	—	—		—	—	
No	0.88	0.64, 1.21	0.4	0.92	0.63, 1.33	0.6
MISSING	1.28	1.07, 1.54	0.007	1.26	1.01, 1.58	0.042
Feeding concerns						
Yes	—	—		—	—	
No	1.15	0.88, 1.49	0.3	1.25	0.93, 1.69	0.14
MISSING	1.30	1.14, 1.49	<0.001	1.21	1.03, 1.43	0.018
Charlson group						
No comorbidities identified (0)	—	—		—	—	
Mild (1-2)	1.79	1.42, 2.27	<0.001	1.28	0.98, 1.66	0.065
Moderate (3-4)	2.13	1.65, 2.76	<0.001	1.41	1.04, 1.91	0.027
Severe (5+)	2.96	2.23, 3.92	<0.001	1.96	1.28, 3.00	0.002
Comorbidities (ICD-10 based)						

	Emergency hospitalisation			Emergency department attendance		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
MI or CHF	1.26	1.10, 1.44	0.001	1.29	1.06, 1.58	0.013
Renal	1.02	0.89, 1.16	0.8	0.92	0.73, 1.15	0.5
Pulmonary	1.11	0.98, 1.26	0.091	1.08	0.90, 1.28	0.4
Dementia	1.04	0.91, 1.18	0.6	1.03	0.86, 1.23	0.7
DM	0.99	0.87, 1.12	0.8	0.99	0.81, 1.20	>0.9
Number of emergency inpatient hospitalisations in 30 days prior*	1.54	1.33, 1.78	<0.001	1.36	1.10, 1.68	0.005
ED attendance in 30 days prior*	1.23	0.99, 1.53	0.057	1.59	1.13, 2.23	0.008
Number of community episodes in 30 days prior*	1.00	0.93, 1.07	>0.9	1.01	0.93, 1.10	0.8
Delayed discharge in 30 days prior*	0.58	0.39, 0.86	0.007	0.55	0.34, 0.89	0.014

[1]HR = Hazard Ratio, CI = Confidence Interval

**30 days prior to ECT intervention*

Abbreviations: ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure, DM (Diabetes Mellitus), ED (Emergency Department)

Note: See note on Table 9.21 for a description of how adjustment variables were selected.

9.5.2.4.2 Effect on emergency inpatient length of stay

A visual inspection of the distribution and cumulative distribution of length of stay in days for emergency inpatient hospitalisations indicates very little difference between the two groups (Figure 9.23 – Figure 9.24). The median length of stay for hospitalisations during follow-up for ECT patients after GP fellows were introduced was 9 days compared to 10 days for ECT patients before they were introduced.

Figure 9.23 – Cumulative distribution of length of stay for emergency hospital stays over follow-up by group (0=ECT only intervention, 1=GP Fellows-enhanced ECT intervention)

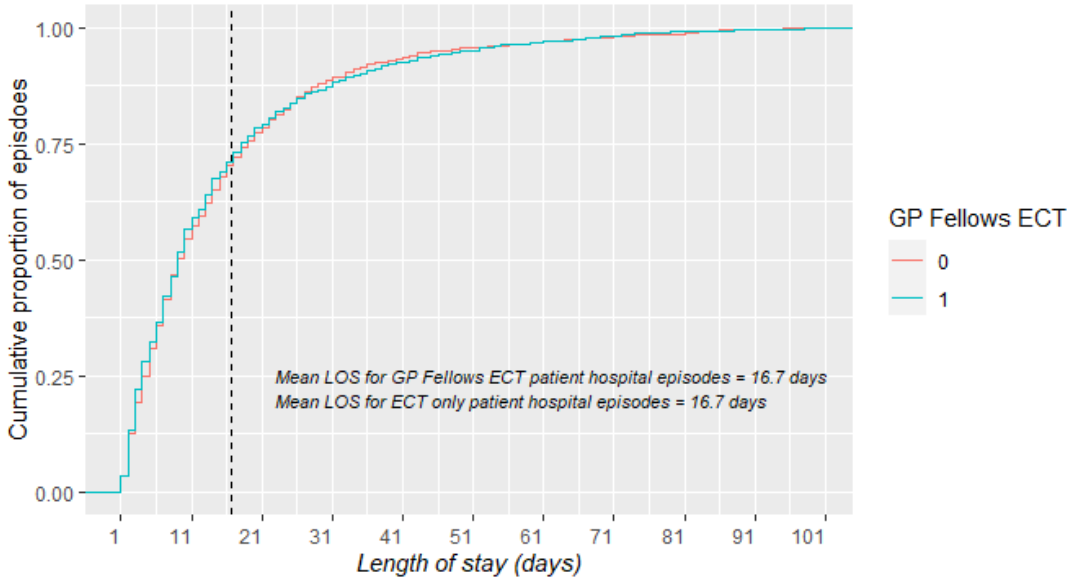
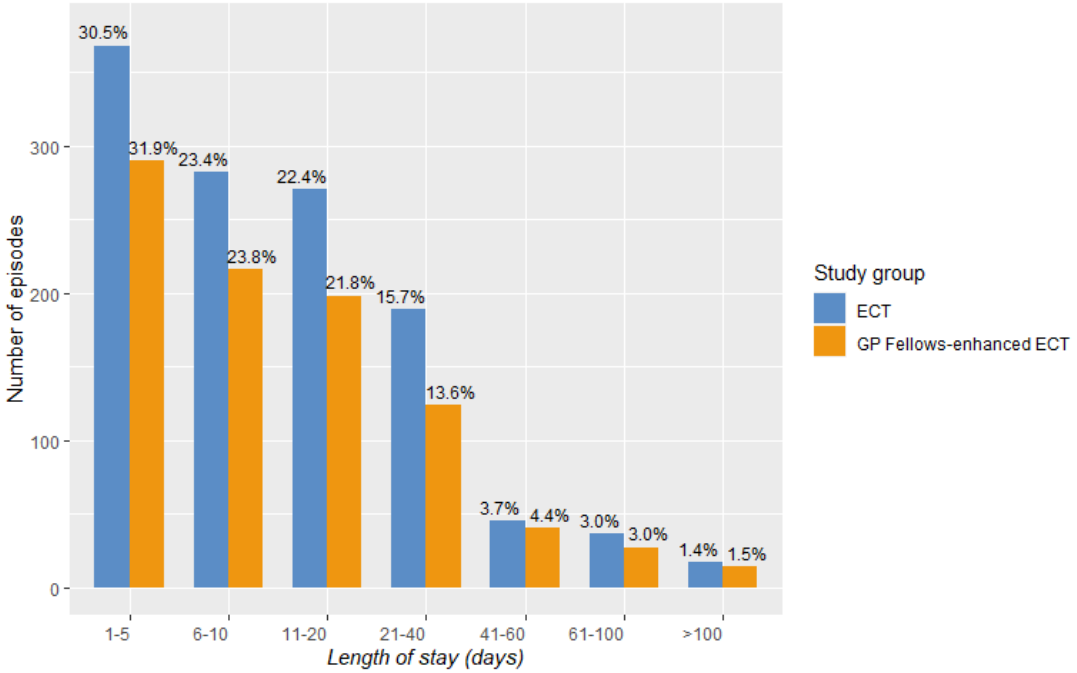


Figure 9.24 – Frequency of emergency admission episodes over follow-up period by length of stay by group



When comparing the effect of GP Fellows as an enhancement to ECT on the hazard of discharge from emergency inpatient hospitalisation following referral to ECT in Cox proportional hazards regression, GP Fellows enhancement was associated with reduced hazard of discharge (i.e. prolonged length of stay) in the unadjusted model, however the result was not significant (HR 0.88, 95% CI [0.65, 1.21], p=0.4).

Table 9.24 below displays the results of the adjusted Cox proportional-hazards models, comparing the effect of GP Fellows as an enhancement to ECT on hazard of discharge. The hazard ratio was marginally higher in the adjusted model, and although the hazard ratio was below one (HR 0.90, 95% CI [0.69, 1.18], p=0.5). (indicating reduced hazard i.e. prolonged length of stay), the result is not significant and is very close to one. Hence, these results indicate that after adjustment, GP Fellows enhancement to ECT makes no difference to length of inpatient stay following ECT referral.

Table 9.24 – Adjusted effect estimates of addition of GP Fellows to ECT on hazard of discharge from emergency inpatient hospitalisation in Cox proportional hazards regression (including time-varying covariates) including estimates for adjustment variables

	Emergency hospitalisation		
Characteristic	HR[1]	95% CI[1]	p-value
Treatment			
ECT (2016)	—	—	
ECT with GP Fellows (2017)	0.90	0.69, 1.18	0.5
Locality			
Clackmannanshire	—	—	
Denny/ Bonnybridge/ Larbert / Stenhousemuir	0.80	0.59, 1.10	0.2
Falkirk Town	0.83	0.64, 1.06	0.14
Grangemouth / Bo'ness / Braes	1.00	0.82, 1.22	>0.9
Rural Stirling	0.88	0.64, 1.22	0.4
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	0.96	0.79, 1.16	0.7
Mobility concerns			
Yes	—	—	
No	1.26	1.05, 1.50	0.013
MISSING	0.96	0.62, 1.49	0.9
Feeding concerns			
Yes	—	—	
No	1.00	0.86, 1.17	>0.9
MISSING	0.90	0.71, 1.14	0.4
Charlson group			
No comorbidities identified (0)	—	—	
Mild (1-2)	1.06	0.79, 1.43	0.7
Moderate (3-4)	1.21	0.87, 1.68	0.3
Severe (5+)	1.20	0.83, 1.72	0.3

	Emergency hospitalisation		
Characteristic	HR[1]	95% CI[1]	p-value
Comorbidities (ICD-10 based)			
MI or CHF	1.06	0.91, 1.23	0.4
Renal	0.91	0.77, 1.08	0.3
Pulmonary	1.13	0.98, 1.31	0.10
Dementia	0.82	0.70, 0.97	0.018
DM	1.08	0.91, 1.27	0.4
Number of emergency inpatient hospitalisations in 30 days prior*	1.29	1.10, 1.51	0.001
ED attendance in 30 days prior*	1.03	0.87, 1.22	0.7
Number of community episodes in 30 days prior*	0.86	0.78, 0.96	0.004
Delayed discharge in 30 days prior*	0.95	0.58, 1.55	0.8

[1]HR = Hazard Ratio (Note: A hazard ratio of less than one corresponds to an increased length of stay, whereas a hazard ratio of greater than one corresponds to a decreased length of stay), CI = Confidence Interval

**30 days prior to ECT intervention*

Abbreviations: ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure, DM (Diabetes Mellitus), ED (Emergency Department)

Note: See note on Table 9.21 for a description of how adjustment variables were selected.

9.5.3 Effect of the Advice Line for You (ALFY) on hospital activity outcomes

This section aims to provide the results of the comparative analysis of the Advice Line for You (ALFY) service, evaluating its effect on hospital activity outcomes. The main aim of the service was to support older people to remain well at home by providing a point of contact for health advice and reassurance and information on available services for those aged 65 or over. The three hospital outcomes investigated were emergency inpatient hospitalisation, emergency department attendance and emergency inpatient length of stay.

9.5.3.1 Study sample and exclusions

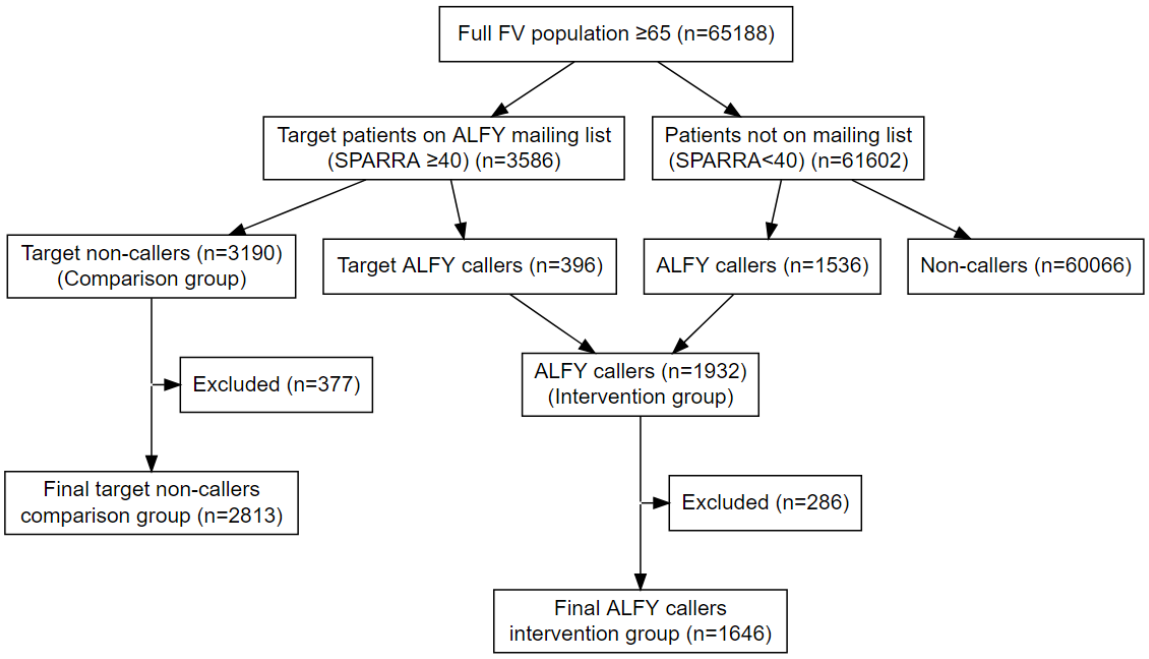
ALFY patients were defined as those calling the service between 1st January 2016 - 1st October 2018, while the control group was defined as a group of eligible patients (based on SPARRA score) who were mailed promotional materials about the service but did not call (ALFY mailing list). Several exclusions were made in

selecting the study cohort, as with the ECT study population (further detail on these exclusions was described in Section 9.5.1.1). The following table describes the exclusions made and frequencies in each study group. Exclusions were made in the listed order.

Table 9.25 – Exclusions for ALFY study cohort by exclusion reason

Exclusion reason	General elderly	ALFY patients
1. *Registered with the prison service GP practice code (code 31391)*	0	0
2. *Not registered with a Forth Valley GP*	1	1
3. *Not resident in Forth Valley, based on postcode*	18	0
4. *Aged under 65 during the observation period (i.e. must have been aged 65 or over between 1st January 2016 – 1st October 2018)*	0	85
5. *Were registered with a Forth Valley GP after the 1st January 2015*	93	95
6. *Transferred out of the Forth Valley health board during the data collection period (1st January 2015 - 1st October 2018)*	39	17
7. *Had died before the start of the observation period (1st January 2016)*	222	2
8. *Death date before date of ALFY call, indicating recording error*	0	4
9. *Not in study cohort for which all demographics were collected*	4	42
10. *For ALFY patients, all their ALFY episodes began before the observation period (before 1st January 2016)*	0	40
Total excluded	**6503**	**276**
No exclusion reason (included)	**57177**	**1303**

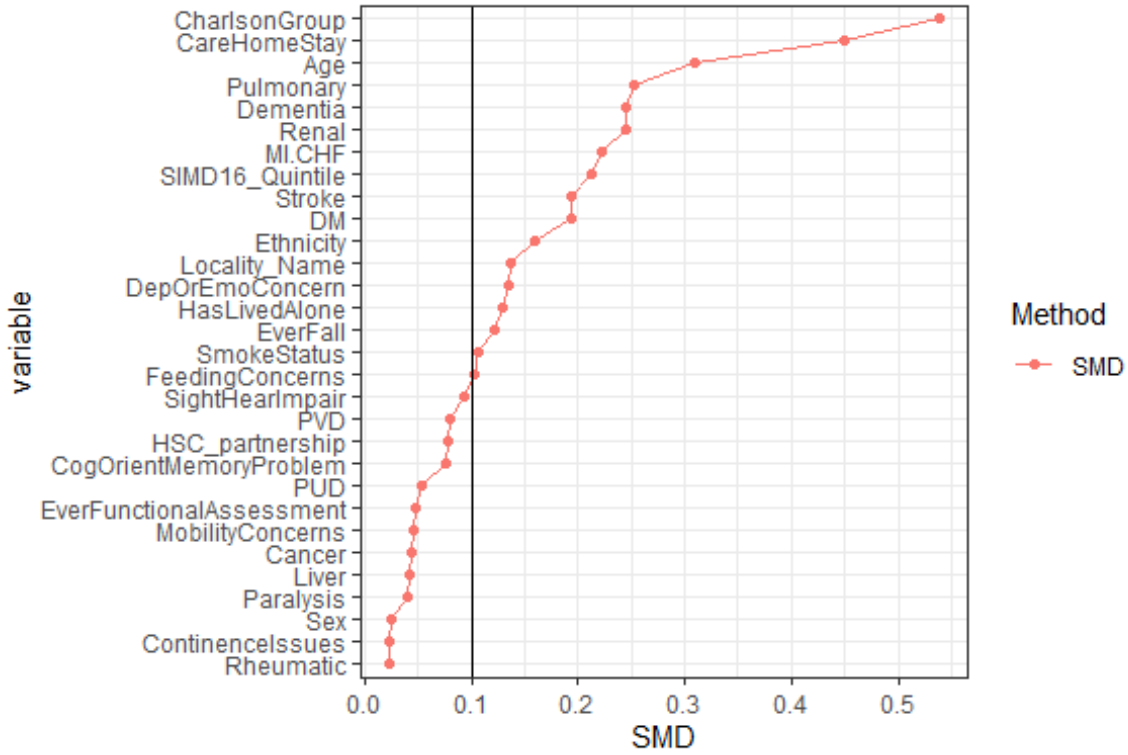
Figure 9.25 – Flowchart outlining ALFY study cohort and exclusions



9.5.3.2 Baseline characteristics of ALFY study sample

This section will describe the characteristics of the ALFY study sample, highlighting those that differ between groups. Table 9.26 presents summary statistics for the baseline characteristics of the ALFY study cohort, including averages of measures that changed over time at a baseline period (2015) and SMDs which highlight key differences. Figure 9.26 displays the SMDs in the baseline characteristics between the groups.

Figure 9.26 - Standardised Mean Differences (SMDs) across baseline variables between ALFY study groups



There are clear differences in the demographics of the ALFY intervention patients compared to those in the target mailing list. There are clear differences in the study groups in terms of their 2015 risk scores and activity. Nearly twice the proportion (1.8 times the proportion) of patients in the comparison group were admitted to the hospital as inpatients or attended the ED in 2015 as were in the ALFY intervention group. Of those admitted, comparison group patients experienced nearly twice the length of hospital stay. Similarly, comparison group patients experienced an average SPARRA score nearly twice (1.9 times) as high as ALFY patients' average score. Comparison group patients received roughly 30% more average monthly prescriptions (BNF paragraphs) as ALFY intervention patients. Comparison group patients also experienced more delayed discharges, with a rate of 90 per 1,000 in 2015 compared to 10 per 1,000 in the ALFY intervention group. In addition, they experienced higher community and outpatient activity. The full differences are displayed in Table 9.26.

Table 9.26 – Baseline characteristics of ALFY study sample

	Comparison group (n=2813)	ALFY (1646)	p-value	SMD
Age (mean (SD))	81.06 (8.04)	78.62 (7.70)	<0.001	0.310
Sex = Male (%)	1189 (42.3)	675 (41.0)	0.429	0.026
Ethnicity (%)			<0.001	0.159
White	2783 (98.9)	1599 (97.1)		
Other	14 (0.5)	6 (0.4)		
Not specified	16 (0.6)	40 (2.4)		
MISSING	0 (0.0)	1 (0.1)		
Smoking status (%)			0.008	0.107
Yes	177 (6.3)	92 (5.6)		
Ex-smoker	402 (14.3)	242 (14.7)		
No	664 (23.6)	460 (27.9)		
MISSING	1570 (55.8)	852 (51.8)		
Health and Social Care Partnership			0.013	0.078
Stirling & Clackmannanshire (%)	1241 (44.1)	790 (48.0)		
Falkirk (%)	1572 (55.9)	856 (52.0)		
Locality (%)			0.002	0.137
Clackmannanshire	443 (15.7)	299 (18.2)		
Denny/ Bonnybridge/ Larbert / Stenhousemuir	423 (15.0)	220 (13.4)		
Falkirk Town	599 (21.3)	279 (17.0)		
Grangemouth / Bo'ness / Braes	550 (19.6)	357 (21.7)		
Rural Stirling	178 (6.3)	117 (7.1)		
Stirling City with the Eastern Villages, Bridge of Allan and Dunblane	620 (22.0)	374 (22.7)		
SIMD16 Quintile ǂ (%)			<0.001	0.213
1	512 (18.2)	267 (16.2)		
2	891 (31.7)	407 (24.7)		
3	480 (17.1)	358 (21.7)		
4	574 (20.4)	330 (20.0)		
5	356 (12.7)	284 (17.3)		
Living alone ever recorded (%)			<0.001	0.129
Yes	786 (27.9)	447 (27.2)		

	Comparison group (n=2813)	ALFY (1646)	p-value	SMD
No	2021 (71.8)	1177 (71.5)		
MISSING	6 (0.2)	22 (1.3)		
Care Home Stay = Yes (%)	759 (27.0)	164 (10.0)	<0.001	0.449
Fall ever recorded (%)			<0.001	0.122
Yes	1663 (59.1)	879 (53.4)		
No	442 (15.7)	272 (16.5)		
MISSING	708 (25.2)	495 (30.1)		
Functional Assessment ever conducted = Yes (%)	1864 (66.3)	1128 (68.5)	0.128	0.048
Mobility concerns (%)			0.352	0.045
Yes	1432 (50.9)	854 (51.9)		
No	323 (11.5)	166 (10.1)		
MISSING	1058 (37.6)	626 (38.0)		
Sight or hearing impairment (%)			0.012	0.092
Yes	1073 (38.1)	702 (42.6)		
No	453 (16.1)	250 (15.2)		
MISSING	1287 (45.8)	694 (42.2)		
Cognitive, orientation or memory problem (%)			0.054	0.075
Yes	948 (33.7)	504 (30.6)		
No	731 (26.0)	472 (28.7)		
MISSING	1134 (40.3)	670 (40.7)		
Feeding concerns (%)			0.004	0.102
Yes	666 (23.7)	460 (27.9)		
No	789 (28.0)	456 (27.7)		
MISSING	1358 (48.3)	730 (44.3)		
Depression or emotional concerns (%)			<0.001	0.135
Yes	461 (16.4)	357 (21.7)		
No	1028 (36.5)	564 (34.3)		
MISSING	1324 (47.1)	725 (44.0)		
Continence issues (%)			0.755	0.023
Yes	1067 (37.9)	608 (36.9)		
No	462 (16.4)	281 (17.1)		
MISSING	1284 (45.6)	757 (46.0)		

	Comparison group (n=2813)	ALFY (1646)	p-value	SMD
Charlson Score group (%)			<0.001	0.539
No ICD-10 codes recorded in past 5 years	10 (0.4)	96 (5.8)		
No comorbidities identified (0)	211 (7.5)	326 (19.8)		
Mild (1-2)	1079 (38.4)	613 (37.2)		
Moderate (3-4)	839 (29.8)	356 (21.6)		
Severe (5+)	674 (24.0)	255 (15.5)		
Comorbidities (ICD-10 based)				
MI or CHF (%)	1042 (37.0)	441 (26.8)	<0.001	0.221
PVD (%)	345 (12.3)	161 (9.8)	0.013	0.079
Stroke (%)	755 (26.8)	309 (18.8)	<0.001	0.193
Pulmonary (%)	1035 (36.8)	415 (25.2)	<0.001	0.252
Rheumatic (%)	111 (3.9)	58 (3.5)	0.528	0.022
PUD (%)	65 (2.3)	26 (1.6)	0.120	0.053
Liver (%)	109 (3.9)	51 (3.1)	0.207	0.042
DM (%)	818 (29.1)	342 (20.8)	<0.001	0.193
Renal (%)	803 (28.5)	301 (18.3)	<0.001	0.244
Dementia (%)	644 (22.9)	222 (13.5)	<0.001	0.246
Cancer (%)	588 (20.9)	315 (19.1)	0.168	0.044
Paralysis (%)	20 (0.7)	18 (1.1)	0.241	0.040
Had SPARRA score in 2015 = Yes (%)	2813 (100.0)	1637 (99.5)	<0.001	0.105
Average SPARRA score 2015 (mean (SD))	48.88 (10.48)	26.14 (17.01)	<0.001	1.610
Had HFRS in 2015 = Yes (%)	2748 (97.7)	1023 (62.2)	<0.001	0.990
Average HFRS 2015 (mean (SD))	5.93 (5.69)	2.84 (3.80)	<0.001	0.638
Average monthly prescriptions (BNF paragraphs)** 2015 (mean (SD))	7.86 (3.08)	5.75 (3.21)	<0.001	0.672
Admitted as inpatient 2015 = Yes (%)	1910 (67.9)	631 (38.3)	<0.001	0.620
Inpatient hospitalisations 2015 (mean (SD))	1.56 (1.89)	0.69 (1.20)	<0.001	0.550
Emergency inpatient hospitalisations 2015 (mean (SD))	1.27 (1.52)	0.50 (1.04)	<0.001	0.589
Non-emergency inpatient hospitalisations 2015 (mean (SD))	0.29 (1.00)	0.19 (0.54)	<0.001	0.125

	Comparison group (n=2813)	ALFY (1646)	p-value	SMD
Emergency inpatient length of stay in days 2015 (mean (SD))*	28.10 (37.25)	14.45 (23.22)	<0.001	0.440
Admitted at ED in 2015 = Yes (%)	1593 (56.6)	523 (31.8)	<0.001	0.517
ED Attendances 2015 (mean (SD))	1.07 (1.56)	0.54 (1.06)	<0.001	0.399
Outpatient attendances 2015 (mean (SD))	3.24 (4.40)	2.63 (2.47)	<0.001	0.169
Community episodes 2015 (mean (SD))	2.18 (2.82)	0.91 (1.79)	<0.001	0.540
Community functional assessments 2015 (mean (SD))	1.63 (4.72)	0.67 (2.37)	<0.001	0.258
Delayed discharges 2015 (mean (SD))	0.09 (0.32)	0.01 (0.13)	<0.001	0.295

† SIMD16 Quintile indicates level of deprivation (1=within most deprived fifth of population, 5=within least deprived fifth)

**Note length of stay includes only length of stay for patients admitted*

***Average monthly number of BNF classes was used to reduce effect of exaggerated polypharmacy and variation for patients who have multiple medications in the class as described in Section 7.2.8.*

Abbreviations: SIMD16 (Scottish Index of Multiple Deprivation 2016 version), ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure), PVD (Peripheral Vascular Disease), PUD (Peptic Ulcer Disease), DM (Diabetes Mellitus), SPARRA (Scottish Patients at Risk of Readmission and Admission), HFRS (Hospital Frailty Risk Score), BNF (British National Formulary), ED (Emergency Department)

9.5.3.3 Visual comparison of trends over time in outcome measures

Two of the main outcome measures (namely emergency inpatient hospitalisations and emergency department attendances), are explored visually over time across groups). Monthly admission or ED attendance rates for each group were calculated by dividing the total number of admissions or attendances each month by the number of patients who were alive at the start of each month. This was done to factor in the different group sizes and to factor in mortality. Figure 9.27 and Figure 9.28 display the trends in admission and ED attendance rates over time for each group.

The figures indicate that the two groups had very difference baseline emergency admission and ED attendance rates and that rates continued to increase among the ALFY caller group after ALFY was implemented.

Figure 9.27 – Emergency admissions rates per 1000 alive at start of each month over time for those calling or not calling ALFY in study cohort by caller group (0=non-callers, 1=ALFY callers)

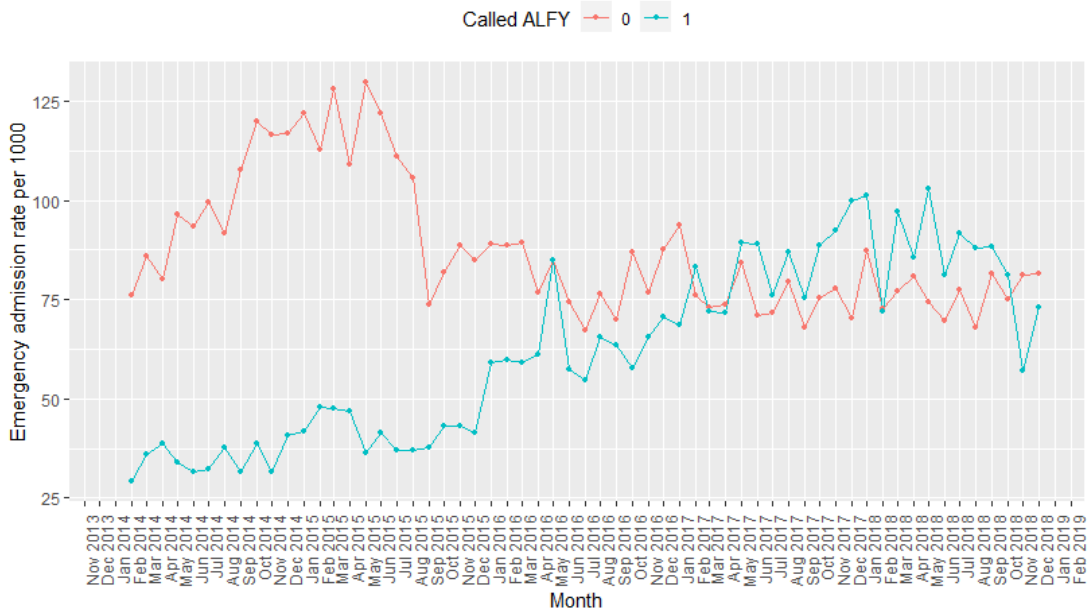
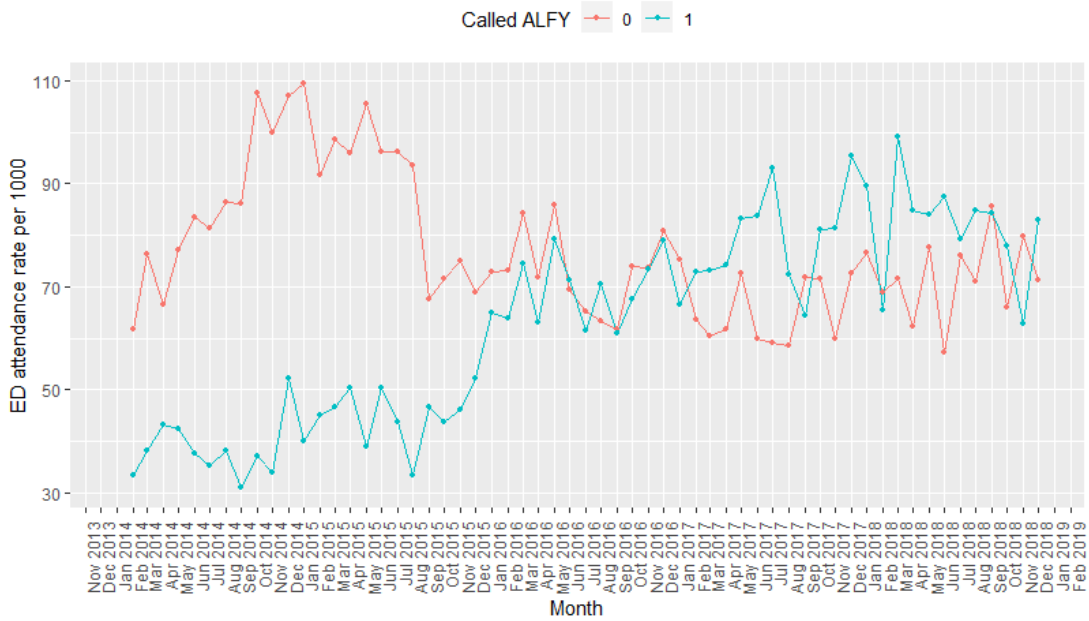


Figure 9.28 – ED attendance rates per 1000 alive at start of each month over time for those calling or not calling ALFY in study cohort by caller group (0=non-callers, 1=ALFY callers)



9.5.3.4 Before and after comparison

In order to take a closer look at hospital activity around index date (first call date) for ALFY callers, hospital activity rates relative to the time of the first call were investigated and are displayed in Figure 9.29 and Figure 9.30. These figures indicate that emergency admission and ED attendance rates within twelve

months on either side of the first ALFY call are highest during the month of the ALFY call, with an increase observed in the three months before the call and a decrease observed thereafter. This is supportive of the fact that the ALFY line was used in times of crisis.

Figure 9.29 – Total number of emergency admissions in the twelve months before and after patients' first ALFY call

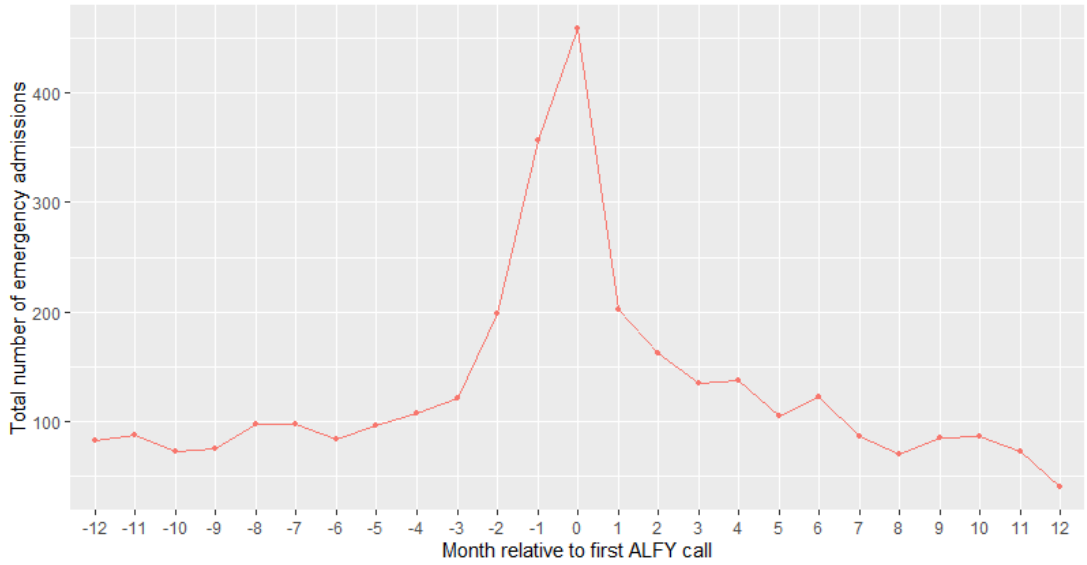
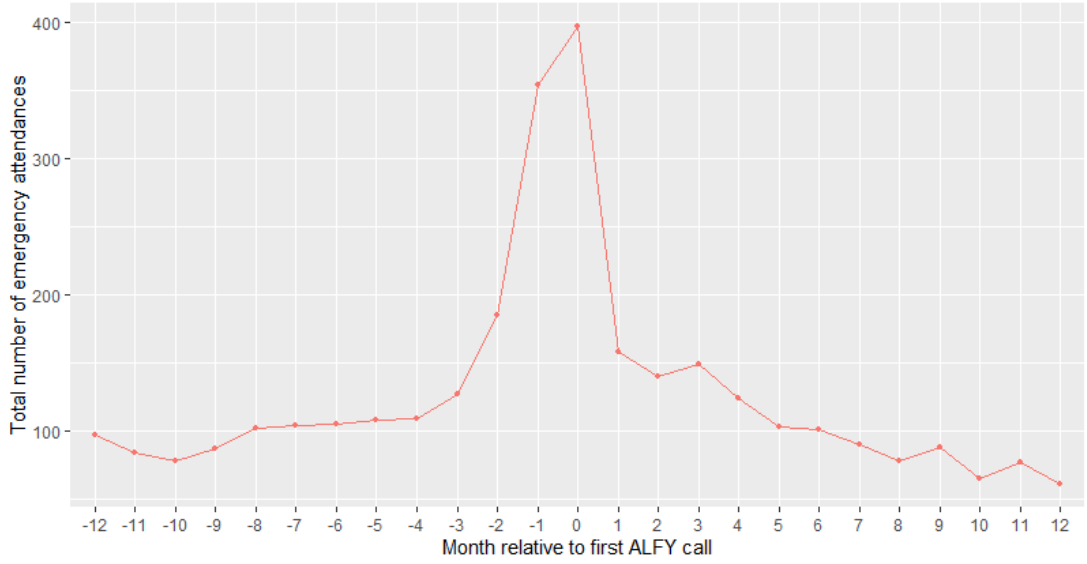


Figure 9.30 – Total number of emergency department attendances in the twelve months before and after patients' first ALFY call



Upon inspection of the figures above, it would appear that the admission rate post-ALFY is lower than the pre-ALFY admission rate. Hence, these pre- and post- admissions were investigated more closely. The table below indicates that emergency admission rates before compared to after ALFY fell by at least 20.3%

and that ED attendance rates fell by at least 42.8%. Though interesting, before and after comparisons cannot attribute the effect of the change to the intervention, due to a lack of comparison group (and a similar comparison cannot be made with the selected control group due to lack of having an index date). Hence, these observations cannot form a part of the comparative analysis and cannot give any information about the comparative effectiveness of ALFY.

Figure 9.31 – Hospital activity rates per 1000 ALFY patients in the time periods before and after their first ALFY call

Measure	Pre	Post	Percentage Change	P-Value
30-day emergency inpatient hospitalisation rate per 1000	311.1	212.2	-31.8%	<0.001
60-day emergency inpatient hospitalisation rate per 1000	460.5	333.6	-27.6%	<0.001
90-day emergency inpatient hospitalisation rate per 1000	545.0	433.8	-20.4%	<0.001
30-day ED attendance rate per 1000	313.5	162.1	-48.3%	<0.001
60-day ED attendance rate per 1000	456.9	261.5	-42.8%	<0.001
90-day ED attendance rate per 1000	535.2	266.7	-50.2%	<0.001

Note: Post-ALFY hospital activity rates factor in mortality, as the denominator is the number of patients alive in the time period after

9.5.3.5 Multivariable model selection for assessment of comparative effectiveness

A multivariable logistic regression model was fitted including all available potential predictors of a patient calling ALFY. Variables found to be significantly predictive of a patient being an ALFY caller were highlighted. In order to select from these predictors, a subset of the variables that are most predictive of a patient being an ALFY caller was found by using a best subset exhaustive search as described in Section 9.2.3. These predictors are identified as potential confounders in order to make appropriate adjustment in multivariable regression. Table 9.27 displays the covariates selected by best subset selection alongside odds ratios (OR) from the multivariable logistic regression model including all potential predictors. Figures displaying the selected predictors at varying values of the BIC are included in Appendix E.

Table 9.27 – Predictors of receiving ALFY highlighting those included in the best subset model

Predictor	OR	95% CI	p-value	SMD>0.1	Best Subset Model
Age	1.00	0.99,1.01	0.619	X	

Predictor	OR	95% CI	p-value	SMD>0.1	Best Subset Model
Sex	0.80	0.71,0.89	<0.001***		
Ethnicity	1.74	1.43,2.11	<0.001***	X	
Locality	1.00	0.97,1.03	0.867		
SIMD16 Quintile	1.17	1.12,1.22	<0.001***		X
Functional Assessment ever conducted	1.50	1.22,1.84	<0.001***		
Living alone ever recorded	0.84	0.75,0.95	<0.01**	X	
Care home stay	0.41	0.34,0.49	<0.001***	X	X
Fall ever recorded	0.99	0.91,1.08	0.805	X	
Mobility concerns	1.07	0.95,1.2	0.266		
Sight or hearing impairment	1.06	0.95,1.19	0.309		
Cognitive, orientation or memory problem	0.85	0.76,0.96	<0.01**		
Feeding concerns	1.30	1.15,1.47	<0.001***	X	X
Depression or emotional concern	1.10	0.98,1.24	0.114	X	
Continence issues	1.00	0.92,1.1	0.974		
Average monthly prescriptions (BNF paragraphs) 2015	0.85	0.83,0.86	<0.001***		X
SPARRA score	0.92	0.92,0.93	<0.001***		X
Charlson Score	0.54	0.48,0.62	<0.001***	X	X
MI or CHF	1.32	1.15,1.53	<0.001***	X	
PVD	1.33	1.11,1.61	<0.01**		
Stroke	1.06	0.91,1.23	0.447	X	
Pulmonary	1.16	1.01,1.34	<0.05*	X	
Rheumatic	1.56	1.18,2.08	<0.01**		
PUD	0.90	0.59,1.37	0.631		
Liver	1.13	0.82,1.55	0.459		
DM	1.38	1.19,1.61	<0.001***	X	
Renal	1.34	1.11,1.61	<0.01**	X	
Dementia	1.19	0.99,1.42	0.064	X	
Cancer	1.63	1.34,1.98	<0.001***		
Paralysis	2.89	1.66,5.02	<0.001***		
HFRS	1.02	1.01,1.03	<0.01**		
Emergency inpatient admissions	1.83	1.54,2.19	<0.001***	X	X

Predictor	OR	95% CI	p-value	SMD>0.1	Best Subset Model
Non-emergency inpatient admissions	1.70	1.33,2.18	<0.001***	X	
ED attendances	1.97	1.69,2.28	<0.001***		X
Outpatient attendances	1.17	1.08,1.26	<0.001***		
Community episodes	1.12	1.02,1.24	<0.05*		
Functional Assessments	1.05	0.98,1.12	0.171		
Delayed discharges	1.81	1.13,2.9	<0.05*		
Inpatient length of stay	1.04	1.02,1.05	<0.001***		X

Abbreviations: SIMD16 (Scottish Index of Multiple Deprivation 2016 version), ICD-10 (International Classification of Diseases 10th Revision), MI (Myocardial Infarction), CHF (Chronic Heart Failure), PVD (Peripheral Vascular Disease), PUD (Peptic Ulcer Disease), DM (Diabetes Mellitus), SPARRA (Scottish Patients at Risk of Readmission and Admission), HFRS (Hospital Frailty Risk Score), BNF (British National Formulary), ED (Emergency Department)

9.5.3.6 Results of statistical models assessing the effect of ALFY on hospital activity outcomes

As described in Section 9.2.2, a Cox proportional-hazards model was used to assess the effect of ALFY on hospital activity outcomes. Cox models allow assessment of effect where there is no index date for the comparison group as was the case here. Additionally, Cox proportional-hazards models enable assessment of the effect of multiple treatment episodes, where the effect estimate is the daily hazard of experiencing an event.

9.5.3.6.1 Effect on emergency inpatient hospitalisation and emergency department attendance

When comparing the effect of ALFY on the daily hazard of experiencing an emergency inpatient hospitalisation or emergency department attendance in Cox proportional hazards regression, ALFY was significantly associated with an increased hazard in the unadjusted models for both outcomes (emergency inpatient admission: HR 2.45, 95% CI [2.23, 2.71], p<0.001; emergency department attendance: HR 2.12, 95% CI [1.88, 2.39], p<0.001). Associated event rates are displayed in Table 9.28 below.

Table 9.28 – Emergency inpatient admission and emergency department attendance event rates and person-years throughout follow-up

		Emergency inpatient hospitalisation		Emergency department attendance	
Intervention	Person-years	Events	Event rate	Events	Event rate
Called ALFY	182.54	406.00	2.22	317.00	2.22
Did not call ALFY	9105.09	7858.00	0.86	7179.00	0.86

**Events represent emergency hospitalisation and event rates are calculated as the ratio of events over exposure time (person years)*

Table 9.29 below displays the results of the multivariable Cox proportional-hazards model comparing the effect of ALFY on emergency inpatient hospitalisation and emergency department attendance after adjustment for the variables identified in Section 9.5.3.5. These results indicate that after adjustment, calling ALFY increased the daily hazard of experiencing an emergency inpatient hospital admission by a factor of 2.41 (95% CI [2.19, 2.66]) and increased the daily hazard of experiencing an emergency department attendance by a factor of 2.01 (95% CI [1.80, 2.26]) when compared to a target group of patients who did not call the service, which is negligibly lower than in the unadjusted models.

Table 9.29 – Adjusted effect estimates of ALFY on daily hazard of emergency hospitalisation in Cox proportional hazards regression (including time-varying covariates), including estimates for adjustment variables

	Emergency hospitalisation			Emergency department attendance		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
Intervention						
Did not call ALFY	—	—		—	—	
Called ALFY	2.41	2.19, 2.66	<0.001	2.01	1.80, 2.26	<0.001
SIMD16 Quintile						
5	—	—		—	—	
4	1.10	1.01, 1.20	0.035	1.01	0.91, 1.12	0.9
3	1.09	1.00, 1.19	0.047	1.13	1.02, 1.26	0.025
2	1.11	1.03, 1.21	0.008	1.17	1.07, 1.29	0.001
1	1.08	0.99, 1.18	0.072	1.17	1.05, 1.31	0.003
Care home stay						
No	—	—		—	—	

	Emergency hospitalisation			Emergency department attendance		
Characteristic	HR[1]	95% CI[1]	p-value	HR[1]	95% CI[1]	p-value
Yes	0.94	0.89, 1.01	0.085	0.91	0.85, 0.99	0.019
Functional Assessment ever recorded	1.27	1.17, 1.39	<0.001	1.12	1.03, 1.23	0.012
Feeding concerns						
No	—	—		—	—	
Yes	1.10	1.03, 1.17	0.005	0.96	0.88, 1.03	0.3
MISSING	1.01	0.90, 1.14	0.8	1.00	0.86, 1.16	>0.9
Charlson Score group						
No comorbidities identified (0)*	—	—		—	—	
Mild (1-2)	1.97	1.73, 2.24	<0.001	1.27	1.13, 1.41	<0.001
Moderate (3-4)	2.60	2.28, 2.97	<0.001	1.42	1.26, 1.59	<0.001
Severe (5+)	3.39	2.96, 3.88	<0.001	1.56	1.38, 1.76	<0.001
Depression or emotional concerns						
No	—	—		—	—	
Yes	1.08	1.01, 1.15	0.022	1.16	1.07, 1.26	<0.001
MISSING	1.03	0.91, 1.16	0.7	1.05	0.91, 1.22	0.5
Baseline prescriptions (Average monthly BNF paragraphs 2015)	0.99	0.98, 0.99	<0.001	0.98	0.97, 0.99	<0.001
SPARRA score in prior interval	1.02	1.02, 1.02	<0.001	1.02	1.02, 1.02	<0.001
Number of emergency inpatient hospitalisations in prior interval	1.40	1.30, 1.51	<0.001	1.05	0.96, 1.16	0.3
Number of ED attendances in prior interval	1.18	1.10, 1.27	<0.001	1.62	1.49, 1.75	<0.001
Length of stay in days in prior interval	1.01	1.00, 1.01	<0.001	1.00	1.00, 1.01	0.3

[1]HR = Hazard Ratio, CI = Confidence Interval

**Note two categories were merged (no ICD-10 codes recorded and zero scores) to form this level to prevent analytical issues with low frequency levels*

9.5.3.6.2 Effect on emergency inpatient length of stay

A visual inspection of the distribution and cumulative distribution of length of stay in days for emergency inpatient hospitalisations indicates very little difference between the two groups (see Figure 9.32 and Figure 9.33).

Figure 9.32 – Cumulative distribution of length of stay for emergency hospital stays over follow-up by group (0=Did not call ALFY, 1=Called ALFY)

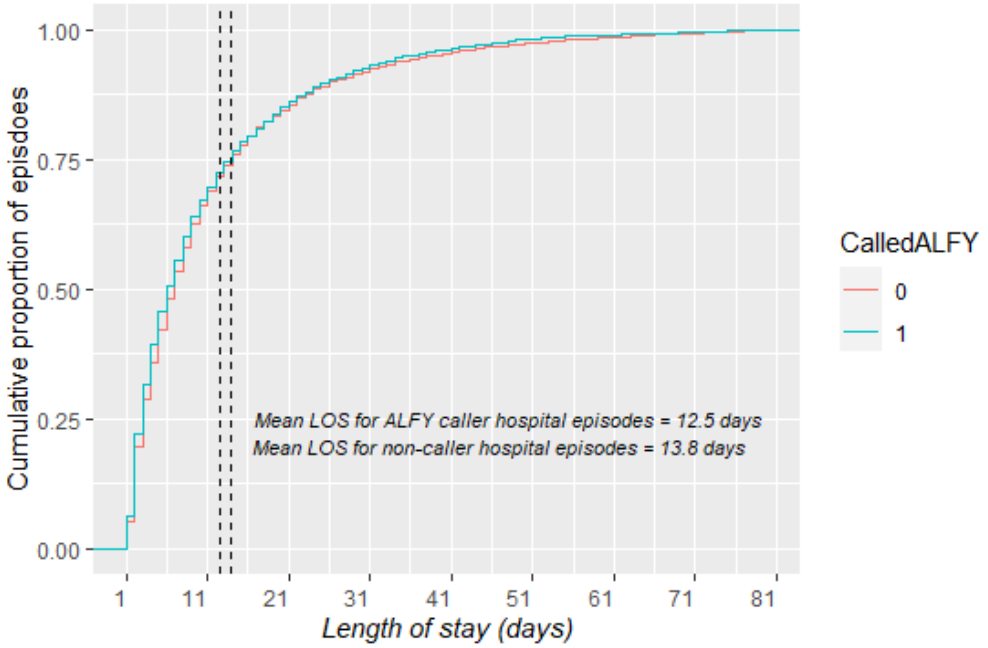
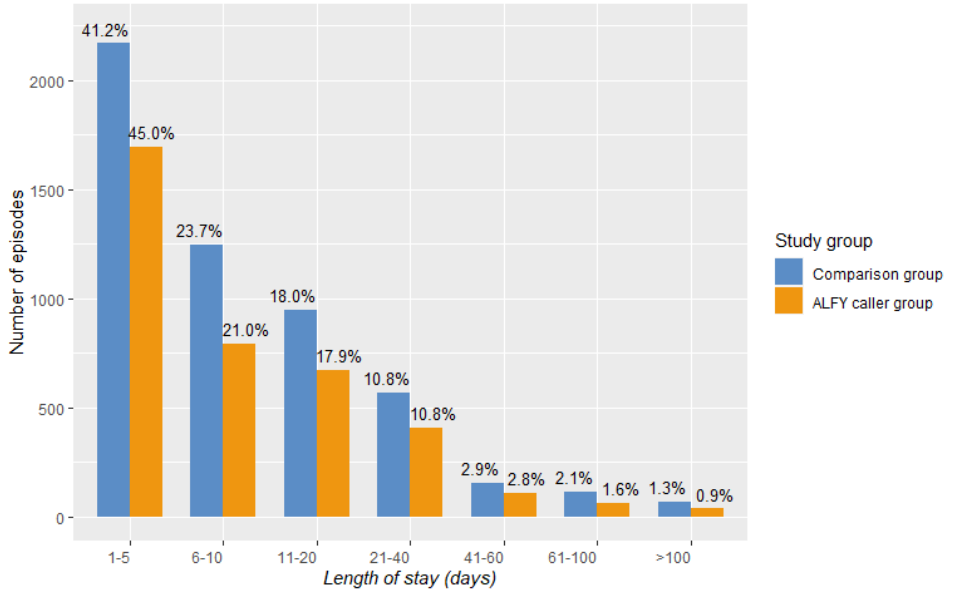


Figure 9.33 – Frequency of emergency admission episodes over follow-up period by length of stay by group



When comparing the effect of ALFY on the hazard of discharge from emergency inpatient hospitalisation following a call to ALFY in Cox proportional hazards regression, ALFY was found to make no difference in both the unadjusted (HR 0.95, 95% CI [0.83,1.09], p=0.5) and adjusted analyses (HR 0.93, 95% CI [0.81, 1.06], p=0.3). Hence, these results indicate ALFY makes no difference to emergency inpatient length of stay. Table 9.30 displays the results of the Cox proportional hazards model adjusted for the variables identified in Section 9.5.3.5.

Table 9.30 – Adjusted effect estimates of ALFY on time to discharge from emergency inpatient hospitalisation in Cox proportional hazards regression (including time-varying covariates), including estimates for adjustment variables

Characteristic	HR[1]	95% CI[1]	p-value
Intervention			
Did not call ALFY	—	—	
Called ALFY	0.93	0.81, 1.06	0.3
SIMD16 Quintile			
5	—	—	
4	0.99	0.87, 1.12	0.9
3	1.03	0.90, 1.17	0.7
2	1.04	0.92, 1.18	0.5
1	1.14	1.00, 1.30	0.055
Care home stay			
No	—	—	
Yes	0.68	0.62, 0.75	<0.001
Functional Assessment ever recorded	0.62	0.54, 0.70	<0.001
Feeding concerns			
No	—	—	
Yes	0.95	0.87, 1.03	0.2
MISSING	1.06	0.90, 1.24	0.5
Charlson Score group			
No comorbidities identified (0)*	—	—	
Mild (1-2)	0.83	0.67, 1.03	0.089
Moderate (3-4)	0.82	0.66, 1.02	0.069
Severe (5+)	0.81	0.66, 1.00	0.054
Depression or emotional concerns			
No	—	—	
Yes	1.02	0.93, 1.12	0.6

Characteristic	HR[1]	95% CI[1]	p-value
MISSING	0.91	0.77, 1.07	0.2
Baseline prescriptions (Average monthly BNF paragraphs 2015)	0.99	0.98, 1.00	0.3
SPARRA Score Complete	1.01	1.00, 1.01	<0.001
Number of emergency inpatient hospitalisations in prior interval	1.30	1.18, 1.42	<0.001
Number of ED attendances in prior interval	1.11	1.04, 1.19	0.003
Length of stay in days in prior interval	0.97	0.97, 0.98	<0.001

[1]HR = Hazard Ratio, CI = Confidence Interval

*Note two categories were merged (no ICD-10 codes recorded and zero scores) to form this level

9.6 Model checks

As previously discussed in Section 9.2.5, Cox models carry certain assumptions including the main assumption of proportional hazards. Three checks were performed to assess the assumptions were met by the models.

1. Are the functional forms of the variables appropriate? (inspection of Martingale residuals against continuous predictors)
2. Is the proportional hazards assumption satisfied? (Schoenfeld residuals test and inspection of Schoenfeld residuals against time)
3. Are there any outliers or influential observations? (inspection of deviance and *dfbetas* residuals)

9.6.1 Correct functional form

A plot of the Martingale residuals for the fitted models (plotted per subject as there are multiple observations per subject), null in each continuous predictor (namely SPARRA score, prescriptions and length of stay in days) against the continuous predictor displays the shape of the relation of the continuous predictor to the outcome. Inspection of the LOESS (locally estimated scatterplot smoothing) lines for these plots for each of the Cox models (for each of the three hospital activity outcomes), displayed roughly linear relationships for all three continuous predictors, indicating that the covariates in their linear form provide a good representation of the contribution of the predictor to the outcome. Therefore, it is reasonable to use the continuous predictors in their current linear functional

forms in the Cox models. The Martingale residual plots can be seen in Appendix C (Figure F-1 to Figure F-3).

9.6.2 Proportional hazards assumption

As previously described, Cox proportional hazards models assume that the ratio of the hazards for any two individuals remain constant over time (proportional). In testing this assumption, the Schoenfeld residuals test indicated significant non-proportionality in some of the included covariates, however, closer graphical inspection of the Schoenfeld residuals, particularly for offending covariates, indicated no pattern in the residuals across time and flat smoothed fit lines, indicating no violation in proportional-hazards. As previously described, it is likely that results of the statistical test appear significant due to large sample size. The Schoenfeld residuals and p-values from the Schoenfeld test for proportionality are included in Appendix F.

9.6.3 Outliers and influential observations

Influential observations can be examined by inspecting the *dfbetas* residuals to check the impact on parameter estimates of removing any single observation. The residual plots indicated that there are no particularly influential observations on the intervention effect estimates as they all have *dfbetas* residuals less than one. For the first two models (emergency admission and ED attendance) this is also the case across all covariates. For the third model assessing effect on length of stay, there is one influential observation on a few of the covariates used for adjustment, but there is no significant effect on the main estimate of interest. The *dfbetas* residual plots are included in Appendix F.

9.7 Summary of findings

The effect of each of the 'Closer to Home' services against hospital activity was investigated in this chapter through several complex analyses investigating various outcomes. Three main outcome measures were investigated, namely the effect on emergency inpatient hospitalisation, emergency department attendance and time to discharge (to analyse length of stay). Logistic regression and Cox proportional hazards models were used to assess these outcomes. The findings on the analyses assessing the effect of each of the 'Closer to Home' services against these outcomes presented in this chapter are summarised here.

9.7.1 Effect of the Enhanced Community Team (ECT) on hospital activity outcomes

It was clear from the initial analysis that patients receiving the ECT service were significantly different from the general elderly population in Forth Valley and that a comparable sample needed to be selected from this pool of potential control patients. Hence, the assessment of the effect of the ECT was conducted through a retrospective matched cohort study, comparing those who received the service to a matched control group selected from the pool of patients over 65 in Forth Valley. Two matched comparison groups were identified through direct covariate matching and propensity score matching respectively.

None of the analyses for neither of the two matched cohorts were able to evidence a reduction in experiencing an emergency inpatient hospitalisation nor emergency department attendance associated with receipt of ECT. In fact, in all of the analyses for both matched cohorts, receipt of ECT was significantly associated with increased odds or hazard of experiencing an emergency inpatient hospitalisation and of experiencing an emergency department attendance following receipt of ECT (see Table 9.31 for effect estimates in unadjusted and adjusted analyses). In all analyses for both matched cohorts, ECT was also significantly associated with prolonged length of emergency inpatient stay (see Table 9.31 for effect estimates in unadjusted and adjusted analyses).

Table 9.31 – Effect estimates assessing effect of ECT across all outcomes for both matched samples

	Rolling entry direct matched sample		**Rolling entry propensity score matched sample**	
	Effect estimate [95% CI[1]]		Effect estimate [95% CI[1]]	
	Unadjusted	*Adjusted*	*Unadjusted*	*Adjusted*
Outcome: *Emergency inpatient admission*				
Within 30 days of referral*	6.29 [4.81, 8.22]	5.51 [3.77, 8.06]	6.37 [5.32, 7.63]	6.19 [4.97, 7.72]
Daily hazard**	3.89 [3.31,4.57]	3.69 [3.14, 4.32]	3.92 [3.51,4.38]	4.19 [3.74, 4.69]
Outcome: *Emergency department attendance*				
Within 30 days of referral*	2.87 [2.16, 3.83]	2.85 [1.82, 4.46]	2.96 [2.40, 3.64]	2.90 [2.24, 3.77]
Daily hazard**	2.13 [1.78, 2.56]	2.09 [1.74, 2.50]	2.08 [1.81, 2.40]	2.03 [1.77, 2.37]
Outcome: *Time to discharge*				
Hazard of discharge**	0.65 [0.52, 0.81]	0.70 [0.54, 0.91]	0.62 [0.53, 0.71]	0.69 [0.59, 0.80]

[1]*CI=Confidence Interval*

**Assessed in conditional logistic regression, hence effect estimates are odds ratios*
***Assessed in Cox proportional hazards regression, hence effect estimates are hazard ratios*

9.7.2 Effect of the GP Fellows as an enhancement to the Enhanced Community Team (ECT)

The effect of the GP fellows as an enhancement to the ECT was assessed by comparing patients who received ECT prior to the introduction of the GP fellows to those receiving ECT after their introduction to the teams. The addition of GP fellows was associated with slightly reduced odds of both 30-day emergency inpatient hospitalisation and emergency department attendance, in both unadjusted and adjusted analyses though the results were not statistically significant (see Table 9.32 for effect estimates). A reduced daily hazard of emergency department was observed, however it was only statistically significant in the unadjusted analysis. Though a reduction in daily hazard of emergency inpatient hospitalisation was observed in the unadjusted analysis (which was not statistically significant), in the unadjusted analyses the hazard ratio is very close to one, hence it appears there is no effect of ECT on daily hazard of emergency inpatient hospitalisation (see Table 9.32 for effect estimates).

In the survival analysis, the addition of GP fellows was associated with a negligibly reduced hazard of discharge (i.e., increased the length of stay in hospital), however this was not statistically significant and was negligible, hence it appears that it made no difference to length of stay.

Table 9.32 – Effect estimates assessing effect of GP Fellows as an enhancement to ECT across all outcomes

	Effect estimate [95% CI[1]]	
	Unadjusted	*Adjusted*
Outcome: *Emergency inpatient admission*		
Within 30 days of referral*	0.76 [0.56,1.04]	0.79 [0.56, 1.12]
Daily hazard**	0.85 [0.68, 1.07]	0.98 [0.77, 1.23]
Outcome: *Emergency department attendance*		
Within 30 days of referral*	0.79 [0.53, 1.18]	0.79 [0.50, 1.22]
Daily hazard**	0.70 [0.50, 0.99]	0.79 [0.56, 1.12]
Outcome: *Time to discharge*		
Hazard of discharge**	0.88 [0.65, 1.21]	0.90 [0.69, 1.18]

[1]CI=Confidence Interval

**Assessed in conditional logistic regression, hence effect estimates are odds ratios*
***Assessed in Cox proportional hazards regression, hence effect estimates are hazard ratios*

Note: Estimates are not statistically significant where the 95% CIs span a value of one

9.7.3 Effect of the Advice Line for You (ALFY) on hospital activity outcomes

It is clear from the analysis that the patients who called ALFY are different to the initial target group for ALFY, both in their characteristics and hospital activity. It was of note that when looking at the periods immediately before and after the ALFY callers first call, a reduction in admission rates was observed, factoring in mortality. However, this comparison provides little evidence of an effect without using a comparison group.

To analyse the comparative effect of ALFY, a Cox proportional-hazards model was used, comparing emergency admissions over time in callers and non-callers. Statistical adjustment was required to reduce bias arising from the differences between the groups. ALFY was found to significantly increase the daily hazard of both experiencing an emergency inpatient hospitalisation and of attending the emergency department, in both unadjusted and adjusted analyses (see Table 9.33 for a summary of estimates). In the survival analysis examining time to discharge, ALFY was found to make no difference to hazard of discharge (i.e., no difference to length of stay in hospital).

Table 9.33 – Effect estimates assessing effect of ALFY across all outcomes

	HR[1] [95% CI[1]]	
Outcome	*Unadjusted*	*Adjusted*
Daily hazard of emergency inpatient admission	2.45 [2.23, 2.71]	2.41 [2.19, 2.66]
Daily hazard of emergency department attendance	2.12 [1.88, 2.39]	2.01 [1.80, 2.26]
Hazard of discharge from emergency inpatient hospitalisation	0.95 [0.83, 1.09]	0.93 [0.81, 1.06]

[1]HR=Hazard Ratio (note HRs are not statistically significant where the 95% CIs span a value of one), CI=Confidence Interval

9.8 Discussion and limitations

This analysis was of course limited by several factors, the primary of which was the retrospective, observational design. The study design and analysis highlight

the difficulty in identifying suitable control groups for interventions such as the 'Closer to Home' services, where comparable, eligible groups of patients not receiving the interventions have not been prospectively determined.

Although alternative methods were available for determining comparable control groups (matching in study of effect of ECT, historic control group in study of effect of ECT enhanced with GP fellows and a target mailing list group in the study of effect of ALFY), they all came with their limitations.

Though matching appeared a promising method and resulted in very similar comparison groups in the study of the effect of ECT, residual differences were still apparent. It was found that even by matching on time-dependent covariates and on historic hospital activity in the month prior to receipt of the intervention, at index date, historic hospital activity was very different. The phenomenon observed may indicate that a month's period prior to intervention is not sufficiently narrow to capture the increase in activity just prior to intervention to obtain a comparable matched sample. It is difficult to analyse that level of detail and it was not computationally feasible in this case to attempt matching on more narrow intervals of historic activity.

Though an eligible group of patients for the study assessing the effect of ECT enhanced with GP Fellows was available, it was retrospectively identified and there were likely to be several other changes to the service as it matured, hence, confounding effects of time or other service changes cannot be ruled out.

Finally, though a previously defined target group of patients who did not call ALFY could be identified, it became apparent that the characteristic profile of ALFY callers was significantly different to that of the target group.

In addition to the evidenced difficulties in study design and in selecting appropriate comparison groups, this analysis also highlights the analytical complexities involved in retrospective, observational studies with no prospectively identified comparison groups. A variety of analyses and techniques were needed to conduct a robust analysis, with the appropriate management of potential confounding proving several challenges and complicating the analysis (e.g. requirement for assessment of potential confounders, for empirical variable selection to identify appropriate matching and adjustment variables and for appropriately adjusted analyses). The data preparation involved to facilitate the complex analyses was time-consuming and often gruelling, particularly the

development of 'counting process' data and generation of time-series data from routinely collected healthcare records.

9.9 Conclusion

Overall, in the presented analysis the 'Closer to Home' programme does not appear to be associated with reduced hospital activity. Though two matched control groups were used and several outcomes were assessed, ECT could not be shown to reduce hospital activity in any of the analyses but was rather associated with increased hospital activity and prolonged length of stay following referral to ECT compared to their matched counterparts who did not receive the service, despite adjustment for observed differences between groups.

However, the addition of GP Fellows as an enhancement to the service appeared to have some effect on emergency inpatient admission and emergency department attendance, reducing both the odds of experiencing these events within 30 days or referral and the daily hazard of experiencing these events by roughly a factor of 0.8. Although not statistically significant, this result may have some clinical relevance. The added expertise of GPs would have enabled the team to provide care for more complex patients and potentially avoid referring them onto hospital where previously the nurse-led team may have had to do. It seems reasonable to conclude that the addition of GP Fellows as an enhancement to ECT appears to reduce emergency hospital activity to a small extent. However, it made no difference to the hazard of discharge from emergency inpatient hospitalisation (i.e. length of stay).

Despite some weak evidence that ALFY may reduce emergency hospital admissions in a before-and-after comparison, when compared to a target control group who did not call ALFY, reduction in hospital activity could not be evidenced, despite adjustment for observed differences between the groups. In fact, the comparative analysis indicated an increased daily hazard of both experiencing a emergency inpatient hospitalisation and of experiencing an emergency department attendance following a call to the service compared to their counterparts who did not call. In addition, no difference to hazard of discharge (i.e. length of stay) was found in the analysis.

The analysis presented in this chapter highlighted the practical difficulties in conducting retrospective, observational research using routinely collected

healthcare data. In particular the difficulties and complexities of study design and analysis were highlighted, including the need for appropriate management of confounding including matching methods and covariate adjustment to reduce bias resulting from a lack of randomisation.

Chapter 10 Qualitative Analysis and Results

10.1 Background and aims

A qualitative study was conducted in order to address the third research question as part of the final phase of this research *("RQ3. What benefits and barriers to the 'Closer to Home' intervention were identified by key stakeholders involved in implementation or delivery of the programme?").* The overarching aim of this qualitative study was to understand the benefits and barriers to implementation of the 'Closer to Home' programme from the perspective of professionals involved in the implementation, delivery, or referral to the programme. The study aimed to meet the following specific aims:

- Identify main benefits and distinctions of the 'Closer to Home' interventions as identified by key stakeholders.
- Identify key barriers to implementation and full adoption of the programme.
- Identify the suitability of existing key performance measures and processes.

10.2 Qualitative study methods

This section describes the specific qualitative methods employed for this study.

10.2.1 Setting and sample

The study was conducted within NHS Forth Valley, a regional health board in Scotland. Inclusion required employment within the NHS Forth Valley health board area and knowledge or involvement in any of the 'Closer to Home' services, aiming to include participants who were closely involved in the design and implementation of the interventions, as well as those having interactions with the services, including those delivering or referring to the services. Four main groups of stakeholders in the 'Closer to Home' programme were interviewed. These were:

- health care and managerial professionals involved in the implementation and management of 'Closer to Home' services

- health care professionals involved in the delivery of 'Closer to Home' services
- health care and social care professionals involved in elderly care who also refer to 'Closer to Home' services or have interactions with the services
- health and social care partnership funding coordinators involved in the funding and monitoring of 'Closer to Home' services

This study was particularly interested in the managerial and care provider point of view; hence patients were not included.

A total of 18 participants were included in the study. The initial participants in the sample were selected through both convenience and purposive sampling, meaning that some participants were included due to being available at the time and some participants were selected due to knowledge of their position within the 'Closer to Home' programme. Further participants were selected through intensity sampling, a type of purposive sampling, where a recommendation for other potential participants with specialised knowledge (rich cases) was made by those in the initial sample (during or after their interviews), by other health care professionals or through contact lists within internal documents.

All participants were contacted by email to request their participation upon introduction by another employee of the health board, if required. In the email, a brief description of the study was included along with the expected interview duration (30-40 minutes) and the reason for why they had been contacted was explained. Four participants who were originally contacted were not available but two of them provided equivalent alternative participants in their place. One participant who was originally contacted was no longer in post but provided an alternative contact. Three participants who were contacted did not reply.

10.2.2 Data collection

Audio-recorded semi-structured interviews were selected as the method of data collection for this qualitative study, due to their structure allowing the participant to voice their thoughts.

A small sample of qualitative studies focusing on interventions for elderly patients or patients with long term conditions was reviewed and instructed the design of the semi-structured interview schedule (Russell et al., 2009; Leighton, Clegg and Bee, 2008; Crilly, 2007).

Normalisation process theory (NPT) was identified as an appropriate coding and thematic analysis framework, due to its focus on exploring the key characterises and mechanisms at play in embedding new health interventions, hence the framework was also used to guide and refine the questions. NPT will be described in more detail in Section 10.2.6. Once a list of questions was set out for each stakeholder, the questions were reviewed by two researchers (PhD supervisors), one with extensive experience in qualitative research and programme evaluation and the other with experience in health care delivery and programme evaluation. Finally, a pilot interview was conducted with a nurse, following through the interview questions and asking about their appropriateness and clarity of wording.

Hence, through an iterative process of refining the interview questions, the following process was followed in developing the final list of questions:

1. Brief scoping of related examples in literature
2. Normalisation process theory framework guidance
3. Review of questions by other researchers
4. Pilot interview testing out the questions

At the end of each interview, participants were asked if they had anything further to add and were also asked if they would be happy to be contacted again if any clarifications were required. A total of five participants were contacted for follow-up interviews. Ten participants were contacted for clarifications over email, six of them replied and five of these provided the clarifications, one replied but did not have capacity at the time.

Demographic data were collected for each participant, including employer, professional group, current role, years of experience in profession and in current role, highest qualification, age and gender.

10.2.3 Research governance and ethics

Ethical approval was sought and obtained from the University of Strathclyde Computer and Information Sciences departmental ethics committee, after submitting a proposal outlining the study design, participant information sheets and interview schedule (approval obtained 18/10/19). Prior to interview, participants completed a consent form to indicate their informed consent. This confirmed their consent regarding the storage of the information collected from them, anonymous dissemination of the results, and confirming their voluntary

participation and consent to be audio recorded (see Appendix G for participant information sheet and consent form).

10.2.4 Interview procedures

Interviews were conducted at a time and place suitable to participants and were arranged through email communication. Where possible a vacant and quiet room was booked ahead of time by either the interviewer or the participant of the interview (or secretary). At times however, this was not possible (due to a convenience interview coming up or due to issues in the building of meeting) and another optimum location could not be arranged due to constraints in the participants work requirements. Hence most of the interviews were conducted in quiet and undisrupted settings, however two interviews had disruptions where the interview recording was paused and then continued when a quiet environment had resumed or an alternative location was found.

Three interviews were conducted jointly (two participants in one interview sitting). In these cases, as much as possible, both participants were individually addressed with the interview questions, but discussion between them was freely allowed.

Upon first meeting with participants, the interviewer introduced herself, explaining the purpose of the study and providing a participant information sheet as well as a consent form. Participants were allowed time to read through them and to provide their informed consent ensuring they understood that the interview would be recorded, that their data would be stored securely and would remain confidential and anonymised and that they could withdraw their participation at any time without consequence. The information sheet contained contact details for the interviewer and main supervisor as well as contact details for the departmental ethics committee. Participants were also asked if they would like to receive the results of the study once completed.

At the beginning of starting the interview recording, the purpose of the interview was reiterated prior to beginning the interview questions. For any questions with multiple parts or requiring introductory information, an introduction statement was made to inform participants of the next interview question (e.g. 'Now I'm going to ask you about the impact of 'Closer to Home' in terms of different stakeholders…").

At the end of each interview, each participant was thanked for their participation and as previously mentioned were asked if they had anything further to add and if they would be happy to be contacted again for clarifications. In addition, their demographic characteristics were collected.

10.2.5 Interview audio-recording and transcript processing

Each interview was assigned an anonymised code and the date of each interview was recorded. Each interview recording was checked to ensure the entire interview had been recorded and that the audio was clear enough to be understood. Each recording was securely transferred to a professional transcribing company. The interviews were sent in three batches. The first batch of transcripts were received by the researcher three months after sending them originally. These were checked to ensure accuracy of transcription and because a satisfactory accuracy was found, the second batch was also sent to the same transcription company and the transcripts were received by the researcher eleven days after the interview files were sent. Finally the third batch was sent using the same transcription company and the transcripts were received twenty-three days after they were initially sent.

Once the transcripts were received, the researcher listened to each interview while checking its respective transcripts to ensure accuracy of the transcripts particularly in the use of setting-specific terms, acronyms and abbreviations. Several small changes were made to the transcripts given incorrectly transcribed acronyms and abbreviations as well as misinterpretations of pronunciations. This process also ensured that any pauses or important gestures were not missed in the transcription. This process was an important first step for the researcher to become familiar with the content of the data to be analysed and to reflect on each interview.

10.2.6 Theoretical framework for qualitative data analysis

McEvoy et al. highlight that the use of theory "can offer us generalizable frameworks that can apply across differing settings and individuals; the opportunity for incremental accumulation of knowledge; and an explicit framework for analysis" (2014, p.2). The use of a theoretical framework can aid the analysis and meaningful evaluation of the complex processes involved in

healthcare interventions (Devlin et al., 2016). Normalization Process Theory (NPT) is a sociological theory that identifies and characterises the mechanisms at play in the implementation of an intervention and was developed by May et al. (2009) (May et al., 2018). As described by May et al., NPT "identifies, characterises and explains key mechanisms that promote and inhibit the implementation, embedding and integration of new health techniques, technologies and other complex interventions" (2018, p.1). Systematic reviews on the use of NPT have found that there is a wide body of literature employing NPT to analyse complex interventions and implementation processes in a variety of healthcare settings, having broadened beyond its original field of e-health (McEvoy et al., 2014; May et al., 2018).

The NPT framework aims to explore how the mechanisms of four main constructs interact to support the embedding of complex interventions in practice, namely, coherence ('What is the process?'), cognitive participation ('Who performs the process?'), collective action ('How does the process get performed?') and reflexive monitoring ('How is the process understood?') (May et al., 2018). Definitions used in both theory and practice for each of these constructs are provided in Table 10.1.

Table 10.1 – Normalisation process theory constructs and definitions

Normalisation Process Theory construct	Definition (Ferguson, Seston and Ashcroft, 2018)	Use in practice (McEvoy et al., 2014)
Coherence	Refers to how individuals and groups 'make sense' of an intervention when they are tasked with implementing a new way of working	Emphasis on understanding and conceptualisation of interventions and their work
Cognitive Participation	The relational work people undertake to legitimise and sustain an intervention.	Emphasis on notions of legitimation and buy-in, both in terms of individuals involved and involving others
Collective Action	The operational work that people do to enact a new intervention.	Emphasis on organisation resources, training and divisions of labour, confidence and expertise as well as workability of the intervention in clinical interactions
Reflexive Monitoring	The appraisal work the people do to understand and evaluate whether the new ways of working are worth sustaining	Emphasis on appraising and monitoring implementation work

NPT is one of the most utilised and highly cited implementation theories in applied healthcare research (Dalkin et al., 2021). Other popular implementation

theories or determinant frameworks used in healthcare research to understand or explain influences on implementation outcomes include the behaviour change wheel (based on the theory that capability, opportunity and motivation interact to generate behaviour), the Consolidated Framework for Implementation Research (CFIR) (which suggests five constructs that are associated with effective implementation namely intervention characteristics, outer setting, inner setting, characteristics of individuals and the implementation process) and Promoting Action on Research Implementation in Health Service (PARIHS) (which suggests that evidence, context and facilitation are associated with successful knowledge transfer) (Bradford et al., 2019).

Given that the aim here was to understand the implementation practices of 'Closer to Home,' the explore the mechanisms at play in why and how new ways of working lead to change, and to understand the reasons for lack of realisation of its primary outcome, namely a reduction in hospital activity outcome (as was evidenced in the quantitative analysis), the following reasons outline why NPT was selected as the theoretical framework underpinning the qualitative analysis over its alternatives: 1) was developed primarily to understand the observed difficulty in implementing new healthcare interventions and ways of working, particularly where widely adopted systems fail to become routinely incorporated despite favourable circumstances and committal of resources (May et al., 2009), 2) characterises mechanisms to explain why and how change occur rather than offering static qualities of determinants (e.g. CFIR) which is especially helpful in qualitatively analysing implementation perspectives (Schroeder et al., 2022), 3) is comprehensive but also intuitive and accessible compared to other complex or time consuming alternatives that may require training to get the most out of (e.g. behaviour change wheel) (Ojo et al., 2019), and 4) has high exposure in literature with a wide range of applied examples and practical guidance on operationalising the framework (this is a limitation of PARIHS) (Dalkin et al., 2021; Bergström et al., 2020).

Here, NPT was used as a guiding framework for identifying related themes and subthemes, rather than strictly adhering to the existing NPT constructs as themes. This was in order to prevent forcing observations into predetermined codes or categories, as has been noted by other authors as a difficulty in using NPT (McEvoy et al., 2014).

10.2.7 Qualitative data analysis procedure and thematic coding

As previously mentioned, NPT was used as a guiding conceptual framework when identifying themes and subthemes. Initial codes were identified according to the categories of questions being asked (interview questions were partly guided by NPT), indicative of initial themes. Codes and themes were mapped onto NPT as a system for organising observed themes and subthemes which resulted in a coding framework of start codes to begin coding data from transcribed interviews [see Appendix H Table H-1 for coding framework of start codes, the framework was based on Devlin et al.'s NPT coding framework (2016)]. Data coding was conducted by the primary researcher in NVivo qualitative data analysis software by encoding narratives in each transcribed interview into nodes representing each of the elements in the coding framework. The coding framework was reviewed by at least one researcher with extensive experience conducting qualitative research (primary supervisor). Additional emergent codes were created as required.

When it came to analysis of themes where several complex and interlinked subthemes were discussed by participants, cognitive mapping was used as an aide towards summarising concepts discussed and to visualise how they were interlinked. Cognitive maps are a type of concept map built with the intention for further analysis, hence go a further step towards sense-making and problem structuring by looking for hierarchy and theming in the concepts being mapped and is predominantly used in the area of operational research (also called management science) (Fran Ackermann, Eden and Cropper, 1992). Concepts can be classified into goals, problems and other categories and links are more intentionally directional. For example, analysing themes or conducting "cluster analysis" to determine groups of concepts that are tightly linked together, identifying "busy" concepts representing central issues (those with the most links in the context of the full cognitive map), "head' concepts (those at the top representing goals or outcomes) and "tail" concepts (those representing triggering events, root causes, and drivers for change). This tool was used in particular when analysing issues and barriers to the full implementation and establishment of the ECT service.

10.2.8 Participant demographics

Several demographic characteristics were collected from participants who were interviewed. The majority of participants were females (88.9%) and the average age of participants was 47. On average, participants had 24 years of experience in their profession and 6 years in their current position at the time of interview. Table 10.2 describes the sample in more detail.

Table 10.2 – Participant characteristics

	Direct patient care	Management	Total
Sampled *n* (%)	9 (50.0)	9 (50.0)	18
Gender *n* (%)			
Female	7 (77.8)	9 (100.0)	16 (88.9)
Male	2 (22.2)	-	2 (11.1)
Age *M (SD)*	44 (9.58)	50 (8.56)	47 (9.34)
Place of employment n (%)			
NHS	9 (100.0)	5 (55.6)	14 (77.8)
Health and Social Care partnership	-	2 (22.2)	2 (11.1)
Local authority	-	2 (22.2)	2 (11.1)
Primarily employed as *n*			
Nurse	3	-	3
Nurse manager	-	1	1
Physiotherapist	1	-	1
AHP manager	-	2	2
Health care assistant	2	-	2
GP	2	-	2
Geriatrician	1	-	1
Funding co-ordinator	-	2	2
Social care managers	-	2	2
Senior community services manager	-	1	1
Senior partnership manager	-	1	1
Highest qualification *n* (%)			
Secondary school education	2		2
Bachelor's degree or graduate diploma	4	5	9
Postgraduate degree or diploma	3	4	7
Years of experience in profession *M (SD)*	20.22 (9.81)	27.56 (9.99)	23.89 (10.32)
	"Closer to Home"	**Non-"Closer to Home"**	
Years of experience in current role *M (SD)*	3.33 (1.61)	9.04 (8.33)	5.87 (6.21)

The full list of participants with further details about their position can be seen in Table 10.3 below.

Table 10.3 – Full details of participants

ID	FIRST INTERVIEW	PLACE OF EMPLOYMENT	PROFESSION	TYPE	DELIVERS 'CLOSER TO HOME'
P1	11/10/2018	NHS FV	Nurse	Patient care	Yes
P2	07/11/2018	NHS FV	Nurse manager	Manager	Yes
P3	14/11/2018	NHS FV	AHP manager	Manager	Yes
P4	19/11/2018	NHS FV	Senior community services manager	Manager	No
P5	26/11/2018	NHS FV	AHP manager	Manager	Yes
P6	26/11/2018	NHS FV	Physiotherapist	Patient care	Yes
P7	29/11/2018	NHS FV	GP	Patient care	Yes
P8	29/11/2018	NHS FV	Nurse	Patient care	Yes
P9	10/12/2018	H&SCP	Senior partnership manager	Manager	No
P10	20/12/2018	NHS FV	Nurse	Patient care	Yes
P11	17/01/2019	NHS FV	Health care assistant	Patient care	Yes
P12	17/01/2019	NHS FV	Health care assistant	Patient care	Yes
P13	30/01/2019	NHS FV	Funding co-ordinator	Manager	No
P14	30/01/2019	H&SCP	Funding co-ordinator	Manager	No
P15	07/02/2019	NHS FV	Geriatric consultant	Patient care	No
P16	08/03/2019	NHS FV	GP	Patient care	No
P17	15/08/2019	Local authority	Social care manager	Manager	No
P18	15/08/2019	Local authority	Social care manager	Manager	No

10.3 Results of thematic analysis

Thematic analysis using NPT resulted in seven overarching themes, displayed in Table 10.4. The main results are reported under these overarching themes, using counts and example excerpts from the interviews. The number of participants making a statement or point is reported with the intention of making the summaries more precise and does not attempt to interpret the significance of the reported numbers (Becker, 1970).

Table 10.4 – Overarching themes and subthemes of thematic analysis

Overarching themes	Subthemes	NPT constructs
Clarity of 'Closer to Home' services and their acknowledged intrinsic value	Clear understanding of service aims and role contribution Difficulty in defining referral criteria Differences to previous practice Perceived benefits to service users Perceived benefits to professionals	Coherence

	Perceived organisational benefits 'Closer to Home' team engagement and buy-in	Cognitive participation
Contextual and relational barriers to full implementation of 'Closer to Home'	Operational and embedment issues System readiness issues Health and social care integration issues Organisational engagement and buy-in issues	Collective action
Measuring and monitoring 'Closer to Home' and similar admission avoidance interventions for the elderly	Adequacy of existing appraisal processes and outcomes Following-up outcomes for a complex population	Reflexive monitoring

10.3.1 Clarity of 'Closer to Home' services and their acknowledged intrinsic value

Participants were asked about their understanding of the 'Closer to Home' services including its significance, its aims, benefits and their understanding of their role within the service. This corresponds to the NPT constructs of 'Coherence' (how individuals and groups 'make sense' of an intervention) and 'Cognitive participation' (the relational work people undertake to legitimise and sustain an intervention including buy-in). The overarching theme that emerged from the responses surrounding these constructs was the clarity of 'Closer to Home' services and their acknowledged intrinsic value. This section will first describe the overall understanding that participants have of the services and their role within them, and will then go on to describe each of the subthemes identified within this overarching theme.

10.3.1.1 Clear understanding of service aims and role contribution

10.3.1.1.1 Understanding of service aims

All participants who were asked to describe the ECT services described it as a service that aims to prevent unnecessary hospital admissions (n=16). The other aims of ECT were described as follows:

- To support patients for an early discharge home from hospital (n=2)
- To support people who are unwell to be able to remain at home (n=11)
- To support patients to get well again at home if possible (n=3)

One participant described the goals of the GP Fellows programme. In addition to delivering the ECT goals, they described the GP Fellows programme goals as follows:

- To upskill GPs that entered the fellowship to be more equipped to manage complex conditions and have a greater understanding of management of frail patients in the community, with a view of also developing these skills in other clinicians in primary care

Only three participants of those who were asked about referral criteria for the ECT service (n=16) could not clearly describe the criteria. These participants were not directly involved in the management or delivery of ECT. One participant in particular, a geriatric consultant, felt lack of clarity on the types of patients ECT would see, and described the service and its main goals as vague. Another participant, a social care manager, although they understood the service, felt that their colleagues in social work were not aware of ECT or were unsure of its purpose.

Participants described ALFY as a self-referred 24-hour health and support advice line and as a single point of contact to navigate statutory services or local third sector groups (n=3). One participant, an ALFY nurse, was asked to describe the main aims of the ALFY service and its referral criteria. This participant stated that initially its main goal was to keep people well at home, prevent unnecessary crisis care or hospital admissions that may be related to social issues. As the service developed, the goal also included supporting hospital discharges through telephone follow-up to prevent re-admission. This participant was also able to clearly describe the criteria for using the service.

10.3.1.1.2 Understanding of individual role contribution

All participants involved the management or delivery of 'Closer to Home' services reported a clear understanding of their individual tasks and responsibilities within the 'Closer to Home' services (n=10). The majority of these reported feeling confident in their daily work (n=8), while some reported feeling confident most of the time (n=2). Three of these participants expressed that their confidence has grown over time (n=3). The majority of these participants (n=8) reported that they felt that they could clearly see how their role as an individual contributes to the service goals. Two participants who are not co-located with the rest of the team felt that they have in the past been able to see how their role contributes to the

service goals, but that this is more difficult to see when they don't have regular meetings with the team (n=2).

All participants who were potential referrers to 'Closer to Home' services not involved in their management or delivery also reported a clear understanding of their individual tasks and responsibilities within their role (n=4). Two of these participants reported feeling confident in their daily work and one reported feeling confident most of the time. All of these participants stated that they could clearly see how their role as an individual contributes to their own service's goals within elderly care (n=4).

10.3.1.2 Difficulty in defining referral criteria

Four participants who deliver or manage the ECT service commented on whether they felt the referral criteria for ECT have been difficult to define. Two of these, both ECT nurses, felt that they understood the eligibility criteria clearly and know who is right for their service. These participants felt that sometimes it is difficult for referrers to interpret the eligibility criteria and that due to this sometimes they get inappropriate referrals. All four participants stated that setting the eligibility criteria is difficult, but appropriately so due to the complexity of patients they see and of the service. Two participants stated that sometimes eligibility cannot be defined properly until they see the patient and another stated eligibility should be determined on a case-by-case basis. When discussing eligibility criteria, there were descriptions like "there's always a bit of blurring over the lines" (P8, Nurse) and "it's a grey area and quite flexible" (P7, GP).

One participant emphasised that it is a good thing to have flexible criteria, particularly because it allows for more complex patients to be taken on, for whom the service is most suitable. This is illustrated in the following excerpt:

> *"Yes, but I think that's a good thing because patients are complex anyway and I think with a lot of the patients that were accepted initially with the team, it sounds like they were quite straightforward clinically to manage and I think it's more useful to get more complex patients coming through the team. I think it's the complex ones that then get admitted to hospital. So, if the criteria is too tight and too specific then a lot of the more complex patients will just get admitted straight away because they don't fit that criteria. You need to have some criteria there, but I think it's reasonable to have it loose, because it's a grey area and everyone has a different perception of what patients can manage at home and which ones should be admitted to hospital. So, I'd probably say yes, it's fine for it to be on a grey area and for each patient to be considered individually."* (P7, GP)

Another participant stated that defining eligibility criteria was particularly difficult during implementation because of the developing nature of the service, as illustrated in the following excerpt:

> *"I think in the setting up of any service you can start it off as some ideas of how you think it'll run. Actually I think it's right that things change over time, you're responsive to the need. You can hypothetically think what would be your client group, but it's not until you've got a service up and running that things develop more and you've got a much better understanding of people who need the service. I think things do change and I think that's right that they change over time."* (P3, AHP Manager)

Three participants who were potential referrers to the service were asked about the clarity of the referral criteria for ECT. One participant, a GP from primary care, did not feel difficulty with referral criteria. The other two participants felt a lack of clarity about the referral criteria. One of these, a geriatric consultant, felt a strong lack of clarity on the referral criteria for ECT and another participant, a social care manager, felt that their colleagues were not clear on who the service was for.

Three participants who commented on whether they felt the referral criteria for ALFY have been difficult to define similarly stated that it was difficult for patients to understand what the service was for, particularly when the service first started. Similarly to ECT, respondents indicated that setting referral criteria was challenging for an evolving service, as illustrated in the following excerpt.

> *"[…] so it was sold as just a general advice line […] I'm not sure how specific we were about why you would phone. But then we didn't, other than over 65s and that you need some advice, but equally I don't think we wanted to make it too specific either but people would then think, oh well it's not for me. I guess what we thought was that we would, over time, build up a clinical mass of knowledge, about ALFY that would go from word to mouth and that people would then get a sense of, oh well if I've got a problem with, discharges on the medication, I'll just phone ALFY and that people would then start to use it, even just to find out, can you help me or not or can you tell me how I can get help."* (P4, Senior Community Services Manager)

The difficulty in establishing and communicating a clear purpose, impacting organisational buy-in is further discussed in Section 10.3.2.4.2.

10.3.1.3 Differences to previous practice

On the whole, there was a clear understanding of how the 'Closer to Home' services are distinct to existing or previous services or practices.

With regards to the ECT service (including GP Fellows), most participants who commented on the topic (n=16) could clearly recognise how ECT differed to

previous or existing practices, although one participant felt they could not clearly make the distinction. The majority of participants agreed that most ECT patients would likely have been admitted to the acute hospital (n=15). Some participants stated ECT patients may also have approached an out-of-hours GP (n=3). There was some agreement that ECT patients would have also been supported in their own homes by various community services including GPs, district nursing, social services or AHPs, but as separate services (n=7). The following differences regarding the structure and remit of the service were highlighted by participants compared to previous or existing community rehabilitation services:

- Primary focus on medical care provision (n=6)
- Care delivered by one service, compared to separate services delivering each element of care, resulting in greater consistency and co-ordination in delivery of care (n=4)
- Urgent and timely response model (n=5)
- Intensive support with potential for daily review (n=2)
- Ability to prescribe medication (n=1)
- Relative and caregiver support engrained into the service (n=2)
- Ability to provide social care for duration of care (n=2)

The following differences regarding the approach to care were also highlighted:

- Holistic approach, addressing all aspects of care (n=4) and reviewing adequacy of services already in place (n=1)
- Greater focus on teaching self-management (n=1)
- Greater push to keep patients at home (n=4)
- Greater focus on linkage and referral to other appropriate services (n=3) such as the frailty clinic or social work services

A further distinction was made regarding the GP Fellows service, with one participant stating that GP Fellows brought a higher level a higher level of medical decision-making into the team and enabled the team to take on more complex cases.

Only one participant, a geriatric consultant, felt could not clearly describe how the service is different to existing practices and felt an overall lack of clarity about the service.

With regards to the ALFY service, all participants who commented on the topic (n=3) could clearly recognise how ALFY differed to previous practices, agreeing that previously there hadn't been anything like it and that previously patients would likely have approached their GPs. Some participants indicated they may have alternatively approached a nurse (n=1), social care providers or individual

agencies (n=2), or they would have gone to the hospital front door (n=2) or minor injuries department (n=1).

10.3.1.4 Perceived benefits to service users

All participants were asked about the benefits to services users (patients and their family/caregivers) that they perceive 'Closer to Home' services provide and they were all able to describe benefits clearly. Seventeen participants described benefits of the ECT to service users and three participants described benefits of the ALFY service to service users. The benefits identified according to the 'Closer to Home' service they were reported for is in Table 10.5 below. Each of these benefits will be discussed in detail in this section.

Table 10.5 – Benefits to service users of 'Closer to Home' services reported by participants when compared to traditional hospital and community-based care

Reported benefits	'Closer to Home' service benefit reported for
Preserving independence and security at home	ECT (n=13)
Reducing hospital related risks	ECT (n=5)
Provision of person-centred care	ECT (n=10)
Caregiver reassurance and support	ECT and ALFY (n=1)
Provision of intensive and holistic assessment	ECT (n=6) and ALFY (n=2)
Consistency, flexibility and personalisation in service provision	ECT (n=5) and ALFY (n=1)
Timeliness and urgent response	ECT (n=4) and ALFY (n=1)

10.3.1.4.1 Preserving independence and security at home

Participants stated that the ECT service enables patients to preserve their independence and security at home, in their own surroundings and familiar settings, which is what they usually prefer and feel more comfortable in (n=13). Four of these participants stated that relatives and caregivers also share this benefit as the home environment is what they usually prefer for their loved ones, with two participants stating that an acknowledgment of hospital related risks factors into this preference. Six participants stated that ECT removes the stress of travel for hospital visits for relatives or caregivers. One of these highlighted this is particularly the case for patients living in rural areas with further distances from hospitals.

Two participants highlighted that a hospital setting can put down a patient's spirits as they are outside their normal environment including their home setting

and family and friends around them. Participants also highlighted that a hospital admission disrupts and can confuse a patient's daily life (n=4), with one participant highlighting that this is particularly the case for those with cognitive impairments. Participants stated that a hospital setting may involve many transfers and movements and many staff, reducing the patient's sense of security (n=3). A lesser disruption to life including separation from loved was also reported as a benefit to relatives or caregivers (n=3).

> *"One of the big things, and it's sad sometimes when you hear… I was just doing a case recently where the couple had been together for 50 years, never spent a night separate and the gentleman was to go and get a knee replacement and he was just so distraught the fact that he was leaving his wife who had Alzheimer's and what was going to happen her and he didn't want her to go and get put into a care home. So trying to work with him and saying, 'that won't be the case, your wife will be fine.' The sooner they can get you sorted at the hospital they'll get you home. But if things can be done at home, that is a lot better."* (P17, Social Care Manager)

10.3.1.4.2 Reducing hospital related risks

Several participants indicated that ECT may reduce the hospital-related risks for patients including hospital-acquired infections (n=4) and falls (n=1). In addition, three participants stated that ECT patients may make better progress in their own home that they would otherwise in the hospital. Two of these participants highlighted that with ECT, a patient has greater opportunities in their own home for early mobilising leading to quicker recovery, which is more difficult in a hospital bed environment.

One participant, a GP, commented that in their experience, transfers in and out of hospital can lead to medication errors, hence ECT may also reduce medication errors by preventing an admission but also for patients receiving ECT care after being discharged from the hospital, ECT may reduce medication errors, as they receive an in-depth medication review.

10.3.1.4.3 Provision of person-centred care

Several participants highlighted how ECT enables the provision of person-centred care through providing patients with an alternative choice for their care, enabling their wishes to be honoured and providing reassurance that their choices matter. Four participants stated that for patients with chronic conditions meaning they have frequent admissions, ECT gives them and their relatives or caregivers reassurance and hope that there is another alternative for their care and that they won't always need to be admitted to a hospital.

> *"Also sometimes social, because it's to show that there is that support that exists within the community, so an education that it doesn't have to come to crisis and they end up in hospital, that they've actually got that choice…a different alternative. And sometimes, not so much for the patient, it's happening to them, but I think for carers roundabout, I think it makes them feel more at ease because they know that it won't always estimate to that, to them having to go into hospital, they've got another option, it won't always be that you keep having to keep chasing the GP to come out. If you get them onto ECT all that element is taken care of."* (P6, AHP Manager)

> *"Just having that peace of mind that your options are not just home or hospital… there is home with this very high level of support."* (P5, Physiotherapist)

Six other participants stated that ECT enables more options for patients' care and for their wishes and preferences to be honoured, especially when patients wish to stay in their home environment.

> *"Honouring people's wishes or we would say it's about people's personal outcomes, getting their personal outcomes to make sure, being where they want to be"* (P17, Social Care Manager)

> *"I suppose if you're looking at patient outcomes I suppose it would depend on what the patient's outcome was, what they wanted to achieve in the first instance, and nine times out of ten with those patients it's the desire to be kept at home and not be admitted to hospital. […] But I suppose the team would tell you what's successful is meeting the patient's outcomes, if the patient outcome is to stay in his own home and they've achieve that, well that's what they've achieved is to make somebody better or have a clearer understanding of their condition as well and how they can manage things themselves."* (P2, Nurse Manager)

> *"[…] It's to try and keep their wishes and either keep them at home or make sure they're comfortable and reduce unnecessary trips up to the hospital and unnecessary tests and things."* (P7, GP)

10.3.1.4.4 Caregiver reassurance and support

Participants also reported benefits to relatives or caregivers in terms of reassurance that they may not receive with alternative services. The benefits reported for the ECT service were emotional support (n=8), including access to a direct contact number for the team (n=2), reassurance of daily home reviews for their relative (n=4), education on management of their relative's condition (n=1), greater understanding of their relatives condition as the clinical team are more consistent and have more time with patients (n=1). Three participants explicitly stated that they would expect ECT to relieve some carer's stress. These benefits are illustrated in the following excerpts:

> *"I think for them to know that just for the next week, someone is going to be coming and checking I'm okay, makes a big difference."* (P9, Health and social care partnership senior manager)

> *"[…] actually, the feedback that we've had from carers is that they've actually felt very supported and that there has been this opportunity for the carers to understand better the patient's condition. And when they should be worried about the patient and when they shouldn't. Because sometimes things get escalated because the family member panics and doesn't understand what's happening. That kind of education for the carer to know, actually this is okay but if it gets any worse I know I need to phone 999, that's the benefit."* (P4, Senior Community Services Manager)

Reassurance for patients and their relatives or caregivers was also a benefit cited by one participant discussing the ALFY service. This participant, an ALFY nurse, felt that ALFY was able to provide patients and their relatives or caregivers' with confidence about self-management, as the service was able to provide guidance and advice from a medical professional where patients have small concerns and doubts about managing their condition. This participant also felt that ALFY was able to benefit patients through reassurance following discharge from a hospital stay. The participant explained that this was done as a trial, with ALFY providing telephone follow-up support as they had noted that on discharge patients may feel confident but as they get home, they may lose that confidence without support. They found that ALFY was able to provide reassurance and confidence for those patients to be able to remain at home in addition to picking up support needs.

This participant also stated that ALFY was able to act as the patients' advocate and contact other professionals on behalf of patients or their relatives or caregivers where patients felt they couldn't express their concerns or were worried about their care being impacted after voicing their concerns. This participant also stated that ALFY was able to help patients and their relatives or caregivers make informed decisions and understand their options, which is highlighted in the excerpt below. Hence, ALFY also benefits patient in helping honour their wishes and have their voice heard.

> *"Because we're helping, we're acting as a patient's advocate and problem solving a lot of the time. Stepping in where family don't feel they've got the experience or the knowledge to help make the decisions, and being more realistic about what it actually involves. […] So one in particular [we] provided a lot of advice and support to the family and they would quite happily speak to us about their concerns but they wouldn't actually speak to the staff in the ward about their concerns […] So it was encouraging them to discuss sometimes actually phoning on their behalf and just expressing their concerns for them because they didn't feel they could. I think maybe they felt if there were any negatives or anything they wanted to discuss, they were worried it would have an impact on the care that their relative would get."* (P10, Nurse)

10.3.1.4.5 Holistic assessment

Six participants highlighted that ECT provides an intensive and holistic assessment in the patient's own environment, personalised and suited to the patient's needs, identifying social and environmental issues in addition to addressing their medical needs. One participant also highlighted that ECT provides anticipatory care planning which is a benefit that likely would not be provided in hospital or other community services. This is highlighted in the following excerpts:

> *"It's addressing all aspects. It's addressing their personal care, it's addressing their health issues, it's addressing their physical needs. Sometimes it feels as though we don't have a stone unturned."* (P5, AHP Manager)

> *"An acute setting? I think they're different, in that we probably look at the bigger picture. I think the end goal is the same, that you make the patient well but I think we've got different goals and we tend to take responsibility for each section of the patient's life, rather than signposting on automatically. We'll take that responsibility. I think we… yes, it's not [only] about the patient. I think we look more at the family and every aspect of their life, rather than just that illness that is often just looked at in a hospital."* (P8, Nurse)

Three participants described the potential that ECT, through these in-depth assessments, may actually identify unmet need, which is a benefit to patients, as described in the following excerpts:

> *"[…] we assess patients and do a lot of investigations. So I suppose we might come up with some things GPs wouldn't have, because they don't do as much of an assessment as we do, in terms of investigations." (P1, Nurse)*

> *"[…] it could be obviously with the team going in they're highlighting medical conditions that haven't been highlighted before […]" (P17, Social Care Team Leader)*

Two participants also mentioned the benefit of anticipatory or preventative assessment for the ALFY service, as it was able to link patients to services that may have prevented their conditions from escalating.

10.3.1.4.6 Consistency, flexibility and personalisation in service provision

Three participants highlighted that because ECT is a single team bringing together several professionals and providing several services, it is able to provide more consistency and unity in service provision that they might otherwise receive in hospital or with other community services. One participant highlighted that in a hospital setting, patients would need to be deferred to community services, for example.

In comparison with hospital and other community services including social care packages, participants felt that ECT is able to provide more time and flexibility in their care provision, enabling patients to feel cared for and relaxed (n=2).

> *"I think in the community you're more at a one to one with the patients, you've got more time to deal with them [...] I think it's more relaxed and you can deal with your patients better and you kind of get a wee bond when you go in and they feel relaxed when you go in."* (P11, Health Care Assistant)

> *"I think that's why the patients like us! Because we spend a wee bit more time and that's maybe 'cause we can – we're a bit more flexible I'd say than a care company."* (P12, Health Care Assistant)

Consistency was also stated as a benefit of ALFY by two participants, who highlighted that ALFY provided a single point of contact for queries that previously would have required a patient to approach several services. They stated that this was very well received by service users. Flexibility and personalisation were also stated as benefits of the ALFY servicer by one participant, in comparison to generic advice lines, such as NHS24. This is illustrated in the following excerpt:

> *"A lot of feedback we get of NHS 24 is because they're following an algorithm they've got to ask certain questions and a lot of the feedback we get is quite negative about that. [...] I think because they were speaking to someone and because we were able to access the clinical portal and their community nursing records, we're able to gather a lot of information so they know that, and they sound like you know more about them than if they were to phone up NHS 24 as such."* (P10, Nurse)

10.3.1.4.7 Timeliness and urgent response

Two participants who worked with a community rehabilitation team commented that other community rehabilitation services may provide care to urgent cases within 24 hours, but that ECT as a dedicated service, can provide a much more urgent response within two hours of the crisis being identified. One participant highlighted that ECT provides confidence of a daily review and extra social care support that may not be provided with other services, which both patients and their relatives or caregivers value. In addition, one participant stated that having the extra input especially at weekends is a big advantage for patients who might otherwise need to call out of hours services

Timeliness was also a benefit cited by one participant when discussing the ALFY service. This participant felt that ALFY was able to provide more timely support for patients requiring care in the community due to having direct contact with other local services, whereas with an alternative such as NHS24, there is a longer

waiting time due to it being a generic service that needs to triage and then find the appropriate local services.

> *"They do it as well but I think what we've found was patients who were having recurrent problems, for example we had a lady with a colostomy bag that kept bursting and she would need a lot of input, for her to call NHS 24 she was having to wait an awful long time and was getting quite distressed by this. Whereas we were given a note of the nurses that were on call over the weekend and we had direct contact to them, so actually saved them time because they weren't having to go back to their areas of work, wait for NHS 24 summary to come through to them to then go back out, so it was kind of fast tracking that a wee bit."* (P10, Nurse)

10.3.1.5 Perceived benefits to professionals involved in care

Fifteen participants were asked about the benefits to professionals (clinicians, social carers, health professionals etc.) that they perceive 'Closer to Home' services provide and they were all able to describe benefits clearly. Fourteen participants described benefits of the ECT to professionals and one participant described benefits of the ALFY service to professionals. The benefits identified according to the 'Closer to Home' service they were reported for is in Table 10.6 below. Each of these benefits will be discussed in detail in this section.

Table 10.6 – Benefits to professionals of 'Closer to Home' services reported by participants when compared to traditional hospital and community-based care

Reported benefits	'Closer to Home' service benefit reported for
Preferable patient-clinician environment	ECT (n=5)
Ability to see holistic patient journey	ECT (n=4)
Valuable skills development and role variety	ECT (n=8)
Improved communication and links with other services	ECT (n=4) and ALFY (n=1)
Reduced pressure on GPs	ECT (n=5)

10.3.1.5.1 Preferable patient-clinician environment

Several participants reported that the home-based nature of ECT lends itself to a preferable environment for the patient-clinician relationship (n=5). These participants stated that they felt it is preferable working in patients' homes as they get to know the patients better (n=3) and they value having more time to spend with patients, in comparison with other settings (n=4). One participant stated that patients tend to be brighter and in better spirits in their own homes, which is preferable for health professionals.

One participant added that the holistic assessment conducted by ECT nurses is also a benefit to the health care assistants or social carers working with them as it gives them a better understanding of the patient including their medical needs.

10.3.1.5.2 Ability to see holistic patient journey

Four participants stated that the holistic nature of ECT allows them to be a part of the patient's journey starting from the beginning when they're unwell right through to recovery, which participants stated brings great job satisfaction. This was compared to working in the hospital where they might only be involved in a smaller part of their journey. This benefit is illustrated in the following excerpt:

> *"Yes, I think it's that all round assessment that we do of the patient. I think we get to know the patient quite well in a relatively short space of time. I think a patient that goes well and comes to the service and improves and is discharged and you've signposted them on to different services and those services have been able to be inputted, just gives you great job satisfaction to know you've done everything for that patient and they've remained at home."* (P8, Nurse)

10.3.1.5.3 Valuable skills development and role variety

Several participants discussed that working with ECT has led them to develop valuable skills they didn't have before (n=8). Two participants stated that working with ECT empowers clinicians, allowing them to develop their decision-making and problem solving skills in an environment where they need to work more independently of other clinicians. For ECT nurses, participants reported that this was facilitated by receiving training in prescribing, Advanced Clinical Examination, falls training from AHPs as well as working alongside GP Fellows (n=4). Working with ECT has also helped healthcare assistants to develop their skills and received training in monitoring bloods, ECGs, using nebulisers and oxygen which was all new to them (n=3). One participant added that the variety of the work including independent working and travelling is appealing. This is illustrated in the following excerpt:

> *"I prefer working out here in the community than in the hospital. You're given empowerment. You're going into someone's home and making a lot of decisions yourself, a lot of problem solving yourself as well. So, I think it does empower yourself as a clinician, compared to in the hospital. When you're in the hospital you're in a safe environment and you've got lots of other health workers around you. I quite like that you're out on your own and travelling and going into patients houses, I think it keeps it quite interesting."* (P1, Nurse)

Three participants discussed that working with ECT has also empowered clinicians working in the community by giving them confidence and equipping them to manage patients at home in order to prevent an admission (n=3).

> *"I think I feel more secure as a clinician now. You used to sometimes go into situations and know that you weren't medically that great but you were having to make this judgement call. Do I phone this GP and ask for them to be admitted, because I know that's quite an extreme step? Now you've got this middle ground so you can open up a conversation and say I am concerned about them being at home,*

we need more support. So, there's something in between that exists. I think that is a benefit now." (P6, Physiotherapist)

10.3.1.5.4 Improved communication and links with other services

Four participants discussed that ECT has provided ease of communication between professionals and/or services. Participants stated that due to the coordinated and multidisciplinary approach of ECT they have found it easier to communicate and link with the clinicians they need to contact in the community, whereas contacting clinicians outwith the team can require finding out the patient's GP practice and identifying the clinicians designated to that practice (n=2). One of these participants stated that this especially the case because of the nature of having a relatively small team. Another participant indicated that due to ECT having been set up with close links to social care, equipment support and technology enabled care, clinicians benefit from this being made easier to put in place for patients. Another participant added that this is also a benefit to social care providers as ECT can provide valuable medical or equipment advice very quickly for patients they see, especially out of hours.

One participant also reported improved communication as a benefit to clinicians for the ALFY service. It benefitted clinicians in the community (district nursing and GP practices) by being a point of contact for information on services available to their patients; however, the impact was felt to be minimal by this participant.

10.3.1.5.5 Reduced pressure on GPs

Five participants stated that they felt that ECT reduces pressure on GP's workload. Three participants stated that ECT reduces GP workload of conducting home visits especially given that ECT has direct access to social care and community healthcare professionals meaning they can access these resources more quickly that a GP would. One participant stated however, that the effect may be limited due to the small size of the service.

10.3.1.6 Perceived organisational benefits

All participants were asked about the organisational benefits that they perceive 'Closer to Home' services provide (e.g. to the NHS and/or local authorities). Seventeen participants were all able to describe benefits, however some participants were conflicted about the extent of these benefits. Sixteen participants described organisational benefits of the ECT and two participants described organisational benefits of the ALFY service. The benefits described

generally fell under three categories for both services: reducing pressures in NHS hospitals, in primary care and on social care provision. These will be described in detail in this section.

10.3.1.6.1 Reducing pressures in NHS hospitals

Thirteen participants reported that ECT benefits the NHS as an organisation as contributes towards alleviating pressures for hospital resources. Several participants felt that the ECT benefits the NHS because it frees up hospital resources, alleviating the pressure for hospital beds (n=11) and reducing length of stay (n=4). Reduced pressures in the emergency department was reported as a benefit to the NHS of the ALFY service.

> *"I think there are a lot of people that have not called out emergency services when they would have, because they've just been able to get reassurance or told what they should do."* (P10, Nurse)

Some participants stated however that the effect of ECT on NHS hospitals may be limited due to the small size of the service (n=4). This is illustrated in the following excerpt:

> *"I think it benefits the wider service as in the hospital as it reduces admissions. However, we only manage to see a small number of patients for the wide area we cover. I wonder if it's not really that significant an impact and it might just be a drop in the ocean really."* (P7, GP)

Some participants stated that by preventing hospital admissions ECT may be or should be saving money for the NHS (n=4) whereas other participants weren't sure about whether it is necessarily saving them money (n=2). Two participants added that they felt that whether there are savings or not, a benefit of the service to the NHS is being able to provide better outcomes through bespoke person-centred care in patients' own home, which should come secondary to monetary savings among NHS priorities. This is illustrated in the following excerpt:

> *"As I said before, you've got to assume that by avoiding admission to hospital we are saving something somewhere. It may well be that, as I say as a whole, yes the wards are still full. But what would it be without it? I suppose that's the scenario we need to ask as well, if that wasn't there? And even if 80% of the folks we see would have ended up in hospital, what difference or impact would that have had on the system? Would it have made it explode, I feel like? In terms of personal outcome, what is a good experience for the patient? Is it good for the patient, if they're 85 and have dementia and they've only got a urine infection, is the right place for them to be the emergency department at Forth Valley Royal? Even if it's just to be seen and turned around again. Or is it being supported in their own home? Surely it's a much more meaningful pathway for people to experience. And if we're about getting it right for the person, then surely the money and everything else should follow it."* (P9, Health and social care partnership senior manager)

Three participants felt that the NHS benefits from ECT by allowing NHS hospitals to focus on acute healthcare provision by reducing unnecessary resource use in hospitals for conditions or situations that can be resolved at home or the community, including social issues (n=3).

> *"So, for the NHS and going back to the 2020 vision, that really is the delivery of what the government's aspirations are, trying to improve hospital care, so hospitals become a place for people who are acutely unwell who absolutely cannot be supported anywhere else. It means you've got acute beds providing acute care and can hopefully help them flow through the system."* (P3, AHP Manager)

10.3.1.6.2 Reducing pressures in primary care

Some participants highlighted that both ECT and ALFY help reduce pressures in GP practices, which is also an organisational benefit for the NHS (n=6). As previously highlighted, participants felt that ECT relieves GP pressures by taking over their patient's care for the duration of the acute illness and conducting home visits where they may have needed to (n=5). One participant stated that ALFY relieves GP pressures by providing reassurance or advice that may otherwise have meant unnecessarily contacting their GP. This is illustrated in the following excerpt:

> *"I think GP practices are the same as well with maybe phone us just to sound an idea of us instead of wasting a GP appointment or a house call or attending the hospital."* (P10, Nurse)

10.3.1.6.3 Reducing pressures on social care provision

Some participants felt that ECT benefits both the NHS and local authorities because it is able to provide instant access to social care for the patients they see, given that there are long waiting lists for social care in the community (n=2). One participant acknowledged this provides only a short term solution, however and others felt that the impact to local authorities and social work is minimal (n=2). One participant stated that ALFY benefitted local authorities by conducting assessments for social care need (single shared assessments) over the phone, which reduces duplication and would otherwise require a local authority worker to visit or contact a patient.

10.3.1.7 'Closer to Home' team engagement and buy-in

All participants were asked about their belief in continuing the 'Closer to Home' services including why they should be sustained. They were also asked if they would personally be willing to drive forward the 'Closer to Home' program. Some

participants were also asked what keeps them motivated to continue in their daily work. The responses will be discussed in the following section.

10.3.1.7.1 Should 'Closer to Home' be sustained and why?

All participants were asked whether they felt that the 'Closer to Home' services should or should not be sustained. The majority of participants who were asked about the ECT service (including GP fellows) stated that they believed it should be sustained (n=11). Six of these used wording such as "definitely," "absolutely," "has to continue" and "hopeful it would continue," indicating they felt strongly that ECT should continue. Four participants stated that they believed ECT should be sustained subject to improvements (n=4). Though one participant believed ALFY should be sustained, the majority of participants who were asked about the ALFY service stated that they believed it should not be sustained (n=3), though they all acknowledged there is a need for a service like this.

When asked why they believed ECT should be sustained, respondents made arguments in three main categories: strategic/organisational benefits (n=8), service user and clinician benefits (n=5) and finally, personal experience (n=2). The details of the arguments made can be seen in detail in Table 10.7 below.

Table 10.7 – Arguments made by participants for continuing the ECT service

CATEGORY	ARGUMENTS FOR SUSTAINMENT OF THE ECT SERVICE
STRATEGIC/ORGANISATIONAL BENEFITS	• Because it is a key service for future models of sustainable healthcare, providing an alternative to the acute setting where pressures will continue to increase (n=6) • Because it is saving money and hospital beds (n=3) • Because it is helping to provide a bridge between primary and secondary care (n=1)
SERVICE USER AND CLINICIAN BENEFITS	• Because of the positive feedback from patients indicating it's making a positive difference to them (n=3) • Because of the positive impact it is making on caregivers/family members (n=1) • Because the care patients receive at home is more attentive and personalised (n=1) • Because of the positive feedback from colleagues in primary care (n=1) • Because it opens up options to clinicians and to patients for their care (n=1)
PERSONAL EXPERIENCE	• Because of personal experience of seeing the service make a difference (n=2)

Two of the participants who described specific arguments above added that ECT should be sustained because it is a service that has shown itself to be of value. Two participants did not state specific reasons but stated that they felt ECT should be sustained because of the benefits to patients, caregivers, clinicians and the NHS they had previously stated.

The one participant who believed ALFY should be sustained stated that it should be sustained because it's an important service providing an alternative to face-to-face services in this digital age, which has the potential to reduce costs for face-to-face visits. This participant added that they also believe it should be sustained because of personal experience of the service making a difference. When the participants believing ALFY should not be sustained were asked why they believed it should not continue, they stated the following main reasons: a lack of achieving its aims, a lack of activity leading to inappropriate resource use and poor communication about the service. These are detailed in Table 10.8 below.

Table 10.8 – Arguments made by participants against continuing the ALFY service

CATEGORY	ARGUMENTS AGAINST SUSTAINMENT OF THE ALFY SERVICE
LACK OF ACHIEVING AIMS	• Because it did not achieve what was intended with the service (n=3) • Because it did not achieve a close link to other 'Closer to Home' services or social care/third sector services as was hoped (n=2)
LACK OF ACTIVITY AND INAPPROPRIATE RESOURCE USE	• Because of lack of activity which also caused it to be expensive, making inappropriate use of a highly skilled resource (n=1)
POOR COMMUNICATION	• Because there was poor communication and confusion about what the service was for (n=1)

The participant believing ALFY should be sustained stated that they felt that despite the issues with low activity and high resource use that the alternatives patients would approach would be more costly.

> *"Yes, because I think even although you would need so many of us, if you didn't have us I do think it's going to have an impact on – well who are they going to call now that they don't call us? I think they will call the nurses, I think there'll be a lot of kind of wasted visits or unneeded visits because they've not been able to just pick up the phone any more. There might be a spike in other [activity]"* (P10, Nurse)

10.3.1.7.2 Would you be willing to drive 'Closer to Home' forward?

All participants were asked whether they would be willing to drive the 'Closer to Home' services forward if their continuing was being questioned.

The vast majority of participants stated that they would be willing to drive ECT forward if it's continuing was being questioned (n=16). Several participants used wording such as "definitely," "putting my hand on my heart" and "[I] would get down and fight for it" (n=5). One participant felt that they would be willing to drive ECT forward if it developed further, but that in its current state they would not because they didn't feel they needed more information about its current state. The following excerpts illustrate some of the strong willingness to drive ECT forward.

> *"So this is a service that can really, putting my hand on my heart, that keeps people closer to home and that might be that home setting"* (P2, Nurse Manager)

> *"Yes, so I guess there is something about it meeting the organisational objectives as well and being clear about where that fits in, and I think it absolutely does roundabout the challenges we have roundabout unscheduled care. So I think for the future it really is, yeah."* (P3, AHP Manager)

> *"Personally for me, I would say yes, I'm keen to continue driving it forward. Because I think we can all see the benefits of the service. The restrictions on us are very challenging. But definitely, I have been and still will continue to be keen to drive it forward as a service."* (P5, AHP Manager)

One participant, an ALFY nurse, stated that they would have been willing to drive ALFY forward if it had been an option. They stated: *"Yeah, I would love to, if we'd been involved or if that had been an option."*

10.3.1.7.3 What keeps you motivated in your daily work?

Eight participants involved in caring for patients in their homes or managing teams that do were asked about their motivation in their daily work.

Six participants including five ECT team members and one ECT manager were asked what keeps them motivated in their daily work and involvement with ECT. Four of these participants stated that being able to keep patients comfortable in their own home according to their wishes and seeing them improve their condition in their own environment keeps them motivated. One participant stated that feedback from patients and referrers to the service kept them motivated and another participant stated that having more time to spend with patients and working in a team environment with other clinicians and nurses keeps them motivated. The following excerpts illustrate the participants' responses.

> *"Keeping people at home, keeping them safe, keeping them well. The feedback we get from the patients make it all worthwhile. We're getting amongst all this, we've got patients, we've got carers, we're got relatives, so I think getting really good feedback from them and being able to make someone well again. Seeing someone improve in their condition. […] I feel I've been trying to sell the concept of the service*

since it started and sometimes it does feel like a slow engagement process, however when we get positive feedback from patients and referrers to the service it makes it feel worthwhile." (P2, Nurse Manager)

"I think when you see the patients in the house how they come on, you just want to improve to everybody you're going to see. So you want to do that with everybody out of the community, you really want to make them happy." (P11, Health Care Assistant)

Two participants who were managers for teams providing social care for older people in their homes were asked what keeps them motivated in their daily work in social care. They expressed that providing the best possible care, in the right place, at the right time kept them motivated, as illustrated in the following excerpts.

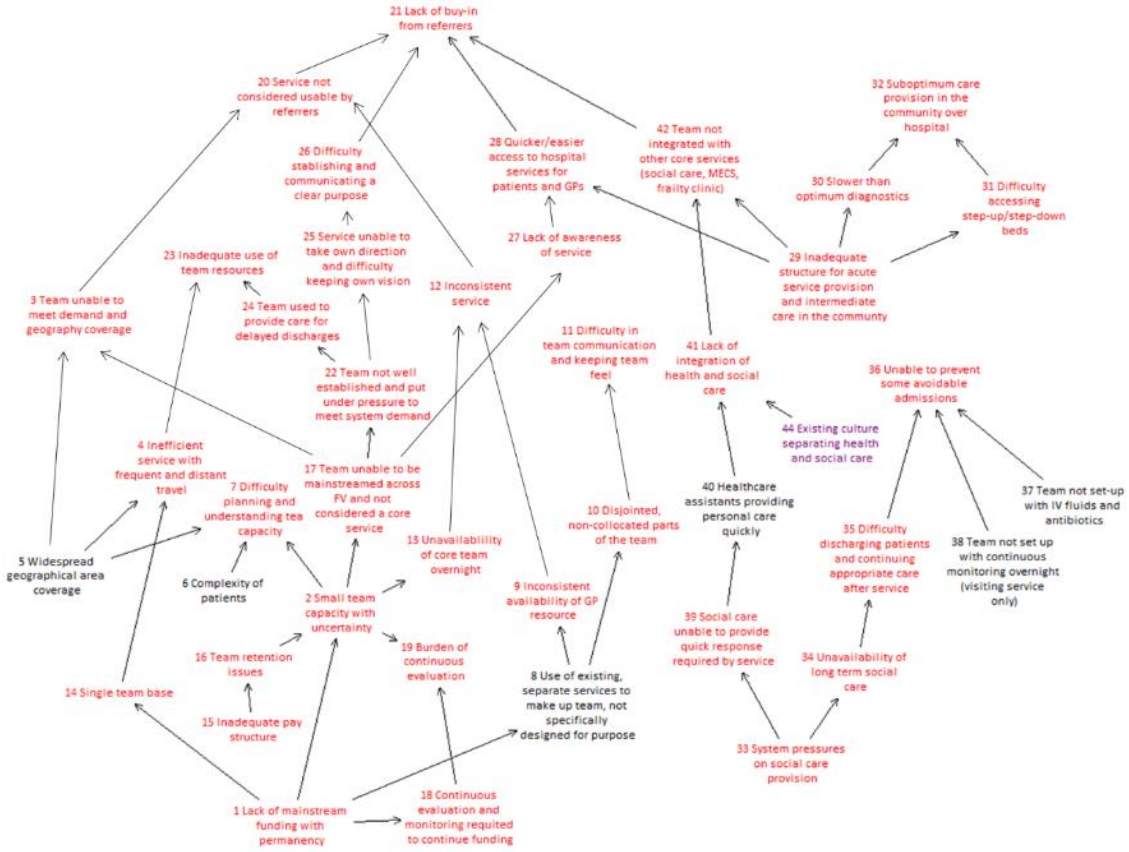
"At the end of the day you go home and knowing that people have had services, they're safe at home [...], knowing that people have been cared for and getting the care that they need at the right time, the right place and the right time." (P17, Social Care Manager)

"What motivates me? What motivates me is I like to see things happening, correctly for other people. That makes me happy, that gets me up in the morning, I just need to know that everything's where it should be and I can give them the best that I could possible give them particularly the older people that we look after." (P18, Social Care Manager)

10.3.2 Contextual and relational barriers to implementation of 'Closer to Home'

All participants were either directly asked or throughout the interviews described issues and barriers to the full implementation and establishment of the 'Closer to Home' programme. This led to the development of the overarching theme around contextual and relational barriers to implementation, which relate directly to the NPT construct 'Collective action' (the operational work that people do to enact a new intervention). The issues described were complex and interlinked, hence, cognitive mapping was used to organise these issues and illustrate their interconnections. The below concept map (Figure 10.1) is the result of thematically analysing participant's responses, and was then used to conduct that further step of cognitive mapping to look for hierarchy and theming.

Figure 10.1 – Concept map of contextual and relational barriers to implementation faced by the 'Closer to Home' programme

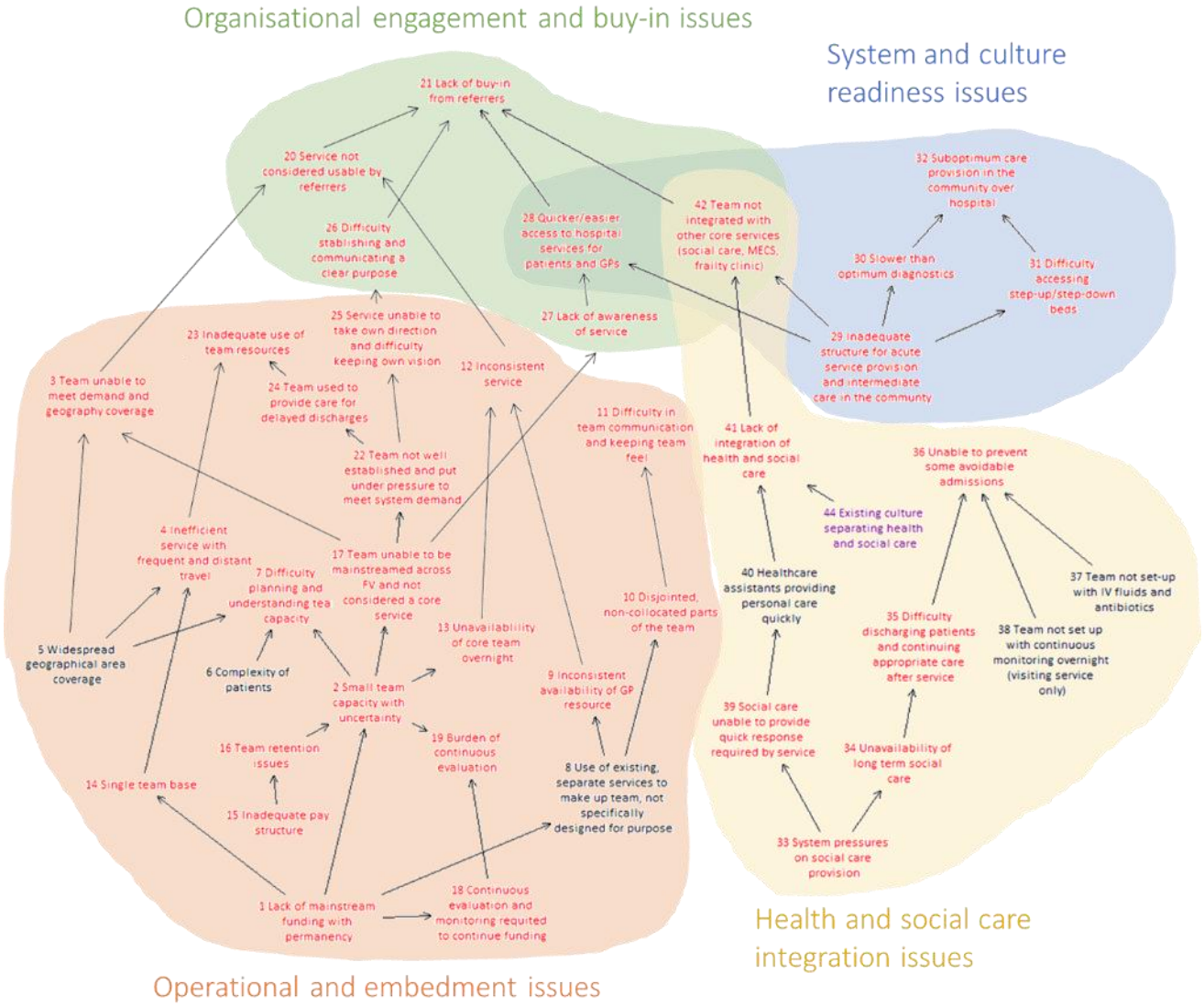


To make sense of the above concept map, a cluster analysis (a cognitive mapping technique) was conducted by reviewing the organisation and hierarchy of the map, grouping related concepts both visually and thematically. This resulted in the identification of four related "clusters" or sub-themes summarising the contextual and relational barriers to the full implementation of 'Closer to Home':

- Operational and embedment issues
- System and culture readiness issues
- Health and social care integration issues
- Organisational engagement and buy-in issues

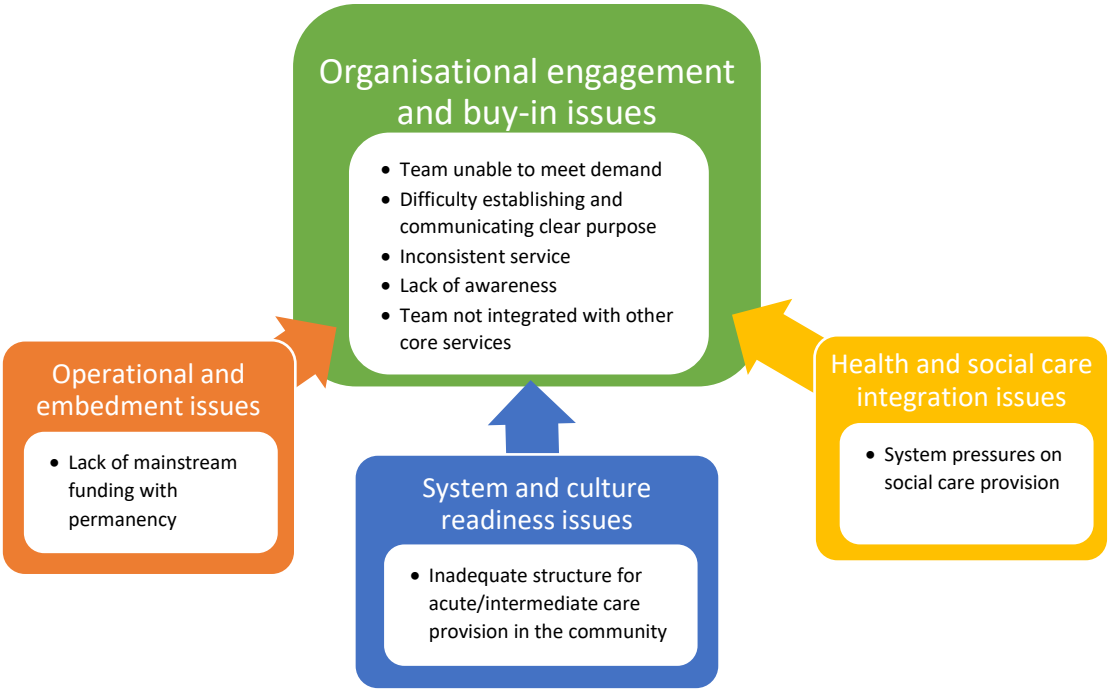
These four sub-themes will guide the discussion in this section. These sub-themes have been highlighted in Figure 10.2, in the context of the full concept map.

Figure 10.2 – Concept map of contextual and relational barriers to implementation of 'Closer to Home,' highlighting "clusters" or sub-themes



By looking at the tails (links at the bottom of a hierarchical cognitive map) of each thematically grouped part of the cognitive map, the root causes of each of the thematic issues were identified as follows in Figure 10.3:

Figure 10.3 – Identified "clusters" or sub-themes of contextual and relational barriers, indicating their root causes (tails in each grouped section of the concept map)



Hence, three main organisational root causes of the issues were identified as follows:

- Lack of mainstream funding with no permanency
- Inadequate structure for acute service provision and intermediate care in the community
- System pressures on social care provision

These root causes will be used to guide the discussion for each of the sub-themes.

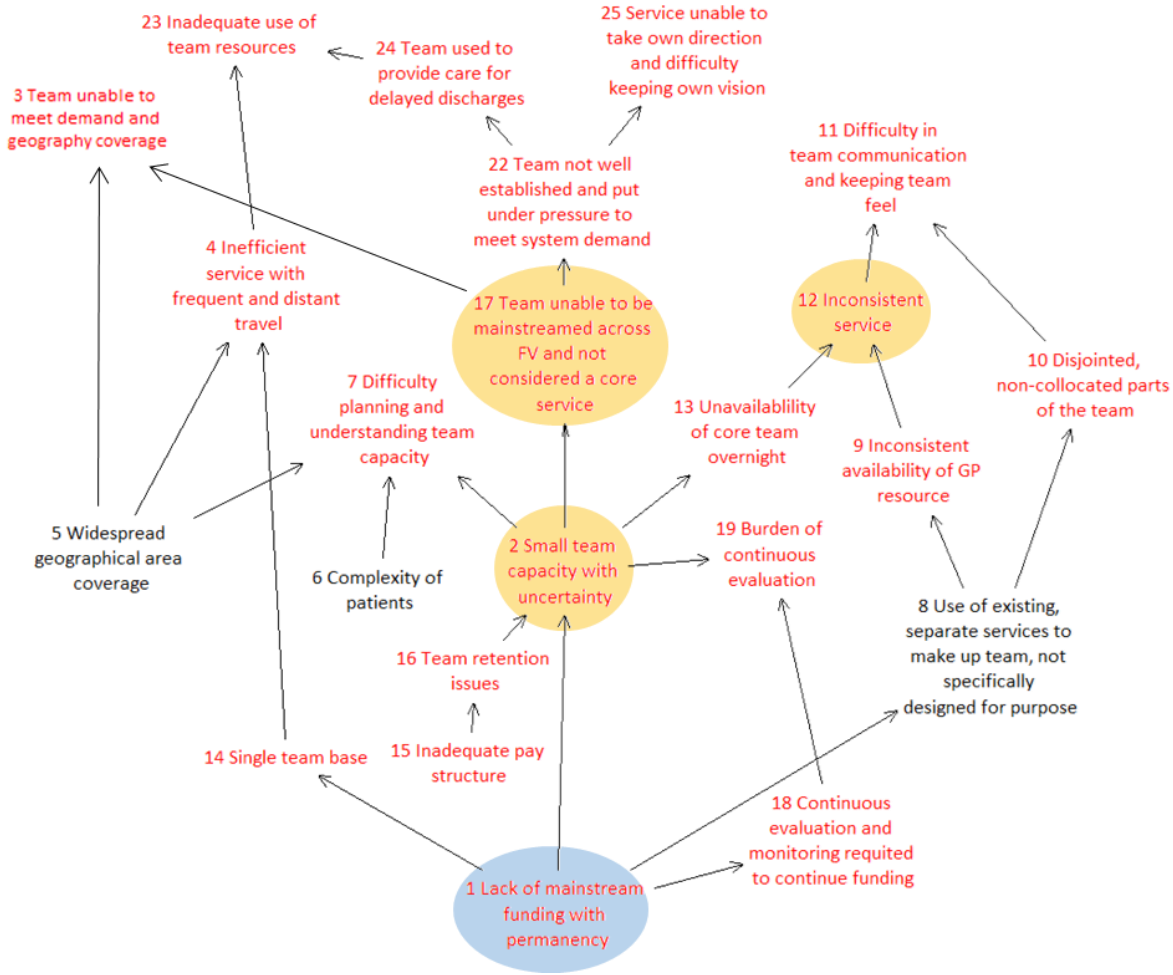
10.3.2.1 Operational and embedment issues

This sub-theme, operational and embedment issues, surrounding the contextual and relational barriers to full implementation of ECT, was the biggest sub-theme observed (i.e. had the most related concepts). As previously discussed, the root cause, as reported by participants, is the lack of mainstream funding for the service. Three central issues were identified (issues with the most links in the context of the full cognitive map), with the root cause identified as lack of mainstream funding with uncertainty:

- Small team capacity with uncertainty
- Team unable to be mainstreamed across Forth Valley and not considered a core service
- Inconsistent and disjointed service

Figure 10.4 displays the concepts identified as operational and embedment issues and highlights the root cause and central issues identified. This section will begin by discussing the root cause (the lack of mainstream funding) and will then go into detail about each of the identified central issues.

Figure 10.4 – Operational and embedment issues, highlighting root cause (blue) and central issues (yellow) (this concept map comes directly from the larger concept map in Figure 10.2)



10.3.2.1.1 Root cause: Lack of mainstream funding with permanency

Several participants described various issues surrounding the lack of mainstream funding for the service, which has no permanency. Two participants expressed that ECT has never had mainstream funding nor any permanency around funding for the service, which has been one of the root causes of many of the issues that it faces as a service. It has led to the service having a very small team capacity with uncertainty and to inconsistency of the provision of the service. The lack of mainstream funding has also led to the need for continuous monitoring and evaluation of the service which two participants expressed has been a burden

given the small capacity of the team with no dedicated resource for evaluation. This is illustrated in the following excerpt:

> *"We had to do a lot of work in terms of evaluation and measurement of framework. We've felt quite a lot we really need to fight our corner. Resource itself is a small bit of resource, based on the overall community based services. I think sometimes we've felt it's been a bit disproportionate for the amount of work we have to do for that continued funding."* (P2, Nurse Manager)

10.3.2.1.2 Central issue: Small team capacity with uncertainty

Five participants described the key challenge to the service of having insufficient team capacity to provide care for the demand and geography coverage of the service, as it covers all of the Forth Valley area. The main cause is the organisational barrier of lacking mainstream funding for the service, however one participant also discussed issues surrounding staff retention. This participant described the team having a high turnover of staff for whom great investment in training has been made (ACE and prescribing), due to being able to obtain a higher paid position as an Advanced Nurse Practitioner (ANP) at GP practices with this training. They indicated this issue is not unique to their service but has been reported among teams in other health boards. At the root of this issue is an inadequate pay structure for such positions in the health service. The following excerpt illustrates this issue:

> *"I think the main challenge is that we've had a high turnover of staff. So, we've trained staff in ACE and prescribing. At the moment there's a high push from a GP practice point of view, from ANP point of view, they're offering a higher rate of pay so we've lost four members of staff to GP practice after we've trained them in ACE and prescribing because they'll get that higher banding. Because they're private practice and they can offer them more money, so that's been a challenge. […] [They get an] ANP role, band seven or eight. Because we're NHS employees we're matched with the agenda for change point of view. So, we don't have the ability to offer them different terms and conditions. That's been a big challenge, because every person who's come through the educational training has left, well not all of them. Out of the original team there's only two left out of the original seven. […] So, that's been a challenge, educating and training everybody and making sure everybody does these courses, ACE is six months long, prescribing is four months long. So, they have put a numerous amount of staff through that training, for them just to walk into GP practice. I have another vacancy coming up because that person is leaving as well. It's this point and I don't think it's the service that they're leaving for. It's the fact we've given them the skillset to get a higher position. At the end of the day you can't blame people. […] I didn't expect the attrition rate to be so high to be honest. But to be fair, GP practice, the role of the ANP has evolved over the last three years, there's been a big push on, it's just been timely for those staff. I believe speaking to other hospital at home teams in other areas, it's a similar thing, it's not something that is just for Forth Valley."* (P2, Nurse Manager)

The small team capacity with this uncertainty has led to the inability of the service to be mainstreamed across Forth Valley and be considered a core service within the health board. The issues surrounding this barrier will be described in the following section.

10.3.2.1.3 Central issue: Team unable to be mainstreamed and not considered a core service

Having this small team capacity with uncertainty mainly due to lack of mainstream funding has meant that the service has been unable to be properly mainstreamed across the health board and considered a core service, which was identified as a key challenge to the service by five participants. This has meant that the service has been unable to become well established. In addition, the service was put under pressure to meet system demand, particularly surrounding the winter period, which led to the service being used for a purpose it wasn't intended to. Seven participants expressed that ECT has been used to provide care for delayed discharges, primarily providing social care, which was not originally intended with the service and has been a key challenge.

Due to these factors, two participants reported that the service has found it difficult to take its own direction and maintain its original vision and purpose. This is illustrated in the following excerpts:

> *"One of the other challenges is knowing what the vision is. So, what we started off to do and all set out to do, as you're aware because you've been involved all these years, is we become a care agency sometimes. That's frustrating. When we've got a vision about moving forward to do things, develop the role of the healthcare assistant, constantly being pulled back and providing care packages."* (P2, Nurse Manager)

> *"Again, if I think about ECT, I know when they were originally set up, it wasn't an ask that they would support people who were discharged from hospital, but we opened a service on the 5th December. It just hit Christmas and the festive period and all of a sudden it was like, ah who's got capacity to help get folk out of hospital, then how do you recover from that? Because immediately you've got a pathway people will try to use to get people out of hospital."* (P9, Health and social care partnership senior manager)

The lack of mainstream funding has led to the team being unable to be mainstreamed, in conjunction with the team only having one base to operate across the whole health board, which covers a vast geographical area. Nine participants discussed issues surrounding travelling long distances due to the need to access patient notes and communicate with the rest of the team. This is illustrated in the following excerpt:

> *"One of them for me is probably time. With the days that I work on a Friday and a Thursday it can be a bit stretched. Especially given the geographical range of patients. And it can be across the Forth Valley area and it can be a bit of a slow process to get an overview of all the patients and then see some individual patients that could be quite a few miles away. They're quite complex so you need to spend some time with them. Then again, come back to the base to document your management plan, your findings, then pass that onto the team. Because we're not with the team every day. It's really just passing that information on to the rest of the team. That's probably the main challenge with it."* (P7, GP)

Having only one team base to input medical notes has meant that highly skilled health professionals are travelling long distances unnecessarily, which is an inadequate use of the team's resources (n=2). The reconfiguration of the ECT service to provide social care for delayed discharges has also led to inadequate use of the team's resources, particularly at the beginning of the service when they didn't have access to health care assistants providing personal care (n=3). This is illustrated in the following excerpts:

> *"[…] sometimes you're responsive to organisational demands rather than the demands of patients, who are the best fit for the service? So, a lot of the discharge facilitation would not necessarily be the core business and the staff find themselves doing things they wouldn't otherwise be doing, not necessarily the best use of their skills."* (P3, AHP Manager)

> *"It was something that they had to decide to do, so in the winter when people were waiting to come home from hospital they were taking them along, the same as the [care] providers. But when there's not a date for them to stop that service they were finding that they were literally becoming a care at home provider as opposed to being an advanced care team that they should be. […] So they were really good at [inputting that holistic assessment] but what was happening was that their whole time was taken up becoming a provider."* (P18, Social Care Manager)

10.3.2.1.4 Central issue: Inconsistent and disjointed service

The ECT service was set-up as a nurse-led service and the funding was used to set up a dedicated nursing resource specifically for ECT. However, the non-nursing elements of ECT were made up of existing, separate services, not specifically designed for the purpose of the service. This is likely to have been influenced to the lack of mainstream funding, however this was not explicitly stated by participants. Participants did however directly discuss issues relating to having several disjointed parts providing the ECT service (n=3).

One participant highlighted that the existing resources dedicated to the ECT service (ECT nurses and GP Fellows) are only provided during the day. At night time, the service has been able to make use of the night nursing service, however the night nursing team do not have the same specialised training as the ECT

nurses. Hence, although ECT is a 24 hour service, this limitation in lack of dedicated resource to cover night time has led to inconsistency in the service provision overnight.

One participant highlighted that the team have also had issues with consistency in the provision of GP fellows care within the team. The GP fellows aspect of ECT was added in one year after the service had started, as part of a wider GP Fellowship programme, funded separately. This meant that there hasn't been permanency about the GP fellows' involvement. As part of the programme, after the first year, they were given permanent posts in GP practices across Forth Valley, but were able to continue providing care for ECT with limited availability. Overall this has led to inconsistency in the GP fellow care the team is able to provide. This is illustrated in the following excerpt:

> *"Other challenges being the GP cover. The GP fellows, are you're aware came and were placed with us after year one. They've now all got permanent GP contracts and come back and work a day with us. So every day we have someone different which doesn't give continuity in the team and doesn't give continuity for the staff or patients. We don't have cover on a Monday or Tuesday morning at the moment. We have three and a half days cover out of seven days. […] But we actually want to be a credible service, we want to do it and do it properly. On a Monday, we cannot do this because we don't have GP cover, on a Friday we can, because we've got…So, these kinds of things."* (P2, Nurse Manager)

The use of existing, separate resources has also led to some parts of the team feeling disjointed. The AHP aspect of ECT was achieved through the use of AHPs working with the existing ReACH service. This meant they were part of a separate service with their own workload and were not co-located with the rest of the ECT. AHP participants reported that one main challenge they faced as AHPs working with both ECT and with the ReACH service, especially at the beginning, was managing conflicting priorities, where they needed to reach an immediate response target with ECT, but often felt they had patients in their ReACH service requiring more immediate support (n=2). They expressed that over time they have felt this improved as the team began to understand each other's roles more clearly, however they still expressed this being a challenge. This issue is illustrated in the following excerpt:

> *"As we said, there's quite a few elements to the ECT service, so you can have someone who has reached crisis point that the GP has seen, who thankfully considers ECT as the required service. So, then they get the nursing input, they get the carers input, they get the AHP input. We could get a referral from someone other than a GP for a patient who has reached crisis point and they have no care package, they have no family, GP hasn't been out to see them and we're the only*

service really going in at that point. It's about that vulnerability of the patient and being able to determine…it's then a more complex route to try and get support for that individual that you've gone out to as an urgent, as opposed to an ECT. The ECT once have those nurses going in, they have that support. You could have someone else who is the same age, same geographical location, they could be the same, but one is very well supported and one has nothing." (P5, AHP Manager)

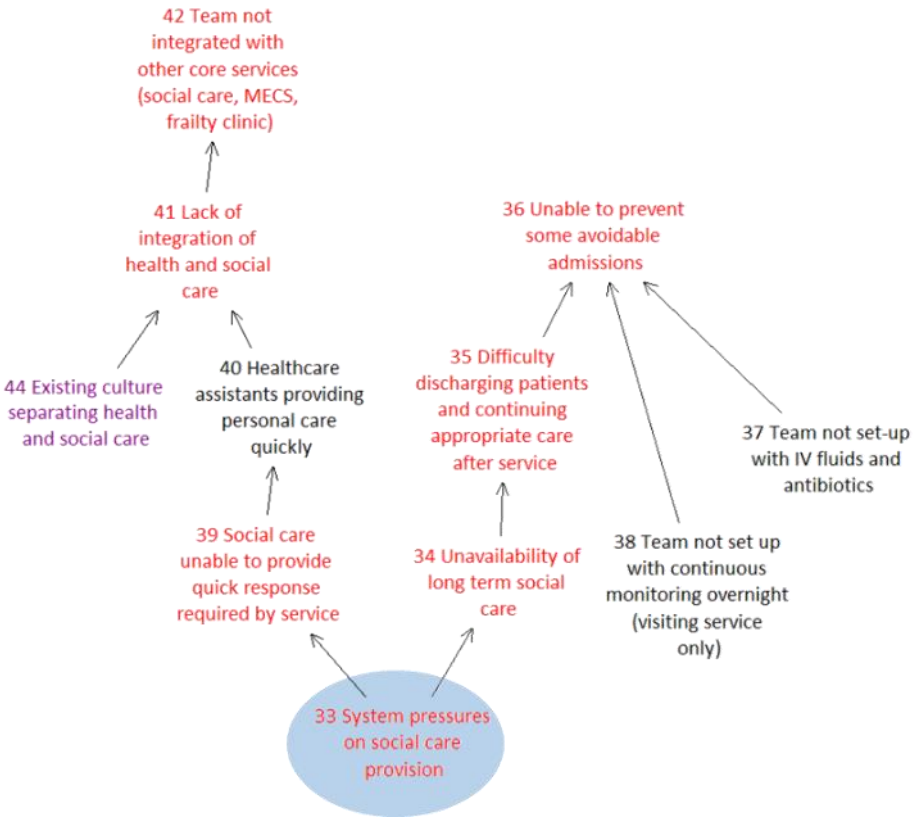
They reported that another main challenge has been having a team feel and being included in service development (n=2). These challenges around AHPs working with ECT feeling disjointed from the rest of the team were attributed to resource issues by one participant in that the existing resource is too small for co-location. The following excerpt illustrates these issues relating to team feel:

"I think there's always going to be a challenge about having a team feel. I think although it is a team, because you're not co-located it's very difficult. You don't know every nurse, so when you phone up, it may be that there's a couple I know very well but that's just through circumstance that you've maybe been on a couple of visits with them. I think until you have…to get a cohesive team you need to be working with people on a fairly weekly basis so that you get to know their characters, you build a rapport, and I think that is something isn't it. […] I think collocation would give more insight into each of the dynamics of the team. I think work has tried to be done to let us see what the nurses do and let the nurses see what we do. But unless you were with somebody and collocated for a minimum of two weeks, you're never going to gain that insight. I do think it's got better with time. […] But I think because we're not in one team as such, you aren't aware of someone's capacity until you get that phone call saying there's no capacity. But I don't see how you could get round that. The co-location has to be because of the resource of the service. There's no way we could have AHPs with the nurses because it's such a small resource." (P6, Physiotherapist)

10.3.2.2 Health and social care integration issues

Social care emerged throughout the interviews as being and integral aspect of care provision for ECT patients, to enable them to remain safely at home. Health and social care integration issues were identified as another contextual and relational barrier to the full implementation of ECT. Figure 10.5 displays the concepts identified as health and social care integration issues and highlights the root cause identified. This section will discuss the root cause (system pressures on social care provision) and the issues that have led on from it, impacting the full implementation of ECT into the healthcare system.

Figure 10.5 – Health and social care integration issues, highlighting the root cause relating to operational and embedment issues (blue)



10.3.2.2.1 Root cause: System pressures on social care provision

Ten participants discussed issues surrounding system pressures and lack of capacity in social care provision that have had an impact on the integration of the ECT service with social care. One root cause, relating to operational issues, was identified as insufficient social care resource at the disposal of the ECT service and the wider health board. Several issues have stemmed from the lack of social care resource including a lack of integration of health and social care and a difficulty in discharging patients with appropriate long-term care in place, which are described in the next sections.

10.3.2.2.2 Central issue: Lack of integration of health and social care

Three participants discussed that social care hasn't had the capacity or availability to provide packages of care for ECT patients where they were needed. Five participants discussed that social care services have found it very difficult to provide the immediate care that ECT patients need (within 2 hours), partly due to capacity issues as mentioned by one participant and partly due to system readiness as indicated by another participant, where social care services haven't

been set up to provide an emergency response. Two participants mentioned there was a willingness on both sides to work together, however it was not practically possible. These issues are illustrated in the following excerpts:

> *"Although we tried to put… and there was a lot of willingness on our social care partners to support this team but that proved challenging, just on a practical level because we've got a commitment to respond within four hours and if we take someone on, you may need a social care worker that night or within an hour and it just became impractical, it just didn't seem to work. We just didn't seem to be able to get people to take someone on."* (P4, Senior Community Services Manager)

> *"[…] our social work service wasn't geared up or able to respond to the kind of pace that ECT wanted or needed to make the model work. So, you know, they were asking for packages of care or enhanced packages of care and we just didn't have in social work the carers to provide that. So it didn't work […]"* (P14, Funding co-ordinator)

This then meant that the ECT service had to find resources elsewhere and was able obtain some funding (bank staff funding initially) for employing health care assistants as part of the team to provide the social care aspect (n=3). Although this was seen as a positive addition by several participants, it did hinder the integration of the ECT health service with social care services. This is illustrated in the following excerpts:

> *"As I said, I think when it was established, it was set up that where the ECT needed additional support they would get that from our re-ablement teams and our care at home services. The resource was never actually there to be able to do that, in terms of staffing and capacities and teams to be able to respond. Because if someone needs a service they need it today and the re-ablement teams found that difficult to respond to. The funding was diverted to support healthcare support workers, to be employed by the NHS to deliver that additional support through the ECT directly. That worked really very well. I think the guys that are in that team have been upskilled and been able to deliver some more healthcare type tasks to take things away from the qualified nurses, as such. So, that's a really good thing. But what that doesn't do is actually integrate our teams fully."* (P9, Health and social care partnership manager)

> *"I think the main thing that we would reflect on is roundabout the social care and the idea that we would be able to access carers really quickly to support people to stay at home has never really worked the way that we'd hoped that it would. […]…we really hoped to be able to put social care in place really quickly and the key issue was really about being able to access that response of social care and as we know that's been quite tricky. […] What's worked well is I guess is that we've been able to put in an alternative model with a healthcare carer support workers. So kind of circumvented the need for social carers really but it hasn't worked well because while we've resourced it, we've put money into it in the beginning there just hasn't been the people to be able to do that and that's just limitation roundabout packages of care and responsive carers. So, yeah, it's an issue really."* (P3, AHP Manager)

One participant added that while the health care assistants were set-up and providing care for the ECT service, efforts were made to find a solution that integrated social care, however as the health care assistants became more involved, the ECT service found it to be a more effective way to work, as illustrated in the following excerpt:

> *"So [having the social work service provide care for ECT] didn't work, and at that point the ECT then requested, to support their nursing care that they had health care assistants who could do some of the basic care at home tasks but with some additional nursing components around that. We funded that via bank staff […] for quite a significant amount of time, and at the same time tried a lot to facilitate the discussion between social work and the ECT team to see if we could find a more sustainable solution that social work could actually be involved in the team. That didn't ever work out. The argument being that the health care assistants being co-located with the team and part of that team was more effective, and we didn't really ever move beyond that"* (P14, Funding co-ordinator)

10.3.2.2.3 Central issue: Difficulty discharging patients with appropriate care

Four participants stated that a key challenge for the service is often in being able to access social care for their patients so that they can be discharged to remain at home safely. This is directly linked to the overall capacity issues in social care provision and unavailability of long term packages of care. This is illustrated in the following excerpts:

> *"Care packages, as we know, there's huge delays in hospital waiting care packages. There is also a huge list in the community waiting on care packages. The benefit of our carers being in the service is we can get instant access. The difficulties it causes, we've got no one to pass them on to. It solves a short term problem but not another."* (P2, Nurse Manager)

> *"Because when it's care at home, we've experienced difficulties or challenges in being able to move people on to longer term care at home services. So, if someone has been unwell and been supported through the enhanced care team for a week, then that's ideal. But if they've had no choice but to keep that person on in their case load for three weeks, then that obviously has an impact on the new people they can support."* (P9, Health and social care partnership manager)

10.3.2.3 System and culture readiness issues

System readiness issues were identified as another sub-theme among the theme of contextual and relational barriers to the full implementation of 'Closer to Home'. The root cause was identified as having an inadequate structure for acute service provision and intermediate care in the community, which was discussed by four participants.

Figure 10.6 – System and culture readiness issues, highlighting the root cause (blue) (this concept map comes directly from the larger concept map in Figure 10.2)

Several participants described difficulties accessing services required for patient care and that are easier to access from the acute hospital. One participant discussed that in their experience, step-up/step-down beds in community hospitals are much easier to access through the acute hospital. This is illustrated in the following excerpt:

> *"And actually use the community hospital properly, again step up step down. Hospital beds, again, are run by geriatricians, so you can only get in a community hospital bed by going to the front door and then getting a referral over. If you actually needed nursing care in a community environment, because that person is not safe. So, if step up is not available you it's beyond carers looking after them and you need nursing input. You've got home, step up beds, community hospital, and the acute hospital. But the way the services are linked at the moment the service is everyone coming into the acute hospital and that's often the route to get these other things."* (P2, Nurse Manager)

This was also reported to be the case with access to diagnostic testing by three participants, in particular that due to existing structures it is much quicker to access diagnostics from the acute hospital, as illustrated in the following excerpt:

> *"I think the way that they've set up secondary care there's things that we can only access in a timely way if somebody's an inpatient. So for particular tests people would have to go on a waiting list to get them, whereas if they're an inpatient they get them in a much more timely way. I think we need to challenge ourselves roundabout the process that we've put in place because that doesn't make any sense. So at the moment the way we've set up systems, yes, there are things that people can only access if they're an inpatient."* (P3, Nurse Manager)

Three participants also reported that due to existing structures it is actually easier for patients and for GPs to access the acute hospital than it is to access ECT. Their responses indicated that the existing structures and culture within

the healthcare system have not been ready to encourage the implementation of ECT into the whole system, as illustrated in the following excerpts:

> *"I think there's something about decision making at front doors as well, I think there's more that can be done to turn people around, which is why I'm really keen that people come to a community team rather than go to the front door. Because I do think if you don't have a pathway that says you have to support someone at home first, and if the default pathway, the easiest way is to always send them to acute hospital then that's what people will do. I think once you get to hospital, people will admit. So, there is something for me about a culture change in terms of how we use these services. Our service at any one time will maybe have 20 people but we'll get 200 attendances in A&E in any one day. So, there's something about the scale and the culture and the pathways into acute hospitals. We have set up systems where it's really easy to get into acute hospitals. Easier to pitch up at the front door than it is to get a GP appointment. So, there's a systematic flaw in how these things are delivered."* (P3, AHP Manager)

> *"[…] I think that if GPs need to get somebody treated quickly, then quite often the quickest thing to do is to phone an ambulance and get somebody taken up to hospital. So, I think GPs have got to make an active decision to call ECT. […] So I think there's always been something for me about how you scale up the service and how you turn it into a much, much bigger service so that the default…the default is probably still, for GPs, is probably still in ambulance, if you take people to Forth Valley Royal or to refer up to Forth Valley Royal. We need to turn that on its head and make the default, for the GP, you've got someone who is deteriorating, that the default is the ECT."* (P4, Community Services Manager)

> *"I've got an example where I know somebody who called an ambulance. The ambulance staff agreed it was probably something minor but they would just take them to the hospital anyway, just in case. So, I think it's that kind of mindset that we have to change and educate healthcare staff, maybe at a higher level, that they take that risk and to be clear of their own clinical decision. So, that paramedic was obviously very sure what it was but still sent the patient up to the hospital, just to be on the safe side. […] I do it myself, get somebody to have a look at something that I may be uncertain of as well. But I think it's just education isn't it? And having back up available to keep patients at home rather than sending them up to hospital for a clinician at the hospital to review as well. […]"* (P8, Nurse)

Finally, nine participants highlighted that improvements could be made in terms of ECT's integration with other related core services around Forth Valley including social care, Technology Enabled Care (TEC), clinicians including GPs and geriatricians, the frailty clinic, ALFY and third sector organisations. Three participants offered some insight into the lack of integrative and collaborative working between departments. Participants did not offer a clear rationale for this observation, however, from their discussions, one of the reasons appears to be a work culture of departments operating separately and silo working, as discussed in the following excerpts:

> *"Your whole approach here, it's not about ECT, it's a standalone service, there's a range of services in the community that would support you better, if we weren't sitting in silos. That's probably one of my frustrations."* (P2, Nurse Manager)

> *"Some of the feedback we've had about how we need to develop service has been about joining it up with other social care services like MECS and looking at it at much more of an integrated process, rather than that's ECT and that ALFY and that's MECS"* (P4, Senior Community Services Manager)

> *"I just think for the partnership it's pulling all these teams together, you've got my team, the care at home teams, you've got the TEC teams, you've got the enhanced teams it should just be one team."* (P17, Social Care Manager)

One participant provided further insight into the role of an inadequate infrastructure for joint working across settings including acute provision in the community.

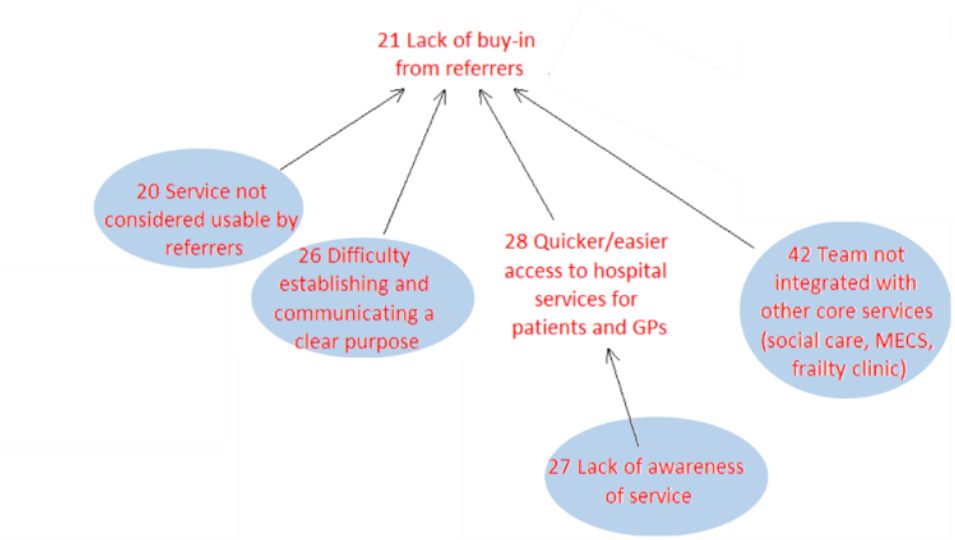
> *"I mean trying to get information is a complete nightmare […], our IT systems don't talk to each other, so primary care doesn't talk to secondary care. But secondary care can talk to primary care, and that's just for the medical stuff, it's not even getting into all the kind of – like when our physios and OTs talk about assessments that they've had say by a community rehab team, I've got no access to that but they do, so that's ridiculous. Then we've got the mental health side of it as well where we've now got access to it but mental health notes that are separate to medical notes, which are separate to primary care notes. So no-one's talking to each other. That probably actually is the biggest challenge I would say the kind of joined up communication."* (P15, Geriatric consultant)

10.3.2.4 Organisational engagement and buy-in issues

The above three clusters or themes identified relating to contextual and relational barriers to implementation of 'Closer to Home,' namely operational and embedment issues, health and social care integration issues and system and culture readiness issues, together have led to overall organisation engagement and buy-in issues. The following four root causes were identified within this cluster which ultimately arise from the previously three discussed contextual and relational barriers:

- Service not considered usable by referrers
- Difficulty establishing and communicating clear purpose
- Lack of awareness of the service across the organisation
- 'Closer to Home' services not integrated with other core services

Figure 10.7 – Organisational engagement and buy-in issues, highlighting the root causes (blue) (this concept map comes directly from the larger concept map in Figure 10.2)



10.3.2.4.1 Root cause: Service not considered usable by referrers

Primarily as a result of operational and embedment issues, specifically lack of mainstream funding and small team capacity, the ECT service found itself unable to meet demand and geography coverage required and provided an inconsistent service, as previously highlighted. These issues in turn have led the ECT service to be perceived as difficult to use by referrers affecting the credibility and buy-in into the service by referrers as noted by five participants. The following narratives illustrate these issues.

> *"I think from a GP perspective, from the referrers, a lot of people especially near the beginning, tried to refer their patients into the service and there wasn't capacity. So, it put them off using the service. You will find there's pockets of GP practices that will use ECT and there will pockets of GPs that will never consider it. Either because they had a bad experience or it's just completely fallen off their radar, because they seldom feel it's of benefit. I think if you were to ask the referring population that question, I think they would say that because the capacity of the team is very small, it's not a very Forth Valley wide, usable service."* (P5, AHP Manager)

> *"So every day we have someone different which doesn't give continuity in the team and doesn't give continuity for the staff or patients. We don't have cover on a Monday or Tuesday morning at the moment. We have three and a half days cover out of seven days. Again, feedback before we started the service were was from patient's own GPs, their concern was why would we refer them to you if we're going to have to provide medical cover? In the main, because the nurses have got the skillset now, not a lot goes back to the patient's own GP. But we actually want to be a credible service, we want to do it and do it properly. On a Monday, we cannot do this because we don't have GP cover, on a Friday we can, because we've got…So, these kinds of things."* – (P2, Nurse Manager)

> *"[…] there's such a variation in the service as well that even though we have the huddle that they phone into, you will most of the time be told either there's no*

capacity or maybe one or two depending on where the person lives and what's wrong with them. […]" (P15, Geriatric consultant)

10.3.2.4.2 Root cause: Difficulty establishing and communicating a clear purpose

As previously described in Section 10.3.1.2, setting the eligibility criteria for the ECT service is difficult, primarily due to the nature and complexity of patients they see but also due to the evolving nature of the service as a complex intervention. Confusion over the purpose of the ALFY service was also briefly discussed in Section 10.3.1.2. This has led to difficulty for these services in establishing and communicating a clear purpose which in turn has impacted organisational buy-in. Five participants described a lack of clarity and understanding about the ECT service from referrers, three of which described it as being a key challenge for the service.

> *"I asked a question as recent as two or three months ago and was told, 'We take everyone, we take unwell people and we need to take more of these unwell people.' When I said, 'Can you define that a little bit more specifically what you mean?' 'Just phone us.' And that's been consistent since they started. So in terms of trying to get a list of criteria for who they take and who they don't take is very difficult and it seems to vary depending on staffing levels as well."* (P15, Geriatric consultant)
>
> *"[…] GPs can be uncertain what the service is able to provide or may feel patients are too complicated to be managed by the team. These can be similar hurdles for referrals from paramedics. […]"* (P7, GP)

One participant also noted issues in communication on roles and responsibilities in clinical management of patients the ECT cared for.

> *"Well I had another patient who's got multiple morbidities who had electrolyte problems, who I would have admitted and it was good that he didn't need to be admitted because the Closer to Home team were able to do his blood monitoring until it was a bit better... But what puzzled me a bit was he did ultimately require an admission and was discharged but the Closer to Home team became involved with him after his discharge, unknown to me and there was no communication either, you know, from the hospital about that or from the Closer to Home team about what their role was after discharge. It was unclear who was doing what and who was responsible, you know, for clinical management. So I found that, you know, a bit unsatisfactory."* (P16, GP)

Similarly, a lack of clarity and understanding of what ALFY was and its main purpose was described by five participants. The following excerpts describe this issue.

> *"I think it was quite hard for patients to understand what our advice line was at the start, we were getting a lot of non-health and social calls, looking for tradesmen, looking for help, general help at home… Yes, 'cause they've seen the signs and the publications maybe not been as – if they've seen it as ALFY and thought they were going to be speaking to a man called Alfy, so they phoned up to speak to Alfy but not understanding what the concept is."* – (P10, Nurse)

"I just don't think it was set up and communicated properly, even workers was like I can phone ALFY I'll be able to get a carer, no, that's not the case, so it was that kind of thing. Communication. […] That's what I would say, lack of clarity what it actually was, because even some of the… I've not got one here, even the wee cards and that, they weren't very clear was it was." (P17, Social Care Manager)

10.3.2.4.3 Root cause: Lack of awareness of service

Five participants referred to a lack of awareness about the ECT service among potential referral sources, particularly at the beginning of the service, however several participants referred to this as an ongoing issue.

"[…] I think for a lot of us nobody knew about it so particularly over Christmas and the New Year, part of the simple thing was we didn't even have a phone number for them. I spent a lot of time in the emergency department seeing older people that I would then phone up and ED were like, 'We've never heard of this.'" (P15, Geriatric consultant)

Four participants reported a lack of awareness of ALFY among target service users. As a self-referred service, ALFY relied on public promotion which was heavily invested in, however, challenges in promoting the service publicly remained. Respondents could not identify clear reasons for this difficulty, however they hypothesised that there may have been difficulties in reaching the particular demographic of users for the service or that there may have not been enough time invested towards communicating and embedding ALFY as a core service, as illustrated in the following excerpts:

"[…] I'm still amazed that people wouldn't know about it and I didn't understand because I feel that there's a poster everywhere. Or I feel that we've sent a mail shot to thousands and thousands of people that...So, yeah, it was just making people aware of the service. […] Well like we say, we were making contact with patients that had come home from hospital, maybe going more into the acute sector and trying to – or we had talked about having stands in supermarkets and places where elderly go on a kind of day to day basis, the shopping centres and things like that to just again make it more of a presence known, but throughout the whole time we have found word of mouth, no matter how much publication we've put in, went on the hospital radio and things... When we've asked people where they've heard of the service it's been word of mouth." (P10, Nurse)

"[…] it's difficult to know why people didn't phone a phone line because we gave people leaflets, we called people after they were discharged from hospital and told them about ALFY. So we communicated with people quite extensively but people just didn't use it. […] it might have had something to do with demographic but I suspect it was just that at the time that we were giving people information, they didn't need ALFY and then maybe at the time they did, they had maybe forgotten that it was there. […] I guess we thought that over time, you would build up that critical mass of knowledge and understanding in the same way that people have that knowledge about minor injuries or A&E but maybe you need years to do that, rather than a couple of years." (P4, Senior Community Services Manager)

One participant offered some insight into the difficulty of maintaining awareness of new services, including the 'Closer to Home' services, within general practice.

> *"Well no matter what you try and get a group of general practices to do, there will always be some that either don't remember about it or claim they've never been told about or don't want to change what they normally do, you know, to use a different service. So there'll always be, I don't know what proportion it is, about a third maybe, you know, that it's difficult to get to do anything. So you have to keep on publicising something, you have to keep on encouraging people and almost showing them how to do it, you know? So there's different reasons for that but it tends to be what we find trying to get people to do new services, but in general I think it's probably true that even if people know about something, three months later they want to use the service, they may have forgotten how to do the referral or the actual mechanism of doing it, and that might be enough to stop people using it just because they can't find the number or something."* (P16, GP)

10.3.2.4.4 Root cause: Team not integrated with other core services

As previously described in Section 10.3.2.3, system and culture readiness issues have led to a lack of integration of 'Closer to Home' services with other core services including social care, Technology Enabled Care (TEC), clinicians including GPs and geriatricians, the frailty clinic, ALFY and third sector organisations. This in turn has affected organisational engagement and perception of 'Closer to Home' as a standard NHS Forth Valley service for older patients. This is evidenced by the responses of three potential referrers to the service who indicated the 'Closer to Home' services would be greatly improved by improving integration with core services. As put by one participant "it's about linking with the other services that are already out there" (P18, Social Care Manager).

10.3.3 Measuring and monitoring 'Closer to Home' and similar admission avoidance interventions for the elderly

All participants were asked about measurement and assessment of value as part of service evaluation within 'Closer to Home' and the areas they work in (older people's care). This led to the overarching theme around measurement and monitoring of 'Closer to Home' and similar interventions, which directly relates to the NPT construct 'Reflexive monitoring' (the appraisal work the people do to understand and evaluate whether the new ways of working are worth sustaining).

Nine participants had at least some idea of the key performance indicators used for assessing the value of 'Closer to Home' services. They reported the use of the key performance indicators outlined in Table 10.9.

Table 10.9 – Key performance indicators used for assessing value of 'Closer to Home' services by funders, as reported by participants

Key performance indicators
Process measures
• Number of ECT patients seen and managed at home (n=4), numbers of ALFY calls (n=3)
• Care hours or number of patients receiving personal care through ECT or care hours (n=2)
• Number of onward referrals (n=1)
Hospital activity measures
• Number of saved bed days (n=3), number of hospital admissions avoided (n=1) or an observed reduction in admissions (n=1)
Cost measures
• Cost savings (n=3)
Qualitative measures
• Patient stories and feedback (n=3), ALFY (n=1)
Physical or functional measures
• Risk reduction (traffic-light system categorising risk of admission before and after ECT) (n=3)

10.3.3.1 Adequacy of existing appraisal processes and outcomes

Several participants commented on the adequacy of the existing appraisal processes and outcomes for the 'Closer to Home' services and similar admission avoidance interventions for older people. Participants generally expressed that current appraisal processes are heavily focused on evidence of reduction of hospital activity and cost savings. Five participants expressed frustration at this limited focus. These frustrations are illustrated in the following excerpts.

> *"[…] you're looking at cost and it does come down to cost. You could have one person having a great opinion of the service, what counts is numbers and the money you've saved at the end of the day. Unfortunately that's what it comes down to, and that's being realistic in this world. You could have a service where you see five people and give a great service but realistically it is about numbers and money. Not saying that's the right thing, but that's what happens and that's what we're measured against. […]"* (P2, Nurse Manager)

> *"[…] the ones that people are most interested in are what I've talked about, the numbers, what are new referrals? Our activity numbers and our outcomes. I think what's really important is the patients stories that we've used as well and that more qualitative information. […] I guess for people funding the service, what they want to know is what am I getting for my money? How much and what difference has it made? […] For the people who fund our services, I don't know if we think that's the right thing, because I guess for me I'm more interested in the outcomes of the people we support at home. The service for me is about the 2020 vision, supporting people to live well in their own environment. Unfortunately, what we're challenged with is*

> *what difference does it make to acute hospital, which is actually philosophically different. But that is the world that we live in."* (P3, AHP Manager)

> *"[…] I think there's something as well, in terms of a slight disjoint, in an almost obsession, fixation, in getting people out of hospital, rather than supporting them to avoid. It's a tough thing to evidence. […]"* (P9, Health and social care partnership manager)

> *"They're just looking at numbers, they're not looking at quality, they're looking at quantity. […]"* – (P10, Nurse)

Six participants expressed that they felt these measures are adequate but provide a limited view of the impact of the services. Four participants felt these measures are not adequate, particularly process measures, as stated by one participant "Because most of them are outputs, so we don't actually really understand the impact of the service." Two participants explained that they felt that existing measures and appraisal processes fail to provide a comprehensive assessment of the services, particularly lacking in robust analyses and in the less tangible elements such as the 'why' and 'so what.' They stated "[…] that's the bit, the why and the so what is the bit that we're missing" and "I'm not sure if it's the measures and I'm not sure if it's the data, I think it's the analysis that's missing."

Two main frustrations were observed surrounding these issues: frustration about a lack of resources for improving on these measures and difficulty in evidencing impact and identifying measures for a complex intervention like 'Closer to Home'. Several participants voiced that the existing measures and appraisal processes are limited by resources (n=3), describing for example that these measures are "the best we've got," or "the most we can do at the moment." The following excerpt illustrates the frustration about lack of resources.

> *"So all we've done up until now is look at the usage of the beds, so it's been about bed numbers as opposed to the value. What did the person get from it, did it prevent them from going into hospital, when we got them home, how did they get on, there's no capacity to do that kind of thing."* (P18, Social Care Manager)

The second frustration was around difficulty in evidencing impact and identifying measures for a complex improvement programme like 'Closer to Home' (n=8). The following excerpts illustrate these issues.

> *"A lot of the things we're trying to measure are really difficult to measure, I think that's what we have to acknowledge. I've described before about activity at the front door. People would love us to be able to say, this is the attendances we've avoided. That's really difficult to capture. I think what we've got is the best. You can always*

improve things but I think it's probably the best we can do, given that there are things that are really difficult to measure. […] People want to know by supporting somebody at home, did we avoid a hospital admission? Yes or no? And if so, how long would they have been in hospital for? And what would they have required when they came out? That's really difficult to try and get your head round. […]" (P2, Nurse Manager)

"I think the difficulty we have is showing cause and effect. How do we show that if there is a reduction in readmissions or reduction in admissions that that is directly because of the closer to home service? I think it is quite difficult to show, you can see in the case of that patient, we are pretty sure that that patient would have ended up as an inpatient admission if they hadn't been taken on by the closer to home team. But are we changing the bigger trajectory? Are we changing the dynamic of care? I don' think we can demonstrate that, that's much more difficult to demonstrate. […]." (P4, Senior Community Services Manager)

"The toughest thing to evidence is actually to say, in that sort of scenario, if we hadn't provided that care in that person's own home on that day, they would definitely have been admitted to hospital. Because we might have avoided that admission but somebody else was admitted that day, let's face it. They're not realising, necessarily any massive saving. It's not like we've got a hospital sitting half empty. So, it becomes very difficult. Guys are working their socks off, but equally in terms of impact of that, the whole system is groaning in terms of actual volumes of the people they need to support. So, it's a really difficult one to get to the bottom of. I know that the team in the ECT have previously done work around saying, say they supported 20 in a month, that's 20 people we avoided admission to hospital. That would have cost us X, Y, Z. But that's an assumption, all of that is based around an assumption, I think that's a really hard one. If we could find a way of being able to quantify that, then that would be a really positive outcome." (P9, Health and social care partnership manager)

"So it would actually be quite helpful to understand of those people do they then, you know, after a period of time come back into the system again, what is their longer term outcome beyond the ECT intervention. I guess the challenge would be in actually looking at, well we don't have anything to compare that well so what would that actually tell us? I think it is really tricky to measure any kind of health project like this which I guess is why you're evaluating it." (P14, Funding co-ordinator)

"It's notoriously difficult to record or measure avoidance of admission because you've avoided the admission! You know? How do you demonstrate and evidence and measure that you stop something happening that would otherwise happen, we don't know unless you pull out this great big chunk of service and wait and see if it all goes wrong, and I'm not going to do that. It's really, really difficult […]" (P13, Funding co-ordinator)

The following funding coordinator's perspective highlights that this difficulty is not unique to the 'Closer to Home' interventions but is more widely observed among other complex, multi-faceted interventions for complex elderly populations.

"It's really, really difficult, I think we've spent quite a bit of time as [participant] just said, thinking about this and ECT and ALFY aren't on their own there. I would

say for my 20 that I have at the moment... I'm very used to KPIs, I'm very used to working in that type of way but because these are all so different and because they haven't been done before, a lot of them, and because they're parts of services, sometimes we fund a couple of posts within a bigger team, it is quite difficult to get that and even if you do get the data..." (P13, Funding co-ordinator)

10.3.3.2 Difficulty evidencing impact and following-up outcomes for a complex population

Nine participants discussed issues around measuring effect and evidencing impact among complex, elderly populations. These nine participants particularly made reference to the difficulty in observing impact on hospital activity for very elderly, frail patients who are unlikely to see improvements in their health and very likely to continue to deteriorate, despite 'Closer to Home' intervention. The following excerpts illustrate these issues.

"What I would say is we're looking at people who are very frail and at the end stages of their life, maybe 12 to 18 months, so there would be this expectation that this group of people would need acute hospital admission. Even people we bring onto the team, we can't avoid an admission because ultimately they are so unwell. So, I guess for me there's a feeling of trying to fight that tide of demographic move. More old people who are frail who are unwell who actually need acute services. So, are you proving that we're managing to…is it a legitimate model in terms of what we're trying to do and stop that flow into hospital? I suppose in my view is it's the best we've got." (P3, AHP Manager)

""[…] And it's not a world that is static, so you're not measuring admissions and readmissions in a static population, because the population keeps increasing. And comorbidity and complexity keeps increasing. So, you're not really measuring in an environment…it's not a static population […] You've got to understand with older people, what we might be doing is pushing back the time period where someone might require an admission or you might be reducing the frequency of admissions. You're not necessarily preventing it forever, it's just the nature of it." (P4, Senior Community Services Manager)

"Because our population is getting older and living with the long term conditions, it's about re-educating the public about self-care and self-management. I personally think we've lost…you've got people in their 80s and 90s, the odd person that can manage. But if you're looking at frailty and its broadest term, you've got a point where you can get a person rehabilitated and self-managed and self-cared. I think because they've just started that approach now, our 80 and 90 year olds have gone beyond that. They've been living with comorbidities and long term conditions, the chances are they will need care […]. If I'm looking to the client group that's coming to us, it means we're getting the right client group, because people will die unfortunately, because they are elderly and unwell. But they also might get admitted to hospital, that's not unrealistic either. You're back to your question about what was expected at the beginning. To keep everybody at home? No, we're not going to keep everybody at home because people will continue to become more unwell. […] Although there might be increased admissions, it's because the public is getting more elderly and there's more core morbidities and longer term conditions

> *and people are getting sicker. By the time you're getting to 80 or 90 and had these core morbidities since you were 40 it's not going to be the same as you or I having two conditions at the moment and me being able to manage them."* (P2, Nurse Manager)

> *"[…] you generally see [among] the cohort patients that we see, the majority of them die within 12 months or 18 months after we've seen them. That just reflects that this is a frail population with complex problems that we see and that they, no matter what input is given to them, them will die in that timeframe likely. That's comparable with patients, as you say with the same demographics that go into hospital. I think what can reduce that, as I say, is anticipatory care work and education for the patient, their families that there's different ways of being realistic with our conditions and there's different ways of managing them. With the best will in the world, we're not going to stop people dying. It's to try and keep their wishes and either keep them at home or make sure they're comfortable and reduce unnecessary trips up to the hospital and unnecessary tests and things."* (P7, GP)

The participants' perspectives point towards the idea that 'Closer to Home' programme intervenes at a stage in a patient's trajectory where an initial admission may be avoided but future hospitalisations may be unavoidable in their longer term healthcare journey. They alluded to the programme intervening at a point in their trajectory where there is no longer scope to reduce or prevent further deterioration, hence the extent to which it can provide anticipatory or preventive care is limited. Several participants referred to the potential that these services may be delaying hospital admissions but may not be able to ultimately prevent them. Participants alluded to the idea that for this type of population, changing the shape of the curve of increasing admissions rather than reducing it may be more realistic, as described in the following excerpt:

> *"[…] I don't think these services would be too ambitious to say that what we're trying to do is change the shape of the curve. What you're trying to do, is well, yes changing the shape of it, not necessarily reducing it. So, I think you just need to be realistic about what you can expect these services to do. I think they are part of a whole jigsaw of other things we need to do and they're never going to be a substitute for inpatient admission or inpatient assessment. But I think they do have their place."* (P4, Senior Community Services Manager)

Finally, one participant also highlighted the difficulty of collecting qualitative information from a complex population "So I compare it as well like palliative care, trying to get feedback from patients that are – it's quite hard, it's a really, really hard..." (P10, Nurse).

10.4 Summary of findings

10.4.1 Coherence and cognitive participation

The coherence construct of NPT is about making sense of a new healthcare programme. Coherence is strong when there is a shared understanding of the programme, including an understanding of the distinction from previous ways of working and understanding the potential benefits. The cognitive participation construct of NPT is about the relational work people undertake to legitimise and sustain a programme. Cognitive participation is evident where there strong buy-in and strong motivation from those involved to invest time and energy in the programme. Discussion around coherence and cognitive participation observed among the participant's responses gave rise to the theme of clarity of 'Closer to Home' services and their acknowledged intrinsic value among those involved.

- Overall, coherence was strong given that participants had a clear understanding of the 'Closer to Home' services. Those involved directly in management or delivery of the services overall indicated strong understanding of their tasks and responsibilities, their role contribution and reported high confidence in their daily work.
- Overall, there was a clear understanding of how the 'Closer to Home' services are distinct to existing or previous services or practices. Participants overall could clearly describe the benefits of the services in comparison with previous ways of working. The benefits are summarised in the table below.

Table 10.10 – Benefits of 'Closer to Home' services reported by participants when compared to traditional hospital and community-based care

Reported benefits	**'Closer to Home' service benefit reported for**
Benefits to service users	
Preserving independence and security at home	ECT (n=13)
Reducing hospital related risks	ECT (n=5)
Provision of person-centred care	ECT (n=10)
Caregiver reassurance and support	ECT and ALFY (n=1)
Provision of intensive and holistic assessment	ECT (n=6) and ALFY (n=2)
Identification of unmet need	ECT (n=3)
Consistency, flexibility and personalisation in service provision	ECT (n=5) and ALFY (n=1)
Timeliness and urgent response	ECT (n=4) and ALFY (n=1)

Benefits to professionals involved in care	
Preferable patient-clinician environment	ECT (n=5)
Ability to see holistic patient journey	ECT (n=4)
Valuable skills development and role variety	ECT (n=8)
Improved communication and links with other services	ECT (n=4) and ALFY (n=1)
Reduced pressure on GPs	ECT (n=5)
Organisational benefits	
Reducing pressures in NHS hospitals	ECT (n=13) and ALFY (n=1)
Reducing pressures in primary care	ECT (n=6) and ALFY (n=1)
Reducing pressures on social care provision	ECT (n=2) and ALFY (n=1)

- Cognitive participation was strong for the Enhanced Community Team strand of 'Closer to Home,' with the majority of participants indicating strong belief that the service should be sustained, strong motivation in their daily work and a strong willingness to drive the programme forward. A few participants, however, particularly referrers to the service, believed it should only be sustained and driven forward subject to some improvements.
- Cognitive participation was not strong for the ALFY service, where only one of four participants believed it should be sustained, though they all acknowledged there is a need for a service like this. The primary reasoning was due to a lack of achieving its aims, a lack of activity leading to inappropriate resource use and poor communication about the service.
- These observations indicate strong ownership of the ECT intervention by those involved in implementing and delivering the intervention, while the converse was observed for the ALFY service.

In summary, coherence – that is, a shared understanding of the 'Closer to Home' programme and its benefits – was strong among participants, however, cognitive participation – that is, buy-in and motivation to invest and participate – though strong for the ECT service, was very weak for the ALFY service, for which there was low buy-in and ownership by participants.

10.4.2 Collective action

The collective action construct of NPT is about the operational work that people do to enact a new intervention. The discussions around collective action by participants gave rise to the theme of contextual and relational barriers to the

implementation of 'Closer to Home.' Though coherence and cognitive participation among those implementing and delivering the ECT service was strong, when it came to the enacting work required for its success, several issues and barriers were observed that prevented the full embedding and mainstreaming of the service. Similar issues were observed for the ALFY service, for which cognitive participation was already weak. These issues gave rise to the overarching theme of contextual and relational barriers to the implementation of 'Closer to Home.' Four main subthemes were identified – operational and embedment issues, health and social care integration issues, system and culture readiness issues and organisational engagement and buy-in issues.

- Operational and embedment issues were particularly observed within the Enhanced Community Team service, where lack of mainstream funding with permanency gave rise to three central issues, namely small team capacity with uncertainty, inability to be mainstreamed and considered a core service across Forth Valley and an inconsistent and disjointed service.
- Health and social care integration issues were also particularly observed within the ECT service, where system pressures on social care provision in part have led to difficulty in integrating the ECT healthcare service with the existing social care resources which were unable to meet the urgent level of social care required by the service.
- System and culture readiness issues were observed particularly in the implementation of ECT, where participants described an inadequate structure for acute service provision and intermediate care in the community, such as difficulty accessing timely diagnostics in the community setting in comparison to the acute setting. This inadequate structure was observed in combination with culture readiness issues, where easier access to the acute setting has led to health professionals defaulting to hospitalisation. In addition, participants referred to a culture of silo working and a lack of integrative and collaborative working between departments as a culture readiness issue which has acted as a barrier to the integration of 'Closer to Home' into the wider healthcare system.
- These issues overall have led to organisational engagement and buy-in as a core barrier to implementation. The underlying causes were identified as a perception from referrers that the service is not usable as a result of the

previously described operational issues, a difficulty establishing and communicating a clear purpose, again, given the operational issues and because of having poorly defined services partly due to their evolving nature, a lack of organisational awareness of the 'Closer to Home' services, partly due to the difficulty in defining and communicating the service effectively (in addition to a general difficulty in introducing new services particularly in general practice) and ultimately a lack of integration of 'Close to Home' with other core services and the wider healthcare system.

10.4.3 Reflexive monitoring

The reflexive monitoring construct of NPT is about the appraisal work the people do to understand and evaluate whether the new ways of working are worth sustaining. Half of the interviewed participants had at least some idea of the existing key performance indicators used for assessing the value of 'Closer to Home' services, which included process measures, hospital activity measures, cost measures, qualitative measures and physical or functional measures.

The discussions around reflexive monitoring gave rise to the overarching theme of measuring and monitoring 'Closer to Home' and similar admission avoidance interventions for the elderly. Two main subthemes were identified, namely challenges with the adequacy of existing appraisal processes and outcomes and challenges following-up outcomes for a complex population. The following observations were made.

- Participants indicated that current appraisal processes are heavily focused on evidence of reduction of hospital activity and cost savings, including some frustration at this limited focus. Participants generally felt that the existing appraisal processes and measures are adequate but provide a limited view of the impact of the services and fail to provide comprehensive assessment of the true value of these services.
- Participants described a lack of resources for improving on these measures which may lead to this limited view but perhaps more notably, difficulty in evidencing impact and identifying measures for a complex intervention like 'Closer to Home.' Participants noted that admission avoidance is a difficult concept to measure and that showing cause and effect or conducting a counterfactual analysis are particularly difficult for this type

of intervention. These issues were noted as not being unique to 'Closer to Home' but are observed more widely among similarly complex interventions.

- Participants noted issues around measuring effect and evidencing impact among frail, elderly patients. They noted that at the point of 'Closer to Home' intervention in this type of patients' trajectory, there may not be scope to prevent further deterioration and that these services may delay hospitalisations but may not be able to ultimately prevent or reduce them.

Overall, it was clear that in the view of participants, the current focus on cost savings and reduction in hospital activity as primary aims of these services is inappropriate and that other measures need to be considered to provide an accurate understanding of the true impact of services like 'Closer to Home'. Participants described the ability of these services to meet patients' wishes for their care, thus providing a more person-centred approach than the traditional hospital pathway, as being a key value point of these services, as summarised in the following excerpts:

> *"[…] there's different measures that you can use but at the moment it's a black and white measure, do they go into hospital or did they not, and I think it's the people talking about possible admissions, it's actually the state of the patient as well. So you might avoid them going in but actually what was their journey like in amongst all of that, was it safe, did you achieve their goals, their outcomes, yeah, you stopped somebody going into hospital but as I've said to you already sometimes that's not the right thing either."* (P2, Nurse Manager)

> *"As I said before, you've got to assume that by avoiding admission to hospital we are saving something somewhere. It may well be that, as I say as a whole, yes the wards are still full. But what would it be without it? I suppose that's the scenario we need to ask as well, if that wasn't there? And even if 80% of the folks we see would have ended up in hospital, what difference or impact would that have had on the system? Would it have made it explode, I feel like? In terms of personal outcome, what is a good experience for the patient? Is it good for the patient, if they're 85 and have dementia and they've only got a urine infection, is the right place for them to be the emergency department at Forth Valley Royal? Even if it's just to be seen and turned around again. Or is it being supported in their own home? Surely it's a much more meaningful pathway for people to experience. And if we're about getting it right for the person, then surely the money and everything else should follow it."* (P9, Health and social care partnership manager)

10.5 Conclusion

The thematic analysis revealed that the potential benefits and distinctions from existing practice of the 'Closer to Home' interventions are clear to staff. The benefits identified as part of the thematic analysis extended beyond merely

preventing hospital admissions and included: *preserving independence and security at home, reducing hospital related risks, provision of person-centred care, intensive and holistic assessment, consistency, flexibility and personalisation in service provision.*

However, the analysis also revealed that the 'Closer to Home' interventions were unable to fully realise their benefits mainly due to several operational and work culture challenges. In particular, because the services were never implemented at scale, it was clear they became fringe services and faced many difficulties that prevented their full realisation and success.

The analysis revealed the following observations towards understanding the lack of full realisation of the identified potential benefits:

- Clear lack of dedicated resources towards meeting service need and conflicting priorities relating to resource
- Lack of system and culture readiness with inadequate structure for acute service provision and intermediate care in the community
- Lack of full embedding and mainstreaming of the services into the wider healthcare system leading them to become fringe services.
- Lack of mainstreaming has led to a low volume of patients (confirmed through quantitative analysis), which in turn has made it difficult to justify and sustain the services, particularly the ALFY service
- Lack of coherent direction and leadership that enables continuous improvement (top-down approach where actors struggle to shape the service)
- Clear difficulties integrating health and social care which are key towards the success of a community healthcare intervention, with a lack of drive towards integration
- Lack of ownership of the ALFY service by its actors

The thematic analysis also identified some key issues around measurement and evaluation of complex interventions for elderly populations.

- Existing appraisal processes are heavily focused on evidence of reduction of hospital activity and cost savings which provide only a limited view of the true impact of the services

- Showing cause and effect and identifying appropriate counterfactuals is particularly challenging for complex interventions which continuously evolve
- Reductions in hospital activity may not be achievable for elderly populations given continuing deterioration hence alternative measures should be more widely considered for understanding the effect of interventions like 'Closer to Home'

In summary, it is clear from the analysis that 'Closer to Home' services have a key role to play in the healthcare ecosystem in Forth Valley but that a clear operational remit, resources for mainstreaming and sustaining them and a cultural shift away from the default to hospitalisation may enable its implementation into mainstream routine care. In addition, measurement of these services is clearly challenging, and evaluation of such services needs to widen its focus from evidencing reductions in hospital activity and cost savings and more widely consider further potential benefits such as those identified from this analysis, particularly evidencing the achievement of person-centred care through such services.

Chapter 11 Discussion and Conclusion

This chapter concludes this thesis by summarising the key findings and contributions in relation to each research question set out at the beginning of the thesis. A discussion of the findings, their relation to other research and their implications follows. Recommendations based on the findings and discussion are then made for others developing or evaluating admission avoidance programmes for elderly patients, such as 'Closer to Home.' The chapter then continues with a discussion of the key limitations and concludes with suggestions for possible directions of future work relating to this research.

11.1 Summary of Findings

The main findings of this research are summarised according to the three main research questions.

RQ1: *What were the structures and operational processes of the 'Closer to Home' programme?*

The evaluation of the 'Closer to Home' programmes' structures and operational processes involved process mapping and describing the specific criteria, resources and organisational aspects required to run the programme. The characteristics of the patients receiving the programme were also described as part of the quantitative evaluation of the programme.

Patients receiving care from the 'Closer to Home' programme were identified to be on average 79 years of age and mostly (59%) female. This is a similar average age to that of patients enrolled in admission avoidance programmes reviewed in the scoping review included in this thesis (80.3 years of age on average).

The 'Closer to Home' programme was identified to be a complex intervention made up of various interconnecting parts, however its three main components were identified as the Enhanced Community Team (ECT), the GP Fellows programme and the 'Advice Line for You' telephone consultation line

It was found through the exploratory process mapping phase of this research (Phase I) that the ECT was initially made up of a dedicated team of managerial staff and nurses but drew on existing teams of allied health professionals

including physiotherapists and occupational therapists, and home care staff who also worked in other areas. The GP Fellows programme was developed for GPs, who worked closely with the ECT, providing additional medical expertise to the team, while also working in other areas as community physicians, particularly within elderly care.

Following the scoping review presented in this thesis, it becomes clear that the intended model of care of the ECT along with the GP Fellows is aligned with early discharge and admission avoidance hospital at home models. The scoping review identified the range of professionals involved in such programmes including nurses (100% of interventions), physiotherapists (67%), physicians (or general practitioners) (61%), geriatricians (61%), occupational therapists (56%) and social care workers (28%), which is closely aligned with the model of the Enhanced Community Team (aside from not having geriatricians as a resource). As an early discharge and admission avoidance hospital at home model of care, the ECT provides care that substitutes entirely for an inpatient acute hospital admission.

As identified through the descriptive analysis of services use and activity in Phase IV of this research, ECT received 47 referrals to their service per month and conducted on average 12 contacts directly with patients and 7 indirect contacts every day. The levels of activity indicated that the service had limited reach. The descriptive analysis also found that ECT provided hospital discharge facilitation care in a quarter of cases and provided care for a range of conditions including chest infections, urinary tract infections, reduced mobility, increased confusion and delirium, falls and exacerbations of chronic conditions. Patients were referred for the service by their own GP in about half of cases though patients also originated from discharge coordination hubs among other sources. Although ECT episodes often resulted in successful input allowing patients to remain at home, according to the discharge reason recorded, in roughly a quarter of cases (22.8%) the reason was recorded as admission to acute hospital, giving some indication that it may have limited impact on reduction of hospital activity.

The 'Advice Line for You' was made up of a team of experienced community nurses knowledgeable on care provision and services available to elderly people in Forth Valley. The service provided medical advice and reassurance to over 65s in Forth Valley, including signposting or referral to relevant community services such as

social care. The descriptive analysis of service activity conducted in Phase IV found that the service was significantly underutilised, handling on average 96 calls a month (equating to three calls per day). It also found that ALFY calls usually resulted in the resolution of the query on the call, with onward referrals often being made to other services including community nursing, social work, community rehabilitation or primary care.

Process mapping also identified data collection steps and processes involved in the operation of the 'Closer to Home' programme. Data entry was identified to take place at each point of referral, contact and discharge from the 'Closer to Home' services, hence it was deemed feasible to use existing data to build a study cohort and collect data around their interaction with 'Closer to Home' services.

RQ2: *Is participation in the 'Closer to Home' intervention associated with reduced hospital activity outcomes?*

The quantitative analysis conducted as part of this research, comprising a retrospective cohort study revealed the following main findings.

- In a retrospective matched cohort study, where the control group was defined to be a group of patients matching the characteristics of intervention patients using at least two different matching strategies, ECT was not found to be associated with reduced hospital activity following intervention in either matching strategy. In fact, it was found to be associated with an increase in hospital activity (emergency inpatient hospitalisation and emergency department attendance) and with prolonged emergency inpatient stay. A discussion around this result is provided in Section 11.2.
- In a retrospective cohort study, where a historical group of patients who received the ECT intervention was compared to a group of patients who received ECT enhanced by the addition of GP Fellows, the GP Fellows enhancement was found to be associated with a small reduction of hospital activity (emergency inpatient hospitalisation and emergency department attendance) following intervention which was not statistically significant but appears clinically relevant. Hence, enhancing a nurse-led admission-avoidance service with the expertise and practical support of GPs with training in elderly care may lead to reduced emergency hospital activity

than a service without it. It was however found to make no difference to length of stay.

- In a retrospective cohort study, where the control group was a group of previously defined eligible patients who did not use the service, ALFY was not found to be associated with reduced hospital activity following intervention. In fact, it was found to be associated with an increase in hospital activity (emergency inpatient hospitalisation and emergency department attendance) and made no difference to emergency inpatient length of stay.

As highlighted by the scoping review conducted for this research, there are mixed results on the effectiveness of services like 'Closer to Home' at reducing hospital activity, hence these results are not surprising. However, the quantitative analysis highlighted the practical difficulties in terms of study design and analytical methods for assessing the effect of admission avoidance services retrospectively, without a previously defined or prospectively selected comparison group. The analysis highlighted the need for complex methods to account for the effects of confounding resulting from key differences between groups including matching methods and multivariable models and the need for the development of often complex time-series ('counting process') data out of routinely collected electronic health record data due to the lack of entry date for comparison patients.

RQ3: *What benefits and barriers to the 'Closer to Home' intervention were identified by stakeholders involved in implementation or delivery of the programme?*

The qualitative analysis conducted as part of this research, comprising a thematic analysis of data from semi-structured interviews with health and social care staff, identified a range of perceived benefits of the 'Closer to Home' programme and barriers to its full implementation, using Normalisation process theory (NPT) as a thematic framework.

Benefits of the 'Closer to Home' programme

There was a shared, clear understanding of the 'Closer to Home' programme and its benefits amongst participants, where they were able to clearly describe how it differs from existing or previous practice (NPT – coherence). Three main types of benefits were identified – benefits to service users, to professionals involved in

care and organisational benefits, when compared to usual hospital-based care. Though participants were able to describe organisational benefits of the 'Closer to Home' programme including reducing pressures in NHS hospitals, in primary care and on social care provision, they described a much broader spectrum of benefits to service users and professionals involved in care. Frequently cited benefits to service users included the ability of the programme to preserve independence and security at home for elderly patients, providing intensive and holistic assessment and providing reassurance, provision of person-centred care and personalisation, enabling patient wishes to be honoured (full benefits were detailed in Table 10.10 in Chapter 10). Benefits to professionals involved in care included enabling valuable skills development and role variety, the home environment was seen to be a preferable patient-clinician environment, and overall health professionals felt greater visibility of the holistic patient journey.

Barriers to implementation of the 'Closer to Home' programme

Although buy-in and motivation to invest and participate among actors (NPT – cognitive participation) in the Enhanced Community Team (ECT) was strong, there was a lack of buy-in to the ALFY service, where participants acknowledged a need for a service like it but did not believe it should be sustained due to failing to achieve its aims, low service use and poor communication about the service. Lack of buy-in from its actors was one barrier to the implementation of ALFY, however, underlying were a range of barriers to the implementation of the 'Closer to Home' programme, identified under the NPT construct of collective action i.e. the operational work that people do to enact a new intervention.

Four main contextual and relational barriers to implementation were identified, namely operational and embedment issues (particularly lack of mainstream funding leading to small team capacity with uncertainty, an inconsistent and disjointed service, and ultimately inability to be mainstreamed as a core service across Forth Valley), health and social care integration issues (particularly within the ECT service, where system pressures on social care provision proved to be a barrier towards truly integrating the service with existing social care resources), system and culture readiness issues (inadequate structure for acute service provision in the community including lack of timely diagnostics and a culture of defaulting to hospitalisation, culture of silo working and lack of collaborative working between departments) and issues with overall organisational

engagement and buy-in (as a result of operational issues, perception of poor service definition and usability, difficulty establishing and communicating a clear purpose, particularly due to evolving nature, overall leading to lack of organisational awareness and integration with core services).

Finally, existing appraisal processes (NPT – reflexive monitoring) were identified as a barrier to full implementation and adoption of the 'Closer to Home' services. In particular, 'Closer to Home' services have struggled to both evidence an effect and meet the standards they are being measured against, leading to a continued lack of mainstream funding and implementation. The analysis revealed challenges with the adequacy of existing appraisal processes and outcomes and challenges following-up outcomes for a complex population. Participants indicated current appraisal processes are heavily focused on reduction of hospital activity and cost savings, and that provide only a limited view of the impact of the services, failing to provide a comprehensive review of their true value. Participants also described difficulty evidencing impact and showing cause and effect for complex interventions including 'Closer to Home' and for complex, elderly populations for whom further deterioration is ultimately unavoidable.

11.2 Discussion

Existing literature on the effectiveness of admission avoidance programmes for older people points to conflicting results (Shepperd et al., 2009a, 2016; Caplan et al., 2012; Huntley et al., 2017; Low, Yap and Brodaty, 2011). The scoping review conducted as part of this research similarly found mixed results as to whether these programmes achieve reductions in emergency hospital use or cost savings in particular.

The quantitative evaluation conducted as part of this research was not able to evidence a reduction in hospital activity associated with receipt of the 'Closer to Home' programme. In fact, it was found that patients receiving the 'Closer to Home' services had higher odds and hazard of experiencing emergency hospital activity compared to their control groups. These findings are well aligned to those of other evaluations of complex integrated care interventions employing observational methods, specifically observational cohort studies using matching methods. Two studies evaluating multidisciplinary, community-based interventions for older people published by the Health Foundation and Nuffield

Trust, employing matched control methods using administrative data also could not find a reduction in emergency hospital admissions and in several cases found higher admission rates in the intervention groups (Steventon et al., 2011; Vestesson et al., 2020). Additionally, a recent study investigating the effect of hospital-at-home programmes for older people in Scotland on costs and mortality, through a propensity-score matched retrospective cohort study using administrative data found an increase in costs and in mortality associated with the programmes (Tsiachristas et al., 2019).

The counterintuitive finding that hospital activity may be increased as a result of integrated care and multidisciplinary team programmes has been questioned and discussed by other researchers. They have offered the following hypotheses of why we might be observing this phenomenon, which are aligned with what was found in this research.

- Hypothesis 1: Delivery as intended is too challenging in real world settings (Kumpunen et al., 2019; Lloyd et al., 2021)
- Hypothesis 2: Evaluation of these programmes is difficult and complex (Kumpunen et al., 2019; Lloyd, 2020; Keeble, 2019)
- Hypothesis 3: Commissioners have unrealistic expectations and a limited focus on what these programmes can achieve (Kumpunen et al., 2019; Lloyd, 2020)
- Hypothesis 4: These programmes may identify unmet need leading to increased healthcare activity (Steventon et al., 2011, 2012; Lloyd et al., 2021; Kumpunen et al., 2019)

Hypothesis 1: Delivery as intended is too challenging in real world settings

Kumpunen et al. (2019) propose that integrated care programmes may not be having their desired effect due to an inability to be implemented as intended or to be fully implemented in the real world. They highlight that multidisciplinary teams in particular can have difficulty in specifying objectives and roles, and may face issues with team working and communication among other issues. As part of the qualitative evaluation, this research identified a range of contextual and relational barriers to implementation of the 'Closer to Home' programme, including operational issues, health and social care integration issues, system and culture readiness issues and issues with overall organisational engagement and

buy-in, all leading to a service that was not fully embedded in the healthcare system nor considered a core service. Poor service definition and usability of the 'Closer to Home' services, difficulty establishing and communicating a clear purpose are certainly issues observed by other researchers (Kumpunen et al., 2019). Health and social care integration issues have been observed in other areas also finding limited communication between departments, silo working and a lack of information systems that support integrated working (Spalding, 2019). Culture issues have also been noted, for example, a culture of defaulting to hospitalisation noted by other researchers who found that "there was still a sense that hospital remained a 'default' option in many cases. While there were accounts of a wide range of health and social care services available in the community, there was some doubt from local professionals as to whether these were really viable alternatives to hospital admission for frail older people, particularly in very rapid timescales" (Glasby et al., 2016, p.40). Organisational engagement and buy-in has also been noted by other researchers highlighting that "local integrated care interventions may not be adequately supported by wider system and policy changes, such as increased investment in community-based care," which was the case with 'Closer to Home' (Lloyd et al., 2021).

In summary, delivery as intended was certainly a challenge for 'Closer to Home,' hence it may be a reason for the observed results and has been highlighted by other researchers studying integrated care programmes.

Hypothesis 2: Evaluation of these programmes is difficult and complex

Kumpunen et al. (2019, p.6) highlight that "evaluations of these types of services are complex and messy." There are several reasons for this, one of them being that these services, including 'Closer to Home,' are usually complex, multi-faceted and have several interconnected parts, often having an evolving nature which makes evaluation particularly difficult (Kumpunen et al., 2019). It can be especially difficult to isolate the effects of integrated care programmes and to find suitable control groups as their effects may be confounded by the effects of several other initiatives being implemented at the same time and/or in the same populations, given that they are complex interventions with many interconnected parts which may crossover with other initiatives (Keeble, 2019). This is quite likely also the case with the 'Closer to Home' programme, as the process mapping process

highlighted several interconnected services. Kumpunen et al. (2019, p.7) comment that "finding an appropriate, 'uncontaminated' control group is also challenging. Integrated care is happening across a number of sites in various forms, therefore locating a group of patients who have no contact with any form of integration may be difficult. Without reliable controls, cause and effect may be hard to establish and important impacts may not be detectable."

The quantitative analysis conducted as part of this research highlighted the difficulty in identifying suitable control groups and in conducting a robust statistical analysis, a lengthy process which included identifying potential confounders and using matching methods and/or statistical adjustment to suitably manage confounders. One of the findings of the qualitative analysis around appraisal processes was a particular difficulty conducting appropriate analyses and finding suitable comparison groups.

Hence, as was the case here, finding a true counterfactual can be very challenging or isn't always possible and complex analytical methods that can appropriately account for confounding of effects are usually required but have their limitations. Ultimately, as is often the case with observational research particularly using administrative data, despite attempts to adjust or control for confounding of effects, it cannot be ruled out that the findings may be due to differences between comparison groups that could not be accounted for (unmeasured confounding), which is particularly emphasised by other researchers (Tsiachristas et al., 2019; Lloyd, 2020).

Hypothesis 3: Commissioners have unrealistic expectations and a limited focus on what these programmes can achieve

In their evaluation of integrated care programmes, primarily those aimed at older people aged over 65, Lloyd et al. (2021) conclude that "it is unrealistic to expect that integrated care programmes, such as those evaluated here, can be used as an approach to reducing avoidable demand for emergency hospital use in the short term. Our analyses showed that in the first couple of years of the programme, emergency hospital use is unlikely to change – and may even increase."

Why it is an unrealistic aim for integrated care programmes to reduce emergency hospital use? The present research along with other researchers are able to provide some insight. In the qualitative enquiry conducted as part of this research

participants described that there may not be scope to prevent further deterioration among frail, elderly patients and that these services may delay hospitalisations in the short term but may not be able to ultimately prevent or reduce them. This is aligned with Lloyd (2020) who highlights that "multidisciplinary teams typically target high-risk, high-need individuals. But there may be limited scope to reduce hospital use for these patients. It may be easier to improve the health outcomes of patients who are less acutely ill."

In addition to having unrealistic expectations about the impact on hospital activity that programmes like 'Closer to Home' might have, commissioners of evaluation may have too narrow a focus on what these programmes can and should achieve. The qualitative enquiry conducted as part of this research found that current appraisal processes of 'Closer to Home' were heavily focused on reduction of hospital activity and cost savings, which are only a part of the picture of the impact of these services.

This is further highlighted by the fact that in Scotland, particularly in Glasgow City, projects trialled under the 'Reshaping Care for Older People Strategy,' like 'Closer to Home' were asked to evaluate their impact against one of three measures, namely, emergency admissions to hospital, length of stay and days lost to delayed discharge (Levin and Crighton, 2017). A much wider range of potential benefits were identified and described by this research, including a reduction of hospital-related risks, greater ability to provide person-centred care, caregiver reassurance and support, and several benefits to care professionals including increased role variety, skills development and a preferable work environment.

The following excerpt from Kumpunen et al. (2019) summarises this concept well:

> *"Another challenge is that evaluations of integrated care tend to focus on a limited number of outcomes. It was discussed how outcomes are often set based on the availability of health data and current policy concerns, rather than thinking more broadly on the (intended and unintended) impacts in other sectors linked to health or the other health care services that people would regularly come into contact with. […] The system-wide priority to examine the impacts of health innovations, including integrated care programmes, has set an unhelpful precedent to aim for impact on emergency admissions – even in cases where the programme should not logically have a significant impact on them."* (Kumpunen et al., 2019, p.7)

In summary, a possible explanation for programmes like 'Closer to Home' producing unexpected results is that commissioners of these programmes have

unrealistic expectations of what they can achieve among these particularly frail, high-risk patients, having too narrow a focus on seeing reductions in emergency hospital use when these programmes are achieving a wider range of impacts they should also be measured against.

Hypothesis 4: These programmes may identify unmet need leading to increased healthcare activity

One of the findings of the qualitative enquiry conducted as part of this research was that 'Closer to Home' may uncover unmet need through the in-depth assessments and investigations that they conduct. Though this was reported as a benefit of the programme by participants, they acknowledged the possibility that it may lead to increased healthcare activity. Other researchers have also noted this hypothesis (Steventon et al., 2011, 2012; Lloyd et al., 2021). Steventon et al. (2011, p.3) describe in their study that "one possible explanation for our findings is that the process of 'case finding' identified unmet need. In other words, when patients first entered into the interventions, the professionals may have identified problems that necessitated hospital admission." Lloyd et al. (2021) suggest that "proactive care initiatives such as multidisciplinary teams may initially identify unmet need, which in the short term may best be treated in a hospital setting and only impact a patient's emergency hospital needs many years later."

11.3 Recommendations

Given the findings of this research and the hypotheses that have been generated about what is being observed, several recommendations can be made for others developing or evaluating admission avoidance programmes for elderly patients, such as 'Closer to Home.'

11.3.1 Challenge expectations

This and other research calls for commissioners of these programmes to challenge their expectations of what their programmes can achieve. Steventon et al. (2019, p.7) highlight that "commissioners of evaluations can often hold unrealistically high expectations for health improvements and cost savings as the outcome of integrated care initiatives." Commissioners should reflect on the finding that the nature of the population these programmes are aimed at means they have limited

ability to impact hospital activity, for example. They should carefully examine their programme design and intended population to ensure they have realistic expectations of what they can and should achieve.

Commissioners should also reflect on the finding that delivery as intended is very challenging in these settings and that it may be very difficult to achieve their intended aims in practice. Some researchers even suggest that commissioners may see more success or more rapid progress with simpler, single-faceted interventions (Kumpunen et al., 2019; Lloyd, 2020). Lloyd (2020) highlight that "different patient groups may benefit differently from multidisciplinary teams, with these group effects hidden when looking at the overall effect. For example, there may be conditions where input from several different professionals is needed and there is particular benefit from collaborative working." By developing more targeted interventions (e.g. COPD, falls prevention) or at least having clear, separate pathways for distinctly different types of patients, it may be more realistic to achieve implementation as intended and to isolate the effects of the interventions.

11.3.2 Recommendations for future service development

This research was able to analyse the implementation of the 'Closer to Home' programme qualitatively, from which a range of recommendations for future service development can be made. Strong coherence (i.e. clear understanding of the intervention and its benefits as well as strong understanding of role contribution) is an essential building block for the successful implementation of programmes like 'Closer to Home,' however, it is not sufficient towards building a strong foundation for implementation, also requiring participants to have a strong motivation and willingness to drive the intervention forward (cognitive participation) as well. This was evidenced with the ALFY service for which a lack of ownership by its participants led to its early conclusion. At the minimum, implementers should ensure both coherence and cognitive participation are strong for implementing programmes like 'Closer to Home.'

Beyond this essential foundation, there are many lessons to learn from the implementation issues faced by 'Closer to Home' when it came to the operational work required to enact the new interventions. In alignment with the three main root causes of the identified operational and engagement issues which acted as

barriers to the implementation to 'Closer to Home,' the following recommendations can be made.

- **Operational considerations***:* ensuring there is sufficient resources allocated to meet demand and provide a consistent service, and considering future-proofing allocated resources to reduce team uncertainty and mainstreaming issues are important considerations to mitigate the risk that operational issues will hinder implementation. Ask the questions: *Is the service usable by referrers with the allocated resources? Does resource allocation enable clear service definition such that it can establish and communicate a clear purpose? Do resource allocation and implementation plans foster mainstreaming and widespread organisational awareness?*
- **Health and social care integration considerations:** a thorough investigation of the feasibility and utility of social care utilisation before considering the integration of these resources taking into account competing demands and interests with particular attention to timeliness given the urgent requirements of these programmes.
- **System and culture readiness considerations:** implementers must ensure an adequate structure for acute provision in the community is in place (e.g. timely diagnostics, timely record keeping) and must also consider the readiness of the existing work culture and structures for the community pathway. Ask the questions: *Is there a culture of defaulting to hospitalisation? Is it easier to access acute care? Are there issues of silo working which may prove a barrier?*

Finally, appraisal processes (i.e. reflexive monitoring) were identified as a barrier to both the implementation of 'Closer to Home' and its future development and sustainability; hence, implementers should take careful consideration of the appraisal and evaluation processes they put in place. This research highlights there is much to learn and take forward in this area and makes recommendations including continuous evaluation and expanding the range of outcomes considered which are described in more detail in the following sections.

11.3.3 Continuous evaluation

Given the identified difficulty in evaluating these programmes due to their complexity and evolving nature, evaluation should be considered early on, ideally

before implementation, and a flexible, real-time approach should be taken, ideally 'continuous reflective learning' as has been described by other researchers (Goodwin, 2019). Not only will this approach be more appropriate in capturing the ever-changing aspects of these programmes, and aid in identifying appropriate measures, but as Steventon et al. (2011) describe, "it is important to monitor hospital-avoidance interventions in real-time so that improvements can be made where necessary to improve effectiveness." In their commentary on understanding and evaluating the complexities of integrated care programmes, Goodwin (2019) provides the following reflection:

> *"The conclusion to be drawn is that programme evaluations, however well designed to work through economic and other impacts, are likely to have limited ability to explain how integrated care works in practice. Process evaluations within these will pick up on important key themes and issues in implementation, but not the tools and approaches that were used to enable them. What is needed is a shift in tactic where evaluation takes a more practical and participatory form to support continuous reflective learning that is embedded within integrated care projects and which act as a tool for quality improvement. Evaluation and monitoring practices may then become built-in to the DNA of everyday working practice, valued by all participants, and so enable the complexities of integrated care in specific contexts to be resolved in real-time."* (Goodwin, 2019, p.2)

11.3.4 Expand range of outcomes

Given the finding from this and other research that commissioners of these programmes primarily have a focus on reducing hospital activity and achieving cost savings, and that in reality they may have limited or counterintuitive impact on these, this research calls for commissioners of these programmes to expand their horizon on the outcomes they might achieve. In particular this research found a much wider range of benefits and impacts programmes like 'Closer to Home' might have. It is understandable that these wider impacts are not routinely evaluated, as benefits such as caregiver reassurance, improved quality of life or achieving person-centred care are difficult to evaluate robustly as they are not routinely captured and may require more time-consuming qualitative methods (Lloyd, 2020). In addition, in terms of level of evidence, qualitative data may be seen as a lower grade of evidence, however, as Kumpunen et al. (2019, p.14) put it, "the limitations of some of the existing approaches means that it is worth

taking risks and using more qualitative and mixed-methods work, including case studies."

Commissioners should consider the wider impacts of these programmes and should consider investing in qualitative or alternative approaches. Those implementing these programmes should consider implementing the routine collection of data for these wider impacts, including implementing more qualitative data collection. Other researchers have suggested investing in co-design with patients and other involved professionals in order to identify the right measures and right questions to be asking (Kumpunen et al., 2019).

11.4 Limitations of this research

11.4.1 Reliance on secondary data

The quantitative analyses conducted for this research relied on secondary data from existing databases. Chapter 7 described in detail the issues surrounding the use of existing data. The data familiarisation stage revealed various data quality issues and discrepancies requiring continuous measurement and assessment. Another prevalent issue was a lack of documentation, hence a lengthy process of verification and consultation with information services was undertaken to ensure a correct understanding of the data and to aid in the handling of any discrepancies observed. Discrepancies included missing columns of data which were due to having access to extracts rather than full datasets. These were resolved by requesting and obtaining full extracts accordingly. Other issues included missing patient identifiers or the use of incorrect or multiple patient identifiers (through the consultation process it was found that some patient identifiers change over time). Data quality issues and discrepancies were corrected where possible, for example, data linkage was used to recover missing identifiers or merge identifiers, by matching on name and date of birth. However, although best efforts were made to correct issues with quality, the limitation of using secondary data with possibly further discrepancies remains.

In addition, the measurement of comorbidity and frailty relied on ICD-10 codes from hospitalisation records (the accuracy of which is dependent on policies and procedures followed by clinical coders), which means comorbidity and frailty were unmeasured among patients without hospitalisation records. As previously highlighted however, the lack of measurement itself is a likely indicator of

reduced comorbidity and frailty given the lack of hospitalisation (Gilbert et al., 2018).

Missing data among particular columns of the final linked dataset were highlighted in Chapter 9, Section 9.4.1. Best efforts were made to assess and handle the missing data, however, ultimately it is missing data, hence it is certainly a limitation. Missing data is a widespread issue with healthcare databases in general, especially data obtained from routine electronic health records which are not usually designed for research and evaluation (Mazzali and Duca, 2015). Further effort on increasing the quality of healthcare databases is needed among commissioners hoping to make use of existing data systems for the purpose of evaluation, especially among community services in order to reduce this research limitation.

It must be highlighted however, that the use of secondary data reflects real-world circumstances and enables the assessment of interventions as they occur in practice rather than in a controlled environment. Hence, the use of secondary data may also be considered a strength of this research, particularly as the first study to examine and make use of routinely collected data to assess a new model of care that had never been attempted before.

11.4.2 Unmeasured data and unmeasured confounding

Patient-centred outcomes including quality of life, self-reported health and satisfaction with care are highly valuable indicators for the effectiveness of programmes like 'Closer to Home.' Unfortunately, these measures are not routinely recorded within electronic health systems, including NHS Forth Valley. Hence, as this research was limited to observational routinely recorded outcomes, they could not be examined, which is a limitation of this research. These measures are highly sought after as outcome measures in evaluation, hence further effort is needed towards incorporating patient-centred outcomes as part of routine data collection among health care providers, in order to reduce this limitation within medical informatics research.

Confounding to the results of the quantitative analysis was handled through a systematic approach to identifying confounders (particularly causal diagrams) and managing them appropriately (matching methods and covariate adjustment). Through the confounder identification process, confounders for which we have no

data were identified and noted immediately as limitations of the quantitative analysis conducted for this research. These unmeasured confounders include:

- Clinical measurements (e.g. oxygen saturation, laboratory results)
- Self-reported health
- Weight loss
- Quality of life (QoL)
- Caregiver factors (e.g. health and quality of life)

Again, such variables are not routinely collected in electronic healthcare systems, meaning healthcare informatics research making use of existing data and systems is often limited by unmeasured confounding of variables such as quality of life.

Partial data for several other potential confounders previously described (those with missing values) and limited data for other potential confounders (frailty and comorbidity) also lead to only partial confounding for these variables. This is a missing data limitation which was previously described.

11.4.3 Researcher bias

The qualitative analysis conducted as part of this research, evaluating the implementation of the 'Closer to Home' programme, involved thematic analysis where there is a risk that the researcher's previous knowledge, experience, motivation and/or beliefs may have influenced the thematic analysis. The risk is somewhat mitigated by the fact that the researcher was from outside the organisation and completely independent of the implementation process. Additionally, the process of thematic coding involved iteratively discussing samples of coded data with the supervisory team. Finally, the use of a thematic framework that has been well-established and widely used (NPT) may also mitigate some of this risk, as the thematic coding was guided by previously published research rather than being completely led by the researcher. Despite these actions to mitigate the risk of researcher bias, it should be recognised as a limitation of this research and is widely recognised as a limitation among qualitative research (Cohen and Crabtree, 2008). It should be noted however that despite this limitation, qualitative research is extremely valuable, providing insights that cannot be obtained through other methods, and in some perspectives, researcher subjectivity is viewed as "something used actively and creatively through the research process rather than as a problem of bias" (Cohen and Crabtree, 2008, p.333)

11.4.4 Generalisability

Selection bias is a threat to the external validity of the findings from the qualitative evaluation as a relatively small (n=18) sample of health and social care staff were interviewed. In particular, it was difficult to find interviewees who could represent perspectives on the ALFY service as it was coming to an end at the time of interviews, so only one participant who worked directly with the ALFY service could be interviewed. The views of the selected sample may not have been completely representative or generalisable of the whole.

In addition, although data for the entire population of the Forth Valley area, where the 'Closer to Home' programme was implemented, were analysed for the quantitative evaluation, the findings may not be generalisable to the wider population or to other healthcare services. However, this research was guided by an evaluation framework which took a holistic approach and aimed to capture the complexities of the system being studied, documenting its context, processes and outcomes. Hence, other researchers are able to use this evaluation and compare it or tailor it to their particular setting as appropriate, having an understanding of how their setting differs or compares.

11.5 Future Work

Traditional approaches such as controlled trials and summative evaluation have been highlighted by this and other research to have limitations in their ability to determine the true effect of admission avoidance programmes for elderly populations. This research calls for further work into understanding and defining the alternative approaches to evaluation previously described, that is continuous, reflective evaluation or theory-based approaches that are able to unpack the mechanisms of these complex interventions and are more adaptable to their ever-changing nature. Specifically, research is needed to define and specify theory-based evaluation as an approach to evaluating admission avoidance programmes for elderly patients, which is adapted to the complexity of the population and is able to capture the mechanisms involved in delivery and successful implementation of these programmes. Further, researchers should aid in developing standardised tools for assessing some of the less tangible outcomes that are not routinely captured (which limited this research as noted previously), where possible, such as the extent to which person-centred care is achieved,

patient-reported level of independence or security at home or other patient-centred outcomes.

While this research added substantive value by analysing the perspectives of staff involved in the 'Closer to Home' programme, qualitative analysis of the perspectives of patients using the services was outside the scope of this research as the focus was on analysing implementation. It is recognised however, that analysis of patient perspectives of both implementation but more importantly the value they receive from the services would be invaluable. Hence this is noted as an area for future work for gaining further insights into the 'Closer to Home' programme. More widely, it is noted that little attention has been paid in published research to exploring the effectiveness of integrated care initiatives like 'Closer to Home' from the perspective of users and carers (Cameron, Bostock and Lart, 2014). This stems naturally from the fact that these programmes have historically focused on hospital admission avoidance rather than person-centredness (Vaartio-Rajalin and Fagerström, 2019). Following on from the recommendation made by this research that commissioners of these programmes should expand the range of outcomes they hope to achieve and evaluate, this research calls for future work to prioritise the qualitative evaluation of patient and carer perspectives.

Finally, another area for future work would be a cost-effectiveness evaluation of the 'Closer to Home' programme, which was outside the scope of this research but would add substantive value towards the existing body of evidence in this area.

11.6 Summary and conclusions

This research found that 'Closer to Home' services have a key role to play in the healthcare ecosystem in Forth Valley but they have been unable to fully realise their potential benefits, having not become fully embedded and implemented in the healthcare system. Several barriers to implementation including cultural, operational and relational barriers and issues with organisational buy-in were observed which are common of these types of complex interventions. In addition, overall, the 'Closer to Home' services were not found to reduce emergency hospital admissions which was one of the aims of the initiative, in fact, patients receiving the services were found to have higher emergency admission rates that their comparison groups. Other researchers have observed this counterintuitive finding

among integrated care initiatives and along with this research can offer several hypotheses for what is being observed. This and other research are finding that delivery as intended is too challenging in real world settings, that evaluation of these programmes is difficult and complex, that commissioners have unrealistic expectations and a limited focus on what these programmes can achieve and finally that these programmes may identify unmet need leading to increased healthcare activity.

This multidisciplinary, health informatics PhD research has provided the first comprehensive, mixed-methods evaluation of the 'Closer to Home' admission avoidance programme in NHS Forth Valley. A key research contribution has been the exploration of the implementation, operational processes, data and quantitative effect of a new model of care within Forth Valley that had never been trialled before.

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Appendices

Appendix A Contextual Documents and Figures

Figure A-1 Strategic Outcomes for Optimising Older People's Quality of Life in Scotland (Cohen et al., 2014, p.10)

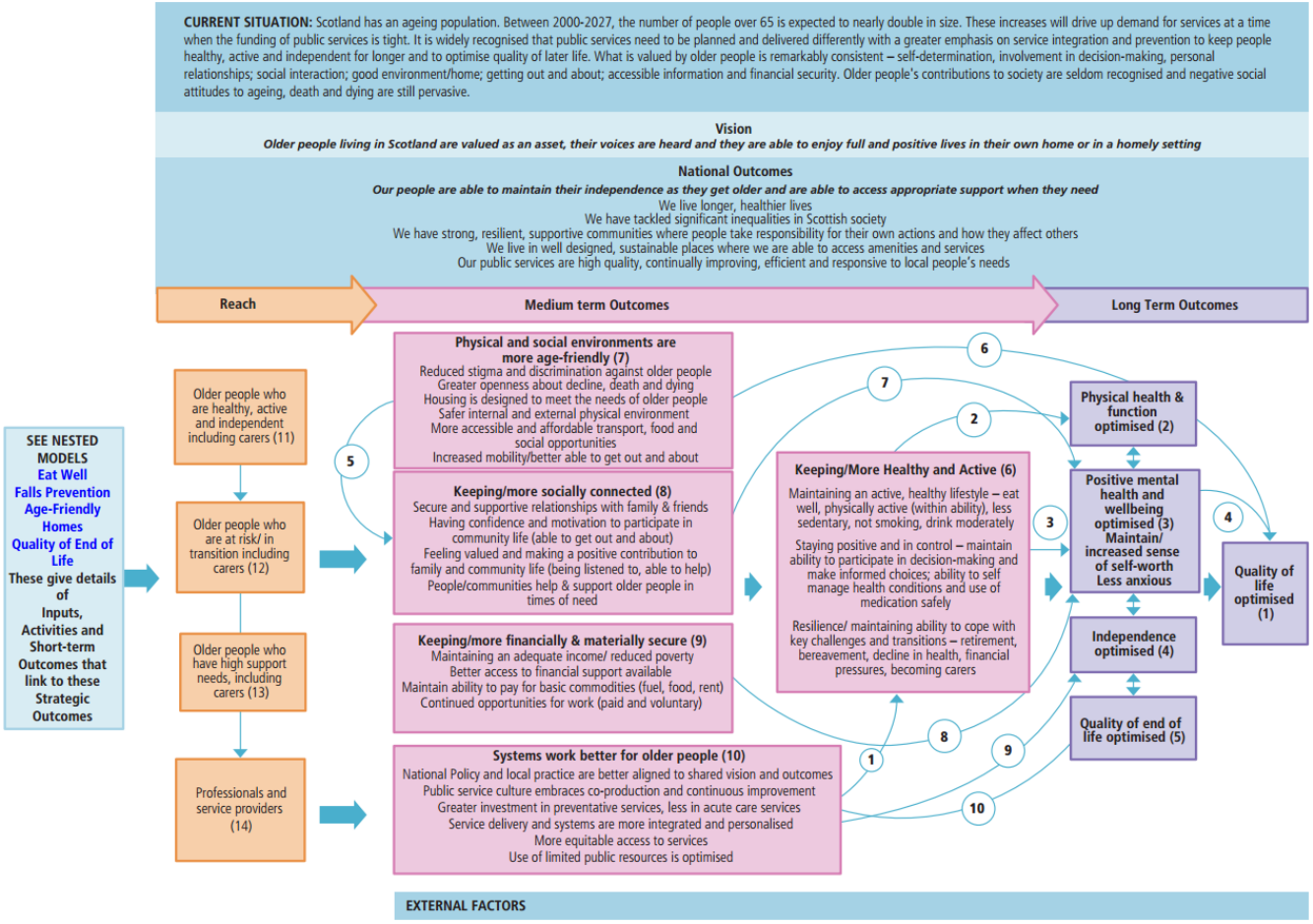

Figure A-2 Projected percentage change in population aged 75 and over, by council area, 2014 to 2039 (National Records of Scotland, 2016, p.29)

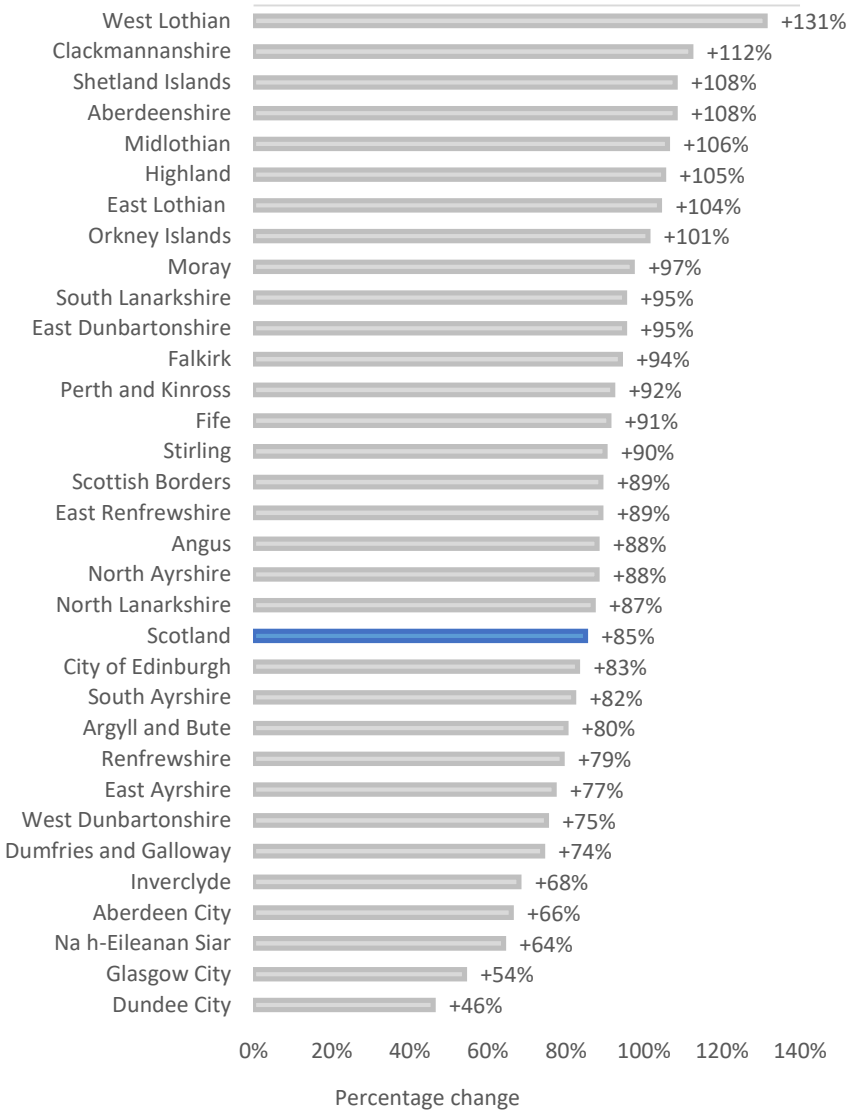

Figure A-3 Timeline of significant events in NHS Forth Valley relating to the RCOP strategy 2002-2014 (Niven, Middlemiss and McNairney, 2015)

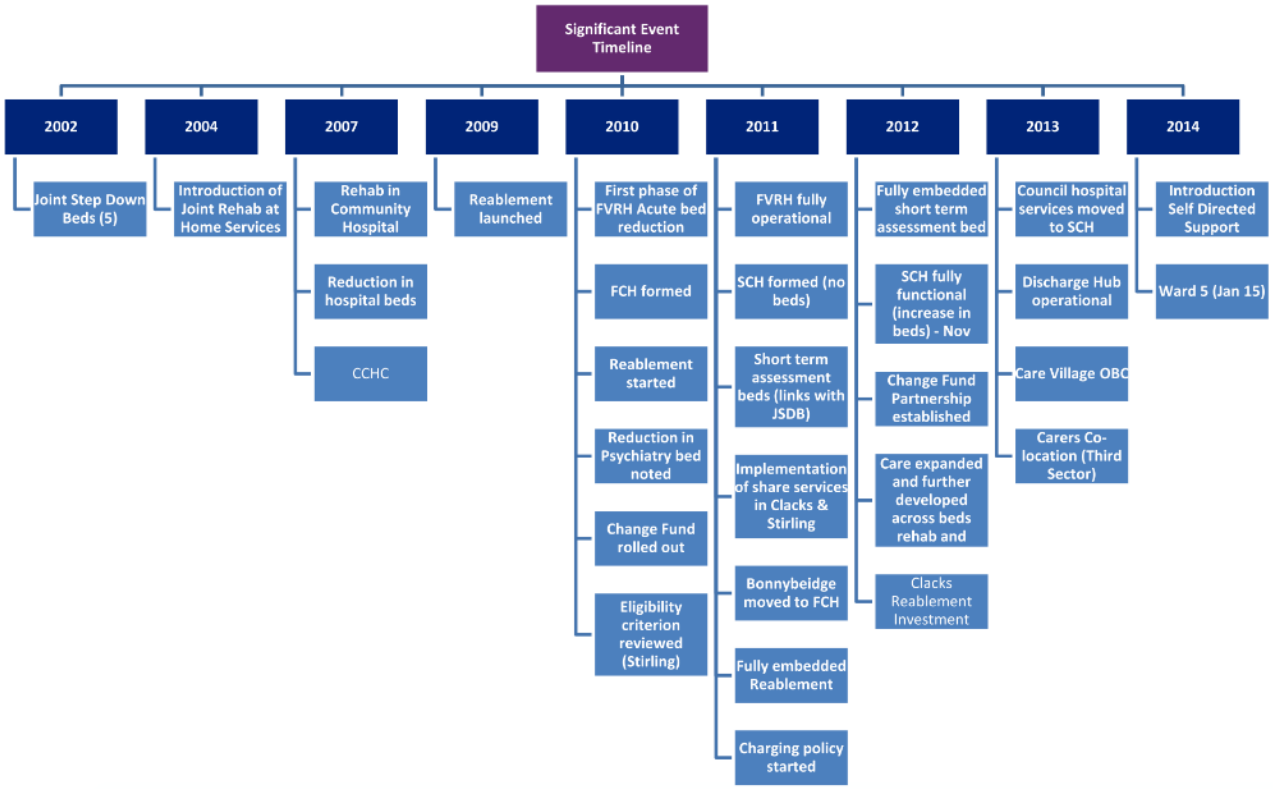

Table A-1 Clackmannanshire & Stirling Reshaping Older People's Care Change Fund Partnership – End of Programme Report for period 2011/12 – 2014/15 (Financial Overview) (Niven, Middlemiss and McNairney, 2015)

Project Title	Delivery Body	2011/12 Allocation (£)	2012/13 Allocation (£)	2013/14 Allocation (£)	2014/15 Allocation (£)
Development of Intermediate Care Services					
Clackmannanshire Intermediate Care Services	Clackmannanshire Council & NHS Forth Valley	N/A	87,032	367,449	126,932
Intermediate Care Stirling — Bridging model including Stirling Social Work Assessment and Allocation	Stirling Council & NHS Forth Valley	N/A	245,738	345,966	345,966
Social Work Hospital Allocation Review	Stirling Council & NHS Forth Valley	N/A	N/A	31,500	N/A
Stirling Community Hospital — Ward 4 Enhanced Discharge — AHP Component	NHS Forth Valley	N/A	79,166	96,000	86,389
Community Living Integrated Care Team - Integrated Service Model in West Stirlingshire	Stirling Council & NHS Forth Valley	N/A	N/A	82,412	166,452
Medicine Management at Home	Clackmannanshire Council & NHS Forth Valley & Stirling Council	N/A	72,500	N/A	N/A
Enabling Self Medication Before Discharge	NHS Forth Valley	N/A	26,869	N/A	N/A
Review & Redesign of Home to Home Pathway	NHS Forth Valley	10,345	12,932	5,140	N/A
Enhanced Discharge Stirling Council SW OT	Stirling Council	N/A	39,386	42,577	N/A
Stirling Reablement	Stirling Council	100,000	N/A	N/A	N/A
Clackmannanshire Reablement	Clackmannanshire Council	70,000	N/A	N/A	N/A
Anticipatory and Preventative Services					
Frailty Rapid Access Service	NHS Forth Valley	N/A	N/A	315,350	189,820
Anticipatory Care Planning – Nursing	NHS Forth Valley	31,000	12,350	89,641	139,706
Intermediate Care Coordinator (Falls Prevention)	Clackmannanshire Council & NHS Forth Valley & Stirling Council	N/A	31,786	63,573	N/A
Care Home Liaison: Supporting Older Adults with Complex Mental Health Needs	NHS Forth Valley	N/A	29,676	44,931	44,931
Implementing the adapted '6 Steps' approach'— to palliative and end of life care in care homes	Strathcarron Hospice & NHS Forth Valley	N/A	N/A	16,222	16,022
Supporting Acute Flow — AHP 7 Day Model	NHS Forth Valley	58,000	28,158	43,466	N/A
Acute Psychiatric Liaison	NHS Forth Valley	41,000	41,000	41,000	N/A
Sliding Doors	Stirling Council	N/A	N/A	8,050	N/A

Carers					
Anticipatory Care Planning - Carers	Princess Royal Carers Centre — Clackmannanshire & Falkirk	N/A	16,031	21,375	55,500
Enhanced Hospital Discharge - Carers	Princess Royal Carers Centre — Clackmannanshire & Falkirk	N/A	10,800	14,400	
Community Training for Carers	Princess Royal Carers Centre — Clackmannanshire & Falkirk	N/A	17,311	13,849	
Carer Centre Development	Princess Royal Carers Centre — Clackmannanshire & Falkirk	N/A	4,863	11,185	
Anticipatory Care - Carer Support Officer	Stirling Carers Centre	N/A	22,465	29,953	111,587
Enhanced Discharge - Carer Support Officer	Stirling Carers Centre	N/A	16,848	22,464	
Adult Rural Carer Support Officer	Stirling Carers Centre	5,602	36,575	37,614	
Development Manager - Carer Engagement	Stirling Carers Centre	N/A	18,135	41,024	
Supporting Service Users with Dementia and Mental Health conditions					
Dementia Friendly Community	Dementia Services Development Centre	N/A	N/A	50,000	50,000
Post-diagnostic Support & Community Connections Programme	Alzheimer Scotland	5,267	61,700	64,890	58,152
Friendship Groups, Services Assistant, and Cognitive Stimulation Therapy	Town Break — Dementia Support Services	1,739	18,297	24,002	15,613
Open Door - Supported Volunteering Service	Stirlingshire Voluntary Enterprise - SVE	6,416	51,327	68,402	27,751
Developing Community Capacity / Community Supports					
Stirling Community Support Services (incorporating Home from Hospital service)	Royal Voluntary Service	N/A	63,300	61,358	32,440
Clackmannanshire Community Transport and Good Neighbours	Royal Voluntary Service	N/A	N/A	44,155	43,736
Active Living for Life – Brief Intervention Exercise Referral	Active Stirling	N/A	14,064	34,000	17,010
Retired and Senior Volunteer Programme (RSVP) Forth Valley	Retired and Senior Volunteer Programme (RSVP) Forth Valley	6,875	30,000	37,423	28,067
Dallas Living it Up	NHS Forth Valley	N/A	2,906	11,125	11,125
Forth Valley Community Equipment Project	NHS Forth Valley	N/A	N/A	20,000	20,000

Community Equipment Project No.2 Jan15	NHS Forth Valley	N/A	N/A	N/A	15,000
Clackmannanshire Healthier Lives	Signpost Recovery	25,200	75,600	61,846	N/A
Palliative Care Workforce Training	Crossroads Stirling	259	3,364	N/A	N/A
Palliative Care Workforce Training	Crossroads West Stirlingshire	412	4,939	N/A	N/A
Change Fund Support Team including: 2 x 3rd Sector Engagement Officers; Data Analyst, Organisational Development Adviser; Planning and Coordination staff	Clackmannanshire Third Sector Interface (CTSi); Stirlingshire Voluntary Enterprise (SVE); NHS Forth Valley; Clackmannanshire Council; Stirling Council.	59,279.5	259,279.5	252,376	256,486
Total allocation for the year		621,394.5	1,434,397.5	2,514,718	1,858,685
Programme Total Allocation			6,429,195		
Total allocation to Carers (Direct & Indirect).		74,714.7	409,860	560,075	404,994
Programme Total to Carers			1,449,643.7		
Total allocation to Clackmannanshire		241,225.1	447,547.6	883,842	496,703
Programme Total to Clackmannanshire			2,069,317.7		
Total allocation to Stirling		380,169.4	986,849.9	1,630,876	1,361,982
Programme Total to Stirling			4,359,877.3		
Total allocation to NHS		236,800.75	471,413.35	1,042,853.7	785,651.4
Programme Total to NHS			2,536,719.2		
Total Allocation to Social Services		266,455.75	428,091.15	748,320.3	547,673.6
Programme Total to Social Services			1,990,540.8		
Total Allocation to Third Sector		118,138	534,893	723,544	525,360
Programme Total to Third Sector			1,901,935		

Figure A-4 'Aide Memoire' – Introductory prompts and questions used by community nurses while on the ALFY line

ASK ALFY - Nursing Support Line – Process

Introductory Prompts – Aide Memoire

To be read in conjunction with the Flow Charts for in and out of hours

Conversation Questions

Hello, NHS Forth Valley ALFY Nursing Support Line, [state your name]

Q1 **Can you confirm the name, address and date of birth of the person you are calling about** *(or the caller if it is him/herself)*

Q2 **Can you confirm the address?**

Q3 **What's the best number to call you back on ? (in case you get cut off)**

Q4 **We will need to log details of this call onto the computer and may have to share it with other health and social care professionals. Are you happy to proceed on that basis?**

Q5 **Does the person you are telephoning about know you are calling? (If the call is concerning someone other than him/herself)** Please be aware of issues in relation to information disclosure/ confidentiality.

Q6 **How can I help you ?** (today / this evening)

If caller describes a situation that is a medical emergency or requires medical assistance , advise the caller to contact 999 or 111.

Talk back = So you are calling today about ..... *(ensuring person centred approach)*

Q7 **Can you tell me a bit more information about the reason for your call?**

Q8 **What have you done so far to alleviate the situation?**

Q9 **Does the person you are telephoning about have a Personal Plan?** *(if the caller or the person the caller is phoning on behalf of has a Plan, ask if they have access to it as it may be useful to talk through it)*

Please see further information below

- Offer Your Plan and ALFY information – this can be posted out
- Offer ACP if appropriate
- Offer Carers trust to family
- Ask where they heard about ALFY
- Have we helped today ? remember to tick all signifiers that apply on E-WARD!

Selecting the appropriate Option (s)

- **Refer to A4 sheets for further information in relation to each option.**
- **Choose one or several options, dependent on what support the caller requires.**
- **Log all details of the call on the Activity Log sheet.**
- **Email to the OOH Administrator / Night Nursing Service / or log directly onto the database**

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Appendix B Supplementary tables for scoping literature review

Table B-1 Study codes and references for studies included in scoping literature review

Study code	Reference
Aimonino2008	Aimonino Ricauda, N., Tibaldi, V., Leff, B., Scarafiotti, C., Marinello, R., Zanocchi, M. and Molaschi, M., 2008. Substitutive 'hospital at home' versus inpatient care for elderly patients with exacerbations of chronic obstructive pulmonary disease: a prospective randomized, controlled trial. *Journal of the American Geriatrics Society*, 56(3), pp.493–500.
Caplan2005	Caplan, G.A., Coconis, J., Board, N., Sayers, A. and Woods, J., 2006. Does home treatment affect delirium? A randomised controlled trial of rehabilitation of elderly and care at home or usual treatment (The REACH-OUT trial). *Age & Ageing*, 35(1), pp.53–60.
Caplan2006	Caplan, G.A., Coconis, J. and Woods, J., 2005. Effect of hospital in the home treatment on physical and cognitive function: a randomized controlled trial. *The journals of gerontology. Series A, Biological sciences and medical sciences*, 60(8), pp.1035–1038.
Closa2017	Closa, C., Mas, M.A., Santaeugenia, S.J., Inzitari, M., Ribera, A. and Gallofre, M., 2017. Hospital-at-home Integrated Care Program for Older Patients With Orthopedic Processes: An Efficient Alternative to Usual Hospital-Based Care. *Journal of the American Medical Directors Association*, 18(9), pp.780–784.
DiPollina2017	Di Pollina, L., Guessous, I., Petoud, V., Combescure, C., Buchs, B., Schaller, P., Kossovsky, M. and Gaspoz, J.-M., 2017. Integrated care at home reduces unnecessary hospitalizations of community-dwelling frail older adults: a prospective controlled trial. *BMC Geriatrics*, [online] 17(1), p.53. Available at: <http://www.ncbi.nlm.nih.gov/pubmed/28196486> [Accessed 8 Jun. 2018].
Isaia2009	Isaia, G., Astengo, M.A., Tibaldi, V., Zanocchi, M., Bardelli, B., Obialero, R., Tizzani, A., Bo, M., Moiraghi, C., Molaschi, M. and Ricauda, N.A., 2009. Delirium in elderly home-treated patients: a prospective study with 6-month follow-up. *Age (Dordrecht, Netherlands)*, 31(2), pp.109–117.
Kwok2004	Kwok, T., Lee, J., Woo, J., Lee, D.T. and Griffith, S., 2008. A randomized controlled trial of a community nurse-supported hospital discharge programme in older patients with chronic heart failure. *Journal of clinical nursing*, 17(1), pp.109–117.
Kwok2008	Kwok, T., Lum, C.M., Chan, H.S., Ma, H.M., Lee, D. and Woo, J., 2004. A randomized, controlled trial of an intensive community nurse-supported discharge program in preventing hospital readmissions of older patients with chronic lung disease. *Journal of the American Geriatrics Society*, 52(8), pp.1240–1246.
Leff2005	Leff, B., Burton, L., SL, M., Naughton, B., Burl, J., SK, I., III, G.W.B., Guido, S., Langston, C., KD, F., Steinwachs, D. and JR, B., 2005. Hospital at home: feasibility and outcomes of a program to provide hospital-level care at home for acutely ill older patients. *Annals of Internal Medicine*, [online] 143(11), pp.756–798. Available at: <http://search.ebscohost.com/login.aspx?direct=true&AuthType=athens,cookie,ip,url,uid&db=rzh&AN=106400915&site=ehost-live>.
Leff2006	Leff, B., Burton, L., Mader, S., Naughton, B., Burl, J., Clark, R., Greenough, W.B. 3rd, Guido, S., Steinwachs, D. and Burton, J.R., 2006. Satisfaction with Hospital at Home Care. *Journal of the American Geriatrics Society*, [online] 54(9), pp.1355–1363. Available at: <https://search.proquest.com/docview/210372711?accountid=14116>.

Study code	Reference
Leung2015	Leung, D.Y.P., Lee, D.T.-F., Lee, I.F.K., Lam, L.-W., Lee, S.W.Y., Chan, M.W.M., Lam, Y.-M., Leung, S.-H., Chiu, P.-C., Ho, N.K.F., Ip, M.-F. and Hui, M.M.Y., 2015. The effect of a virtual ward program on emergency services utilization and quality of life in frail elderly patients after discharge: a pilot study. *Clinical interventions in aging*, [online] 10, pp.413–420. Available at: <https://www.dovepress.com/the-effect-of-a-virtual-ward-program-on-emergency-services-utilization-peer-reviewed-fulltext-article-CIA>.
Lewis2017	Lewis, C., Moore, Z., Doyle, F., Martin, A., Patton, D. and Nugent, L.E., 2017. A community virtual ward model to support older persons with complex health care and social care needs. *Clinical interventions in aging*, 12, pp.985–993.
Lin2015	Lin, F.O., Luk, J.K., Chan, T., Mok, W.W. and Chan, F.H., 2015. Effectiveness of a discharge planning and community support programme in preventing readmission of high-risk older patients. *Hong Kong Med J* , [online] 21(3), pp.208–16. Available at: <http://www.hkmj.org/system/files/hkmj144304.pdf> [Accessed 18 Sep. 2017].
Mas2016	Mas, M.À., Closa, C., Santaeugènia, S.J., Inzitari, M., Ribera, A. and Gallofré, M., 2016. Hospital-at-home integrated care programme for older patients with orthopaedic conditions: Early community reintegration maximising physical function. *Maturitas*, [online] 88, pp.65–69. Available at: <https://search.proquest.com/docview/1783912019?accountid=14116>.
Mas2017	Mas, M.A., Inzitari, M., Sabate, S., Santaeugenia, S.J. and Miralles, R., 2017. Hospital-at-home Integrated Care Programme for the management of disabling health crises in older patients: comparison with bed-based Intermediate Care. *Age & Ageing*, 46(6), pp.925–931.
Mendoza2009	Mendoza, H., Martín, M.J., García, A., Arós, F., Aizpuru, F., Regalado De Los Cobos, J., Belló, M.C., Lopetegui, P. and Cia, J.M., 2009. 'Hospital at home' care model as an effective alternative in the management of decompensated chronic heart failure. *European Journal of Heart Failure*, [online] 11(12), pp.1208–1213. Available at: <http://doi.wiley.com/10.1093/eurjhf/hfp143> [Accessed 14 Aug. 2017].
Parsons2018	Parsons, M., Parsons, J., Rouse, P., Pillai, A., Mathieson, S., Parsons, R., Smith, C. and Kenealy, T., 2018. Supported Discharge Teams for older people in hospital acute care: a randomized controlled trial. *Age & Ageing*, 47(2), pp.288–294.
Senior2014	Senior, H.E.J., Parsons, M., Kerse, N., Chen, M.-H., Jacobs, S., Hoorn, S. Vander and Anderson, C.S., 2014. Promoting independence in frail older people: a randomised controlled trial of a restorative care service in New Zealand. *Age & Ageing*, 43(3), pp.418–424.
Shyu2013	Shyu, Y.-I.L., Liang, J., Tseng, M.-Y., Li, H.-J., Wu, C.-C., Cheng, H.-S., Chou, S.-W., Chen, C.-Y. and Yang, C.-T., 2013. Comprehensive and subacute care interventions improve health-related quality of life for older patients after surgery for hip fracture: a randomised controlled trial. *International journal of nursing studies*, 50(8), pp.1013–1024.
Tibaldi2009	Tibaldi, V., Isaia, G., Scarafiotti, C., Gariglio, F., Zanocchi, M., Bo, M., Bergerone, S. and Ricauda, N.A., 2009. Hospital at home for elderly patients with acute decompensation of chronic heart failure: a prospective randomized controlled trial. *Archives of internal medicine*, 169(17), pp.1569–1575.
Wright2013	Wright, P.N., Tan, G., Iliffe, S. and Lee, D., 2013. The impact of a new emergency admission avoidance system for older people on length of stay and same-day discharges. *Age and Ageing*, [online] 43(1), pp.116–121. Available at: <https://search.proquest.com/docview/1520311872?accountid=14116>.
Ziden2008	Ziden, L., Frandin, K. and Kreuter, M., 2008. Home rehabilitation after hip fracture. A randomized controlled study on balance confidence, physical function and everyday activities. *Clinical rehabilitation*, 22(12), pp.1019–1033.

Table B-2 Full study details for each of the studies included in the scoping literature review

Study code	Aimonino2008
Reference	Aimonino Ricauda, N., Tibaldi, V., Leff, B., Scarafiotti, C., Marinello, R., Zanocchi, M. and Molaschi, M., 2008. Substitutive 'hospital at home' versus inpatient care for elderly patients with exacerbations of chronic obstructive pulmonary disease: a prospective randomized, controlled trial. *Journal of the American Geriatrics Society*, 56(3), pp.493–500.
Setting (Location)	University hospital and community in Torino, Italy
Study population size	n=104 (52 per group)
Target population (eligibility)	Aged ≥75 years, admitted to the ED with a diagnosis of acute exacerbation of COPD having been evaluated for at least 12-24 hours with stable clinical conditions. (Inclusion criteria: living within catchment area, appropriate care supervision at home, telephone connection, informed consent. Exclusion criteria: severe hypoxemia, severe acidosis or alkalosis, suspected pulmonary embolism, suspected MI, need for hemodialysis, severe renal impairment, cancer except skin cancer, hepatic failure or severe dementia)
Intervention group	Patients immediately transferred home from ED by ambulance to physician-led substitutive hospital-at-home care (GHHS), provided by a multidisciplinary team of three geriatricians, 13 nurses, two PTs, one SW and one counsellor, with access to seven cars, in addition to usual ED care. Hospital-level care included blood tests, ECG, antimicrobials and other medicines, blood transfusions, surgical treatment of pressure ulcers, echocardiograms, echographs, Doppler ultrasonographies. Other care includes physiotherapy, occupational therapy, patient and caregiver disease management education and counselling. Patients requiring hospital diagnostics (e.g. x-ray, endoscopy) were transferred to hospital during the GHHS episode but returned home within a few hours. In first few days, patients receive daily physician and nurse visits, followed by daily nurse visits and physician visits every 2-3 days subsequently. The service was available 7 days a week, with staff available at all times for urgent visits. Average number of home visits: 14.1 nursing, 9.9 physician.
Comparison group (controls)	Patients receiving usual hospital inpatient care for exacerbations of COPD at a general medical ward (GMW) after attendance at the same ED where usual care included standard clinical evaluation, blood tests, pulse oximetry, ECG, chest radiographs, hand-held spirometry and pneumologist's assessment where required.
Study population baseline demographics (intervention vs control)	Age (mean): 80 vs 79 (n.s.), Gender: 44% vs 25% female (n.s.), Married: 52% vs 56% (n.s.), Family support at home: 100% in both groups, Non-smoker (vs current or ex-smoker): 21% in both groups, Comorbidity (CIRS)/14 (mean): 2.6 vs 3.0 (n.s.), APACHE severity of illness score/100 (mean): 9.5 vs 10.3 (n.s.), ADL/6 (mean): 2.3 vs 1.9 (n.s.), IADL/14 (mean): 7.1 vs 8.1 (n.s.), Depression (GDS/30) (mean): 16.1 vs 17.2 (n.s.), Cognition (MMSE/30) (mean): 21.8 in both groups (n.s.), Nutrition (MNA/30) (mean): 17.1 vs 18.3 (n.s.) (Overall no significant differences)
Study design (classified)	Randomised single-blind controlled trial (RCT)
Study design (self-reported)	Randomised single-blind controlled trial (RCT)
Primary outcome measure(s)	Hospital readmission rates and mortality at 6 months follow-up
Secondary outcome measure(s)	Time to readmission (days), Length of stay of acute episode and Direct costs per patient per day of acute episode in both groups (hospital or GHHS). Changes in depression status (GDS), functional status (ADL/IADL), cognitive status (MMSE), quality of life (NHP), nutritional status (MNA) and caregiver stress (Relatives' Stress Scale) from baseline to 6 months follow-up. Patient satisfaction (ad hoc questionnaire) at discharge.
Follow-up period	Outcomes assessed at baseline and 6 months follow-up. Recruitment period: 1 year.

Study code	Isaia2009
Reference	Isaia, G., Astengo, M.A., Tibaldi, V., Zanocchi, M., Bardelli, B., Obialero, R., Tizzani, A., Bo, M., Moiraghi, C., Molaschi, M. and Ricauda, N.A., 2009. Delirium in elderly home-treated patients: a prospective study with 6-month follow-up. *Age (Dordrecht, Netherlands)*, 31(2), pp.109–117.
Setting (Location)	University hospital and community in Torino, Italy
Study population size	n=144 (84 intervention, 60 control)
Target population (eligibility)	Aged ≥75 years, community dwelling, admitted to the ED for an acute illness (conditions not specified) (Inclusion criteria: absence of probable or definite delirium at enrolment determined by CAM, caregiver, informed patient or proxy consent. Exclusion criteria: inability to undergo interview, severe dementia making MMSE unfeasible, coma, aphasia or intubation or terminally ill expecting less than 6 months survival)
Intervention group	Patients transferred home from ED for physician-led substitutive hospital-at-home-care (GHHS), provided by a multidisciplinary team of three geriatricians, 13 nurses, two PTs, one SW and one counsellor, operating seven days a week, in addition to usual ED care. For details of hospital-level and other care provided by GHHS see intervention details for Aimonino Ricauda et al., 2008. In addition monitoring of predisposing risk factors for delirium and delirium prevention strategies adopted as in usual care (control).
Comparison group (controls)	Patients receiving usual hospital inpatient care at a geriatric hospital ward (GHW) after attendance at the same ED where care included standard clinical evaluation, blood tests, ECG, chest radiograms and further investigations where required. Additional inpatient care included monitoring of predisposing risk factors for delirium and delirium prevention strategies adopted including: reorientation techniques (name boards, clocks), environmental modifications to prevent cognitive deprivation (current events, word games twice daily), daily mobilisation (at least three times daily), prevention of sleep deprivation, prevention of malnutrition and dehydration.
Study population baseline demographics (intervention vs control)	Age (mean): 86.1 vs 84.7 (n.s.), Gender: 76.2% vs 70.0% female (n.s.), Married: 42.8% vs 43.3% (n.s.), Living alone: 0.0% vs 6.7% (n.s.), Number of medications at enrolment (mean): 5.8 vs 4.3 (n.s.), High risk of delirium: 38% vs 40% (n.s.), ADL/6 (mean): 2.0 vs 3.4 ($p<0.05$), IADL/14 (mean): 5.4 vs 6.1 (n.s.), Cognition (MMSE/30) (mean): 18.1 vs 21.6 ($p=0.05$), Nutrition (MNA/30) (mean): 15.7 vs 14.4 ($p<0.05$), GDS/30 (mean): 13.2 vs 13.3 (n.s.), QoL (NHP) (mean) 18.1 vs 21.3 (n.s.), Comorbidity (CIRS)/13 (mean): 2.1 vs 0.9 ($p<0.001$), Illness severity (APACHE II/71) (mean): 19.8 vs 18.6 ($p<0.05$), Hearing impairment: 40.5% vs 36.6% (n.s.), Visual impairment: 42.8% vs 46.6% (n.s.) (Overall main significant difference in comorbidity, severity of illness, ADL, nutrition and cognition)
Study design (classified)	Concurrently controlled prospective cohort study (PCS) (allocation decision seems to be based on information collected prospectively potentially availability of resources, specified as observational but allocation rule not described)
Study design (self-reported)	Prospective non-randomised observational study
Primary outcome measure(s)	Incidence of delirium, severity of delirium (Delirium Rating Scale), mortality, hospital readmission (stated but not reported in results on for both groups) and institutionalisation rates at 6 month follow-up.
Secondary outcome measure(s)	Onset of delirium (days), Duration of delirium episode (days), Number of psychoactive drugs used during acute episode, LOS of acute episode, Number of complications during acute episode, Caregiver stress (Relatives' Stress Scale), Cost of home or hospital care per patient per day.
Follow-up period	Outcomes assessed at baseline and 6 months follow-up. Recruitment period: 3 months.

Study code	Tibaldi2009
Reference	Tibaldi, V., Isaia, G., Scarafiotti, C., Gariglio, F., Zanocchi, M., Bo, M., Bergerone, S. and Ricauda, N.A., 2009. Hospital at home for elderly patients with acute decompensation of chronic heart failure: a prospective randomized controlled trial. *Archives of internal medicine*, 169(17), pp.1569–1575.
Setting (Location)	University hospital and community in Torino, Italy
Study population size	n=101 (48 intervention, 53 control)
Target population (eligibility)	Aged ≥75 years, with a pre-existing diagnosis of CHF, admitted to the ED for acute decompensation of CHF assessed as bing in need of hospital care (Inclusion criteria: American Heart Association Stage C CHF, persistent functional impairment NYHA class III or IV, appropriate care supervision at home, telephone connection, living within catchment area, at least 1 previous admission for acute CHF, need for IV treatment and informed consent. Exclusion criteria: new-onset HF, absence of family and social support, need for mechanical ventilation, hemodialysis or intensive monitoring, severe dementia MMSE<14, terminal malignant neoplast, severe renal impairment, hepatic failure, serum hemoglobin level <9g/dL and planned cardiac surgery)
Intervention group	Patients transferred home from ED within a few hours by ambulance for physician-led substitutive hospital-at-home-care (GHHS), provided by a multidisciplinary team of three geriatricians, 13 nurses, two PTs, one SW and one counsellor, operating seven days a week, in addition to usual care ED care (control). For details of hospital-level and other care provided by GHHS see intervention details for Aimonino Ricauda et al., 2008. The most common conditions treated at home were cardiopulmonary, cerebrovascular, metabolic and neoplastic diseases. Average numbers of home visits: 13.8 nursing visits and 11.1 physician visits. Average treatment duration: 20.7 days.
Comparison group (controls)	Patients receiving usual hospital inpatient care for CHF at a general medical ward (GMW) after attendance at the same ED, where care included standard clinical evaluation, routine blood tests, pulse oximetry, ECG, chest radiography, echocardiography for LVF (if not performed in last 6 months), cardiologist assessment where required. Protocols for frail elderly patients such as prevention of nosocomial infections, bed sores and immobilisation routinely adopted during inpatient care. Average treatment duration: 11.6 days.
Study population baseline demographics (intervention vs control)	Age (mean): 82.2 vs 80.1 ($p<0.05$), Gender: 54% vs 43% female (n.s.), Married: 46% vs 45% (n.s.), Family support at home: 100% in both groups (n.s.), Schooling <5 years: 69% vs 68% (n.s.), Infection: 35% vs 43% (n.s.), New AF: 29% vs 32% (n.s.), Hypertensive crisis: 14% vs 17% (n.s.), Functional status (BI/100) (mean): 66.5 vs 62.2 (n.s.), IADL/14 (mean): 6.8 vs 7.7 (n.s.), Cognition (MMSE/30) (mean): 22.6 vs 24.6 (n.s.), Nutrition (MNA/30) (mean): 18.9 vs 20.8 (n.s.), Comorbidity index (CIRS CI/14) (mean): 3.6 vs 3.4 (n.s.), Illness severity index (CIRS SI/5) (mean): 2.7 vs 2.9 (n.s.), Severity of disease (APACHE II/100) (mean): 10.7 vs 11.6 (n.s.), QoL (NHP/38) (mean): 18.9 vs 16.5 (n.s.), caregiver stress (RSS): 25.4 vs 17.1 ($p<0.01$) (Overall main significant difference in age and caregiver stress)
Study design (classified)	Randomised single-blind controlled trial (RCT)
Study design (self-reported)	Prospective single-blind randomised controlled trial (RCT)
Primary outcome measure(s)	Mortality at 6-months follow-up
Secondary outcome measure(s)	Incidence of medical complications (infections, delirium) during acute care episode, incidence of nursing home admission, and subsequent all-cause hospital admissions during 6-month follow-up. LOS of acute episode, Time to first readmission after discharge from intervention or usual care and LOS (days). Changes in caregiver stress (RSS) from admission to discharge from intervention or usual care. Changes in functional status (BI and IADL), depression (GDS), nutritional status (MNA), cognition (MMSE) and QoL (NHP) from baseline to 6-month follow-up. Total mean cost of acute episode per patient.
Follow-up period	Outcomes assessed at admission to intervention or usual care and at 6-month follow-up. Recruitment period: 1 year.

Study code	Caplan2005
Reference	Caplan, G.A., Coconis, J., Board, N., Sayers, A. and Woods, J., 2006. Does home treatment affect delirium? A randomised controlled trial of rehabilitation of elderly and care at home or usual treatment (The REACH-OUT trial). *Age & Ageing*, 35(1), pp.53–60.
Setting (Location)	Tertiary referral teaching hospital and community in Syndey, Australia
Study population size	n=100 (51 intervention, 49 control)
Target population (eligibility)	Aged >65 (targeted towards them though younger patients included, 23% under 60), including nursing home patients, admitted to the ED for acute (pneumonia, UTI, cellulitis) and subacute (endocarditis and osteomyelitis) infections requiring IV antibiotics, DVT, minor CVA and cardiac failure. (Inclusion criteria: living within catchment area, caregiver at home, patient and caregiver consent, safe home suitable for home treatment with running water, electricity and toilet. Exclusion criteria: evidence of shock, requiring oxygen, judged too unwell by team)
Intervention group	Patients transferred home from ED within 24 hours of diagnosis (8 hours on average) for admission substitution to hospital-in-the-home (HITH), provided primarily by nurses. Average numbers of home visits: 9 by nurses, 0.8 by physician, 0.9 by hospital doctor, 0.2 by PT, 0.1 by OT. Average length of intervention: 10.1 days. Treatment according to diagnosis at ED, including medication administration, blood transfusions, IV antibiotics, subcutaneous enoxaparin injections and warfarin for DVT.
Comparison group (controls)	Patients receiving usual hospital inpatient care for acute and subacute conditions after attendance at ED (inpatient within 12 hours), with standard regimens and no intervention of HITH team.
Study population baseline demographics (intervention vs control)	Age (mean): 70.5 vs 69.7 (n.s.), Gender: 58.8% vs 51.0% female (n.s.), Living at home: 72.5% vs 67.3% (n.s.), Living in nursing home: 23.5% vs 26.5% (n.s.), Rehabilitation admission BI/20: 15.2 vs 14.8 (n.s.), IADL/12: 6.8 vs 6.2 (n.s.), Mental Status Questionnaire/10: 7.1 vs 6.9 (n.s.) (Overall no significant differences)
Study design (classified)	Randomised controlled trial (RCT)
Study design (self-reported)	Randomised controlled trial (RCT)
Primary outcome measure(s)	Changes in Functional status (BI), Functional independence (IADL index) and Cognition (MSQ score) from admission to discharge
Secondary outcome measure(s)	Time in the ED before transfer to home or hospital bed.
Follow-up period	Outcomes assessed at baseline and at discharge (average length of stay for intervention 10.1 days, control 7.4 days). Follow-up at 6 months to identify whether alive (not reported on) and accomodation. Recruitment period: 5 months.

Study code	Caplan2006
Reference	Caplan, G.A., Coconis, J., Board, N., Sayers, A. and Woods, J., 2006. Does home treatment affect delirium? A randomised controlled trial of rehabilitation of elderly and care at home or usual treatment (The REACH-OUT trial). *Age & Ageing*, 35(1), pp.53–60.
Setting (Location)	Tertiary referral teaching hospital and community in Syndey, Australia
Study population size	n=104 (70 intervention, 34 control)
Target population (eligibility)	Inpatients for acute hospitalisation (conditions not specified) with a LOS>6 days referred for geriatric rehabilitation (Average age: 84), expected to live independently after rehabilitation. (Inclusion criteria: living within catchment area, patient and caregiver consent. Exclusion criteria: living in a nursing home)
Intervention group	Patients transferred home from hospital after an inpatient stay, once able to mobilise sufficiently to toilet themselves, to early discharge rehabilitation at home provided by a hospital-based multidisciplinary team of nurses, doctors, PTs and OTs. Care provided include rehabilitation, treatment of any deterioration such as infections through IV antibiotics and provision of equipment. Average number of home visits: 20. Average length of rehabilitation: 15.97 days.
Comparison group (controls)	Patients transferred to an in-hospital geriatric rehabilitation ward after an inpatient stay, once a bed was available and acute illness was settling. Average length of rehabilitation: 23.09 days.
Study population baseline demographics (intervention vs control)	Age (mean): 83.9 vs 84.0 (n.s.), Gender: 68.3% vs 66.7% (n.s), Ischemic heart disease: 42.9% vs 58.9% (n.s.), Diabetes: 27.1% vs 21.2% (n.s.), Number of medications (mean): 5.6 vs 5.7 (n.s.), Number of medical problems (mean): 6.7 vs 7.1 (n.s.), Functional independence (FIM) (mean) (range 13-126): 75.5 vs 78.5 (n.s.), Cognition (MMSE/30) (mean): 22.7 vs 23.8 (n.s.), Depression (GDS/30) (mean): 10.3 vs 10.2 (n.s.) (Overall no significant differences)
Study design (classified)	Randomised controlled trial (RCT) with 2:1 allocation
Study design (self-reported)	Randomised controlled trial (RCT)
Primary outcome measure(s)	Incidence of delirium during rehabilitation (CAM positive scores/all CAM scores - measured every second day) and odds of developing delirium during rehabilitation
Secondary outcome measure(s)	Functional status (Functional Independence Measure), cognitive status (MMSE), depression status (GDS) at enrolment, at start and completion of rehabilitation, 1 month and 6 months follow-up. Acute and rehabilitation LOS, hospital bed days for episode of care, cost of acute care and rehabilitation. Patient, carer and GP satisfaction with quality of rehabilitation (1=unsatisfactory, 5=excellent). Readmission within 28 days after rehabilitation, Mortality rate at 6 months follow-up.
Follow-up period	Primary outcome assessed every second day for duration of acute and rehabilitation stay. Health status outcomes assessed at enrolment, at start and completion of rehabilitation, 1 month and 6 months follow-up. Recruitment period: 7 months.

Study code	Mas2016
Reference	Mas, M.À., Closa, C., Santaeugènia, S.J., Inzitari, M., Ribera, A. and Gallofré, M., 2016. Hospital-at-home integrated care programme for older patients with orthopaedic conditions: Early community reintegration maximising physical function. *Maturitas*, [online] 88, pp.65–69.
Setting (Location)	Intermediate care hospital and community in Badalona, Spain
Study population size	n=270 (69 intervention, 201 control)
Target population (eligibility)	Aged ≥65 years, admitted to ED or acute ward for acute orthopaedic condition (hip/pelvic/vertebral/other fracture), with geriatric/frailty conditions (previous low level of disability, cognitive impairment or falls) (Inclusion criteria: good functional prognosis)
Intervention group	Patients receiving rehabilitation at home (HHU) within 24 hours of discharge from the acute setting, from specialist geriatric health team providing the same post-acute protocol of usual care (control group) but in a home setting. All the same staff providing usual care were available for HHU. Average numbers of home visits: 5 by physicians, 15 by nurses and 19 by PTs or OTs. Average length of intervention: 50 days. Management of comorbidities and acute illness, with specialist nurses able to manage complex conditions such as severe functional loss and delirium with access to diagnostic techniques (e.g. blood tests, ECG) and acute treatments (e.g. IV treatments) from acute hospital. (Inclusion criteria: 24hr caregiver at home including nursing home, patient and caregiver consent to intervention - if these not met then patients were in control group)
Comparison group (controls)	Patients receiving care at an in-hospital geriatric rehabilitation unit within 24 hrs of discharge from the acute setting, by rehabilitation medicine physicians, geriatricians, nurses, physiotherapists, and occupational therapists, carrying out a post-acute care protocol including individualised CGA (protocols for the management of delirium, cognitive impairment, malnutrition and deconditioning), MDT weekly review and up to five 45 minute structured rehabilitation therapy sessions per week. Management of comorbidities and acute illness, with specialist nurses able to manage complex conditions such as severe functional loss and delirium with access to diagnostic techiques (e.g. blood tests, ECG) and acute treatments (e.g. IV treatments) from acute hospital. Average stay in GRU: 57 days.
Study population baseline demographics (intervention vs control)	Age (mean): 83 vs 84 (n.s.), Gender: 81.2% vs 81.6% female (n.s.), Number of geriatric syndromes (mean): 4 vs 5 ($p<0.05$), Cognitive impairment: 27.5% vs 24.9% (n.s.), Pre-admission BI/100 (mean): 88 vs 95 ($p<0.05$), Rehabilitation admission BI/100 (mean): 40 vs 43 (n.s.), Prevalent delirium: 18.8% vs 7.5% ($p<0.01$) (Overall main significant difference in delirium, pre-admission BI and number of geriatric syndromes)
Study design (classified)	Concurrently controlled prospective cohort study (PCS) (allocation based on patient and caregiver consent (assigned to control if declined treatment), i.e. allocation decision based on information collected prospectively)
Study design (self-reported)	Observational cohort study
Primary outcome measure(s)	Change in functional status (BI) from rehabilitation admission to discharge from rehabilitation (functional gain)
Secondary outcome measure(s)	Length of rehabilitation in hospital or home unit (days), Rehabilitation efficiency (functional gain/length of rehabilitation), Post-rehabilitation discharge destination
Follow-up period	Outcomes assessed at baseline (prior to acute stay), at admission to rehabilitation and at discharge from rehabilitation. Recruitment period: 2 years.

Study code	Mas2017
Reference	Mas, M.A., Inzitari, M., Sabate, S., Santaeugenia, S.J. and Miralles, R., 2017. Hospital-at-home Integrated Care Programme for the management of disabling health crises in older patients: comparison with bed-based Intermediate Care. *Age & Ageing*, 46(6), p.925-31
Setting (Location)	Acute hospital, intermediate care hospital and community in Badalona, Spain
Study population size	n=849 (244 intervention, 605 control)
Target population (eligibility)	Older patients with acute medical or orthopaedic conditions after a) being identified in the community, b) being admitted to ED or c) after acute ward stay, requiring hospital-level or post-acute care (Inclusion criteria: hemodynamic stability, without requiring 24-hour follow-up in an acute ward)
Intervention group	Patients receiving either rehabilitation/early supported discharge at home (HHU - ESD) after discharge from the acute setting, or admission avoidance hospital-at-home (HHU - AA) after attendance at ED or from the community providing the same acute or post-acute protocol of usual care (control group) but in a home setting, with up to 2-3 visits per day. All the same staff providing usual care were available for both HHU - ESD and HHU - AA. Management of comorbidities and acute illness such as infections or heart failure, with specialist nurses and therapists able to manage complex conditions such as severe functional loss leading to immobility, delirium or behavioural symptoms, with access to diagnostic techniques (blood and microbiologic tests, ECG, radiology) from acute hospital. (Inclusion criteria: 24hr caregiver with enough physical and cognitive capacity to assure health care at home including nursing home, patient and caregiver consent - if these not met then patients were in control group) Average length of intervention: 46.6 days.
Comparison group (controls)	Patients receiving usual inpatient care followed by care at an intermediate care bed-based unit (BBU) including rehabilitation, by rehabilitation medicine physicians, geriatricians, nurses, physiotherapists, and occupational therapists carrying out a post-acute care protocol including individualised CGA, MDT weekly review and up to 2-3 health visits per day if required. Management of comorbidities and acute illness such as infections or heart failure, with specialist nurses and therapists able to manage complex conditions such as severe functional loss leading to immobility, delirium or behavioural symptoms, with access to diagnostic techniques (blood and microbiologic tests, ECG, radiology) from acute hospital. Average stay in BBU: 55.5 days.
Study population baseline demographics (intervention vs control)	Age (mean): 83.8 vs 83 (n.s.), Gender: 68.4% vs 73.4% female (n.s.), Main diagnostic (medical vs orthopaedic): 62.3% vs 35.3% ($p<0.001$), Early supported discharge (vs Admission avoidance): 56.6% vs 80.2% ($p<0.001$), Pre-admission BI/100 (median): 75.2 vs 83.9 ($p<0.001$), Hospital or home unit admission BI/100 (median): 41.5 vs 42.6 (n.s.), Comorbidity (Charlson index) (median): 2 for both groups (n.s.), Number of geriatric syndromes (median): 5 vs 4 ($p<0.001$), Cognitive impairment: 41.4% vs 26% ($p<0.001$), Delirium: 16.8% vs 13.4% (n.s.), Mood disorder: 19.7% in both groups (n.s.) (Overall main significant differences in main diagnostic, ESD/AA strategy, baseline functional staus, cognitive impairment, number of geriatric syndromes)
Study design (classified)	Concurrently controlled prospective cohort study (PCS) (allocation based on patient and caregiver consent (assigned to control if declined treatment), and availability of resources i.e. allocation decision based on information collected prospectively)
Study design (self-reported)	Quasi-experimental longitudinal study
Primary outcome measure(s)	Health crisis resolution (discharge to primary care at end of intervention), Functional resolution (patient recovered at least a third of functional loss observed defined as the change in BI prior to acute stay to hospital or home unit admission), Favourable crisis resolution (previous two outcomes met, health + functional)
Secondary outcome measure(s)	Length of stay in hospital or home unit (days), Length of acute stay for Early Supported Discharge (rehabilitation) strategy patients, Rehabilitation efficiency (functional gain defined as change in BI from admission to each unit to discharge from rehabilitation/length of stay in hospital or home unit), Post-hospital or home unit discharge destination
Follow-up period	Outcomes assessed at baseline (prior to acute stay), at admission to hospital or home unit and at discharge from hospital or home unit. Recruitment period: 3 years.

Study code	Closa2017
Reference	Closa, C., Mas, M.A., Santaeugenia, S.J., Inzitari, M., Ribera, A. and Gallofre, M., 2017. Hospital-at-home Integrated Care Program for Older Patients With Orthopedic Processes: An Efficient Alternative to Usual Hospital-Based Care. *Journal of the American Medical Directors Association*, 18(9), pp.780–784.
Setting (Location)	Acute hospital, intermediate care hospital and community in Badalona, Spain
Study population size	n=367 (91 intervention, 276 control)
Target population (eligibility)	Aged >65, attended by acute orthopaedic surgery/traumatology unit at ED or acute ward, after a fracture (hip/pelvic/vertebral/other) or arthroplasty (hip/knee), suffering a decline in functional status suitable for rehabilitation (Inclusion criteria: good orthopaedic prognosis and clinical status sufficiently stable to participate in rehabilitation)
Intervention group	Patients receiving rehabilitation at home (HHU) from geriatric rehabilitation team providing the same post-acute rehabilitation as usual care (control group) but in a home setting. All the same staff providing usual care were available for HHU. Average length of intervention: 49.4 days. Management of comorbidities and acute illness such as infection with access to diagnostic techniques (e.g. laboratory and imaging tests) and acute treatments (IV antibiotics, corticoids, diuretics, nebulizers) from acute hospital. (Inclusion criteria: caregiver willing to accept responsibility of program, patient consent - if these not met then patients were in control group)
Comparison group (controls)	Patients receiving care at an in-hospital geriatric rehabilitation unit (GRU) within 24 hrs of discharge from the acute setting, by rehabilitation medicine physicians, geriatricians, nurses, physiotherapists, and occupational therapists carrying out a post-acute care protocol including individualised CGA (protocols for the management of delirium, cognitive impairment, malnutrition, cardiorespiratory function, treatment of pain and prevention of pressure ulcers), MDT weekly review, up to seven nursing visits per week, up to five rehabilitation therapy sessions per week (up to one hour each) for reducing joint stiffness, strengthening muscles, reducing edema and pain, re-educating transfers and basic ADL. Management of comorbidities and acute illness such as infection with access to diagnostic techniques (laboratory and imaging tests) and acute treatments (IV antibiotics, corticoids, diuretics, nebulizers) from acute hospital. Average stay in GRU: 61.6 days.
Study population baseline demographics (intervention vs control)	Age (mean) 82 vs 81 (n.s.), Gender: 85.7% vs 83.7% female (n.s.), Comorbidity (Charlson index) (median): 1 in both groups (n.s.), Number of geriatric syndromes (median) 5 vs 4 ($p<0.01$), Pre-admission BI/100 (median): 90 vs 95 ($p<0.05$), Rehabilitation admission BI/100 (median): 47 vs 51.5 (Overall main differences in pre-admission BI and number of geriatric syndromes)
Study design (classified)	Concurrently controlled prospective cohort study (PCS) (allocation based on patient and caregiver consent (assigned to control if not met), i.e. allocation decision based on information collected prospectively)
Study design (self-reported)	Quasi-experimental longitudinal study
Primary outcome measure(s)	Functional gain/loss ratio (Heinneman index) (Functional gain was the change in BI rehabilitation admission to discharge from rehabilitation, and functional loss was the change in BI from prior to acute stay to rehabilitation admission), Direct cost of care per patient per visit (intervention) or per day (control) (calculated by multiplying the resources used by the unit cost of each resource) and mean difference
Secondary outcome measure(s)	Length of acute hospital stay prior to rehabilitation (days), Length of rehabilitation in hospital or home unit (days), Post-rehabilitation discharge destination
Follow-up period	Outcomes assessed at baseline (prior to acute stay), at admission to rehabilitation and at discharge from rehabilitation. Recruitment period: 2 years.

Study code	DiPollina2017
Reference	Di Pollina, L., Guessous, I., Petoud, V., Combescure, C., Buchs, B., Schaller, P., Kossovsky, M. and Gaspoz, J.-M., 2017. Integrated care at home reduces unnecessary hospitalizations of community-dwelling frail older adults: a prospective controlled trial. *BMC Geriatrics*, [online] 17(1), p.53.
Setting (Location)	2 Home visiting nursing service centres in Geneva, Switzerland
Study population size	n=301 (122 intervention, 179 control)
Target population (eligibility)	Aged ≥60 years, community dwelling, referred to home visiting nursing service aimed at preventing unnecessary hospitalisation by their primary care physician. (Inclusion criteria: presence of frailty as identified as one of the following risk factors: cognitive impairment, falls, social isolation or caregiver frailty as detected by RAI-HC, able to speak French, patient consent)
Intervention group	Patients receiving integrated care at home defined as formally coordinating existing services: home visiting nursing services with nursing teams and a community geriatric unit (CGU) team of home-visiting physicians, PTs, OTs, psychologists and SWs. Nursing teams were able to provide the same care they usually provide, as in the control group (includes management of patient needs and home hospitalisation).The physician performed home geriatric assessment in the following domains: cognition, mood, functional status, gait, nutrition, pain and medication review and adherence. Results were shared with the patient's physician and the nursing teams. CGU teams and nursing teams held meetings for any complex issues. Patients and nursing teams were instructed to contact patient's physician in an emergency and if unavailable, patients had access to a 24/7 medical call service from the CGU. A day hospital was also part of the provided services. Average number of home visits/telephone consultations: 6.3.
Comparison group (controls)	Patients receiving the usual home visiting nursing services by nursing teams, which includes home visits by nurses and nurses' aides one to three times a day. Care included administration of medication, monitoring vital signs and glycaemia, wound care, support of ADL and support for home hospitalisation. No formal case management was provided and in case of emergency, patients were instructed to contact their physician, but if unavailable, they were instructed to contact an emergency service or attend the ED. Average number of home visits/telephone consultations: 1.6.
Study population baseline demographics (intervention vs control)	Age (mean): 81.8 vs 81.9 (n.s.), Gender: 63.9% vs 67.0% female (n.s.), Living alone: 26.4% vs 32.9% (n.s.), ADL/6 (mean): 1.2 vs 1.1 (n.s.), IADL/8 (mean): 5.7 vs 5.4 (n.s.), Perceived poor health: 50.0% vs 40.4% (n.s.), Psychotropic medications: 67.9% in both groups (n.s.), Analgesics: 58.3% vs 55.2% (n.s.), BMI<21: 23.4% vs 21.5% (n.s.), Number of RAI-HC alarms/4 (mean): 2.1 in both groups (n.s.), Cognitive impairment: 50.0% vs 49.2% (n.s.), Falls: 73.0% vs 73.7%, Social isolation: 53.3% vs 48.6% (n.s.), Caregiver frailty: 37.7% vs 36.9% (n.s.), Severe frailty: 24.6% in both groups, Cardiac disease: 45.1% vs 34.0% (n.s.), Diabetes: 25.7% vs 22.2% (n.s.), COPD: 24.5% vc 17.3% (n.s.), Cancer: 23.2% vs 25.2% (n.s.), Depression: 42.6% vs 34.8% (n.s.), Dementia: 27.2% vs 25.0% (n.s.), Stroke: 18.1% vs 18.3% (n.s.), Visual impairment: 47.3% vs 40.1% (Overall no significant differences)
Study design (classified)	Quasi-randomised control trial (Q-RCT) (two clusters of participants based on geographic area were sequentially allocated to an intervention or control nursing team in their area)
Study design (self-reported)	Prospective controlled trial
Primary outcome measure(s)	Number of inpatient hospitalisations over three-year follow-up. Cumulative incidence for the first hospitalization after the first, second and third year of follow-up.
Secondary outcome measure(s)	Length of stay of inpatient hospitalisation (days), at least one ED attendance over 3-year follow-up. Cumulative incidence of first ED attendance after first, second and third year of follow-up. Reasons for inpatient hospitalisation and ED attendances (including unnecessary as identified by research nurse chart review). Institutionalisation and mortality over 3-year follow-up period, cumulative incidence of institutionalisation and mortality after the first, second and third year of follow-up. Place of death.
Follow-up period	Outcomes assessed at one, two and three years follow-up. Recruitment period: 3 years.

Study code	Kwok2004
Reference	Kwok, T., Lum, C.M., Chan, H.S., Ma, H.M., Lee, D. and Woo, J., 2004. A randomized, controlled trial of an intensive community nurse-supported discharge program in preventing hospital readmissions of older patients with chronic lung disease. *Journal of the American Geriatrics Society*, 52(8), pp.1240–1246.
Setting (Location)	2 Acute hospitals and community in Shatin and Taipo, Hong Kong
Study population size	n=157 (77 intervention, 80 control)
Target population (eligibility)	Aged ≥60 years, discharged from medical wards in two hospitals with a primary diagnosis of chronic lung disease (COPD, chronic asthma, bronchiecstasis, cor pulmonale) at high risk of readmission (Inclusion criteria: living within catchment area, at least one admission for chronic lung disease in the past 6 months prior to index admission, caregiver, patient written consent. Exclusion criteria: living in a nursing home, communication problems (deafness, low mental test scores, dysphasia), terminally ill expecting less than 6 months survival)
Intervention group	Patients receiving a supported discharge program through intensive home visits by community nursing teams (CN) in addition to usual care (control). Initial visit in hospital for health promotion and education, encouraging use of a trained clerk telephone hotline in case of deterioration, as part of the intervention (any messages were relayed to nurses by pager). Post-discharge home visits within 7 days of discharge weekly up to 4 months and monthly thereafter up to 6 months for monitoring vital signs, health promotion and education, psychosocial support for patient and family, arrangement of health and social care services as required. Patients refusing home visits could be monitored by phone. Nurses had direct access via phone and pager to hospital geriatricians and respiratory physicians and could alter medication regimes and arrange urgent hospital outpatient and inpatient services after discussion. Prior to the intervention nurses received training and ward experience in management of chronic lung disease. Average number of home visits per patient: 11.8. Average number of telephone calls per patient: 10.3.
Comparison group (controls)	Patients discharged from medical wards receiving hospital outpatient care involving a clinic appointment for review at around 6-12 weeks post-discharge on average and 6-month assessment at the hospital outpatient clinic, both provided by designated geriatricians or respiratory physicians. Physicians were free to refer patients for community nursing post-discharge home visits, though this was not common practice.
Study population baseline demographics (intervention vs control)	Age (mean): 75.3 vs 74.2 (n.s.), Gender: 27% female vs 31% female (n.s.), Mild-severe dyspnea: 24.7% vs 31.3% (n.s.), Long term oxygen: 43% vs 44% (n.s.), Admissions in past year (mean): 2.7 vs 2.4 (n.s.), Cognitive function (AMT)/10 (mean): 9.0 vs 9.2 (n.s.), Psychological health (GHQ)/30 (mean): 7.5 in both groups (n.s.), Handicap in mobility (LHS)/6 (mean): 2.7 vs 3.0 ($p<0.05$) (Overall main significant difference in handicap in mobility)
Study design (classified)	Randomised controlled trial (RCT)
Study design (self-reported)	Randomised controlled trial (RCT)
Primary outcome measure(s)	Unplanned readmission rates at 6 months follow-up
Secondary outcome measure(s)	Unplanned readmission rates within 28 days of discharge. Number of unplanned readmissions, Primary causes of readmissions, Number of hospital bed days, Number of ED attendances, Changes in peak expiratory flow rate, oxygen saturation at rest, physical function (6-min walking test), handicap (London Handicap scale), psychological health (GHQ), perceived control of health (Multidimensional HLC) and Caregiver burden (CCI) from baseline to 6 month follow-up between groups.
Follow-up period	Outcomes assessed at baseline and 6 months follow-up. Recruitment period: 1 year 5 months.

Study code	Kwok2008
Reference	Kwok, T., Lee, J., Woo, J., Lee, D.T. and Griffith, S., 2008. A randomized controlled trial of a community nurse-supported hospital discharge programme in older patients with chronic heart failure. *Journal of clinical nursing*, 17(1), pp.109–117.
Setting (Location)	2 Acute hospitals and community in Shatin and Taipo, Hong Kong
Study population size	n=105 (49 intervention, 56 control)
Target population (eligibility)	Aged ≥60 years, discharged from medical wards in two hospitals with a primary diagnosis of CHF at high risk of readmission (Inclusion criteria: living within catchment area, at least one admission for CHF in the past 12 months prior to the index admission, patient written consent. Exclusion criteria: living in a nursing home, communication problems if without a caregiver, terminally ill expecting less than 6 months survival)
Intervention group	Patients receiving a supported discharge program through intensive home visits by community nursing teams (CN) in addition to usual care (control). Initial visit in hospital for health promotion and education (drug compliance and dietary advice), encouraging use of a trained clerk telephone hotline in case of deterioration, as part of the intervention (any messages were relayed to nurses by pager). Post-discharge home visits within 7 days of discharge weekly up to 4 months and monthly thereafter up to 6 months for monitoring vital signs, medication and compliance review, monitoring CHF control, health promotion and dietary and exercise education, arrangement of health and social care services. Patients refusing home visits could be monitored by phone. Nurses liaised with hospital geriatricians and cardiologists and could alter medication regimes and arrange urgent hospital outpatient and inpatient services after discussion. Average number of home visits per patient: 8.8. Average number of telephone calls per patient: 15.0.
Comparison group (controls)	Patients discharged from medical wards receiving hospital outpatient care invovling a clinic appointment for review at around 6-12 weeks post-discharge on average and 6-month assessment at the hospital outpatient clinic, both provided by designated geriatricians or cardiologists.
Study population baseline demographics (intervention vs control)	Age (mean): 79.5 vs 76.8, Gender: 55% female in both groups, Living alone: 31% vs 18%, Receipient of social security allowance: 47% vs 25%, Cognitive function (AMT)/10 (mean) 8.6 vs 8.7, Psychological state (GHQ)/30 (mean): 5.6 vs 6.1, Ischemic heart disease: 48% vs 46%, Myocardial infarction: 18% vs 27%, COPD: 8% vs 13%, Diabetes: 29% vs 38%, Atrial fibrillation: 29% vs 30%, Hypertension: 54% vs 38%, Diuretic medication: 82% vs 98%, Handicap in mobility, independence, occupation and economic (LHS/6) (median): 3 in both groups, Handicap in social and orientation (LHS/6) (median): 2 in both groups (No statistical testing for differences presented)
Study design (classified)	Randomised controlled trial (RCT)
Study design (self-reported)	Randomised controlled trial (RCT)
Primary outcome measure(s)	Unplanned readmission rates at 6 months follow-up
Secondary outcome measure(s)	Number of unplanned readmissions, Primary causes of readmissions. Changes in physical function (6-min walking test) and handicap (LHS) on six domains (mobility, independence, occupation, social, orientation and economic) from baseline to 6-month follow-up between groups. Public health care and personal care costs.
Follow-up period	Outcomes assessed at baseline and 6 months follow-up. Recruitment period: 1 year 5 months.

Study code	Leff2005
Reference	Leff, B., Burton, L., SL, M., Naughton, B., Burl, J., SK, I., III, G.W.B., Guido, S., Langston, C., KD, F., Steinwachs, D. and JR, B., 2005. Hospital at home: feasibility and outcomes of a program to provide hospital-level care at home for acutely ill older patients. *Annals of Internal Medicine*, [online] 143(11), pp.756–798.
Setting (Location)	Acute care hospitals and community at 3 sites in Buffalo, NY, Worcester, MA and Portland, OR.
Study population size	n=455 (169 intervention, 286 control)
Target population (eligibility)	Aged ≥65 years, admitted to ED or assessed at an ambulatory site as requiring admission for acute conditions by a physician, for one of four target illnesses: community-acquired pneumonia, exacerbation of CHF, exacerbation of COPD, or cellulitis. (Inclusion criteria: living within catchment area, written patient consent. Exclusion criteria: Uncorrectable hypoxema, suspected myocardial ischemia and presence of acute illness other than the target illnesses)
Intervention group	Patients identified as eligible for a substitutive hospital-at-home programme, provided by physicians and nurses, after it was implemented, including both those who received and did not receive it (received usual acute care). Those receiving hospital-at-home were transported home by ambulance from ED or ambulatory site and were evaluated by the physician either at ED or shortly after arriving home, where met by a nurse. The programme involved subsequent direct one-on-one nursing supervision initially for at least 8 hours (site 3) or 24 hours (sites 1 and 2), followed by at least daily visits from both nurses and physician, who was available 24 hours a day for emergency visits. Other care components included medical equipment, oxygen therapy, IV fluids, IV antimicrobials, skilled therapies, pharmacy support, home radiology and diagnostic studies (ECG, radiography). A Lifeline medical alarm device was provided to patients without caregivers. Average duration of stay: 3.2 days. Average daily home visits: 1.5 physician, 1.4 nurse.
Comparison group (controls)	Patients eligible for a substitutive hospital-at-home programme (meeting target illness criteria) at the ED or ambulatory site in an observation phase before it was implemented, who received usual acute hospital care. Average duration of stay: 4.9 days.
Study population baseline demographics (intervention vs control)	Age (mean): 77.2 vs 77.3 (n.s.), Gender: 42% vs 34% female (n.s.), White ethnicity: 86% vs 90% (n.s.), Living in poverty: 19% vs 11% (n.s.), Education less than high school: 34% vs 36% (n.s.), Living alone: 33% vs 43% (n.s.), Any impairment in ADLs: 45% vs 44% (n.s.), Any impairment in IADLs: 65% vs 64% (n.s.), Cognitive status (MMSE) (mean): 25.5 vs 25.2 (n.s.), Fair or poor self-reported health: 45% vs 41% (n.s.), Number of chronic conditions (mean): 5.9 vs 5.8 (n.s.), Charlson comorbidity index (mean): 3.0 vs 3.1 (n.s.), Outpatient medications (mean): 8.1 vs 6.8 ($p<0.005$), Severity of illness (APACHE II) (mean): 11.6 vs 12.6 ($p<0.05$), Pneumonia diagnosis: 32% vs 31% (n.s.), COPD diagnosis: 28% vs 32% (n.s.), Cellulitis diagnosis: 18% vs 12% (n.s.), CHF diagnosis: 22% vs 25% (n.s.) (Overall main significant differences in medications and severity of illness)
Study design (classified)	Historically controlled cohort study (HCS) (slight modification: both comparator and intervention group selected prospectively, comparator group were eligible patients observed prior to the implementation, intervention group were eligible patients treated, presented (and declined) or not presented (due to being outwith operating hours) with the option of HaH, after implementation)
Study design (self-reported)	Prospective quasi-experimental study
Primary outcome measure(s)	Cumulative incidence of delirium, Incidence of other complications (bowel complications, urinary complications, falls, nosocomial infection, sedative medication use, chemical restraints, physical restraints), Number of patients with ≥1 emergency situation or critical complication, Incidence of death (mortality rate), Incidence of transfer to acute hospital from hospital-at-home, Patient and caregiver satisfaction with care (modified Picker Hospital Survey) at 2-week follow-up, Change in functional status (ADL/IADL) from baseline to 2-week follow-up, Cost of index hospitalisation per person
Secondary outcome measure(s)	Time spent in ED (hours), Length of stay of acute episode (days). Number of ED attendances, inpatient hospital readmissions, admissions to skilled nursing facilities and home health visits at 8 weeks follow-up.
Follow-up period	Functional outcomes assessed at baseline and 2-week follow-up, satisfaction assessed at 2-week follow-up, and use of health services assessed at 8-week follow-up. Recruitment period: two consecutive 11-month periods.

Study code	Leff2006
Reference	Leff, B., Burton, L., Mader, S., Naughton, B., Burl, J., Clark, R., Greenough, W.B. 3rd, Guido, S., Steinwachs, D. and Burton, J.R., 2006. Satisfaction with Hospital at Home Care. *Journal of the American Geriatrics Society*, [online] 54(9), pp.1355–1363.
Setting (Location)	Acute care hospitals and community at 3 sites in Buffalo, NY, Worcester, MA and Portland, OR.
Study population size	n=214 (84 intervention, 130 control)
Target population (eligibility)	Aged ≥65 years, admitted to ED or assessed at an ambulatory site as requiring admission for acute conditions by a physician, for one of four target illnesses: community-acquired pneumonia, exacerbation of CHF, exacerbation of COPD, or cellulitis. (Inclusion criteria: living within catchment area, written patient consent. Exclusion criteria: Uncorrectable hypoxema, suspected myocardial ischemia and presence of acute illness other than the target illnesses)
Intervention group	Patients transported home by ambulance from the ED or ambulatory site receiving a hospital-at-home programme, delivered by physicians and nurses. Patients were evaluated by the physician either at ED or shortly after arriving home, where they were met by a nurse. The hospital-at-home program involved subsequent direct one-on-one nursing supervision initially for at least 8 hours (site 3) or 24 hours (sites 1 and 2), followed by at least daily visits from both nurses and the physician, who was available 24 hours a day for emergency visits. The program also included other care components such as medical equipment, oxygen therapy, IV fluids, IV antimicrobials, skilled therapies, pharmacy support, home radiology and diagnostic studies (ECG, radiography). A Lifeline medical alarm device was provided to patients without caregivers.
Comparison group (controls)	Patients identified as eligible for a substitutive hospital-at-home programme (meeting target illness criteria) at the ED or ambulatory site who received usual acute hospital care because they were either presented with the option of hospital-at-home and declined or were not presented with the option of hospital-at-home due to being outwith operating hours.
Study population baseline demographics (intervention vs control)	Age (mean): 76.6 vs 77.1 (n.s.), Gender: 33% vs 26% female (n.s.), Living in poverty: 20% vs 11% (n.s.), Living alone: 43% vs 35% (n.s.), Impairment in >2 ADLs: 52% vs 37% (n.s.), Impairment in >2 IADLs: 68% vs 48% ($p<0.05$), No cognitive impairment: (MMSE≥24): 79% vs 93% (n.s.), ≥6 comorbid conditions: 59% vs 50% (n.s.), Severity of illness score ≥16 (APACHE II, higher score means greater severity): 11% vs 9% (n.s.), Pneumonia diagnosis: 24% vs 39%, COPD diagnosis: 33% vs 17%, Cellulitis diagnosis: 21% vs 24%, CHF diagnosis: 22% vs 20% (ND in primary diagnoses), Moderate to severe depression (GDS≥6): 24% cs 26% (n.s.) (Overall main significant difference in IADL impairment. No significant differences between caregivers in the two groups)
Study design (classified)	Concurrently controlled prospective cohort study (PCS) [allocation based on patient consent (given usual care if declined treatment) and operating hours of intervention (availability of resources) i.e. allocation decision based on information collected prospectively]
Study design (self-reported)	Prospective, non-randomised clinical trial
Primary outcome measure(s)	Patient satisfaction with care on nine domains (physician, nurse, staff, comfort and convenience, safety, pain management, admission procedures, discharge procedures and overall) and caregiver (family member) satisfaction with care on eight domains (same ones except pain management) (modified Picker Hospital Survey) at 2-week follow-up.
Secondary outcome measure(s)	Proportion reporting would choose to receive care again in the same setting and proportion reporting that they would recommend the type of care they received to other family members or friends.
Follow-up period	Satisfaction assessed at 2-week follow-up. Recruitment period: 11 months.

Study code	Leung2015
Reference	Leung, D.Y.P., Lee, D.T.-F., Lee, I.F.K., Lam, L.-W., Lee, S.W.Y., Chan, M.W.M., Lam, Y.-M., Leung, S.-H., Chiu, P.-C., Ho, N.K.F., Ip, M.-F. and Hui, M.M.Y., 2015. The effect of a virtual ward program on emergency services utilization and quality of life in frail elderly patients after discharge: a pilot study. *Clinical interventions in aging*, [online] 10, pp.413–420.
Setting (Location)	4 acute care hospitals and their community nursing services in Hong Kong
Study population size	n=78 (39 in both groups)
Target population (eligibility)	Aged ≥65 years, at high risk of readmission (HARRPE score ≥0.4 or major functional disability) after suffering an acute hospital admission (conditions not specified). (Inclusion criteria: 24 hour caregiver at home, psychologically and physically able to communicate)
Intervention group	Patients receiving post-discharge support ("virtual ward") to prevent readmission provided at home by a team of nurses, physicians, geriatricians and other AHPs. Discharge support included discharge preparation such as medication managment and symptom recognition in consultation with geriatricians. Hospital-level care included bloods measurement, insulin administration, wound dressing with first nursing visit for a health assessment within 48 hours from discharge, first physician visit within first week, with 4 visits per week on average. Other services provided at home visits by nurses included symptom monitoring, management and health education as well as psychosocial support for patients and carers. Patients and their carers also had access to extended out-of-hours service and telephone consultation service aimed at fast-tracking patients to other services such as enhanced nonemergency ambulance transport.
Comparison group (controls)	Patients discharged from a hospital not providing the "virtual ward" who received the usual community nursing services provided to patients discharged from hospitals, which included wound dressing, catheterisation and chronic disease management education for patients. Patients were discharged from the community nursing service once health problems were resolved.
Study population baseline demographics (intervention vs control)	Age: 80.2 vs 80.5, Gender: 28.2% vs 25.6% female, Educated above primary school: 7.7% vs 23.1%, Frailty index (mean): 6.64 vs 6.15, COPD: 30.8% in both groups, Chronic heart failure: 25.6% in both groups, Cancer: 17.9% in both groups (No statistical testing for differences presented)
Study design (classified)	Nonrandomized controlled trial (NRCT) (non-random prospective allocation to concurrent groups by research personnel applying intervention to patients from three hospitals and leaving care as usual for patients at fourth hospital as the control group)
Study design (self-reported)	Matched-control quasi-experimental study
Primary outcome measure(s)	Changes in Number of unplanned emergency hospital admissions in past 90 days at baseline and follow-up, Number of ED attendances in past 90 days at baseline and follow-up, QoL (mQOLC-E) from baseline to 3 month follow-up (or at discharge)
Secondary outcome measure(s)	Length of emergency hospital admission in past 90 days at baseline and 3-month follow-up, Mortality rate at 3-month follow-up
Follow-up period	Outcomes assessed at baseline and 3 months (or at discharge for intervention patients, whichever earlier). Recruitment period: 11 months.

Study code	Lewis2017
Reference	Lewis, C., Moore, Z., Doyle, F., Martin, A., Patton, D. and Nugent, L.E., 2017. A community virtual ward model to support older persons with complex health care and social care needs. *Clinical interventions in aging*, 12, pp.985–993.
Setting (Location)	Day hospital and community in Dublin, Ireland
Study population size	n=54 (intervention patients acting as own control)
Target population (eligibility)	Aged ≥65 years, assessed as moderately to severely frail with complex health and social care needs at high risk of hospital admission, referred to a community virtual ward by a consultant geriatrician from day hospital, outpatient gerontology clinics or prior to hospital discharge (Informed patient consent or family/representative assent obtained retrospectively but not explicitly stated as an inclusion criteria)
Intervention group	Patients receiving care in a community virtual ward (CVW) model, overseen by a clinical case manager (senior nurse working across primary and secondary care) providing risk stratification and conducting home visits and telephone consultations alongside a primary care team (including GP, public health nurse, PT, OT, SW and pharmacist). The CVW had access to a specialist therapist-led integrated care team for those at risk of admission due to functional decline, a nurse-led community intervention team for home-based interventions such as IV therapy, a day hospital in case of clinical or functional deterioration exceeding primary care team service and/or a planned admission to hospital, and increased social support including medication management and nutrition if required. Patients were admitted to the CVW for ~3-7 months, with daily to 2-weekly nursing visits. Conditions managed include delirium, dementia, pain management, symptomatic polypharmacy, dehydration, heart failure, exacerbation of COPD, chest infection and cellulitis
Comparison group (controls)	Patients receiving the intervention acted as their own control group by comparing outcomes 6 months prior to admission to the intervention and on discharge from the intervention. Prior to the intervention, patients were not formally risk stratified and often had multiple service providers.
Study population baseline demographics (intervention vs control)	Age (mean): 81.6, Gender: 68% female, COPD: 16%, Dementia: 42%, Cardiovascular disease: 11%, Hypertension: 27%, Cerebral vascular disease: 14%, Living with a carer: 77%, Living alone: 37%, Informal care: 86%, Frailty (CFS/9) (mean): 6.7, Cognition (MMSE/30) (mean): 19.2, BI/20 (mean): 11.2 (Intervention group acting as own control)
Study design (classified)	Before and after (BA) (Single exposed cohort with outcomes measured 6 months before intervention and at discharge from intervention, retrospectively)
Study design (self-reported)	Quantitative observational study
Primary outcome measure(s)	Number of unplanned hospital admissions, hospital bed days and ED attendances 6 months prior and at discharge from the intervention (timeframe for count of these numbers not provided)
Secondary outcome measure(s)	None.
Follow-up period	Outcomes assessed at 6 months prior to admission to intervention and at discharge. Sample selection period: 1 year.

Study code	Lin2015
Reference	Lin, F.O., Luk, J.K., Chan, T., Mok, W.W. and Chan, F.H., 2015. Effectiveness of a discharge planning and community support programme in preventing readmission of high-risk older patients. *Hong Kong Med J* , [online] 21(3), pp.208–16.
Setting (Location)	1 acute care hospital, 3 rehabilitation hospitals and community in Hong Kong
Study population size	n=1,090 (intervention patients acting as own control)
Target population (eligibility)	Aged ≥60 years, home-dwelling, admitted to acute general medical wards, referred for Integrated Care and Discharge Support (ICDS) due to being at risk of readmission (HARRPE≥0.2) or assessed by a clinician as having frequent readmission, poor social support, inadequate care at home, deterioration in memory, drug compliance problems, repeated falls, issues with mobility or functional impairment. (Exclusion criteria: died before ICDS involvement, discharged to nursing home, moved outwith catchment area or refusing ICDS services before first home visit)
Intervention group	Patients receiving Integrated Care and Discharge Support (ICDS), including risk stratification, multidimensional assessments (including CGA) and discharge planning in hospital, provided by link nurses (serving as 'link' between community and hospital care) working with geriatricians. After assessment, link nurses allocate patients to either 1) Integrated Care Model (ICM) case management with post-discharge home visits (wound care, home oxygen) and telephone support for high-risk patients with complex medical and social problems, provided by SWs, PTs, OTs and APN for around 3 months (44%) or 2) Home Support Team (HST) services, for patients requiring urgent social services, providing rapid and intensive community support (meal delivery, household cleaning, respite care and home assessment and modification) (56%). Link nurses, ICM case managers and HST hold weekly multidisciplinary meetings chaired by geriatrician. Access to rehabilitation in geriatric day hospital and fast-track or follow-up clinics. Average duration: 75.8 days (ICM 101.5 days, HST 55.9 days)
Comparison group (controls)	Patients receiving the intervention acted as their own control group by comparing outcomes 6 months before and 6 months after recruitment to the intervention. No details provided about care prior to the intervention.
Study population baseline demographics (intervention vs control)	Age (mean) 80.4, Gender: 51.1% female, Living alone: 14.1%, Number of medications (mean): 6.3, Comorbidity (Charlson Index) (mean): 2.4, COPD/asthma primary diagnosis: 10.8%, Chest infection primary diagnosis: 15.7%, Falls 10.0%,, Heart failure primary diagnosis 7.2% (Intervention group acting as own control)
Study design (classified)	Before and after (BA) (Single exposed cohort with outcomes measured 6 months before and after intervention, prospectively)
Study design (self-reported)	Prospective cohort study
Primary outcome measure(s)	Number of unplanned acute hospital admissions, hospital bed days and ED attendances during the 6 months before and after admission to the intervention
Secondary outcome measure(s)	Walking ability (MFAC), Functional status (BI) and Cognition (AMT) at admission compared to discharge from the intervention. Potential annual cost-savings compared to hospital admission costs.
Follow-up period	Outcomes assessed during 6 months before and after admission to intervention. Recruitment period: 1 year.

Study code	Mendoza2009
Reference	Mendoza, H., Martín, M.J., García, A., Arós, F., Aizpuru, F., Regalado De Los Cobos, J., Belló, M.C., Lopetegui, P. and Cia, J.M., 2009. 'Hospital at home' care model as an effective alternative in the management of decompensated chronic heart failure. *European Journal of Heart Failure*, [online] 11(12), pp.1208–1213. Available at: <http://doi.wiley.com/10.1093/eurjhf/hfp143> [Accessed 14 Aug. 2017].
Setting (Location)	University hospital and community in Vitoria-Gasteiz, Spain
Study population size	n=80 (39 intervention, 41 control)
Target population (eligibility)	Aged ≥65 years, diagnosed with HF at least 12 months prior to the study, attending the ED for an exacerbation of HF and diagnosed with decompensated CHF (Inclusion criteria: All-day supervision, telephone at home, living within catchment area, patient informed written consent. Exclusion criteria: Admitted in preceding 2 months for exacerbation of HF, severe symptoms such as sudden worsening of HF, poor prognosis factors including haemodynamic instability, no response to ED treatment, active cancer, severe dementia, life expectancy of less than 6 months, acute psychiatric diseases, active alcoholism, active pulmonary tuberculosis, living at psycho-geriatric institution)
Intervention group	Patients receiving care in a Hospital at Home (HaH) unit, including scheduled and urgent visits at home by internal medicine physician every other day depending on condition and a daily by a specialist nurse. Care included nursing and clinical evaluation, home ECGs, sample collection for laboratory tests. Discharge to primary care or cardiology ward in case of no response to treatment. Outside of normal working hours (8am-9pm), patients were instructed to call emergency services. Access to hospital X-ray and ECG services.
Comparison group (controls)	Patients receiving usual inpatient care in a cardiology ward managed by cardiology specialists and nurses.
Study population baseline demographics (intervention vs control)	Age (mean): 78.1 vs 79.9 (n.s.), Gender: 51.4% vs 29.4% female (p=0.06), HF admissions in previous year: 0.65 vs 0.41 (n.s.), Comorbidity (Charlson Index) (mean): 2.5 vs 2.1 (n.s.), AF: 56.8% vs 47.0% (n.s.), COPD: 35.1% vs 29.4% (n.s.), Diabetes: 29.7% vs 35.3% (n.s.), Renal failure: 32.4% vs 23.5% (n.s.), Cancer: 8.1% vs 11.8% (n.s.), Non-severe dementia: 5.4% vs 2.7% (n.s.), Hypertension: 83.8% vs 88.2% (n.s.), Functional status (BI) (mean): 85.5 vs 78.1 (p=0.06), Health-related physical QoL (SF-36) (mean): 31.1 vs 30.6 (n.s.), Health-related mental QoL (SF-36) (mean): 42.7 vs 42.1 (n.s.) (Overall no significant differences)
Study design (classified)	Randomised controlled trial (RCT)
Study design (self-reported)	Prospective randomised study
Primary outcome measure(s)	Incidence of transfer from HaH to inpatient ward during initial admission. All-cause mortality rate, Readmission rate due to HF, Combined outcome of all-cause mortality and cardiovascular event readmission at one-year follow-up. Change in functional status (BI) and health-related QoL (mental and physical) (SF-36) from first admission to intervention or hospital to one-year follow-up.
Secondary outcome measure(s)	Total cost per episode (including cost of stay, pharmaceuticals, investigation and consumables), Total cost during follow-up (including cost of new admission to hospital or HaH, primary care visits, heart failure or cardiology clinic visits, and ED visits)
Follow-up period	Outcomes assessed at initial admission to intervention or hospital and after 12 months, with collection of events (death, new admissions or ED visits) also taken at 1, 3, and 6 months. Recruitment period: 11 months.

Study code	Parsons2018
Reference	Parsons, M., Parsons, J., Rouse, P., Pillai, A., Mathieson, S., Parsons, R., Smith, C. and Kenealy, T., 2018. Supported Discharge Teams for older people in hospital acute care: a randomized controlled trial. *Age & Ageing*, 47(2), pp.288–294.
Setting (Location)	Tertiary hospital and community in Waikato, New Zealand
Study population size	n=193 (97 intervention, 86 control)
Target population (eligibility)	Aged >65 years, discharged from hospital with a variety of conditions (unspecified), with a recent acute illness or injury or reduced ADL/IADL, likely to fail to manage satisfactorily at home despite conventional community support, therefore at risk of hospital readmission or institutionalisation, who did not require ongoing acute hospital based treatment in the judgement of the consultant geriatrician (Inclusion criteria: after assessment considered to have potential for recovery with home rehabilitation within 6 weeks, able to stand and transfer with or without help of a carer, patient or family member written informed consent)
Intervention group	Patients receiving early supported discharge for home-based rehabilitation from a team of healthcare assistants, registered nurses, PTs and OTs, providing home visits up to 4 times daily, 7 days a week up to 6 weeks. Weekly multidisciplinary team meetings with consultant geriatricians and close collaboration with GPs and practice nurses. Care provided utilised functional rehabilitation principles maximising recovery through incorporating exercises with ADL tasks, setting rehabilitation goals with a care plan. Once discharged from the team, patient care was returned to their GP. (Inclusion criteria: consented to being treated at home and agreed with the objectives set by the team)
Comparison group (controls)	Patients receiving usual care in hospital without early discharge, followed by discharge planning from hospital to their place of residence and subsequent community-based services.
Study population baseline demographics (intervention vs control)	Age (mean): 79.8 vs 78.7, Gender: 60.8% vs 51.2% female, Living alone: 59.2% vs 52.3%, Living in a private home: 96.9% vs 86.0%, Independent cognitive skills for daily decision making: 85.7% vs 81.4%, Understands others (comprehension): 83.7% vs 84.9%, Adequate vision: 64.3% vs 75.6%, Hospital days in 6-months prior to enrolment (mean): 22.0 vs 22.2 days (No statistical testing for differences presented)
Study design (classified)	Randomised controlled trial (RCT)
Study design (self-reported)	Randomised controlled trial (RCT)
Primary outcome measure(s)	Number of hospital days during initial hospital episode (index admission)
Secondary outcome measure(s)	Number of hospital days during 6-month follow-up (readmission), Change in health-related costs during 6-month follow-up compared to 6-months prior to enrolment, Change in functional status (InterRAI-CA ADL self-performance and IADL capacity) from baseline to follow-up.
Follow-up period	Outcomes assessed at baseline (prior to hospital discharge) and 6-month follow-up, with additional follow-up interview at 3 months. Recruitment period: 18 months.

Study code	Senior2014
Reference	Senior, H.E.J., Parsons, M., Kerse, N., Chen, M.-H., Jacobs, S., Hoorn, S. Vander and Anderson, C.S., 2014. Promoting independence in frail older people: a randomised controlled trial of a restorative care service in New Zealand. *Age & Ageing*, 43(3), pp.418–424.
Setting (Location)	Hospital, short-stay residential care facilities and community in New Zealand.
Study population size	n=105 (52 intervention, 53 control)
Target population (eligibility)	Aged ≥65 years (≥55 years for Māori), admitted to a hospital medical ward or rehabilitation service (conditions not specified), assessed by hospital clinical team or regional geriatric assessment service as being at high risk of institutionalisation but did not require immediate permanent residential care and assessed as being too unstable to return home immediately on hospital discharge (Inclusion criteria: able to communicate in English, consent. Exclusion criteria: requiring immediate permanent residential care)
Intervention group	Patients discharged from hospital to a 'Promoting Independence Programme' (PIP) to restore function and return patient to living in the community, coordinated by a case manager, conducting CGA with care plan development (integrating physical activity and ADL) in hospital and delivering supported discharge at a short-stay residential care facility, where care plan was delivered by a nurse, PT and OT, followed by home rehabilitation on discharge from residential care 3-4 times per week over 2 to 3 months by a rehabilitation assistant after which care was handed over to trained support workers when sufficient progress had occurred. PT and OT conducted a 3-month visit to re-assess care plan and if goals were attained, patients were monitored by phone and contacted monthly. Patients were referred to specialised care in case of decline. Prior to discharge from short-stay residential care, an OT conducted a home assessment for any modification needs.
Comparison group (controls)	Patients receiving usual care after hospital discharge, including community services or permanent residential care placement, with assessment and service coordination delivered by a centrally based needs coordinator.
Study population baseline demographics (intervention vs control)	Age (mean): 81.9 vs 83.6, Gender: 51.9% vs 56.6% female, Highest education high school: 65.4% vs 43.4%, Living alone: 46.2% vs 45.3%, Living in own home: 77.0% vs 81.1%, Vision impairment: 57.7% vs 54.7%, Hearing impairment: 40.4% vs 4.0%, Memory problems: 51.9% vs 39.6%, Communication problems: 32.7% vs 30.2%, Falls in last 6 months: 51.9% vs 54.7%, Hospital admission in past 12 months: 69.2% vs 64.2%, Requiring help for IADL: 100% in both groups, Using aides for mobility: 98.1% vs 100%, Functional status (ADL short form/28) (mean): 2.00 vs 2.11, Functional abilitiy (IADL summary/21) (mean): 12.0 vs 12.3, Cognition (CPS/21) (mean): 1.20 vs 1.21, Depression (EuroQoL/14) (mean): 2.92 vs 2.98, Pain (EuroQoL/3) (mean): 1.22 vs 1.08 (No statistical testing for differences presented)
Study design (classified)	Randomised controlled trial (RCT) with minimisation by residential care needs ('high' or 'very high'), age, gender and living alone.
Study design (self-reported)	Randomised controlled trial (RCT)
Primary outcome measure(s)	Incidence of permanent residential care placement, Mortality, Combined outcome of permanent residential care placement or death during 2-year follow-up.
Secondary outcome measure(s)	Changes in Functional status (ADL/IADL), Cognitive performance (InterRAI-HC CPS), Depression rating (InterRAI-HC DRS), Pain (InterRAI-HC Pain scale), Changes in health, end-stage disease, signs and symptoms (InterRAI-HC CHESS), health-related QoL (EuroQoL-5D), Carer health-related QoL (SF-36) (physical and mental component) and Caregiver burden (CRA) from baseline to 18-month follow-up. Health service utilisation (personal care, home help, carer support, respite, day centre, day activity centres) over 12-month follow-up.
Follow-up period	Outcomes assessed at baseline and 18-months (healthcare utilisation assessed at 12-months), with overall follow-up of 24-months. Recruitment period: 1 year.

Study code	Shyu2013
Reference	Shyu, Y.-I.L., Liang, J., Tseng, M.-Y., Li, H.-J., Wu, C.-C., Cheng, H.-S., Chou, S.-W., Chen, C.-Y. and Yang, C.-T., 2013. Comprehensive and subacute care interventions improve health-related quality of life for older patients after surgery for hip fracture: a randomised controlled trial. *International journal of nursing studies*, 50(8), pp.1013–1024.
Setting (Location)	Hospital and community in northern Taiwan
Study population size	n=299 (101 subacute intervention, 99 comprehensive care intervention and 99 control)
Target population (eligibility)	Aged ≥60 years, admitted to hospital for hip fracture requiring surgery (Inclusion criteria: living within catchment area, accidental single-side hip fracture, receiving hip arthroplasty or internal fixation, able to perform full range of motion in unaffected limb at admission, pre-fracture Chinese BI>70. Exclusion criteria: severe cognitive impairment determined by Chinese MMSE<10 or terminally ill)
Intervention group	Patients receiving either a subacute care model or comprehensive care model, provided by geriatrician, geriatric nurses and PTs. The subacute care model included geriatric nurse consultation (CGA, physical, cognitive, functional and nutritional assessment before surgery), geriatrician evaluation based on assessment results before surgery, continuous rehabilitation beginning in hospital after surgery and continuing at home after discharge and early discharge planning (including assessment of home, caregiver's competence, family function, self-care ability, need for long-term care) providing care up to 3 months. The comprehensive care model included the components of the subacute model in addition to health-maintenance interventions to prevent falls (falls risk assessment), nutritional assessment (dietician referral based on results) and depression screening and management, providing care up to 1 year. Average numbers of home visits: 7.5 nurse visits and 2.5 PT visits for subacute model, 10.9 nurse visits and 3.2 PT visits for comprehensive care model.
Comparison group (controls)	Patients receiving usual care including 1-2 rehabilitation sessions in hospital, discharge planning without environmental assesssment, no geriatric consultation and no in-home rehabilitation, with access to internal medicine and hospital care by orthopaedists, and are encouraged to ambulate with protected weight bearing for 3 months.
Study population baseline demographics (intervention vs control)	(Ranges given across the three groups) Age (mean): 76.17-76.91 (n.s.), Gender: 59.6-67.3% female (n.s.), Married: 48.5- 57.6% (n.s.), Illiterate: 37.6-52.5% (n.s.), Femoral neck fracture: 50.5-62.4% (n.s.), Intertrochanteric fracture: 35.4- 48.5% (n.s.), Internal fixation: 55.4-68.7% (n.s.), Arthroplasty: 31.3-44.6% (n.s.), Pre-fracture functional status (Chinese BI/100) (mean): 96.16-97.23 (n.s.), Pre-fracture walking independently: 92.9-96% (n.s.), Number of comorbidities (mean): 1.80 to 2.0 (n.s.), Physical status (ASA rating/6) (mean): 2.51 to 2.63 (n.s.), Time from admission to surgery (mean): 2.16 to 2.30 days (n.s.) (Overall no significant differences)
Study design (classified)	Randomised controlled trial (RCT)
Study design (self-reported)	Randomised controlled trial (RCT)
Primary outcome measure(s)	Health-related QoL (SF-36) over 8 domains (general health, general mental health, physical functioning, disability due to emotional problems, disability due to physical health problems, bodily pain, social functioning and vitality) in addition to mental and physical component summaries at 1, 3, 6 and 12 month follow-up.
Secondary outcome measure(s)	None.
Follow-up period	Outcomes assessed at 1, 3, 6 and 12 months after discharge. Recruitment period: 4 years, 11 months.

Study code	Wright2013
Reference	Wright, P.N., Tan, G., Iliffe, S. and Lee, D., 2013. The impact of a new emergency admission avoidance system for older people on length of stay and same-day discharges. *Age and Ageing*, [online] 43(1), pp.116–121.
Setting (Location)	Hospital and community in London, UK
Study population size	n=10,786 (ED geriatric admissions) (5,416 before intervention: 3,084 TREAT-matching, 5,370 after intervention: 3,322 TREAT-matching)
Target population (eligibility)	Aged ≥70 years, admitted to the ED (conditions not specified) and assessed by a consultant geriatrician as medically stable with complex medical and social needs otherwise necessitating admission.
Intervention group	ED geriatric admissions that either were transferred to a Triage and Rapid Elderly Assessment Team (TREAT) following ED attendance or shared the same combination of HRG, treatment function and patient classification as the TREAT admissions (11% received). Admissions that were transferred to TREAT received CGA at the ED followed by prompt intervention and tailored rapid supported discharge on the day of admission, by a multidisciplinary team of a consultant geriatrician, specialist registrar, nurse practitioner, OT and an administrator. Immediately after discharge, a post-acute care enablement team provided short-term nursing support, monitoring and treatment for up to 5 days and a rapid access geriatric 'hot clinic' provided follow-up investigations and tracked recovery progress (unclear who provided the clinic and where it took place). TREAT was available during working hours on weekdays and -am-1pm on weekends or holidays. Admissions that were not deemed suitable for TREAT received usual care.
Comparison group (controls)	ED geriatric admissions that shared the same combination of HRG, treatment function and patient classification as the TREAT admissions (TREAT-matching) in the year before it was implemented. In addition, two reference groups were included as control groups before and after TREAT was implemented: 1) All ED geriatric TREAT-matching admissions 2) Residual ED geriatric admissions not matching TREAT admissions. Admissions receiving routine care both before and after TREAT were admitted to a medical admissions unit (≤48 hours) where they received CGA and intervention, followed by transfer to a geriatric ward, after which they would be discharged with support if needed and receive routine outpatient follow-up. (Exclusion criteria: null or invalid HRG codes, oncology or mental illness treatment function as deemed to be part of necessary patient care rather than emergency and admissions due to consultant clinics)
Study population baseline demographics (intervention vs control)	Not provided.
Study design (classified)	[Retrospective] Controlled before-and-after study (CBA) (Several clusters identified retrospectively, one cluster including intervention patients and those matching their admission details, another cluster of all ED geriatric admissions, and a third cluster of the residual ED geriatric admissions not matching the intervention patients admission details. Observations represent episodes of care i.e. admissions as is usual with this design. Rather than adjustment for the before period observations, this study uses the comparator groups as reference groups.)
Study design (self-reported)	Pre- and post- retrospective cohort study
Primary outcome measure(s)	Same-day discharge rates as a proportion of admissions and hospital LOS in 12-months before and after intervention.
Secondary outcome measure(s)	None.
Follow-up period	Outcomes assessed over the 1 year before and after intervention. Sample selection period: 2 years.

Study code	Ziden2008
Journal	Ziden, L., Frandin, K. and Kreuter, M., 2008. Home rehabilitation after hip fracture. A randomized controlled study on balance confidence, physical function and everyday activities. *Clinical rehabilitation*, 22(12), pp.1019–1033.
Setting (Location)	University hospital and community in Goteborg, Sweden
Study population size	n=102 (48 intervention, 54 control)
Target population (eligibility)	Aged ≥65 years, admitted to a hospital emergency unit with acute hip fracture requiring surgery, medically approved by the responsible geriatric doctor as being in need of geriatric care and rehabilitation (Inclusion criteria: able to speak and understand Swedish, written patient consent. Exclusion criteria: severe medical illness with expected survival of less than one year, severe drug or alcohol abuse, mental illness or severe cognitive impairment)
Intervention group	Patients receiving a geriatric home rehabilitation programme with supported discharge in addition to usual care (control), provided by a PT, OT, nurse and hospital geriatrician. During hospital stay the patient was offered an individually tailored rehabilitation programme and was accompanied by the PT and OT at discharge. Home rehabilitation consisted of PT and OT visits for up to 3 weeks, focusing on physiotherapy, encouraging confidence in locomotion and physical activity, with a focus on outdoor ambulation, in addition to at least one nurse visit (not able to fulfil for all patients due to resources). Hospital geriatrician was medically responsible for patient care during rehabilitation and patients could be readmitted where necessary. Access to a medical social worker and dietician where needed. Average numbers of home visits: 2.4 PT visits, 1.6 OT visits.
Comparison group (controls)	Patients receiving usual care in a geriatric ward not offering the home rehabilitation programme. Usual care within the ward involved early mobilisation within 48 hours, information about surgical treatment and prognosis. Rehabilitation included training bed transfer, dressing, grooming, walking to the toilet and dining room supported by a PT and OT, who also made a home visit where needed to assess need for any technical aides. Standard rehabilitation programme included daily individual training in basic activities, transfer techniques, training with technical aides, indoor and stair walking in addition to PT and OT therapy group sessions, all adapted to individual functional status and personal goals. Patients not discharged home stayed in hospital or transferred to short-term nursing homes. Referrals for social home care and outpatient rehabilitation facilities were available.
Study population baseline demographics (intervention vs control)	Age (mean): 81.2 vs 82.5 (n.s.), Gender: 60.4% vs 77.8% female (n.s.), Living alone: 54.3% vs 72.2% (n.s.), Home help service: 22.9% vs 37.0%, Informal help: 56.3% vs 70.4% (n.s.), No help: 37.5% vs 27.7% (n.s.), Taking outdoor walks: 95.8% vs 92.6% (n.s.), Talking outdoor walks daily: 64.6% vs 46.3% (n.s.), Cervical fracture type: 54.2% vs 51.9% (n.s.), 1-3 medical diagnoses: 89.6% vs 87.0% (n.s.), >3 medical diagnoses: 6.3% vs 9.3% (n.s.), Functional independence (FIM) (mean): 40.6 vs 40.5 Self-care, 20.3 vs 20.1 Mobility, 12.2 vs 11.5 Locomotion (n.s.), Intrumental activities (IAM) (mean): 21.2 vs 19.0 Outdoor, 20.5 vs 19.9 Domestic (n.s.) (Overall no significant differences)
Study design (classified)	Randomised controlled trial (RCT)
Study design (self-reported)	Randomized controlled study
Primary outcome measure(s)	Proportion walking outdoors, Frequency of outdoor walks, Functional lower extremity muscle strength (STS) (secs), Basic physical mobility (TUG) (secs) at one-month follow-up. Degree of independence in daily activities (FIM) (self-care, mobility and locomotion domains), Degree of independence across outdoor and domestic activities (IAM), Frequency of activities (FAI) (domestic, outdoor and leisure and work domains), at one-month follow-up and change in scores from pre-fracture to follow-up. Falls efficacy (balance confidence) (Swedish FES) (total score, self-care, stairs and IADL domains), at one-month follow-up and change in scores from hospital discharge to follow-up.
Secondary outcome measure(s)	Mean LOS of acute episode including hospital stay and rehabilitation.
Follow-up period	Outcomes assessed either at pre-fracture or discharge (or both) and at one-month follow-up. Recruitment period: 1 year 4 months.

Table B-3 Descriptions of analyses employed in studies included in scoping review

Study code	Analysis description	Adjustment factors	Matching strategy where used
Aimonino2008	Analysis on intention-to-treat basis. Differences at baseline and differences in outcome variables: Paired and unpaired t-tests for parametric data, Chi-square tests for non-parametric. Mortality: Kaplan-Meier survival analysis for cumulative proportion survival over 6 months follow-up.	None reported.	None. (No significant differences at baseline - RCT)
Isaia2009	Differences at baseline and unadjusted differences in outcomes: Paired and unpaired t-tests for parametric data, Chi-square tests for non-parametric. Survival (differences in mortality and institutionalisation): Kaplan-Meier for cumulative proportion survival, log-rank test to compare survival curves (this analysis was only for delirious vs non-delirious patients). Adjusted differences in incidence of delirium: Multivariable logistic regression analysis (reporting RR)	Previous history of delirium and gender.	None. (Some differences in comorbidity, severity of illness, ADL, nutrition and cognition)
Tibaldi2009	Analysis on intention-to-treat basis. Differences at baseline and differences in outcome variables: Paired and unpaired t-tests for parametric data, Chi-square tests or Fisher exact tests for non-parametric. Mortality: Kaplan-Meier survival analysis for cumulative proportion survival over 6 months follow-up.	None reported.	None. (Similar at baseline except in age and caregiver stress - RCT)
Caplan2005	Analysis on intention-to-treat basis. Differences at baseline and differences in outcome variables: t-tests for continuous data, Fisher's exact test for proportions. Adjusted improvement in IADL: Multiple regression analysis.	Age, gender, living arrangements, development of confusion and length of stay of rehabilitation.	None. (No significant differences at baseline - RCT)
Caplan2006	Differences at baseline and differences in outcomes: t-tests for normally distributed data, Mann-Whitney U test for non-normally distributed and ordinal data and Chi-square test for categorical data. Odds ratio for developing delirium during rehabilitation in intervention group reported, though regression analysis not described. Analysis on modified intention-to-treat basis, including only patients who started rehabilitation.	None reported.	None. (No significant differences at baseline - RCT)
Mas2016	Overall and diagnostic subgroup analysis. Differences at baseline and unadjusted differences in outcomes: 2-sample t-test or Kruskal-Wallis equality of ranks test for continuous variables, Chi-square test or Fisher exact test for discrete variables. Adjusted rehabilitation efficiency difference: Multivariable linear regression.	Age, gender, functional status at admission, delirium, Charlson index, number of geriatric syndromes.	None. (Similar at baseline except in delirium, pre-admission BI and number of geriatric syndromes - PCS)
Closa2017	Overall and diagnostic subgroup analysis. Differences at baseline and unadjusted differences in outcomes: 2-sample t-test or Kruskal-Wallis equality of ranks test for continuous variables, Chi-square or Fisher exact test for categorical variables. Adjusted functional gain/loss and direct	Charlson index, age, gender, preadmission Barthel score, and number of geriatric syndromes.	One-to-one propensity score matching including age, gender, Charlson index score, baseline Barthel index score, Barthel

	costs per patient per day/visit: Multivariable linear regression including adjustment for differences at baseline ($p<0.2$) and matched analysis for subsample using propensity score matching.		index score at admission to rehabilitation, number of geriatric syndromes, prevalence of delirium at admission, cognitive impairment, and main clinical diagnosis.
Mas2017	Differences at baseline and unadjusted differences in outcome: Unspecified hypothesis testing (p-values reported), Adjusted differences in outcomes: Multivariable logistic regression with propensity score adjustment for binary outcomes (conflicting information on whether PS was used for matching or adjustment but methods section clearly describes PS as covariate-adjustment), linear regression with propensity score adjustment for continuous outcomes (BI and length of stay at hospital or home unit).	Propensity score adjustment including age, gender, diagnostic group, Early supported discharge/Admission avoidance strategy, length of acute stay, baseline BI, BI at admission to hospital or home unit, Charlson index, cognitive impairment, delirium, mood disorder and number of geriatric syndromes.	Appears to be no matching (conflicting information on whether PS was used for matching or adjustment but methods section clearly describes PS as covariate-adjustment). (Some differences in main diagnostic, ESD/AA strategy, baseline functional staus, cognitive impairment, number of geriatric syndromes)
DiPollina2017	Analysis on intention-to-treat basis. Differences at baseline: t-tests, Chi-square or Fisher exact test. Differences in outcomes: Survival analysis adding interaction between intervention effect and time into model where hazards not proportional (Kaplan-Meier survival estimator, log-rank test and Cox regression using competing risk models for mortality), Cumulative incidences compared using a Wald test stratified by nursing team.	Hazard ratios adjusted for allocated nursing team.	None. (No significant differences at baseline - Q-RCT)
Kwok2004	Differences at baseline and differences in outcomes: t-tests (normal data) and Mann-Whitney U tests (skewed data) for continous data, Chi-square tests for categorical (and proportions), paired t-tests for changes in scores within subjects	None reported.	None. (Similar at baseline except in mobility handicap - RCT)
Kwok2008	Differences in outcomes: Chi-square tests for proportions, Mann-Whitney U tests (skewed data) for continuous data (multiple testing correction for comparisons of levels of handicap)	None reported.	None. (Stated to be similar at baseline except in financial hardship, though other differences appear that don't seem to have been statistically tested - RCT)
Leff2005	Analysis on intention-to-treat basis. Differences at baseline: Unspecified hypothesis testing (p-values reported). Unadjusted differences in outcomes: logistic regression for dichotomous variables with sufficient numbers of events otherwise Fisher exact test (for complications), Wilcoxon rank-sum tests (for number of domains of satisfaction). Adjusted differences in outcomes: Multivariable logistic regression (for	Age, gender, severity of illness (APACHE II) and study site in analysis of complications and delirium risk factors in addition for analysis of delirium (visual impairment, cognitive impairment	None. (Similar at baseline except in medications and severity of illness - HCS)

	complications and satisfaction), multivariable linear regression (changes in ADL/IADL). Survival (cumulative incidence of delirium): Proportional hazards model, Kaplan-Meier analysis and log-rank test. Differences in costs: Parametric tests and non-parametric bootstrapping (1000 repetitions).	and dehydration). Depression score (GDS), more than one limitation in ADL/IADL, primary diagnosis, caregiver limited in at least one ADL/IADL, low cognitive status (MMSE) for analysis of patient satisfaction with care. Patient living at poverty level, primary diagnosis, having a child as a caregiver and number of medications for analysis of caregiver satisfaction with care.	
Leff2006	Differences at baseline: Unspecified hypothesis testing (p-values reported). Unadjusted differences in outcome: Bivariate analyses using Chi-square or Fisher's exact test (for proportions satisfied in each domain). Adjusted differences in outcomes: Logistic regression (for individual factors associated with satisfaction always including treatment allocation).	Factors found to be associated with satisfaction - gender, living alone, no cognitive impairment (MMSE≥24), moderate to severe depression (GDS≥6), family member limited in ADL/IADL, family member health.	None. (Similar at baseline except in IADL impairment - PCS)
Leung2015	No statistical testing for baseline differences presented. Differences in outcome variables: paired t-tests or Wilcoxon signed-rank tests for non-normal data, McNemar's test for mortality rate, sensitivity analysis excluding deaths during the study.	None reported.	One-to-one direct matching on age (±5 years), gender, patient disease diagnosis (COPD, chronic heart failure, cancer, other), Clinical Frailty index, carer relationship with patient.
Lewis2017	Differences in outcome variables: Wilcoxon signed-rank test (for paired samples)	None reported.	Before and after study, intervention patients act as own controls.
Lin2015	Intervention group acting as own control (no baseline difference). Difference in outcome variables: Paired t-tests for continuous, Wilcoxon signed-rank test for non-normally distributed variables.	None reported.	Before and after study, intervention patients act as own controls.
Mendoza2009	Differences at baseline and unadjusted differences in mortality and readmission outcomes: Chi-square test for categorical variables, Students t-test for continuous, Mann-Whitney test for non-parametric. Adjusted differences in QoL and functional status: Analysis of covariance.	Adjustment for "basal levels" (unclear but may include oxygen saturation in ED, left ventricular ejection fraction, N-terminal pro-brain natiuretic peptide).	None. (No significant differences at baseline - RCT)
Parsons2018	Analysis on intention-to-treat basis. No statistical testing for baseline differences presented. Unadjusted differences in functional outcomes: Chi-square test, Adjusted differences in hospital days at index admission, hospital days from readmissions and costs: Analysis of variance.	Age.	None. (Stated to be similar at baseline, though differences appear without presenting statistical testing - RCT)

Senior2014	Analysis on intention-to-treat basis. No statistical testing for baseline differences presented. Adjusted differences on 'institution-free survival': Cox proportional hazards regression (HR), Differences in functional and social outcomes: mixed model to measure changes over multiple time points, Differences between various outcomes and to isolate statistically significant variables: ANOVA, t-tests, regression techniques and non-parametric techniques depending on data distribution.	Age, gender, health and disability needs level, living alone included in Cox-ph model. 'Adjusted analyses' described in the case of imbalances at baseline, but these are not described.	None. (Stated to be similar at baseline, though differences appear without presenting statistical testing - RCT)
Shyu2013	Analysis on both intention-to-treat and as-treates bases. Differences at baseline: One-way ANOVA or Chi-square tests. Differences in outcomes: Hierarchical (multi-level) linear models with a reference group (usual care) with time centred given time points and at individual multiple time points across groups to test difference over time	Attrition and pre-fracture functional status	None. (No significant differences at baseline - RCT)
Wright2013	Differences in outcomes: Mann-Whitney U tests for LOS, odds ratios reported for same-day discharges (suggesting logistic regression)	None reported.	All matching admissions on HRG, treatment function and patient classification of ED admissions used to find TREAT-matching admissions as comparison group
Ziden2008	Differences at baseline at outcomes at 6-months: Fisher's exact test (dichotomous variables), Chi-square test (non-ordered categorical variables), Mantel-Haenszel chi-square (ordered categorical variables), Mann-Whitney U-test (continuous variables). Changes over time: Wilcoxon signed rank test (continuous variables) within groups and Mann-Whitney U-test between groups.	None reported.	None. (No significant differences at baseline - RCT)

Table B-4 Findings of studies included in scoping literature

Study code	Functional, physical and mental health outcomes	Mortality	Quality of life (QoL)	Satisfaction with care	Use or cost of health services
Aimonino2008	ND ADL/IADL, cognitive status (MMSE), or nutrition (MNA). Improvement in depression (GDS) compared to control group ($p<0.05$).	ND in 6-month mortality, ND in cumulative proportion survival over 6 months	↑ improvement QoL (NHP) ($p<0.05$), ↑ time to readmission ($p<0.005$), ND in caregiver stress (RSS).	ND in patient satisfaction with care.	↓ incidence of hospital readmissions ($p<0.001$), ↓ costs per patient per day ($p<0.002$), ↑ mean LOS of acute episode ($p<0.01$)
Isaia2009	↓ incidence of delirium ($p<0.05$) and ↓ relative risk [increased RR 3.84(1.8-3.7) for control group, $p<0.05$] of developing delirium, Slower onset of delirium ($p<0.001$), ↓ duration of delirium episode ($p<0.001$), ↓ severity of delirium ($p=0.06$), ↓ number of psychoactive drugs used during acute episode ($p<0.05$).	ND in 6-month mortality rate (p-value not reported).	ND caregiver stress (RSS) (from admission to discharge) in intervention group, while increase observed in control group ($p<0.001$).	N/A	↑ LOS of acute episode ($p<0.001$), ↓ institutionalisation rate ($p<0.001$), ↓ costs of care per patient per day ($p<0.001$).
Tibaldi2009	ND in medical complications (infections and delirium). ND in changes in functional status (BI and IADL) and cognition (MMSE) over 6-months. ↑ improvement in depression (GDS) and nutritional status (MNA) ($p<0.05$) over 6-months.	ND in 6-month mortality, ND in cumulative proportion survival over 6 months	↑ improvement in QoL (NHP) ($p<0.05$) over 6-months. ND in change in caregiver stress (RSS) from admission to discharge from intervention or usual care. ↑ time to first readmission after discharge ($p<0.001$)	N/A	↓ incidence of nursing home admission ($p<0.05$), ↑ LOS of acute episode ($p<0.001$). ND in LOS of first readmission, ND in number of hospital admissions during 6-month follow-up. ↓ total mean cost of acute episode per patient ($p<0.001$).
Caplan2005	↑ improvement in IADL compared to control group (in adjusted and unadjusted analysis) ($p<0.05$), ND functional status (BI), ND cognition (MSQ)	N/A	N/A	N/A	↓ time in ED before transfer to home or hospital ($p<0.005$)
Caplan2006	↓ incidence of delirium ($p<0.01$) and ↓ odds [OR 0.17 (0.03-0.65)] of developing delirium during rehabilitation. ND between groups in functional	ND in 6-month mortality rate	N/A	↑ satisfaction with quality of rehabilitation ($p<0.01$). ND in	↓ rehabilitation LOS ($p<0.05$), ND in acute and overall episode LOS. ↓ hospital bed days per

Study code	Functional, physical and mental health outcomes	Mortality	Quality of life (QoL)	Satisfaction with care	Use or cost of health services
	independence (FIM), cognitive status (MMSE) and depression (GDS) at all follow-up stages.			carer and GP satisfaction.	episode of care ($p<0.001$). ↓ cost of rehabilitation ($p<0.001$) and overall episode of care ($p<0.05$). ND in readmission within 28 days after rehabilitation.
Mas2016	ND in functional gain (overall and for diagnostic subgroups), ↑ rehabilitation efficiency for hip fracture subgroup (due to shorter rehabilitation), ND in rehabilitation efficiency overall and for other subgroups.	N/A	ND in proportion discharged home.	N/A	↓ length of rehabilitation for hip fracture subgroup ($p<0.01$)
Closa2017	ND in functional gain/loss ratio (Heinneman index) (overall and for diagnostic subgroups in adjusted and unadjusted analyses).	N/A	ND in discharge destination (including home).	N/A	↓ length of acute hospital stay prior to rehabilitation ($p<0.001$), ↓ length of rehabilitation ($p<0.001$), ↓ direct costs of care per patient per visit/day ($p<0.001$) (in adjusted and unadjusted analyses).
Mas2017	ND in functional resolution (recovered at least a third of functional loss) in unadjusted analysis, ↑ functional resolution [OR 1.62 (1.09-2.41)] in adjusted analysis.	N/A	ND in health crisis resolution (recovered at least a third of functional loss and discharged to community/primary care) in unadjusted analysis, ↑ health crisis resolution [OR 1.54 (1.06-2.22)] in adjusted analysis.	N/A	↓ length of acute hospital stay prior to admission to hospital or home unit ($p<0.001$), ↓ length of stay at hospital or home unit ($p<0.001$) (unadjusted)

Study code	Functional, physical and mental health outcomes	Mortality	Quality of life (QoL)	Satisfaction with care	Use or cost of health services
DiPollina2017	N/A	↓ two-year mortality rate ($p<0.05$), ND in two-year cumulative proportion survival.	↑ incidence of home death ($p<0.05$). ↑	N/A	ND in number of inpatient hospitalisations, ↓ two- and three-year rate of first hospitalisation ($p<0.05$, HR 0.48), ↓ cumulative incidence of unnecessary hospitalisations ($p<0.05$), ND length of stay over three year follow-up, ↓ incidence of at least one ED attendance ($p<0.05$), ↓ two- and three-year rate of first ED attendance ($p<0.05$, HR 0.43 over three years), ND in institutionalisation.
Kwok2004	ND in functional outcomes (change in peak expiratory flow rate, oxygen saturation at rest, exercise capacity (6-min walking test), level of functional handicap (LHS), psychological health (GHQ))	N/A	ND in perceived control of health (HLC), stability observed in level of social handicap (LHS) while worsening in control group ($p<0.05$). ND in change in caregiver burden (CCI).	N/A	ND 6-month unplanned readmission rate, ND in 28-day unplanned readmission rate, ND in primary causes of readmissions, ND in numbers of unplanned readmissions, ED attendances and number of hospital bed days over 6-month follow-up.
Kwok2008	↑ functional independence (LHS) ($p<0.005$), ND physical function (6-min walking test).	N/A	N/A	N/A	ND 6-month unplanned readmission rate, ↓ number of unplanned readmissions ($p<0.05$), ND in primary causes of readmissions, ↓ hospital bed and emergency care costs per person ($p<0.05$), ND total public health costs per person, total health and social care costs paid per patient, and in total personal costs per patient.

Study code	Functional, physical and mental health outcomes	Mortality	Quality of life (QoL)	Satisfaction with care	Use or cost of health services
Leff2005	↓ likelihood of developing delirium in unadjusted [HR 0.44 (0.23-0.83)] and adjusted [HR 0.26 (0.12-0.57)] analyses. ↓ odds of having sedative medication prescribed in unadjusted [OR 0.45 (0.28-0.73)] and adjusted [OR 0.49 (0.30-0.81)] analyses. ↓ use of chemical restraints ($p<0.05$), ↓ critical complications ($p<0.001$). ND in other complications (bowel, urinary, emergency situations, falls, physical restraints and nosocomial infection). ND in changes in ADL/IADL.	↓ 2-week mortality rate ($p=0.050$)	N/A	↑ number of satisfied domains for both patients and caregivers ($p<0.001$) in unadjusted analysis, remained significant in adjusted analysis (statistics not reported).	↑ time spent in ED ($p<0.005$). ↓ hospital-at-home or hospital length of stay ($p<0.005$). ND in number of ED attendances, inpatient hospital readmissions, admissions to skilled nursing facilities and home health visits. ↓ cost of index hospitalisation per person ($p<0.001$).
Leff2006	N/A	N/A	N/A	↑ proportion of overall patient satisfaction ($p<0.05$) and caregiver (family member) satisfaction ($p<0.001$) in unadjusted analysis. ↑ odds of overall patient satisfaction [OR 2.98 (1.08-8.21)] and caregiver satisfaction [OR 5.61 (1.78-17.66)] in adjusted analysis. ND in proportion reporting to choose care again in same setting and reporting they would recommend the care they received.	N/A

Study code	Functional, physical and mental health outcomes	Mortality	Quality of life (QoL)	Satisfaction with care	Use or cost of health services
Leung2015	N/A	ND in 3-month mortality rate	Improvement in overall QoL (mQOLC-E) (n=18 in each group due to loss to follow-up, $p<0.05$).	N/A	↓ number of unplanned emergency admissions ($p<0.05$), ND in number of emergency attendances and length of emergency admissions (same results in sensitivity analysis excluding deaths, n=24 in each group)
Lewis2017	N/A	N/A	N/A	N/A	↓ number of unscheduled hospital admissions, hospital bed days and ED attendances ($p<0.001$) (6-months before and after)
Lin2015	↑ walking ability (MFAC) and functional status (BI) after intervention ($p<0.001$). ND in cognition (AMT) after intervention.	N/A	N/A	N/A	↓ acute hospital admissions, hospital bed days and ED attendances in 6-month follow-up ($p<0.001$). Potential annual cost-savings achieved compared to cost of hospital admission (not statistically tested).
Mendoza2009	ND in functional status (BI)	ND in 12-month mortality rate	ND in health-related QoL (mental and physical) (SF-36).	N/A	No incidence of transfer from HaH to hospital during initial episode, ND in readmission for HF, ND in combined outcome for mortality and cardiovascular event readmission, ↓ cost of initial HF episode per patient ($p<0.001$), ND in cost per patient during one-year follow-up

Study code	Functional, physical and mental health outcomes	Mortality	Quality of life (QoL)	Satisfaction with care	Use or cost of health services
Parsons2018	↑ improvement in bathing ($p<0.01$) and dressing ($p<0.05$) (ADL self performance domains) from baseline to follow-up. ND in change in other ADL self-performance/IADL capacity outcomes (including personal hygiene, locomotion, toilet use, meal preparation, ordinary housework, managing medications and stairs).	N/A	N/A	N/A	↓ number of hospital days during initial hospital episode ($p<0.05$), ↓ number of hospital days during 6-month follow-up ($p<0.05$), ↑ reduction in health-related costs during 6-month follow-up compared to 6-months prior ($p<0.01$).
Senior2014	ND in functional outcomes (functional status, cognitive status, depression, and instability in health), ND in adverse events	ND in absolute risk reduction of 12-month mortality	Slower decline in caregiver physical health-related QoL (SF-36) ($p<0.01$), ND in other caregiver health-related QoL components, ND in caregiver burden (CRA), ND pain (InterRAI-HC Pain scale)	N/A	ND in absolute risk reduction of combined outcome of death or permanent residential care, ND in absolute risk reduction of permanent residential care placement
Shyu2013	N/A	N/A	ND in HRQoL mental component summary score at 12-months. ↑ HRQoL in physical component summary score at 12-months (subacute: b=5.35, comprehensive: b=4.10) ($p<0.05$). ↑ HRQoL at 12-months in physical functioning (subacute b=10.93, comprehensive: b=10.33) ($p<0.05$), in role disability due to physical health problems (subacute: b=33.41, comprehensive b=24.77) ($p<0.01$), in general health (b=8.35, $p<0.05$) and mental health (b=7.93, $p<0.05$) for comprehensive model, in vitality (b=6.48,	N/A	N/A

Study code	Functional, physical and mental health outcomes	Mortality	Quality of life (QoL)	Satisfaction with care	Use or cost of health services
			p<0.05) and social function (b=9.33, p<0.05) for subacute model. ND in bodily pain at 12-months, worse pain at 3-months in comprehensive care (b=-9.31, p<0.01). ND in health-related QoL in disability due to emotional problems at 12-months. Intervention effects for both models increased over time.		
Wright2013	N/A	N/A	N/A	N/A	↓ LOS in 12-months after intervention in TREAT-matching admissions (p<0.001) (↓ LOS in all ED geriatric admissions and no significant change observed in residual admissions as reference groups), ↑ in proportion of same-day discharges for TREAT-matching admissions (p<0.001) (reduction for residual admissions (p<0.001) as reference group)

Study code	Functional, physical and mental health outcomes	Mortality	Quality of life (QoL)	Satisfaction with care	Use or cost of health services
Ziden2008	↑ proportion walking outdoors ($p<0.001$) and walking outdoors daily ($p<0.001$) at 1-month. ↑ functional lower extremity muscle strength (STS) ($p<0.001$), ↑ physical mobility (TUG) ($p<0.05$), ↑ degree of independence in daily activities (FIM) (in all three self-care, mobility and locomotion domains) ($p<0.001$), ↑ degree of independence across instrumental activities (IAM) in both outdoor ($p<0.01$) and indoor ($p<0.05$) domains, ↑ frequency of activities (FAI) in domestic ($p<0.05$) and outdoor ($p<0.001$) activities only (ND in leisure and work activities), ↑ balance confidence (Swedish FES) in all domains ($p<0.001$) (total, self-care, stairs and IADL) at one-month follow-up. ↑ recovery from pre-fracture to one-month follow-up (as in scores had smaller reductions) in self-care ($p<0.001$), mobility ($p<0.001$), locomotion ($p<0.01$), all domestic activities ($p<0.01$), frequency of leisure/work activities (FAI) ($p<0.05$) (ND in change in frequency of outdoor activities).	N/A	N/A	N/A	ND in mean index hospital LOS

Appendix C Supplementary table on suitability of alternative multiple-failure survival models

Table C-1 Alternative multiple-failure survival models, their general mechanism and their suitability or lack thereof

Multiple-failure models	Mechanism	Comment / Suitability
Wei, Lin and Weissfeld (WLW)	Stratified Cox-based approach that has similarities with AG and PWP models, but regards a subjects as being at risk of all repeated events at the outset (Westbury et al., 2016).	Not well suited to analysis of ordered failure events (Westbury et al., 2016) for which it has been criticised by researchers (Yadav et al., 2018).
Frailty models (random effects)	Introduces a random covariate into the model that describes the excess risk (or frailty). Model assumes recurrent events are independent given covariates and random effects (Amorim and Cai, 2015).	Suitable when a subject-specific random effect can explain unmeasured heterogeneity that cannot be explained by covariates alone (Amorim and Cai, 2015). Computationally intense, interpretation can be less straightforward and variations still being researched (Yadav et al., 2018).
Multi-state models (MSM)	"Investigate the relationship between individual risk factors and the transition probabilities between states representing different failure events" (Westbury et al., 2016, p.6)	Application to epidemiological data is limited (Amorim and Cai, 2015) and rarely used due to lack of application through standard statistical software (Perera and Dwivedi, 2020).

Appendix D Definition of the standardised mean difference (SMD)

The standardised mean difference (SMD) was used to assess covariate balance between groups. Specific definitions of the SMD are defined here.

For binary treatments, SMDs may be calculated for continuous variables as

$$SMD = \frac{(\overline{x}_{\text{treatment}} - \overline{x}_{\text{control}})}{\sqrt{\frac{s^2_{\text{treatment}} + s^2_{\text{control}}}{2}}}$$

Where $\overline{x}$ denotes the sample mean of each covariate and s^2 denotes the sample variance of each covariate (i.e. mean difference in covariate means divided by standard deviation). SMDs are calculated for dichotomous variables as

$$SMD = \frac{(\hat{p}_{\text{treatment}} - \hat{p}_{\text{control}})}{\sqrt{\frac{\hat{p}_{\text{treatment}}(1 - \hat{p}_{\text{treatment}}) + \hat{p}_{\text{control}}(1 - \hat{p}_{\text{control}})}{2}}}$$

where $\hat{p}$ denotes the prevalence or mean of the dichotomous variable (Austin, 2011a).

Appendix E Best subset selection plots

In selecting predictors of receipt of ECT in empirical variable selection of potential confounders, the predictors included in the best subset models of any size and of limited size (up to seven predictors) are visually represented in Figure E-1 and Figure E-2 respectively.

Figure E-1 – Covariates included in best subset models of any size as most predictive of receipt of ECT intervention

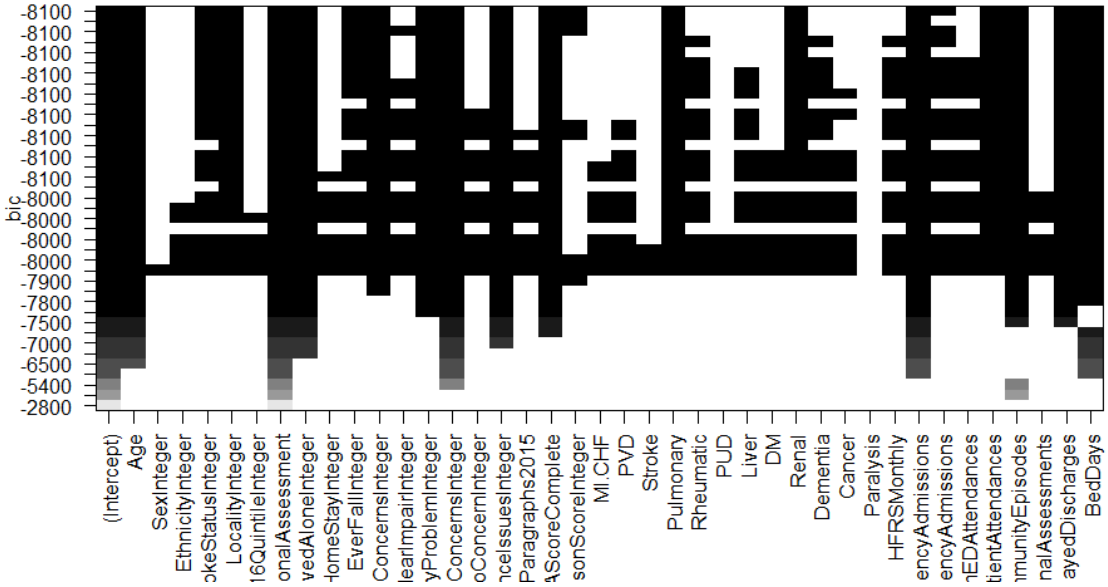
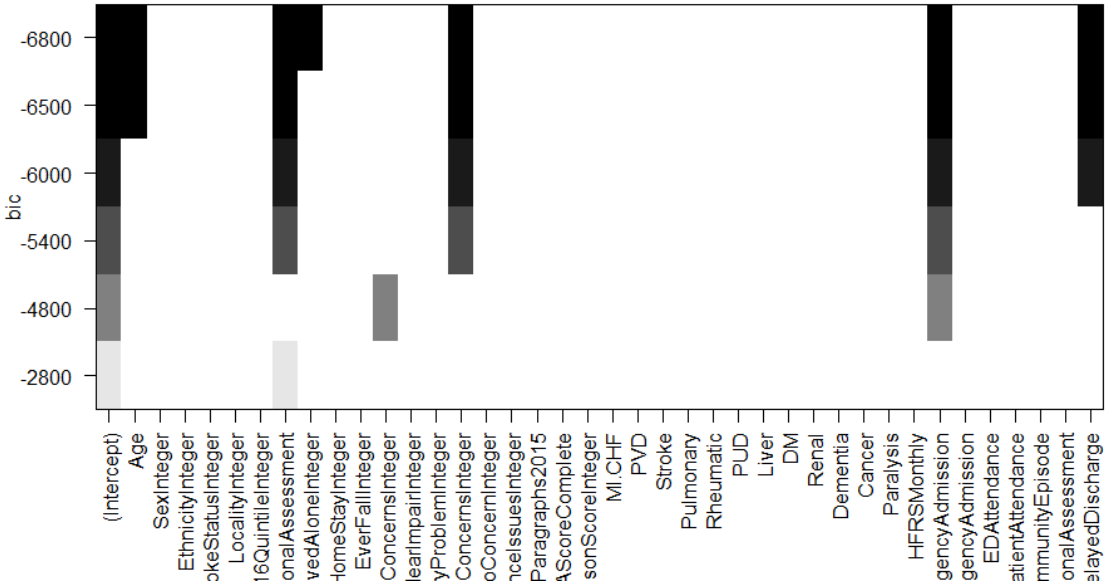
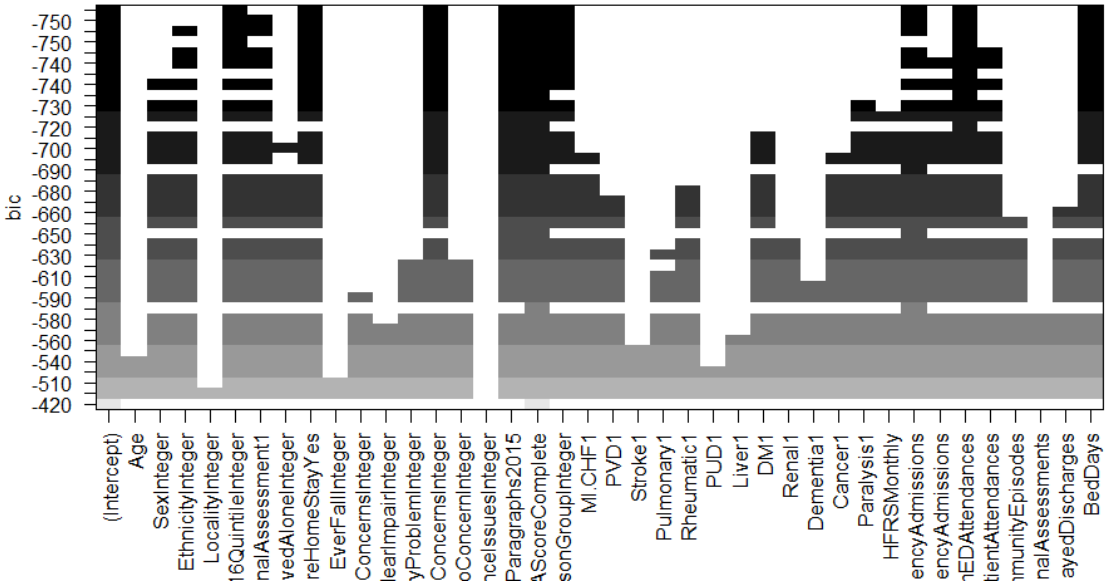


Figure E-2 – Covariates included in best subset models with model size up to seven predictors most predictive o freceipt of ECT intervention



In selecting predictors of receipt of ALFY in empirical variable selection of potential confounders, the predictors included in the best subset models of any size are visually represented in the following figure.

Figure E-3 – Covariates included in best subset models of any size as most predictive of calling ALFY



Appendix F Cox model diagnostic plots

Check #1 – Are the functional forms of the variables appropriate? *(inspection of Martingale residuals against continuous predictors)*

The first check is that the correct functional form of continuous covariates has been included in the model. As previously described, this should be checked before assessing the proportional hazards assumption as incorrect functional forms may appear as violations of the proportional hazards assumption. Correct functional forms of continuous predictors can be assessed by inspecting the Martingale residuals against the continuous predictor. Martingale residuals can be viewed as the difference between the observed number of events for each subject throughout time and the expected numbers based on the fitted model (Xu, 2019).

The figures below display the Martingale residuals for the fitted model, null in each continuous predictor (without SPARRA, prescriptions and length of stay in days respectively, one at a time), against the continuous predictor. The figures display the shape of the relation of the continuous predictor to the outcome. The left plots display the residuals per observation as is usual, however, given that we are using counting process data, where there are several observations per subject, the following phenomenon occurs: "breaking a subject into many intervals has generated multiple observations with a small [expected value] for the interval, leading to a bolus of 0 or near 0 points clogging the centre of the plot. The events, being associated with a small interval at the end of follow-up, also have a small [expected value] and thus a martingale residual near 1" (Therneau and Grambsch, 2000, p.112).

Hence, as per Therneau & Grambsch (2000), the residuals have been plotted per subject on the right hand-side (i.e. totalled over subject) for correct interpretation. As Therneau & Grambsch highlight, plotting in this way requires a decision to choose which of the multiple observed values of the continuous covariates recorded over time to plot against. Here, the baseline values of the continous covariates that are measured over time have been selected (prescriptions were a static covariate), which is not a perfect solution, but enables some assessment of functional form. Note also that in the right hand-side plots, y-limits are set to (-1,1) to enable examination of scaled functional form of LOESS curve (as per (Therneau and Grambsch, 2000)).

*Figure F-1 – Plot of Martingale Residuals of fitted model assessing effect of **ALFY on emergency inpatient hospitalisations** null in the continuous covariate by each covariate, with LOESS line*

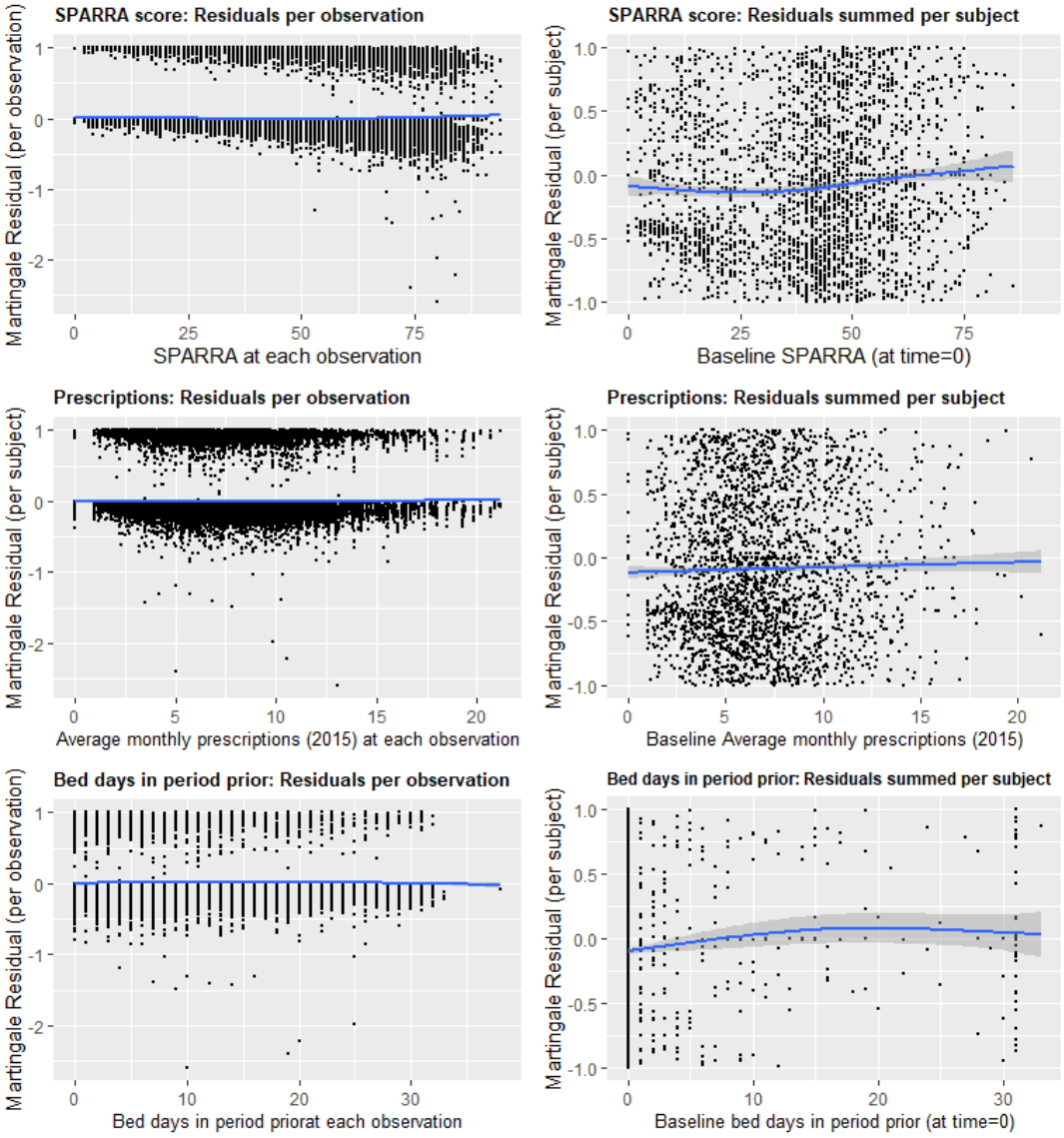


*Figure F-2 – Plot of Martingale Residuals of fitted model assessing effect of **ALFY on emergency department attendances** null in the continuous covariate by each covariate, with LOESS line*

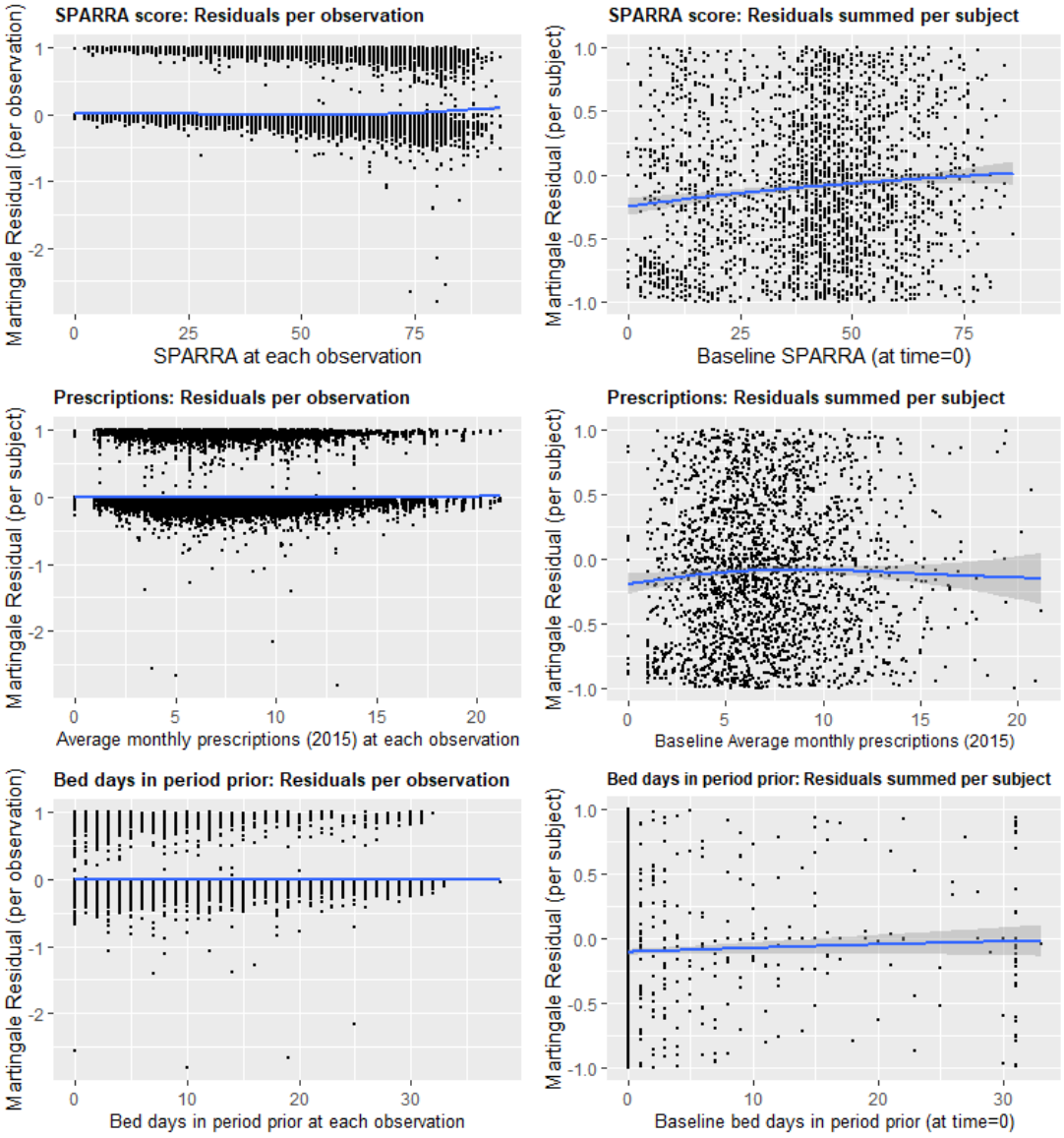
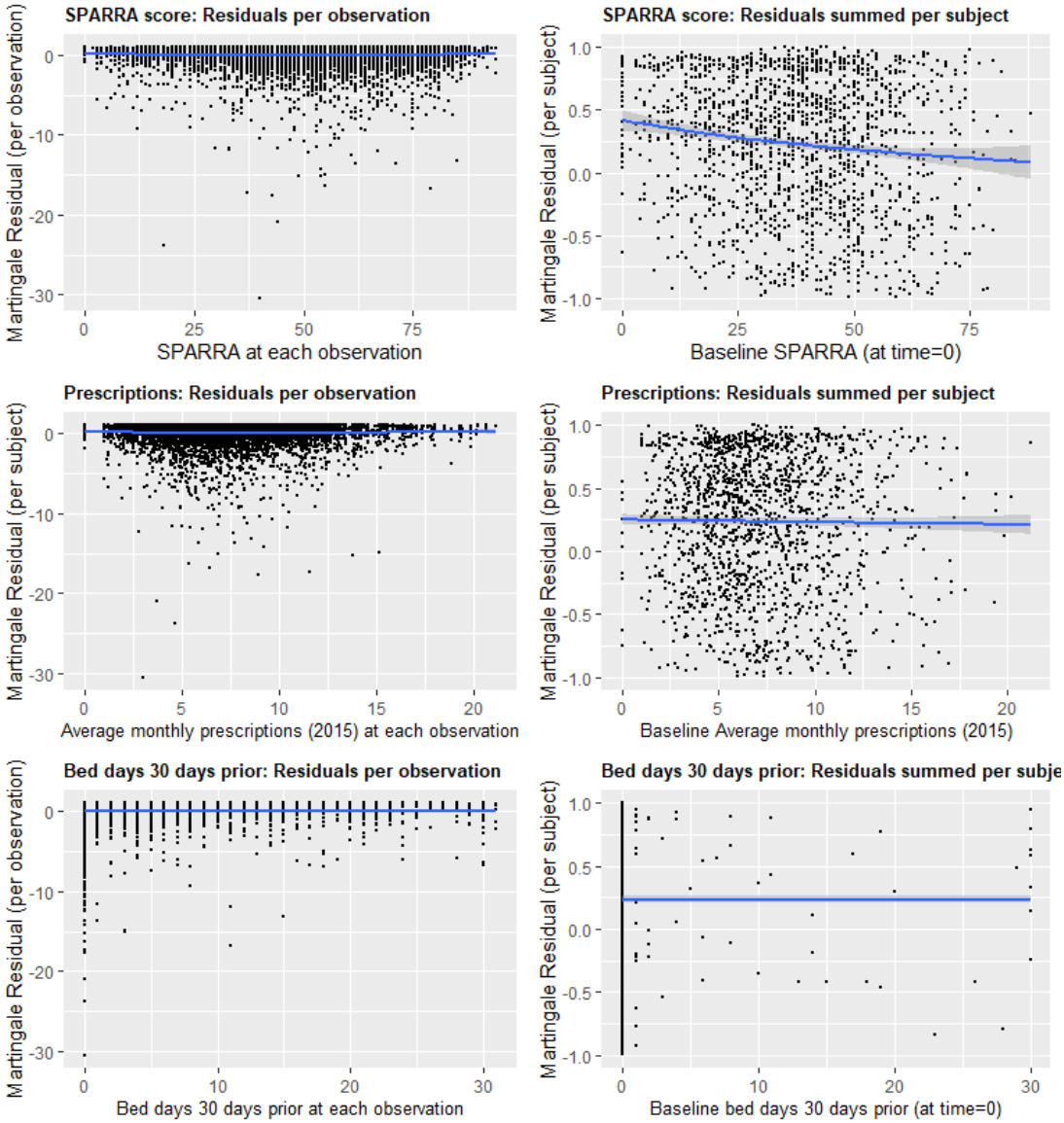


*Figure F-3 – Plot of Martingale Residuals of fitted model assessing effect of **ALFY on emergency inpatient length of stay (time to discharge)** null in the continuous covariate by each covariate, with LOESS line*



The LOESS (locally estimated scatterplot smoothing) lines in these right hand plots indicate a roughly linear relationships for all three continuous predictors, indicating that the covariates in their linear form provide a good representation of the contribution of the predictor to the outcome. Therefore, it was reasonable to use the continuous predictors in their current linear functional form in the Cox models.

Check #2 – Is the proportional hazards assumption satisfied? *(Schoenfeld residuals test and inspection of Schoenfeld residuals against time)*

The Cox model assumes that the ratio of hazards is proportional throughout time for all covariates in the model. Checking the proportional hazards assumption can be done by performing a test and by examining the scaled Schoenfeld residuals against time for each covariate in the model. Schoenfeld residuals represent the difference between values of the observed covariates and those expected by the fitted model, based on the risk set at each failure time (Xu, 2019).

The figures below indicate the results of the Schoenfeld residuals test for each of the covariates in the model as well as plotting the residuals against time. As there is no censoring, the default Kaplan-Meier transformation of time was used in the test (Park and Hendry, 2017). The Schoenfeld residuals test indicates significant non-proportionality in some of the included covariates, however graphical inspection indicates no pattern in the residuals across time and flat smoothed fit lines, indicating no violation in proportional-hazards.

*Figure F-4 – Plots of scaled Schoenfeld residuals against time for each covariate in the adjusted Cox model assessing effect of **ALFY on emergency inpatient hospitalisations**, including the result of the Schoenfeld test for proportionality*

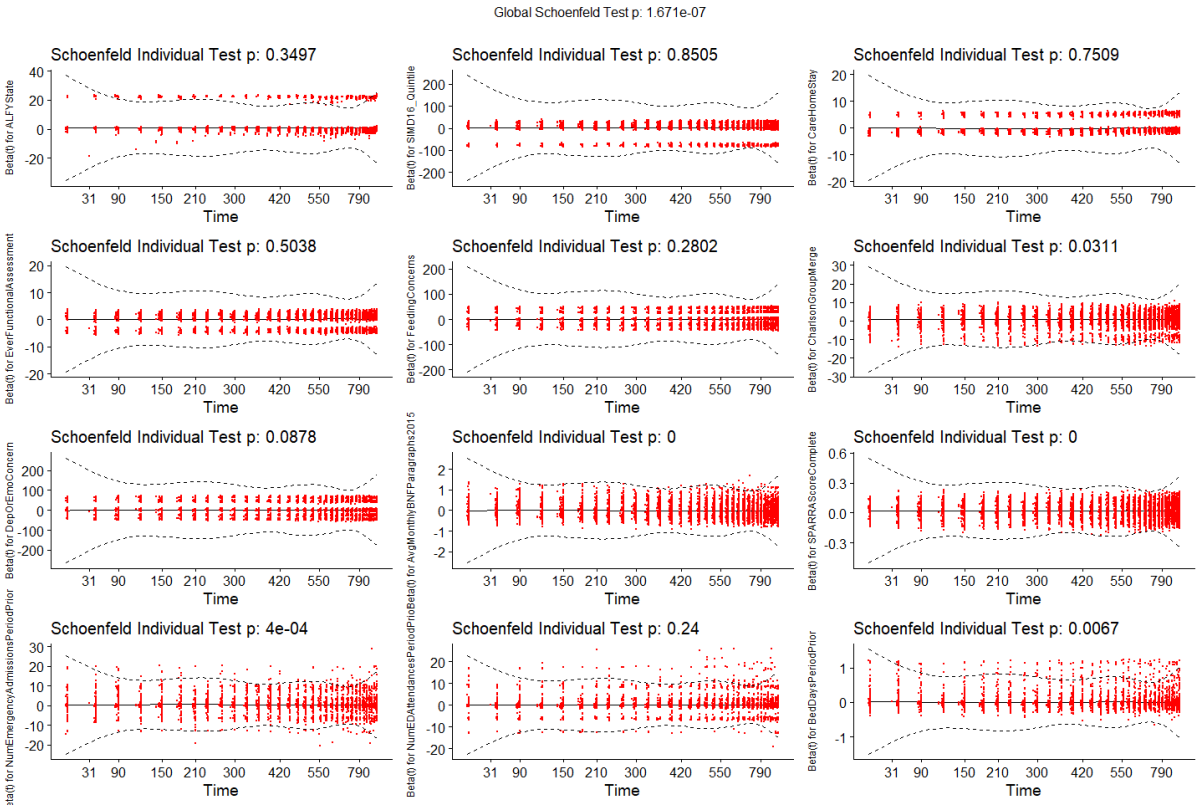


Figure F-5 - Plot of scaled Schoenfeld residuals against time for offending covariates in the adjusted Cox model assessing effect of ***ALFY on emergency inpatient hospitalisations***

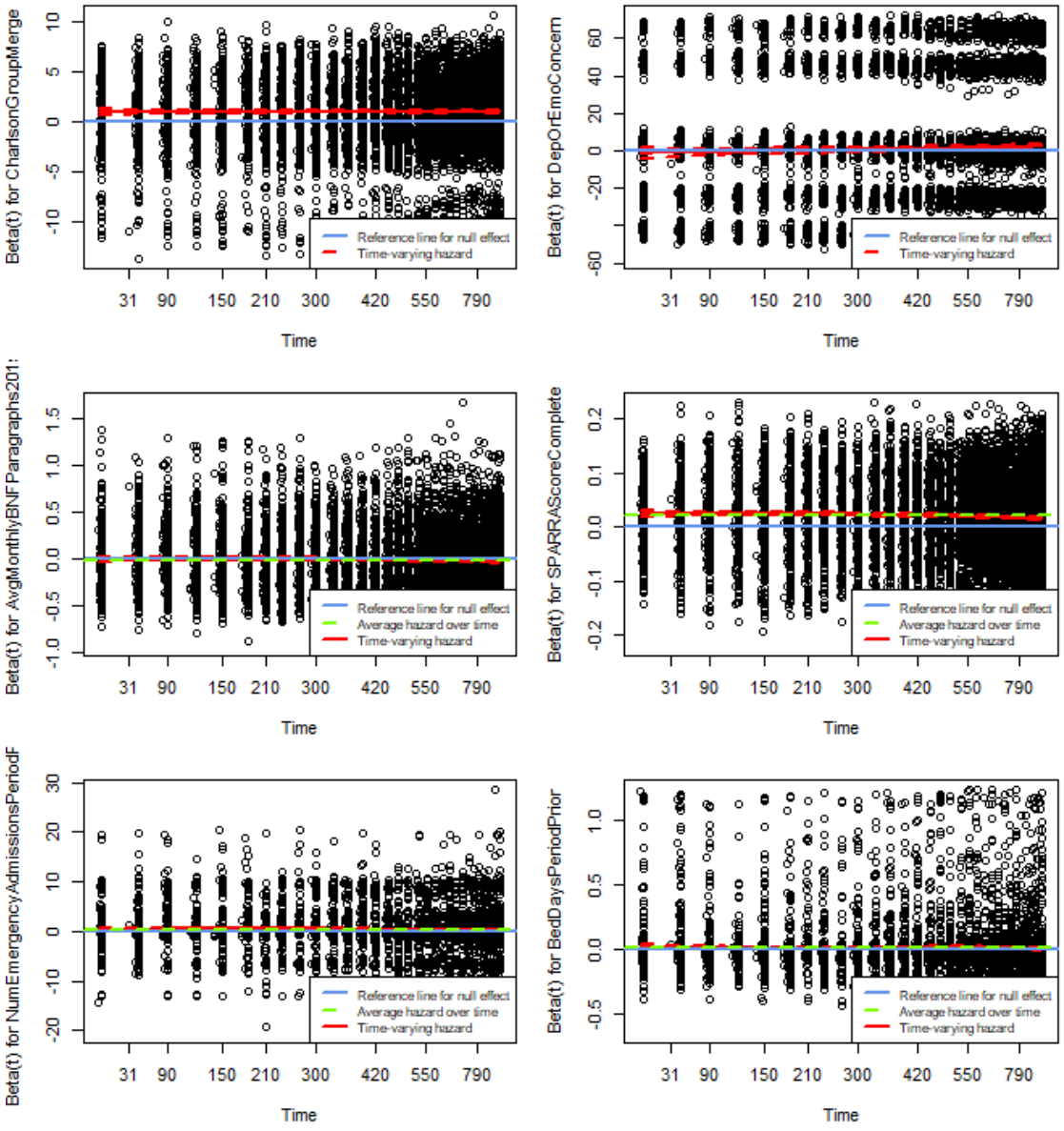


*Figure F-6 – Plots of scaled Schoenfeld residuals against time for each covariate in the adjusted Cox model assessing effect of **ALFY on emergency department attendances**, including the result of the Schoenfeld test for proportionality*

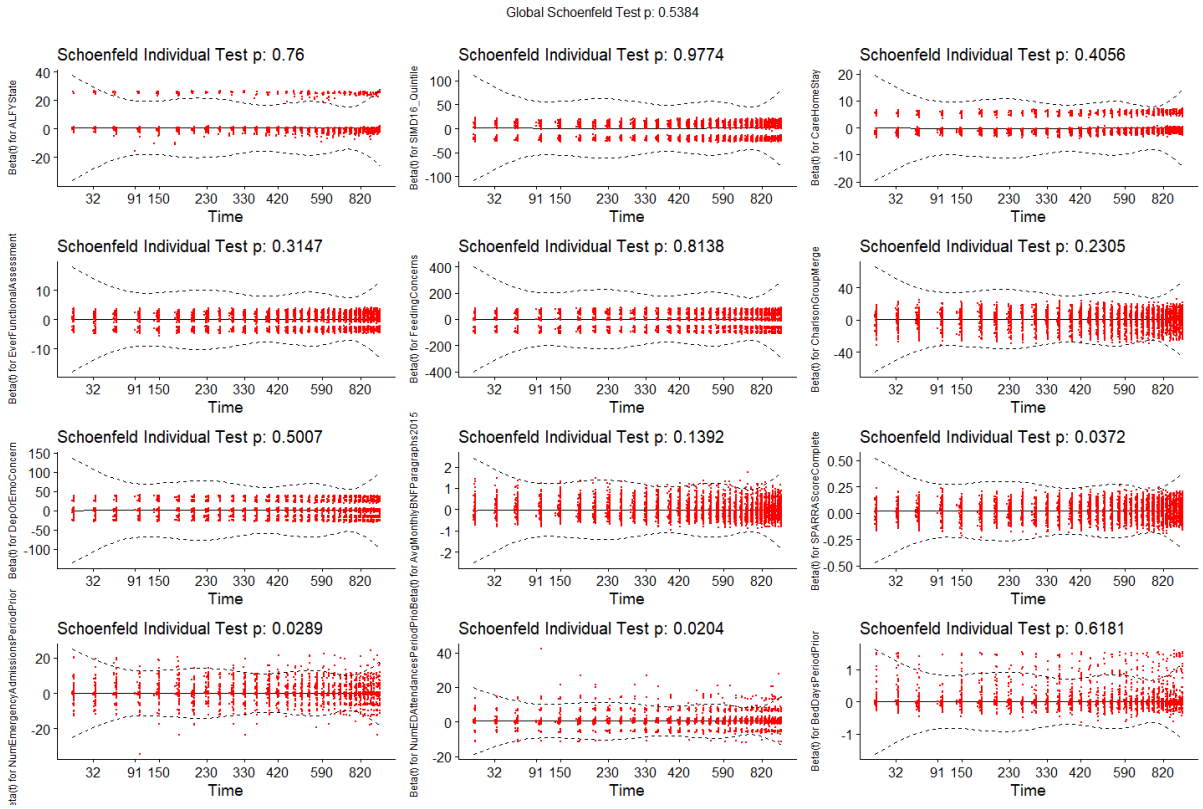


*Figure F-7 – Plot of scaled Schoenfeld residuals against time for offending covariates in the adjusted Cox model assessing effect of **ALFY on emergency department attendances***

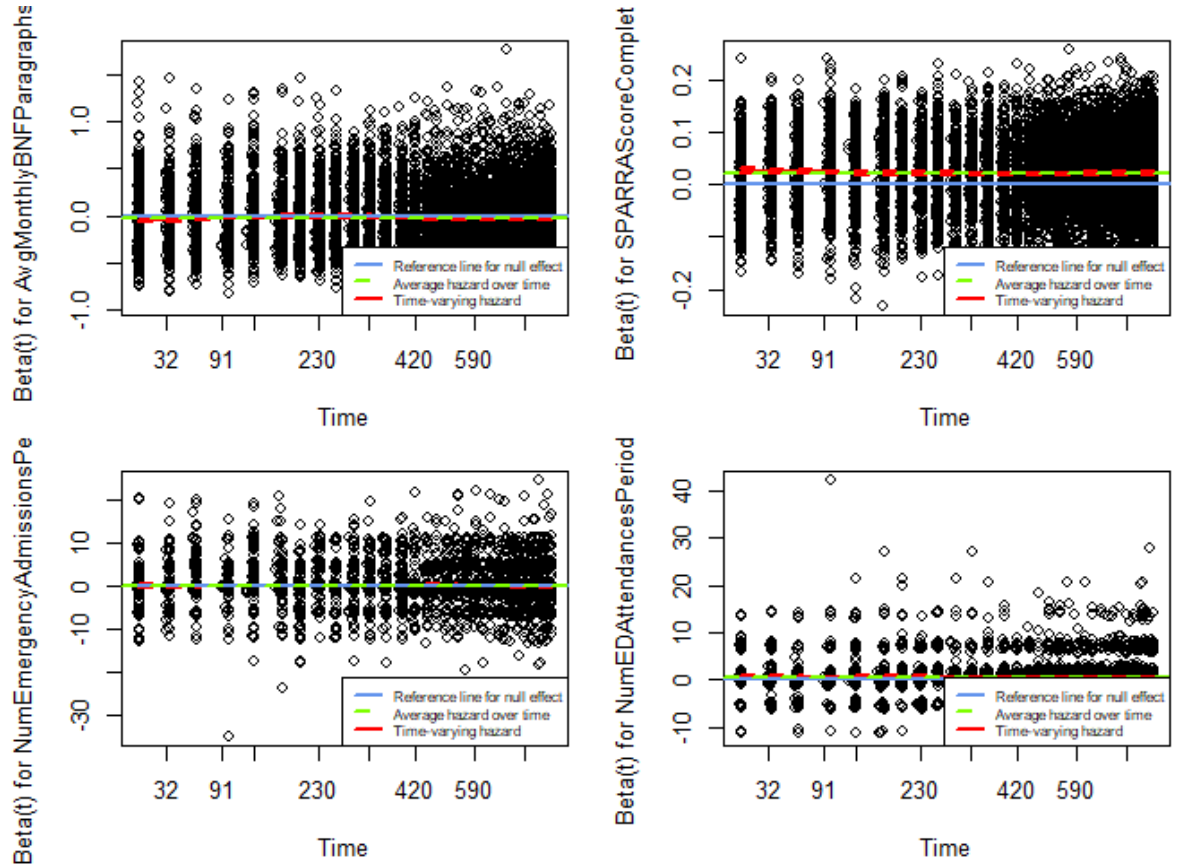


*Figure F-8 – Plots of scaled Schoenfeld residuals against time for each covariate in the adjusted Cox model assessing effect of **ALFY on length of stay (time to discharge)**, including the result of the Schoenfeld test for proportionality*

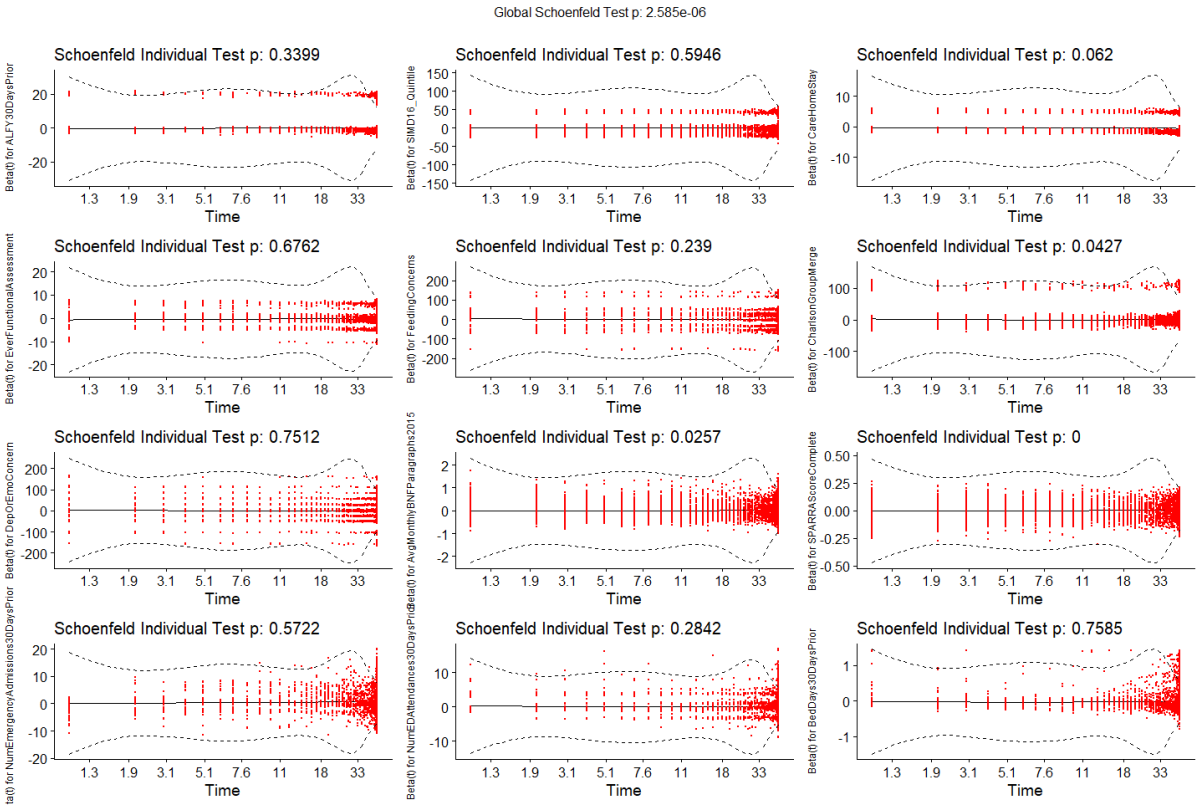
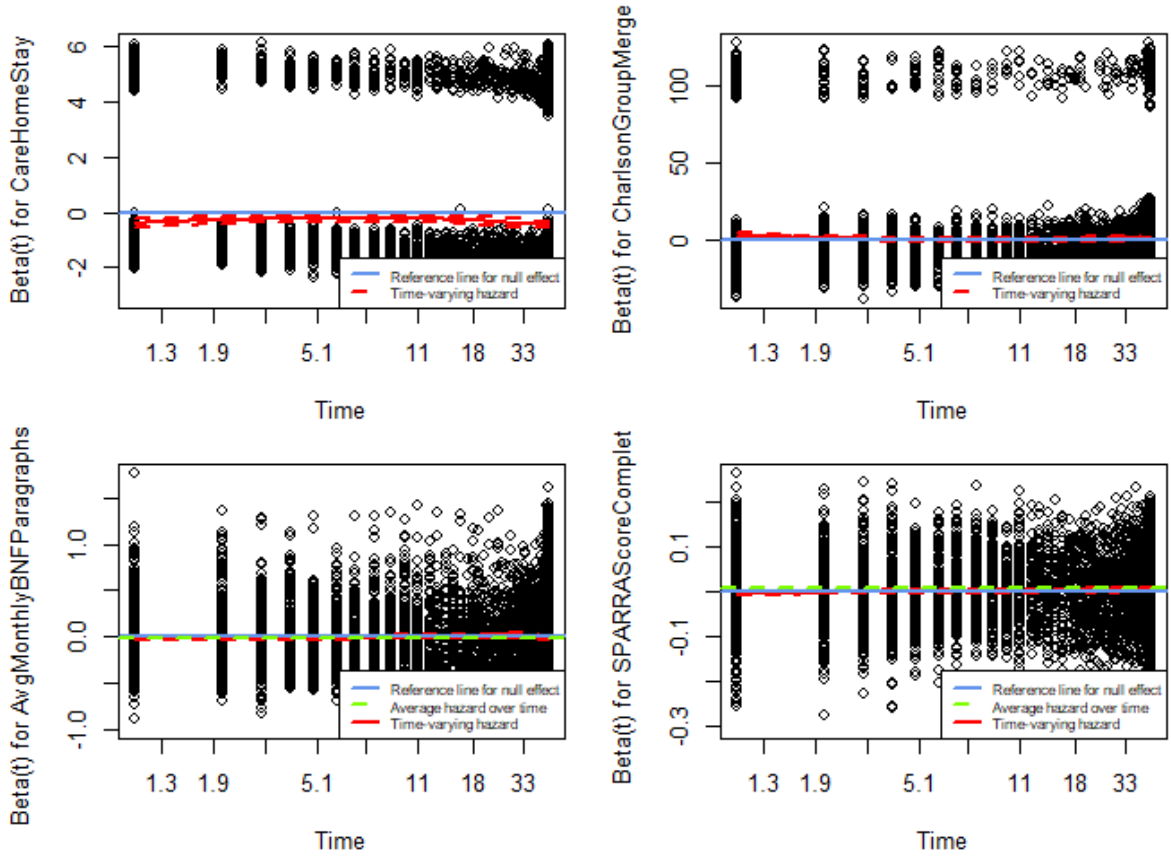


*Figure F-9 – Plot of scaled Schoenfeld residuals against time for offending covariates in the adjusted Cox model assessing effect of **ALFY on length of stay (time to discharge)***



Closer inspection of the offending covariates again indicates a monotone trend over time. As we have established that the correct functional form of continuous covariates is being used, we can rule that out as appearing as a violation of proportional hazards, hence it is likely that results of the statistical test appear significant due to large sample size, as described in Chapter 9, Section 9.2.5.

Check #3 – Are there any outliers or influential observations? *(inspection of deviance and dfbetas residuals)*

To check for influential observations we can examine the *dfbetas* residuals (a transformation of the score residuals) to check the impact on parameter estimates of removing any single observation. The figure below indicates that there are no particularly influential observations on the ALFY effect estimates as they all have *dfbetas* residuals less than one. For the first two models (emergency admission and ED attendance) this is also the case across all covariates. For the third model assessing effect on length of stay, there is one influential observation on a few of the covariates used for adjustment, there is no significant effect on the main estimate of interest (ALFY).

Figure F-10 – Dfbetas residuals representing impact on parameter estimates of removing any single observation (x-axis represents index number of observation) in adjusted Cox model assessing effect of ***ALFY on emergency inpatient hospitalisation***

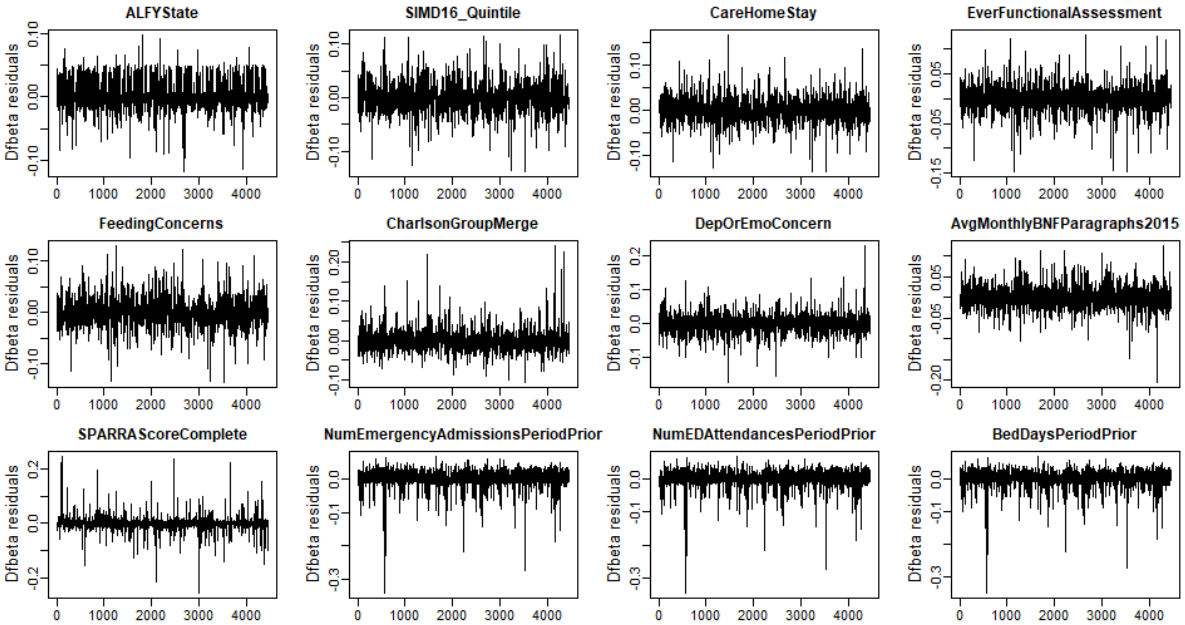


Figure F-11 – Dfbetas residuals representing impact on parameter estimates of removing any single observation (x-axis represents index number of observation) in adjusted Cox model assessing effect of ***ALFY on emergency department attendance***

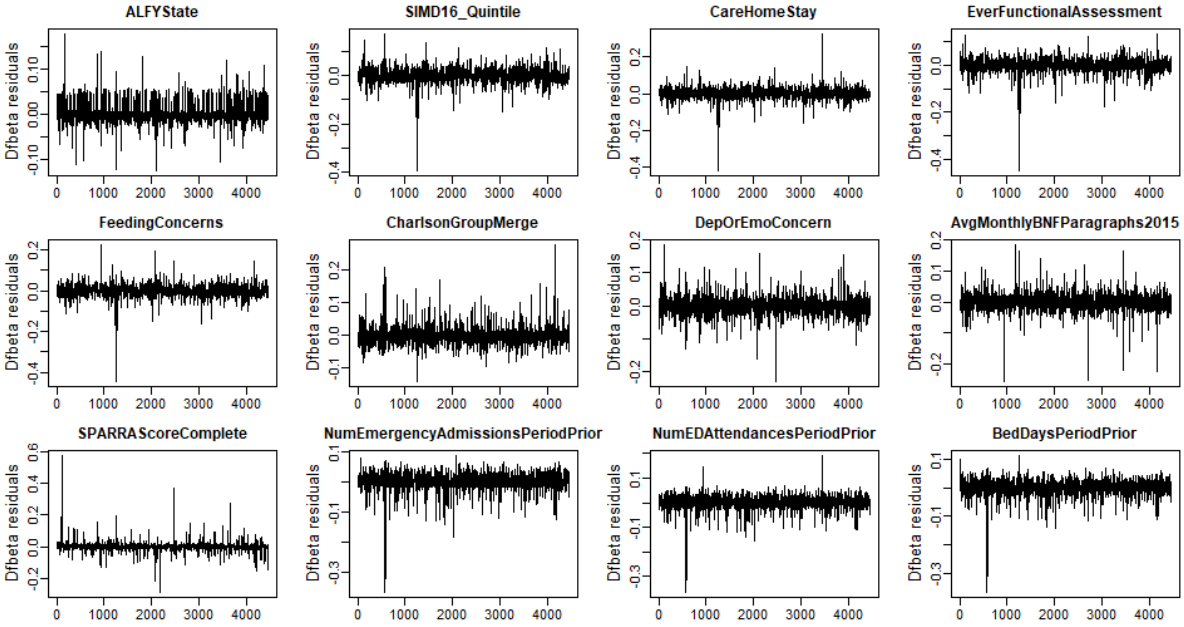
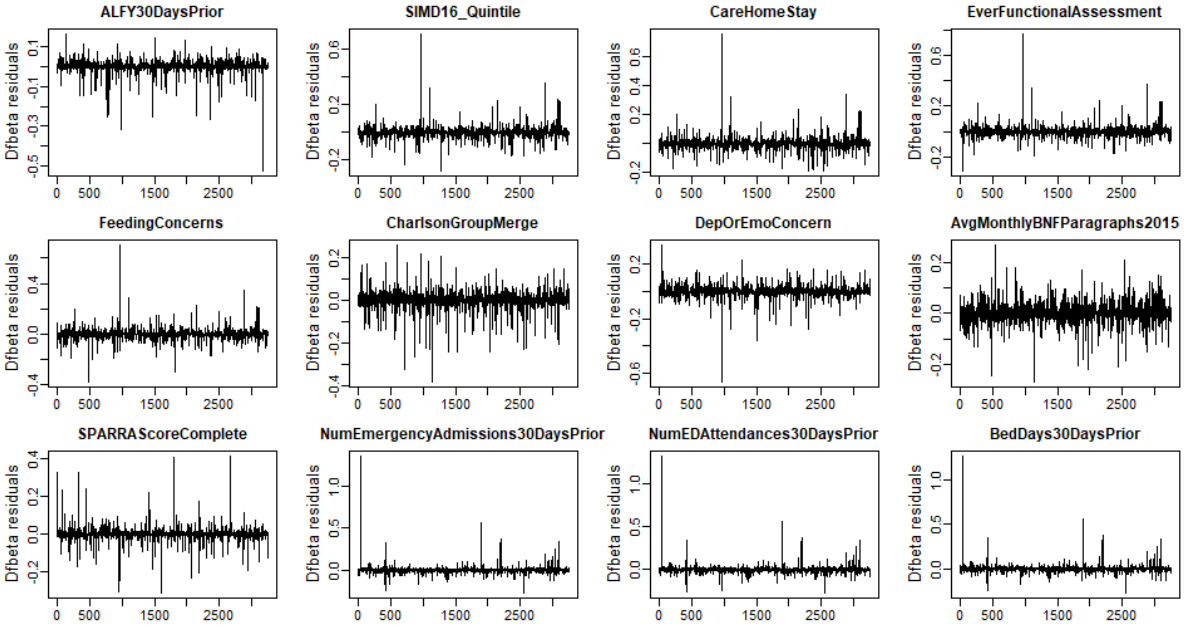


Figure F-12 – Dfbetas residuals representing impact on parameter estimates of removing any single observation (x-axis represents index number of observation) in adjusted Cox model assessing effect of ***ALFY on length of stay (time to discharge)***



Appendix G Participant information sheet and consent form

Participant Information Sheet for clinicians, managers or policy makers involved in health care provision for acutely ill, elderly patients

Name of department: Computer and Information Sciences / NHS Forth Valley
Title of the study: Performance measurement and evaluation of acute elderly care provision at home

Introduction
My name is Cristina Martin and I am a PhD student within the Computer and Information Sciences department at the University of Strathclyde. My supervisors are Dr Matt-Mouley Bouamrane (lecturer at the University of Strathclyde) and Dr Paul Woolman (NHS Forth Valley Information Services Manager). We would like to invite you to take part in our study about caring for acutely ill, elderly patients in Forth Valley.

What is the purpose of this investigation?
The purpose of this investigation is to gain insight into the current goals, priorities and challenges with regards to caring for acutely ill, elderly patients. In particular, where applicable, we aim to gain further insight into a community based programme for preventing frail, elderly hospital admissions ('Closer to Home') in NHS Forth Valley in terms of its scope, key performance indicators and challenges. A final aim of this investigation is supplement the quantitative evaluation of the programme.

Do you have to take part?
Participation in this investigation is voluntary and will help further our understanding of care for acutely ill elderly patients to ultimately improve it. If you decide to participate, you can withdraw at any time without any detriment. If you decide not to take part, there will be no affect or consequences.

What will you do in the project?
Your participation in the project involved a single 30-40 minute semi-structured interview. The location will be set to a convenient and comfortable place to accommodate your needs. We aim to complete the interviews by the end of December 2018.

Why have you been invited to take part?
You have been invited to take part as a clinician, manager or as someone involved in policy making in the area of care provision for elderly patients. All participants will be of this nature, as this role can provide the most insight into this type of health care provision. Your contribution is valuable to this research, and the findings will assist in achieving the aims of this study.

How will we be collecting information and what will happen to it?
All interviews will be recorded and transcribed in order to analyse themes from the responses. The recorded interviews will be kept and securely stored on the University IT systems for the duration of the project and will be securely destroyed at the end of the PhD research (expected to be October 2019). Any data collected will be pseudo-anonymised (i.e. the raw data is anonymised and given a code name, with the key for code names stored in a separate location

from the raw data within NHS Forth Valley IT systems) and will not include personal data. A summary of the anonymised findings will be made available for other researchers to use.

What are the potential risks to you in taking part?
There are no known risks to your participation.

The University of Strathclyde is registered with the Information Commissioner's Office who implements the Data Protection Act 1998. All personal data on participants will be processed in accordance with the provisions of the Data Protection Act 1998.

Thank you for reading this information – please ask any questions if you are unsure about what is written here.

What happens next?
If you are happy to be involved in the project, you will be asked to sign a consent form to confirm this. A suitable time for an interview will be arranged with you. If you do not wish to be involved in the project, you are welcome to contact the researcher to find out more.

We aim to publish the results of this research. If you wish to be informed of the results, please contact the researcher. Thank you for your attention.

Researcher contact details:
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This investigation was granted ethical approval by the Computer and Information Sciences Departmental Ethics Committee.

If you have any questions/concerns, during or after the investigation, or wish to contact an independent person to whom any questions may be directed or further information may be sought from, please contact:

Secretary to the Departmental Ethics Committee
Department of Computer and Information Sciences,
Livingstone Tower
Richmond Street
Glasgow
G1 1XH

Email: ethics@cis.strath.ac.uk

Consent Form for clinicians, managers or policy makers involved in health care provision for acutely ill, elderly patients

Name of department: Computer and Information Sciences / NHS Forth Valley
Title of the study: Performance measurement and evaluation of acute elderly care provision

- I confirm that I have read and understood the information sheet for the above project and the researcher has answered any queries to my satisfaction.
- I understand that my participation is voluntary and that I am free to withdraw from the project at any time, up to the point of completion, without having to give a reason and without any consequences. If I exercise my right to withdraw and I don't want my data to be used, any data which have been collected from me will be destroyed.
- I understand that I can withdraw from the study any personal data (i.e. data which identify me personally) at any time.
- I understand that anonymised data (i.e. .data which do not identify me personally) cannot be withdrawn once they have been included in the study.
- I understand that any information recorded in the investigation will remain confidential and no information that identifies me will be made publicly available.
- I consent to being a participant in the project
- I consent to being audio and/or video recorded as part of the project

(PRINT NAME)	
Signature of Participant:	Date:

Appendix H Framework for start codes in qualitative coding based on NPT

Table H-1 Normalisation Process Theory coding framework for start codes in qualitative coding of initial themes [framework based on Devlin et al.'s NPT coding framework (2016)]

Coherence (sense-making work)	Cognitive participation (engagement/buy in work)	Collective action (enacting work)	Reflexive monitoring (appraisal work)
C1 Differentiation	**P1 Enrolment**	**A1 Skill-Set Workability**	**R1 Reconfiguration**
Is there a clear understanding of how the Closer to Home services differ from existing, current practice and services?	Do implementers, service managers and providers, funding managers, community services directors, and referrers "buy into" the Closer to Home services?	How does the implementation of the Closer to Home services affect division of labour of work practices, roles and responsibilities, or training needs?	Do participants (service mangers or providers/referrers/other individuals) try to develop a "work around" or somehow alter Closer to Home services?
• C1-1 How care would have been delivered before / how it has changed the way service is delivered	• P1-1 What keeps them motivated to continue	• A1-1 Training received for role • A1-2 Written guidelines • A1-3 Changed the way of working (in terms of responsibility, skills etc)	• R1-1 How service has changed (specifically work arounds) ○ R1-1a Goals changed • R1-2 Main challenges related to reconfiguration
C2 Communal Specification	**P2 Activation**	**A2 Contextual Integration**	**R2 Communal Appraisal**
Do the Closer to Home implementers, service managers and providers, funding managers, community services directors, and referrers have a shared understanding of the aims, objectives, and expected benefits of the Closer to Home services?	Do implementers, service managers and providers, and other partners who participate in the Closer to Home program believe it is sustainable? What actions or procedures have been defined that are needed to sustain Closer to Home?	Is there organizational and technical support in terms of resource allocation to enable the service users and service providers to enact a new set of practices to implement the new Closer to Home services?	How do service managers or providers, funding managers or other groups judge and determine the value of the Closer to Home services?
• C2-1 Description aims and, target population • C2-2 Exclusion criteria • C2-3 Referral criteria definition difficulty • C2-4 Type of care provided ○ C2-4a Type of care excluded	• P2-1 Belief in sustainability and requirements • P2-2 Other improvement recommendations	• A2-1 Challenges and failures relating to organisation or structure (e.g. insufficient resource, IV antibiotics, IT systems, team base locations that are a result of organisation, staff retention)	• R2-1 KPIs and routine reports • R2-2 Recipient of results • R2-3 Selection process of services (alignment with vision)

Coherence (sense-making work)	Cognitive participation (engagement/buy in work)	Collective action (enacting work)	Reflexive monitoring (appraisal work)

• C2-5 Needs it caters for
• C2-6 What benefits and for whom
  ○ C2-6a Patients
  ○ C2-6b Carers
  ○ C2-6c NHS/Local authorities
• OC2-7 What benefits and for whom
  ○ OC2-7a Patients
  ○ OC2-7b Carers
  ○ OC2-7c NHS/Local authorities
			○ O4 Funding selection processes (funders or directors)

C3 Individual Specification	**P3 Initiation**	**A3 Interactional Workability**	**R3 Individual Appraisal**
Do all Closer to Home stakeholders have a clear understanding of their own specific tasks and responsibilities in achieving the implementation of Closer to Home services?	Are there key individuals willing to drive the implementation and continuation of the Closer to Home services forward?	Do the Closer to Home services affect the difficulty of people's work or routines of practice? What interactions define and determine success or failure of the Closer to Home services?	Do individual participants/individual service users/other individuals perceive effects of the implementation of the Closer to Home services on them individually and their (work/home, as in context of tool resource, etc.) environment?

• C3-1 Role in specific story or in Closer to Home
• C3-2 Confidence in daily work
• C3-3-What is done when issues arise
	• P3-1 How did they come to be a part of it
	• P3-2 Willing to drive forward
		• A3-1 Easier or more difficult way of working
		  ○ A3-1a Benefits clinicians or social care staff
		  ○ A3-1b Negative impact or workability challenges (e.g. travel, staff safety in homes that are a result of nature of work)
		• A3-2 Good processes of care
		  ○ A3-2a Why is this a good example (outcome achieved)
		  ○ A3-2b What made it work well
		  ○ A3-2c Good processes of implementation
			• R3-1 Any individual effect (e.g. improved confidence, more skills)

Coherence (sense-making work)	Cognitive participation (engagement/buy in work)	Collective action (enacting work)	Reflexive monitoring (appraisal work)

		• A3-3 Bad processes of care
		  ○ A3-3a Why is it a bad example (bad outcome)
		  ○ A3-3b What made it not work	

C4 Internalization	**P4 Legitimation**	**A4 Relational Integration**	**R4 Systematization**
Do all Closer to Home stakeholders understand the value, benefits, significance, and importance of Closer to Home services and their future value?	Do implementers and participants believe it is right for them to be involved in implementation, management or provision of Closer to Home services? Do they feel they can make a valid contribution to the goals of the Closer to Home services?	Do service managers and providers, referrers or other participants have confidence in using the Closer to Home services?	How do participants and implementers determine the effectiveness (benefits and limitations) or usefulness of the Closer to Home services? How can this be measured?

• C4-1 Why it was started
  ○ C4-1a Expected result
• C4-2 Why it should be continued
  ○ C4-2a Reasons to continue if negative or no impact on admissions
  ○ C4-2b Reasons for continued funding
	• P4-1 Can see how individual role contributes to service goals	• A4-1 Reservations of using services	• R4-1 Adequacy of KPIs and how effectiveness is determined
			  ○ A3-1a Adequacy of hospital activity as measure