# *Mixed Methods Evaluation of the Cost Benefit of a Telehealth Programme for Chronic Obstructive Pulmonary Disease in NHS Highland*

This dissertation was submitted in part fulfilment of requirements for the degree of MPhil Computer and Information Sciences

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April 2020

## Declaration of Authenticity and Author's Rights

This thesis is the result of the author's original research. It has been composed by the author and has not been previously submitted for examination which has led to the award of a degree.



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Date: 29-04-2020

## Acknowledgements

I would like to express my gratitude to Dr Marilyn Lennon and Dr Matt-Mouley Bouamrane, my research supervisors, for their patient guidance, enthusiastic encouragement, and useful critiques of this research. Their guidance helped me in all the time of my research and writing of this thesis. My grateful thanks are also expended to Digital Health and Care Institute in Scotland, which funded my MPhil studies. Last but not least, I would like to thank my family; my parents and to my brothers for supporting me writing this thesis and my life in general.

## Abstract

This thesis examines the potential cost-benefit of the Home and Mobile Health Monitoring (HMHM) programme, which is a telehealth programme for patients with chronic obstructive pulmonary disease (COPD) in NHS Highland. COPD was chosen as it is a common and expensive long-term condition. The HMHM programme could be a solution for better monitoring of COPD if it could provide economic savings for NHS Highland for patients with severe COPD who used the programme to monitor their condition. Mixed methods were used to conduct an economic evaluation. Quantitative and qualitative methods were used to collect costs and benefits data for the economic evaluation through interviews and an online survey with experts on the HMHM programme for COPD patients. Interviews were also used to gather patient perspectives (by proxy) as well as those of clinicians, academics, and service managers, and to ask them to highlight the perceived benefits for the patients, clinicians and NHS Highland. From the interviews, it was found that patients and clinicians are satisfied with the programme. Furthermore, the both the patients and clinicians involved in the programme are reported as having gained various benefits from the programme, for example patients felt satisfied with that programme and also clinicians supported that this programme was less labour intensive. The challenges of implementing the programme in NHS Highland and Scotland and more generally of measuring the costs and benefits of the HMHM programme were explored. Some of these challenges include the difficulty to persuade patients to use their mobile phone for texting, another was that the NHS do not have actual proof that the programme works, and other challenge was that the participants were not representable of the whole COPD population as they had at least one hospital admission.This thesis found that the HMHM programme is a beneficial solution for the NHS, as it enabled the NHS to achieve estimated cost savings of £8,819.55 for the group of people who used the HMHM programme in NHS Highland. Interventions such as the HMHM programme can help patients who have severe long-term conditions to have better control of their disease and to be more independent, while the NHS can achieve cost savings because of the reduced need for hospitalisation from acute exacerbations This thesis has demonstrated that while challenges still exist around properly measuring the costs and benefits of telehealth it is possible that the HMHM programme worked and provide a cost-effective solution for the NHS. The contribution of this thesis was the cost benefit analysis that is an economic evaluation method which is not used very often because of the limitations that they face. The CBA is a valuable method why indicate in monetary units whether it worth it or not to do an intervention.

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# Chapter 1: Introduction

Health and social care systems worldwide cannot fully meet people's needs, as there are insufficient resources to satisfy every healthcare demand (Brent, 2014). The need for the use of technology in healthcare delivery and management has emerged partly because of the continuous increase in the population of older people (aged over 65 years) who have chronic diseases or long-term conditions (Odeh et al., 2015). This increasing ageing population increases the funds that the government has to spend on the ongoing care and hospitalisation of this population. The fundamental problem is that the healthcare system's resources are limited and the government does not have enough money to fund every possible healthcare demand. Some healthcare demands are more urgent than others, and therefore careful planning and delivery of services needs to be implemented. Economic evaluation is one way to make decisions on how the resources should be allocated efficiently (Brent, 2014).

In the UK the Scottish government has been seeking at ways to enhance the healthcare services that are offered to all citizens. One way has been through the use of telehealth (remote monitoring land services) to enhance patients' lives (The Scottish Government, 2012). The Technology Enabled Care Programme (TEC) was set up to fund and manage telehealth nationally across Scotland. Telehealth programmes are a new way for patients to manage their health and wellbeing alone at home with the support of technology enabled services, and it is potentially a more cost-effective solution for the NHS than the usual care (The Scottish Government, 2012). The TEC board are keen to identify if and how they can measure the cost-benefit of each of the different telehealth initiatives to determine which ones can improve efficiencies and overall care for the population.

Home and Mobile Health Monitoring (HMHM) is one specific telehealth programme that is used by NHS Scotland. This programme is one of these interventions on the TEC programme, the overall goal of which is to change people's attitudes and to make them take control and self-manage their health and wellness (SCTT, 2017). Using HMHM people who have long-term conditions or chronic diseases can monitor their diseases at home with the use of technology such as mobile phones, tablets and other portable monitoring devices (Hamine et al., 2015). The most common chronic diseases that are managed with drugs but do not have a cure include diabetes, Chronic Obstructive Pulmonary Disease (COPD) arthritis, and hypertension (The King's Fund, 2019). The HMHM programme is an essential intervention that with the use of technology, potentially offers positive outcomes for patients who have chronic diseases (SCTT, 2017). The use of technology in healthcare could lead to fewer hospital admissions and therefore cost savings for the NHS because of reduced hospital admissions and emergency visits (Polisena et al., 2010).

People with chronic diseases need intense monitoring for their diseases. According to the King's Fund, 50% of general practitioner (GP) appointments are for patients with chronic conditions; 64% of outpatient appointments are for patients with chronic diseases, and people with chronic conditions account for over 70% of bed days in hospitals (The King's Fund, 2019). These figures indicate that patients with chronic diseases need intense monitoring. HMHM was created for patients with chronic conditions to receive more integrated care at home. COPD was chosen as the disease to focus on this thesis because it is a common long-term condition, which is an inflammatory disease of the respiratory system which is characterised by many acute exacerbations (Achelrod et al., 2016). COPD is estimated to be the third most common cause of death in the world (McLean et al., 2016). Patients with moderate to severe COPD have, on average, two to three exacerbations per year (McCurdy, 2012). These numbers indicate that these patients need intense monitoring of their conditions in order to support them in independent living, improve patient outcomes and reduce demand in primary and secondary care services.

A cost-benefit analysis (CBA) is an economic evaluation method that calculates costs and benefits in monetary units. The purpose of a CBA is to help make informed decisions regarding public policy. This method has been used to assess the economic efficiency of programmes through predictions and valuations of costs and benefits (Boardman, 2015). The difficulty in interventions such as telehealth is in determining the actual costs and benefits that the NHS has from such programmes. The expenses that the NHS incurs from telehealth programmes are the usual care costs of treatment plus the additional ongoing costs of the telehealth (the device, training, data transfer costs and other), which could not always be identified and calculated easily. This would require a precise and well-informed up to date managerial accounting system that could facilitate the unbundling of accounts for programmes that share resources with the rest of the NHS and even across health and social care. In addition, the benefits of telehealth are difficult to identify and measure in monetary units, as in each of them there are several different factors that should be taken into account, such as the benefits from increased independence, less stress, more confidence for patients in dealing with their condition, and fewer GPs visits. From the patients' perspective, telehealth offers potential benefits such as providing patients with a more independent life at home, fewer visits to hospitals, fewer readmissions in hospitals and generally it could potentially offer them a better quality of life. From the NHS perspective, this might be a cost-effective solution in monetary units if the benefits are higher than the costs. Patients do not need unnecessary or prolonged visits to the hospital, and this has as a consequence that the healthcare professionals could allocate their time more effectively.

This thesis used mixed methods to explore if the use of HMHM for COPD patients was a cost-effective solution in monetary units. The thesis captured some of the perceived and actual challenges of conducting a cost-benefit analysis (CBA) evaluation (quantitative analysis) for the HMHM programme,

more specifically the Florence programme in NHS Highland, Scotland. A specific telehealth programme (HMHM) in a particular region (NHS Highland) for a particular population (COPD patients) was chosen in order to conduct an exemplar CBA. This study also involved a more in-depth qualitative interview-based examination of how the programme works, capturing the perspectives for that programme, and examining how current costs and benefits for telehealth were (or can be) measured and monitored for such telehealth programmes now and in the future.

## Research Questions, Aims, and Objectives

The research question is what the thesis tries to answer based on the research conducted. The aims are the goals that the thesis needs to achieve, and the objectives indicate how the topic will be investigated step-by-step to answer the research question (Thomas and Hodges, 2010). Research objectives are linked to research questions, as objectives are the actions that need to be undertaken to answer the research question. Furthermore, objectives define the aims of the study (Farrugia et al., 2010), which is what the study aims to achieve.

The research question that this thesis examined was:

> "What were the benefits for the National Health Service (NHS) (if any) from the Home & Mobile Health Monitoring programme for patients with Chronic Obstructive Pulmonary Disease in NHS Highland?"

The overall aim of the thesis was to investigate using mixed methods whether the HMHM programme in NHS Highland for COPD patients provided more economic benefits to the NHS than the costs.

The objectives of this thesis were six-fold.

**Objective 1:** To access and present the available costs and benefits data from the HMHM programme in NHS Highland [Chapter 6].

**Objective 2**: To conduct a cost-benefit analysis (CBA) for the HMHM intervention in NHS Highland for COPD patients [Chapter 6].

**Objective 3**: To explore the qualitative perspectives that key informers had on the Florence programme and to identify the benefits for the NHS because of that programme [Chapter 7].

**Objective 4:** To explore the most common challenges of implementing the Florence programme in NHS Highland [Chapter 8].

**Objective 5:** To explore the challenges of measuring costs and benefits in economic evaluations in the Florence programme [Chapter 8].

**Objective 6:** To indicate the gaps in data that exist when a CBA evaluation needs to be done as part of economic evaluation of a telehealth programme [Chapter 9].

# Chapter 2: Background

Health economics has become increasingly important, as each government needs to make important decisions regarding what to do with the unlimited needs and the limited resources it has. If the resources were abundant, then it would be fair for people to consume as many health services as they wanted; however, this is not possible, and therefore it is necessary to decide where to allocate the scarce resources (Brent, 2014). This problem could be examined by economists, who could use different economic tools to find the most efficient solutions. The aim of health economics is not only to save money for the government, but also to improve the level of distribution of health services in the population with the available resources (Guinness et al., 2011).

This thesis examines a telehealth programme for patients with Chronic Obstructive Pulmonary Disease (COPD) that is used by the NHS in Scotland. The programme was introduced because of the need for efficient distribution of the resources. The thesis aims to examine whether it is a beneficial solution in monetary units for the NHS or not. The Scottish government is trying to find alternative ways of monitoring patients to provide them with more integrated care. This chapter discusses Scotland's Technology Enabled Care (TEC) programme, the Home and Mobile Health Monitoring (HMHM) programme, Florence, and what COPD is and why it was chosen, and provides some demographic information regarding the NHS Highland population and COPD patients that are the subject of this thesis.

## 2.1 Scotland's Technology Enabled Care Programme (TEC)

The Scottish government's objective at the time this research was being carried out was to help all people to live longer, healthier lives in their homes or homely settings by 2020 (The Scottish Government, 2012). The use of technology in healthcare is believed to be useful for both patients and the NHS, as there is potentially more efficiency and safety, better health quality for patients, and lower healthcare costs for the NHS (Hughes, 2008). The Scottish government created the TEC programme as a better way to offer health and social care services nationally. The TEC programme is defined as: "where outcomes for individuals in a home or community settings are improved through the application of technology as an integral part of quality cost-effective care and support" (Scottish Government, 2018).

The TEC programme has five areas of work, which are: (i) HMHM (telehealth), (ii) telecare, (iii) video conferencing, (iv) digital platforms for direct access to advice and assistance, and (v) exploring the benefits of switching the system from analogue to digital. The TEC programme is not just about the use of technology, but is a combination of the usual care that patients receive alongside the use of technology. Telecare provides smart home technologies, as patients need continuous, automatic and remote monitoring, while telehealth is remotely monitoring patients with long-term conditions (Scottish Government, 2018). Long-term conditions or chronic conditions are those medical conditions or diseases that cannot be cured but can be managed with medicines. The US National Centre for Health Statistics defines that ***chronic*** is everything that has a duration of more than three months (Flynn, 2006).

## 2.2 Scotland's Home and Mobile Health Monitoring (HMHM)

The HMHM programme aims to help patients to self-manage their conditions and reduce the number of times that they need to visit their GPs or hospitals. It does this by providing technology to monitor people's conditions at home (for example text services, remote monitoring of vital signs etc). The HMHM programme is potentially beneficial for people, as they may feel more comfortable with their conditions and the fact that they are able to manage their conditions better than before (SCTT, 2017). In this way, they could receive treatment and care that is appropriate for their preferences and needs but with a reduced number of visits to primary (their doctor) or secondary (the hospital) care. Patients can make informed decisions in collaboration with their GPs, nurses or other healthcare professionals via remote consultation for example. It is also suggested that patients who participate in programmes for monitoring their condition might have a better understanding of their disease and are able to take actions to control their deteriorations (Healthcare Improvement Scotland, 2016).

The HMHM programme aims to provide benefits to patients, clinicians and the NHS. The benefits for patients could be that they receive better service care, if they spend less time waiting for appointments with healthcare professionals and they are healthier than with the usual care. For healthcare professionals, the benefits are that they have access to patients' data and patients' adherence to treatment is often better, which reduces unnecessary appointments with patients. The benefits for the NHS overall are that it is able to enhance service for patients, offer a more effective service, and reduce the costs for patients especially in rural areas (SCTT, 2017). In addition, interventions of this type are beneficial for the hospitals, as they can reduce the number of hospital admissions and improve the health outcome because of the home monitoring (The Scottish Parliament, 2018). Telehealth can lead to a reduction in the number of times patients need to visit the hospital because of exacerbations for example (The Scottish Parliament, 2018). Patients receive various types of equipment (such as pulse oximeters, tablets) from the NHS depending on which programme they are involved in.

Part of the vision in the implementation of telehealth is that the costs that the NHS faces for each patient will be reduced, as the patients can monitor their disease at home with the help of technological devices. This leads to lower costs, as unnecessary hospital visits will be reduced and healthcare professionals will not devote unnecessarily large amounts of time to these patients. Moreover, it means that in cases of emergency, patients can receive better care due to reduced congestion in hospitals, as this allows clinicians to focus more on the patients who need attention.

## 2.3 Chronic Obstructive Pulmonary Disease

COPD is a lung disease characterised by chronic airflow obstruction. It is not fully reversible and is usually a progressive disease with acute exacerbations for patients with comorbidities (Achelrod et al., 2016; Healthcare Improvement Scotland, 2016). COPD is the second most common disease after asthma in the UK (British Lung Foundation, nd), and around two per cent of the whole population lives with COPD (British Lung Foundation, nd). The problem with this disease is that people have difficulty in recognising the symptoms at an early stage, as the key symptoms of COPD are coughing, breathlessness, sputum production and wheezing. Therefore, patients start to receive treatment to control their condition when they face moderate or severe exacerbations. In those stages, the disease is more difficult to control, and this leads to hospital admissions. Moderate exacerbation is when there is a need for the prescription of antibiotics and steroids, and severe exacerbation is when patients need hospital admission. According to McKinstry (2013), early intervention with antibiotics and steroids can result in avoided hospital admissions. The hospital admission occurs when the symptoms of the exacerbation are very severe and cannot be controlled through the exacerbation treatment. Therefore, patients need to make a hospital admission in order to be monitored more closely.

COPD bears a substantial socioeconomic burden globally. For this reason, the policymakers are trying to find better ways of treatment for patients with COPD. Patients suffer from “exacerbations”, meaning that they have a disease, which is worsening until it leads to hospitalisation. Exacerbation is defined as an acute change in the patient’s dyspnea, cough, or sputum. When this is beyond the normal day-to-day variations, then a change in regular medication for that patient might be needed (Shah et al., 2017). Increased exacerbations lead to reductions in the health-related quality of life for the patients, a higher number of hospital admissions and increased healthcare cost. Acute exacerbations affect patients’ health-related quality of life, mortality, hospitalisation and healthcare needs and present a vital health burden (Sanchez-Morillo et al., 2015).

The researcher of this thesis was able to find only one study that provided the total cost of COPD in Scotland. McLean et al.’s (2016) study provided some information on the total direct cost of COPD in

Scotland from 2011. The reduction of expenses is essential for the NHS, as the total direct cost of the healthcare of COPD was £159 million in 2011 in Scotland, and it is expected that this will increase. The study also found that in Scotland, the cost of dealing with a moderate exacerbation was £118 per incident, while when dealing with a severe exacerbation, the cost was £3,329 per incident (McLean et al., 2016).

## 2.4 Demographic characteristics of people with Chronic Obstructive Pulmonary Disease in the Highlands

This section was considered relevant to be included in this thesis to indicate how many people had this condition in the Highlands, what the hospital admission rate was, and how many days (on average) these patients needed to stay in hospital. This data indicates that COPD is a severe condition in the Highlands and the NHS needs to find ways to provide people with more integrated care.

The current Highlands population is 320,000 (NHS Highland, 2017a) and it is the largest NHS area, as it covers 32,000 square kilometres (NHS Highland, 2017a). The life expectancy of people in the NHS Highland region is 76.6 years for men and 81.3 years for women (NHS Highland, 2017a). The life expectancy nationally in Scotland is 76.1 years for men and 80.6 years for women (NHS Highland, 2017a).

NHS Highland is split into three regions: the North and West Highlands, the South and Mid Highlands, and Argyll & Bute (NHS Highland, nd). According to ScotPHO (2016), in 2015–16 for every 100 people who were registered with a GP in NHS Highland, two people had COPD (compared to 2.32 per 100 in Scotland). If we assume that everyone was registered with a GP, this means that around 6,400 people had COPD in NHS Highland, and the number of people who had COPD in Scotland was 122,960 (ScotPHO, 2016).

Moreover, in NHS Highland, the rate of hospital admissions was 225 patients with COPD per 100,000 people in 2015–16, and nationally it was 356 patients with COPD per 100,000 people. In 2017, the annual total number of patients admitted to hospitals in NHS Highland because of COPD was 720, which is 11.25% of people who have COPD in NHS Highland. For Scotland, this number was 18,868, which is 15.34% of people who have COPD in Scotland (ScotPHO, 2016). For respiratory patients, the average length of stay in hospital in 2017 was 5.7 days in Scotland for all types of admissions (ISD Scotland National Statistics Publication, 2017), and in NHS Highland it was 6.4 days (ISD Scotland National Statistics Publication, 2017). These figures demonstrate that the number of people who have COPD in NHS Highland is below the number of people who have COPD in Scotland.

## 2.5 'Florence' in Highlands for Chronic Obstructive Pulmonary Disease Management

The HMHM programme has four different telehealth programmes in Scotland. These programmes are the Diasend (My Diabetes My Way, 2016), the Motiva Intense Monitoring Solution (Wolters, 2018), the Medvio Home Pod (United4Health, 2015), and Florence (Wolters, 2018). In this thesis, there is an interest specifically in the Florence programme. The Florence programme is a simple automatic interactive telehealth service that sends text messages to patients' mobile phones in order to monitor their symptoms and readings. This programme responds to patients with appropriate advice, reminders, and support, helping patients take ownership of their condition for three months (NHS Highland, 2017b) This programme is free of charge for the patients and can send messages to any mobile phone. It is also a low-cost programme for the NHS as they pay only £0.08 per text and it is easy to use for all people who use a mobile phone and can send text messages. Florence helps patients to self-manage their condition at home, and healthcare professionals and managers are expected to have fewer GP visits, improved compliance with medication, reduced anxiety, and reduced the unnecessary hospital admissions (Hughes, 2016).

If patients have a deterioration, then the Florence system sends a text message to the patient in order to receive their "rescue" medication. This is the medication that patients received from the NHS in order to use in case of an exacerbation. In the Florence programme, patients are responsible for dealing with their exacerbation without contacting a clinician. However, Florence automatically sends emails to the healthcare professionals and informs them that this particular patient has an exacerbation. Clinicians are notified that patients had exacerbations, and they contact the patient in order to check if they received their "rescue" medication and if they are fine (O'Connell, 2018). This programme has as a consequence that deteriorations can be avoided, and the patients can stay safe at home without needing to visit the hospital. Therefore, this can lead to a reduction in the need for hospital admissions, as the clinical outcome is improved (Taylor et al., 2016).

# Chapter 3: Telehealth Programmes Review from Economic Perspective

Using the scoping review approach, this chapter aims to explore what previous research studies examined and what was found in other relevant studies that used economic evaluation techniques to examine telehealth programmes for chronic obstructive pulmonary disease (COPD) patients. Having this knowledge might be helpful in identifying appropriate approaches for this research in accordance with what is acceptable in this research field. All these methods estimate the costs in monetary units; however the benefits are estimated in different outcomes in each method.

In this scoping review, the research question was "What methods have been used to evaluate telehealth programmes for COPD patients from an economic perspective?". This links back to the research question that investigated whether telehealth programmes provide economic benefits for the NHS. To conduct the economic evaluation, the findings of other economic evaluations and their key characteristics were explored.

## 3.1 Scoping Review Methods

The scoping review method was chosen as an appropriate approach, as the research question in the scoping review is often broad. It was used to identify the existing evidence in the field, to clarify key concepts of the topic, to identify how research was conducted in other relevant studies, to identify characteristic costs and benefits for telehealth programmes, and to identify and analyse data gaps (Munn et al., 2018).

The focus of the scoping review was to obtain any published data relevant to telehealth programmes for COPD patients from an economic perspective. The scoping review was conducted using the following digital libraries: MEDLINE, ScienceDirect, PubMed, Web of Science, SpringerLink, and BMJ. The search results were derived using keywords combinations relevant to telehealth for COPD patients, that is, "economic evaluations of telehealth programmes for COPD patients", and "CBA evaluations of telehealth programmes for COPD patients". The inclusion criteria were research studies in which patients had COPD or patients had COPD as one of their comorbid diseases, economic evaluations of telehealth programmes/ telemonitoring programmes, primary and secondary studies, studies published after 2002, and studies in English. The exclusion criteria were studies in which patients did not have COPD, studies in which patients had COPD but there was no economic evaluation of telehealth

programmes for COPD patients, studies published before 2002, and studies in languages other than English.

The search process for this review is presented in Figure 1. After the initial search in digital libraries yielded 227 results, 215 abstracts were excluded, as if the study did not match one or more criteria, it was excluded. 12 abstracts led to the paper being screened, of which three were excluded. Those 12 studies had relevant title and for that reason it read the abstract. From those 12 abstracts another 3 abstracts did not meet the inclusion criteria. Therefore, nine full-text articles were assessed to be appropriate, as they meet the inclusion criteria. Furthermore, another six articles were found to be relevant, and were included in the thesis. Those 6 articles found from reference lists from other studies. From the search in the six different databases, 15 studies were found that met the inclusion criteria. Moreover, it should be mentioned that there was not a second reviewer on the scoping review, as all the relevant studies did not need to be presented on a scoping review. Therefore, it was considered that there was no need for a second reviewer. Furthermore, the researcher was not registered on the online database "Prospero", which includes protocols for systematic reviews on health and social care projects. This scoping review did not include systematic reviews or reviews of reviews.

Figure 1: Scoping Review Process for Evaluation of Telehealth Programmes for COPD Patients from an Economic Perspective

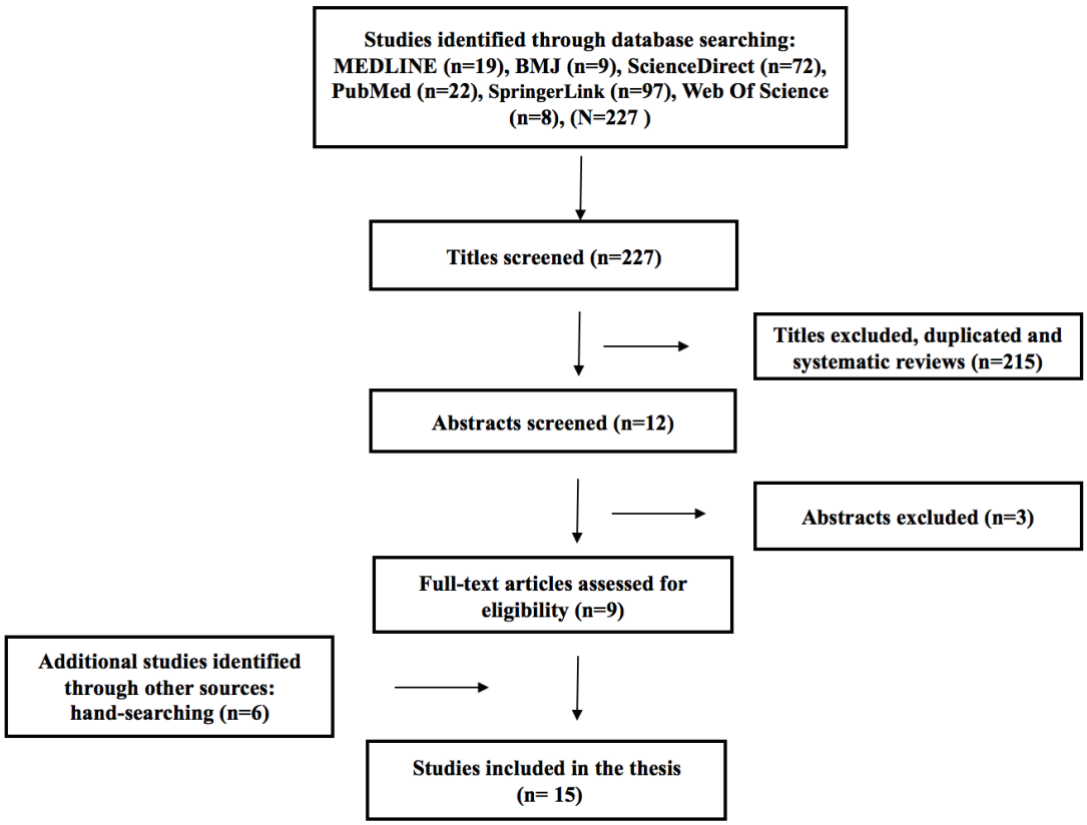


Figure 1 above demonstrates that 15 articles were found to be appropriate in total for the scoping review. These articles used various economic evaluations of telehealth programmes for patients with COPD. Most of these evaluations compared telehealth programmes to the usual care treatment to determine whether the telehealth programme was a more cost-effective solution than the usual care. Moreover, the studies presented results on whether patients had improved quality of life, whether they had less anxiety, and whether the telehealth programme had reduced hospital admissions and exacerbations. All this information was gathered to identify the costs and benefits that were measured in other studies, and to identify any gaps in information derived from the scoping review.

## 3.2 Economic Evaluation Techniques Identified in the Literature

Economic evaluation in health is "the comparative analysis of alternative courses of action in terms of both their costs and consequence" (Drummond et al., 2005, p. 9). These evaluations can examine if there is an improvement in health-related quality of life, if a project is 'worth it' in monetary units or if it provides the desired health outcomes. These evaluations are used to investigate if the appropriate services have been adopted in the healthcare system or whether new technologies and interventions fit in the healthcare system and can offer improvements in the healthcare system and help improve patient's lives (McPake and Normand, 2008).

There are four full economic evaluation techniques identified in the scoping review. Each technique can be used by researchers and decision-makers to evaluate health services. Economic evaluation consists of techniques developed by economists to assist decision-making when a choice has to be made between different actions. It is an essential tool, as it helps people make informed decisions in health economics using techniques, such as cost-benefit analysis (CBA), cost-minimisation analysis (CMA), cost-utility analysis (CUA) and cost-effectiveness analysis (CEA).

One evaluation technique is the cost-minimisation analysis (CMA), which is the most straightforward technique, as it only measures the opportunity cost. Decision-makers consider that the outcome would be the same in each case, and the decision is made only with regards to the cost. This technique is used when decision-makers want to find which approach has the lowest cost for a specific outcome (Bergmo, 2014).

Another evaluation technique is the cost-utility analysis (CUA). It is an economic evaluation method, which measures costs in monetary units and in which the benefits are measured using health utility scales, such as the Quality-Adjusted Life Years (QALYs). The QALYs present the individual preferences and the health gains by combining mortality and morbidity into a single index number

(Bergmo, 2014). QALYs calculate the length and quality of life. The quality of life is measured from 0 to 1, with 0 meaning dead and 1 meaning perfect health. The limitation that the CUA has is that it cannot be assessed as a single programme, but it should make a comparison between two different interventions and indicate which programme has better effects (Palmer et al., 1999).

Another evaluation technique is the cost-effectiveness analysis (CEA). A CEA is a useful method for assisting in the decision-making process (Ceri, 2009). This technique is used when decision-makers or policymakers need to compare different programmes. This evaluation aims to determine how to allocate resources between different options in order to achieve the best allocation. A CEA is an economic evaluation, which measures the consequences of various interventions, measuring in "natural" units, such as how many lives are saved, or how many life-years are gained, how many deaths are avoided, how many heart attacks are avoided. An alternative to CEA is to compare two different healthcare programmes in terms of cost per unit (Ceri, 2009). In addition, the costs are measured in monetary units. Therefore, the most cost-effective solution is the one which has the highest benefit and the lowest cost. Therefore, the policymakers decide solutions with the highest cost because these are more effective solution from the other choices (Tolley and Rowland, 1995).

The last economic evaluation method is the cost-benefit analysis (CBA). CBA was the chosen method used in this thesis because it is the only menhod that calculates costs and benefits in monetary units. CBAs are rarely used in the evaluation of health interventions, as it includes only the outcomes that can be calculated in monetary terms, leaving some things out of the evaluation such as the quality of life that patients have. Moreover, it is considered difficult to put a monetary value on health benefits (Palmer et al., 1999). An important step when someone decides to do a CBA in healthcare is that to determine what kind of costs and benefits should be included and what should be excluded (Hutton et al., 2006).

More preferable evaluation techniques in healthcare are those which measure the results in health outcomes, such as the cost-effectiveness analysis (CEA) that measures whether the health-related quality of life increases or decreases (Hirth et al., 2000). According to Snoswell et al. (2016), the most appropriate technique for economic evaluations in healthcare issues is the cost-utility analysis (CUA). A CUA is considered to be the most appropriate approach in evaluating healthcare programmes, as it indicates if there are gains in the health-related quality of life (Snoswell et al., 2016). However, a CUA is not considered an appropriate method for the evaluation of telehealth programmes. Telehealth programmes are considered to be offering efficiency, convenience, ease of use and access for patients, therefore these kinds of interventions are likely not appropriate for improvements in the patient health-related quality of life (Snoswell et al., 2016).

The most common approach for economic evaluations of telehealth interventions is through a CMA. However, it is not considered an appropriate method for economic evaluation as it compares only the costs and not the benefits or outcomes of the programme. It considers the outcomes to be the same. This method is appropriate only if the policymakers want to find the least costly programme (Bergmo, 2014). The most comprehensive method of economic evaluation is considered to be the CBA (Rudmik and Drummond, 2013). It is considered appropriate for evaluations in telehealth, as it captures non-health and health-related factors, and it puts monetary values in all the factors of the project. For that reason, a CBA can be considered as the most potent economic technique (Robinson, 1993; Snoswell et al., 2016). The CBA method in the healthcare sector has several limitations, as it is not possible to put values on all the factors. However, this method is very interesting, because it indicates whether an intervention is cost-effective or not in monetary units and if the programme should continue. CBA is the only method, which calculates costs and benefits in monetary units.

## 3.3 Synthesis and Reporting Results from Scoping review

Various studies examined telehealth programmes using economic evaluation approaches. All these economic evaluation techniques are connected and provide us with valuable information about the programmes and what the various benefits that telehealth programmes have provided to hospitals. Fifteen studies were found (see Appendices A: Table with References Chapter 3). Those studies were read, organised, and categorised by economic perspective. They were divided into three different categories: CUA, CMA, and CEA. Each of these will be discussed in the following subsections. These economic evaluation methods were used in the evaluation of telehealth programmes for COPD patients and the findings are discussed in more detail below. The choice of the economic method relates to what the researchers aim to investigate, such as how to measure costs, quality of life, life years gained, and other factors.

### 3.3.1 Cost-Utility Analysis

Studies that investigated telehealth programmes for COPD patients using the CUA method are discussed below. The results were measured in quality adjusted life years (QALYs) to measure the value that money has in medical interventions.

Stoddart et al. (2015) calculated the costs and the utility of telemonitoring and the usual care for people with COPD in NHS Lothian in Scotland to determine which was the most cost-effective solution. In the controlled trial, there were 256 patients who were admitted to the hospital because of COPD exacerbations. The results indicated that telemonitoring care was around £2,065.90 more expensive per

patient per year than the usual care. The reported QALYs were higher in this telemonitoring programme compared to usual care (0.43 vs 0.41). The mean incremental cost effectiveness ratio (ICER) was based on the cost of £137,727 per QALY. This means that for each additional QALY delivered by the telemonitoring programme, the cost was £137,727. This indicated that the service can be deemed cost-effective depending on the government's willingness to pay for a QALY. The study found that telemonitoring was generally not a cost-effective solution given the typical level of willingness to pay that NHS pays for a QALY (Stoddart et al., 2015).

Hofer et al. (2016) explored whether the telemonitoring programme was a cost-effective solution that could reduce the costs for hospitals. They estimated the cost of telehealth programmes and found that telemonitoring was €962 per person more expensive and that the savings from patients not needing hospitalisation were €197 per patient. The reported cost-effectiveness was €17,410 per QALY gained. The conclusions of this study were that telemonitoring was perhaps a cost-effective solution, but there were uncertainties about the actual cost of telemonitoring programmes had. The sensitivity analysis indicated that the hospitalisation rate and the cost of the equipment affected the results (Hofer et al., 2016).

Using the CUA method, Jódar-Sánchez et al. (2014) investigated whether patients with severe COPD gained QALYs to determine whether they should use the telehealth programme or continue using the usual care. The pilot study included 45 patients. The cost of the telehealth programme was different from that of the usual care depending on whether patients had only COPD or had comorbidity. The average total cost was €2,300 for the telehealth programme and €1,103 for the usual care, and the QALYs gained were 0.0059 for the telehealth programme and 0.0006 for the usual care. That means that with the telehealth programme, the QALYs enjoyed by patients increased by 0.59%, whereas with the usual care, the QALYs increased by 0.06%. It should also be mentioned that for patients who only had COPD the total cost was €855 in the telehealth group and for the usual care group it was €,135. The QALYs gained were 0.0288 for the telehealth group and 0.0082 for the usual care group, and therefore the incremental QALY gain was 0.0206. The telehealth programme may not have been cost-effective compared to the usual care for patients with comorbidity, but it could be considered cost-effective for patients without comorbidity (Jodar-Sanchez et al., 2014).

Although none of the previous studies obtained significant results, the costs were higher in the telehealth programme in almost all cases. Stoddart et al. (2015) stated that the telehealth programme was not a cost-effective solution, while Jódar-Sánchez et al. (2014) claimed that the telehealth programme was not a cost-effective solution for people with comorbidity, as the cost of telehealth was high for these patients. The difference in the cost of care between the telehealth and usual care programmes was

estimated to be around €1,833 per patient annually. However, Jódar-Sánchez et al. (2014) and Hofer et al. (2016) indicated that telemonitoring is a cost-effective solution for patients who only have COPD.

### 3.3.2 Cost-Minimisation Analysis

Another method that was used for evaluation of telehealth programmes for COPD patients was CMA. CMA is the most common technique used for economic evaluations. This tool compares only the costs of projects to find the intervention with the lower cost. CMA found that the outcomes are equivalent between the projects (Bergmo, 2014; Snoswell et al., 2016). The results of the studies below were positive, as these studies demonstrated that there were savings for the hospitals.

Paré et al. (2006) compared the outcomes and the costs by comparing 19 patients who used the telehomecare programme with ten patients who used the traditional homecare programme. This study was quasi-experimental research and the authors considered only the direct cost of the healthcare services. The results showed that there was a need for hospitalisation for only two of the 19 patients who participated in the telehomecare programme and for six of the ten patients who received traditional homecare treatment. The CMA indicated that the telehomecare programme is $6,750 less expensive, which means that there were savings of $355 per patient annually. The primary saving was from the lower number of hospitalisations, as the cost of hospitalisation is 64% of the total cost in the traditional homecare treatment. Therefore, telemhomecare provided significant savings from fewer hospitalisations and fewer home visits by nurses (Pare et al., 2006).

Paré et al. (2013) assessed the costs of the healthcare service before, during and after the intervention programme and compared them with those of the traditional homecare programme. This study lasted 21.5 months and involved 120 patients in Canada. Of these, 60 participated in the telehomecare programme and 60 in the traditional homecare programme. This study found that the cost of operation of the telehomecare programme was $421 per patient and that the total cost of the programme was $26,520. The economic analysis had positive results: the savings for patients who used the telehomecare programme were $4,818 per patient, while in the usual care, the savings were $3,205 per patient. The savings on the costs of the telehomecare programme were derived from the reduction in hospital admissions and the reduced length of hospital stays. Therefore, the cost saving for patients who used the telehomecare programme was around $1,613 per patient per year compared to traditional care, which means that there is a 14% net gain from the usual care (Paré et al., 2013).

Vitacca et al. (2009) investigated whether tele-assistance is a cost-effective solution compared to a control group. They evaluated the reduction in hospitalisations, exacerbations, GP calls and the related cost-effectiveness of TA. Their study included 240 patients, of which 101 were patients with COPD.

Patients were divided into two groups, the intervention group and the control group, and the trial lasted one year. This study calculated the costs for both programmes and performed an economic analysis using the CMA method. The result of the study was that the number of hospitalisations was significantly lower in the intervention group than in the control group. In the control group, more patients had two hospital admissions during the period of the study, while in the intervention group, more patients did not have hospitalisations. Specifically, COPD patients had fewer hospital admissions per month in the intervention group than those in the control group. The probability of no hospitalisations for the patients was higher in the intervention group than in the control group. Only COPD patients had significantly higher probability of hospitalisation. Furthermore, this study demonstrated that the tele-assistance programme was an effective way to avoid hospitalisation, acute home exacerbation and urgent GP calls. Therefore, TA could be a cost-effective solution (Vitacca et al., 2009).

Maiolo et al. (2003) used cost-simple analysis (CSA), which is the same as CMA. The study evaluated whether the telehealth programme leads to cost savings because of the reduction in acute exacerbations. Maiolo et al. (2003) conducted a study with patients who had COPD and restrictive disease. The study had two phases, traditional treatment for 12 months and telemonitoring for the next 12 months, with 30 patients participating in the study. The results were in favour of the telemonitoring programme, as the acute home exacerbations were lower in the second phase than in the first phase. It was calculated that there was a 50% reduction in hospital admissions and a 55% reduction in acute home exacerbations. In economic terms, it was estimated that the cost of hospitalisation was around €233,000 in the first phase and €133,000 in the second phase. The cost of telemedicine equipment was expected to be €60,000. Therefore, the net saving was €40,000. This study found that patients were satisfied with the health service and the quality of the telemonitoring service. It recommended the implementation of telemonitoring for patients with severe respiratory illness (Maiolo et al., 2003).

All the studies above indicated that the telehealth programme is a cost-effective solution for hospitals, as the usual care is more expensive than the telehealth programme. Moreover, patients who used the telehealth programme did not have as many acute exacerbations as those using the usual care.

### 3.3.3 Cost-Effectiveness Analysis

The most common method of healthcare evaluation is CEA. Eight studies explored the cost-effectiveness of the telehealth programme for COPD patients using CEA. They investigated whether there was a reduction in hospital admissions, length of stay and days of hospitalisation and what happened with the QALYs.

Achelrod et al. (2016) explored whether the largest COPD telemonitoring programme in Europe was a cost-effective solution. The aim of this programme was to reduce morbidity, mortality, healthcare utilisation and the costs. This was the first study that was conducted in Germany to determine whether telehealth for COPD patients was a viable strategy. In the analysis, data from 651 patients who used the telehealth programme and 7,047 patients who used the usual care was used. The total direct medical cost was €895 per patient lower in the intervention programme than the usual care, and the saving from hospitalisation of patients with severe COPD was around €1,056 per patient. The results showed that the mortality hazards ratio was lower in the telehealth group, with this ratio being 3.23 compared to 6.22 for the usual care group. Moreover, this study found that the number of inpatients decreased, but simultaneously the number of outpatients increased. Outpatients also generated expenses for the hospital, as they required more intense prescription of pharmaceuticals and the number of outpatients visits increased. Furthermore, the cost of outpatients visits rose slightly to €69.54 per patient. Therefore, this intervention was a perfect solution for patients who had severe COPD, as they received better treatment and had fewer hospital admissions. Telemonitoring was not a sufficient as an exclusive treatment method for the patients and they had to have high-quality treatment (Achelrod et al., 2016).

Henderson et al. (2013) studied the cost and the cost-effectiveness of telehealth for patients with long-term conditions (COPD, heart failure and diabetes). Of the 3,230 patients who participated in the Whole System Demonstrator programme in the study, 1,573 were patients involved in the research. After 12 months, a follow-up showed that 974 people remained in the programme, meaning that 38% of the participants dropped out of the programme. The telehealth cost was higher than the usual care cost. The cost of telehealth was £1,596 per patient, and for the usual care it was £1,390 per patient. Specifically, the total cost for health and social care was £1,390 per patient for the usual care and £1,139 per telehealth patient annually without the cost of the intervention, in which the cost of the equipment was on average £169 per patient and other direct costs were £289 per patient. Therefore, the telehealth programme was £206 more expensive per patient. The difference in the QALYs between telehealth and the usual care was small (0.012). The conclusion of this study was that telehealth was not a cost-effective solution, as the cost of telehealth was higher than that of the usual care and the QALYs that were gained by telehealth patients were almost the same as those gained by the usual care patients (Henderson et al., 2013).

Pinnock et al. (2013) explored whether telehealth was a cost-effective solution in NHS Lothian for people who had been admitted to hospital because of a COPD exacerbation in the previous year and who were at risk of admission in the future. This study found that the QALYs in telehealth had increased, indicating increased effectiveness compared to the usual care. The results were that the first hospital admission for patients with COPD who had exacerbations was at 362 days for the telemonitoring group and at 361 days for the control group. The average number of COPD admissions

was 1.1 admissions per patient who used telemonitoring and 1.2 admissions per patient who used the usual care. The average length of stay in hospital was 9.5 days for patients who used the usual care and 8.8 days for patients who used telemonitoring. Furthermore, there was no significant difference in the health-related quality of life. The conclusion of the study was that there was no difference in the length of hospital admission and the health-related quality of life, as both groups used the same clinical care. According to this research, telemonitoring was not an effective solution for the NHS (Pinnock et al., 2013).

Udsen et al. (2014) investigated the effects of the telehealth programme on patients who suffered from COPD and assessed the effectiveness and the cost-effectiveness of the programme. The effectiveness was analysed using the clinical outcomes and the quality of life of patients who used the telehealth programme compared to the patients who used the usual care in Denmark. Regarding the effectiveness, the outcomes were better health-related quality of life and a change in the physiological parameters. Although there was no change in mortality rates, the benefits were higher health-related quality of life, lower blood pressure and higher oxygen saturation (Udsen et al., 2014).

Witt Udsen et al. (2017) investigated whether the use of a telehealth programme was a cost-effective solution compared to the usual care in Denmark. They conducted a cluster randomised trial in 13 districts and 1,225 patients with COPD participated in the trial. The outcome of this study was that the telehealth programme was more expensive than the usual care. The healthcare cost for the telehealth programme was €836.20 more per patient annually, and telehealth had an additional cost of €704.20 per patient. Therefore, the difference between these two programmes for patients was €1,540.40 per patient annually. In the base-case scenario, the QALYs were 0.0132 higher in the telehealth programme, which was not considered significantly important, and the ICER was €55,327 per QALY. There is a 50% probability of being cost-effective if there is willingness to pay more than €55,000. This study concluded that the population was too broad. Therefore, the authors recommended that more studies should be conducted to investigate the best practices for implementation which would increase effectiveness and reduce cost without compromising safety and effectiveness. Typically, telehealth is cost-effective for patients who have a severe or very severe condition (Witt Udsen et al., 2017).

Taylor et al. (2012) explored the feasibility, effectiveness and cost-effectiveness of self-management for COPD patients. The 116 patients who participated in this study had moderate to severe COPD. Of these, 78 participated in a six-month programme and the other 38 used the usual care. In these two groups, the differences in the first two months were minor, with the differences becoming more intense over the six-month period and being in favour of the intervention, as patients increased their exercise level and their health-related quality of life, for instance, two patients on the intervention programme stopped smoking. The total cost of the intervention was £30,000 for all the patients, and therefore the

cost per patient was £358 for the duration of the study. The ICER was £11,710 per QALY gained in a six-month period. The intervention had the potential to meet the UK National Institute for Health and Care Excellence criteria for cost-effectiveness. The economic analysis suggested that with thresholds of £20,000 per QALY gained, it is likely to be cost-effective (Taylor et al., 2012).

Conversely, Bentley et al.'s (2014) study conducted in the north of England obtained the opposite results. They investigated whether telehealth was a cost-effective programme and assessed whether there was the potential for a full RCT to be conducted. This study was a small-scale study as only 63 patients participated in it and 15 were excluded. The results of the study were that the patients who used the usual care had lower readmission rates, fewer hospital admissions and fewer inpatient days than who used the telehealth programme. The costs of the telehealth programme were £1,749.80 and the QALYs gained were 0.217. In the usual care, the costs were £580 and the QALYs gained were 0.20. This study showed that telehealth was a cost-effective solution only if the community care cost was included and if the cost of the equipment was £455 for five years. According to this study, the telehealth programme was only cost-effective if the number of hospital admissions was not taken into account. Moreover, a full RCT could not be conducted at that time as only a small number of patients were recruited. The study needed to be multi-centred and have 1,517 participants in each group (Bentley et al., 2014).

McDowell et al. (2015) assessed the effectiveness of telemonitoring for patients with moderate to severe COPD. This study, which was conducted in Northern Ireland over a six-month period, and completed by100 patients, 48 in the telemonitoring group and 52 in the usual care group. The study investigated the primary outcome, which was health-related quality of life, and the secondary outcome was the effectiveness of healthcare utilisation, exacerbations, satisfaction and cost-effectiveness. The results showed that the scores on the St. George Respiratory Questionnaire (SGRQ) were significantly higher for the telehealth group than the usual care group. Furthermore, the anxiety scores were higher in the telehealth group than in the usual care group. In addition, it was observed that the telehealth group had more contacts with healthcare professionals than the usual care group. There was no significant difference in anxiety scores, GP visits, emergency visits, hospital admissions and exacerbations. Patients reported feeling satisfied with telehealth, as they considered themselves to be in more control. Moreover, the difference in the quality of life was 2.18 units in the European Questionnaire Visual Analogue Scale (EQ-VAS) score. The cost of telemonitoring was £10.12 per day and £1,847 for the six-month trial per patient. The EQ-VAS score was 0.02 units for one year and the project lasted for six months; therefore, the EQ-VAS score was 0.01 units and the total cost of the intervention was £2,039. Therefore, the telemonitoring programme was effective in improving the quality of life and anxiety, but it was not cost-effective (McDowell et al., 2015).

The eight studies discussed above that used CEA indicated that the usual care was a more cost-effective solution than the telehealth programmes; however, society is willing to pay for each QALY gained and the telehealth programme could be a cost-effective solution. Bentley et al. (2014) found that the telehealth programme was not a cost-effective solution if they included hospital admissions, while other studies found that the telehealth programmes reduced the healthcare costs and hospital readmissions. In addition, Henderson et al. (2013) found that the QALYs gained on the telehealth programme were the same as those gained in the usual care and the cost of telehealth was higher than that of the usual care. Therefore, telehealth was not a cost-effective solution compared to usual care. Furthermore, although Achelrod et al. (2013) did not find statistically significant results, they stated that telehealth monitoring was postponing hospital admissions and improving quality of life.

## 3.4 Summary

The scoping review in this chapter examined the different economic methods that were found for evaluating telehealth programmes for COPD patients. All the economic evaluation methods used examined whether a programme was worthwhile; however each method used different criteria to determine that. From the studies that presented above derived the essential benefits were reduced length of stay in the hospital, reduced hospital admissions, reduced outpatient visits, and better monitoring, and control of patients' condition.

Telehealth is a controversial programme, as there is no clear view on whether it is cost-effective and better than the usual care. Different economic methods are used to calculate the benefits that each method provides. This chapter examined studies that used different economic methods to evaluate telehealth programmes for COPD patients to identify the different benefits derived from each method. Health economics is heavily reported in this thesis, as the primary research question relates to whether the telehealth programme is a worthy solution in monetary terms.

The studies found that there was broad agreement that telehealth programmes were the preferable solution, but they were not cost-effective solutions. Most of the studies suggested that telehealth programmes provided a better quality of life for patients. They found that there is a small difference between telehealth programmes and usual care in the hospitalisation rates and the reduction of exacerbations. Furthermore, the costs were higher in the telehealth programmes than in the usual care, and the QALYs gained were not significantly higher than in the usual care. Consequently, it is considered that the telehealth programmes are not cost-effective solutions.

It is noticeable that telehealth programmes improved the quality of life in patients. However, several studies (Jodar-Sanchez et al., 2014; Stoddart et al., 2015) mentioned that the telehealth programmes were not cost-effective solutions. This is reasonable as if these studies compared only the costs, and that the telehealth programmes had additional costs because of the equipment that the telehealth programmes required. However, other studies (Hofer et al., 2016; Miaolo et al., 2003; Pare et al., 2006; Paré et al., 2013; Vitacca et al., 2009) calculated the cost savings and found that the hospitals had actual savings because of telehealth programmes.

The CEA studies demonstrated that the telehealth programmes for COPD patients are a practical solution that provides better quality of life and improvement in health treatment than the usual care. However, telehealth programmes are not cost-effective solutions according to the CEA studies, as the hospitals spent less money on the patients who used the usual care treatment than on patients who used the telehealth programme, because the equipment cost that patients receive on telehealth programmes. Furthermore, in the studies that calculated the gained QALYs, the QALYs were higher in the telehealth programme than in the usual care; however there was no significant difference. Therefore, the telehealth programmes were not deemed cost-effective solutions, but they did provide better quality of life.

# Chapter 4: Scoping Review of Qualitative Studies of Telehealth Interventions for Patients with Chronic Obstructive Pulmonary Disease

Many qualitative studies have been conducted to obtain the views of patients, General Practitioners (GPs), and healthcare professionals regarding telehealth programmes. This chapter focused on the qualitative studies that examined telehealth interventions for chronic obstructive pulmonary disease (COPD) patients internationally. These qualitative studies involved interviews, focus groups, observations and self-administered questionnaires to determine whether patients were satisfied with the programme and whether it enabled them to have better quality of life and fewer hospital admissions. These studies demonstrate how these programmes worked and their benefits. The scoping research question in this chapter is "What qualitative methods have been used to assess telehealth programmes for COPD patients?" This chapter also relates to results Chapter 7, which presents qualitative research based on semi-structured interviews regarding the Home and Mobile Health Monitoring (HMHM) programme for COPD patients.

## 4.1 Methods

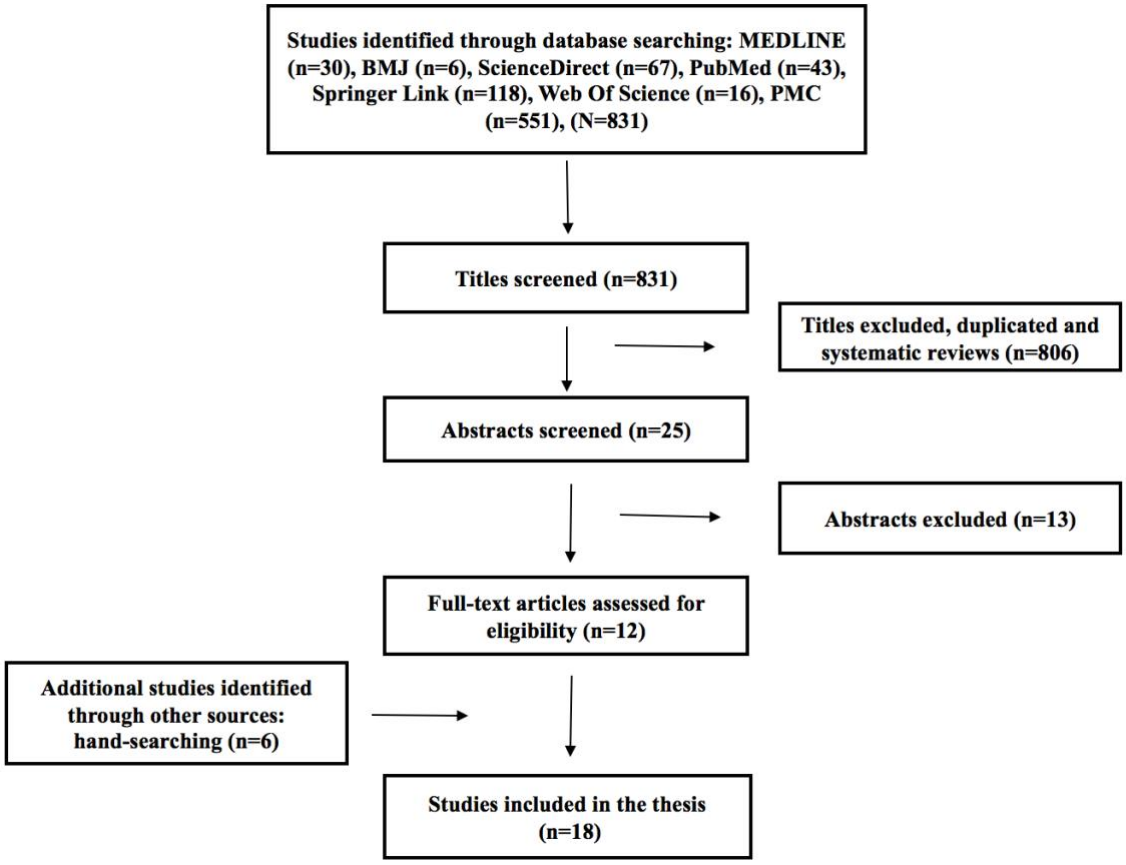
Some of the studies that are presented in this part of the thesis were derived from searching seven databases, while additional studies were found an online search. More specifically, the following databases were used: MEDLINE, ScienceDirect, PubMed, Springer Link, Web of Science and PudMed Central (PMC). The results were derived from the database search. The keywords were a combination of keywords included in the expression: "Qualitative studies on telehealth programmes for COPD patients".

The inclusion criteria were studies that examined COPD patients, qualitative studies on telehealth programmes for COPD patients, primary and secondary studies, and studies that were in English and sourced in the digital libraries mentioned above. The exclusion criteria were studies that were not qualitative studies on telehealth programmes or relevant programmes for COPD patients, patients with diseases other than COPD, systematic reviews, and studies in languages other than English.

The search process is illustrated in Figure 2 below. After the initial search, 831 results were found, 806 titlles of searches excluded because the title did not meet the inclusion criteria. 25 abstracts were screened, and 12 full-text articles were assessed to be appropriate. 13 abstacts excluded as these did not the meet the inclusion criteria. In addition, six articles that were found by hand-searching were added

to the scoping review and included in the thesis. Those 6 articles found from reference lists from other studies. The scoping review did not have a second reviewer and the researcher is not registered on Prospero, which includes systematic reviews for health and social care. This study did not analyse systematic reviews.

Figure 2: Scoping Search Process for Qualitative Studies on Telehealth Programmes for COPD Patients




## 4.2 Synthesis and Reporting Results from Scoping Review

The scoping review identified 18 qualitative studies that investigated telehealth programmes for patients with COPD and their perspective on the programme. Clinicians expressed their concerns about telehealth programmes, the effect of the use of technology on the patients health, the skills that are required by patients to be able to self-manage their condition and whether they needed some additional skills, as well as patients' concerns, fears and barriers. They also discussed whether telehealth programmes have the potential to detect early exacerbations. The analysis used was thematic analysis, which involved reading, organising and categorising the papers considered relevant to the research

question and finding common factors in them. From those papers, the following themes were derived: (i) patient perspectives, (ii) clinician perspectives, (iii) technology, (iv) self-management of their condition, and (v) better clinical outcomes.

### 4.2.1 Patient perspectives

The perspectives of COPD patients on telemonitoring programmes, whether they were satisfied with the programmes and the perceived benefits of the programmes are discussed below as discussed in the liertature reviewed.

Wodskou et al. (2014) presented the views of patients and their families on a telehealth programme for COPD patients. Although most patients were satisfied with the disease management programmes, there were a few criticisms about some aspects that needed improvement, for example, they wanted a flexible system through which patients and their families would have access to healthcare professionals when they needed them. This was necessary as when their symptoms worsened, they did not know what to do and they wanted to have access to a GP. Regarding the usual care, patients often needed to wait for months (even six months in some cases) to see a GP. Their symptoms were affected and they felt unsafe and abandoned. In addition, patients stated that when they had a COPD exacerbation and they needed hospital admission, they faced difficulties in being admitted to the hospital. Furthermore, some stated that they were discharged from the hospital after a short time, which led to readmission. They added that they needed appropriate healthcare services to receive the necessary treatment to avoid readmissions. The care services that were provided were limited as they did not match the patient's needs. Patients did not receive appropriate treatment because of bureaucratic rules and some of the services that the patients needed did not exist (Wodskou et al., 2014).

Fitzsimmons et al. (2016) presented the views of patients in the early stage of COPD. When patients had used their alarms, they were contacted by telephone by a clinician from the COPD service and they received advice. A prescription for medication was faxed to a local pharmacy without the need for a GP visit or a home visit. This study compared the experience of patients who used the telehealth programme to that of those who used the specialist nurse programme after being discharged from hospital. Twenty-six patients participated in the interviews and completed the questionnaires. Patients felt more comfortable with the telehealth programme as they felt that someone was looking after them and that the service was integrated and personalised. The patients withdrew from the telehealth programme when their conditions had improved. Three clinicians who participated in this study stated that the patients were quite old and afraid to use the technology for their treatment. Moreover, some of them had concerns and were nervous. Most questions were about the equipment, such as whether it was easy to use, how the service worked and whether their data would be protected. One patient described the

equipment as “a bit technical”. At the end of the programme, the patients felt confident in using it and they did not want to withdraw from the programme. Clinicians stated that age was not a problem in using the telehealth programme. However, some patients were not in favour of the fact that they withdrew from the intervention, while other patients felt relieved that the intervention was stopped for them. Some were “a little bit lost for a couple of days” (Fitzsimmons et al., 2016).

Odeh et al. (2015) conducted a study over 36 months to measure the impact of telehealth and compare it with the usual care. Patients with COPD and heart failure completed a survey to present their views about it. The patients stated that they were satisfied with the telehealth programme, as it had improved their life, it was a convenient way to provide healthcare service, and they were more involved in the decisions about the care and treatment. They believed that telehealth offered them a better monitoring system from nurses and GPs, leading to more integrated treatment. The data from the patients and the online survey indicated that Accident and Emergency (A&E) admissions and hospitalisations were reduced. As the patients were satisfied with the programme, the researchers needed to expand it to include a larger number of patients. Moreover, patients stated that they did not have concerns about the confidentiality of their data and that telehealth saved them time, and two patients stated that it also saved them money (Odeh et al., 2015).

Ure et al. (2012) investigated the perspectives of patients and professionals on a pilot implementation of a COPD telemonitoring programme before and after its implementation. The researchers conducted 27 in-depth semi-structured interviews with patients who had moderate or severe conditions and a high risk of hospital admission. Patients stated that they were satisfied with this programme, as they were able to detect exacerbations earlier and they had quick responses from clinicians regarding how to resolve their problem. When they used the usual care, they worried about managing exacerbations, as they could not detect exacerbations early and there was a delay in finding a healthcare professional to provide care (Ure et al., 2012).

Fairbrother et al. (2012) presented the views expressed in 70 interviews, of which 38 were with patients who participated in the monitoring programme and patients who had the usual care treatment and 32 were with professionals. The study was conducted in Lothian, Scotland, in 2009 to explore the views of patients and healthcare professionals on the telemonitoring programme TELESCOT. Telemonitoring was considered an improvement in care for patients, as it provided them with better accessibility and a friendly approach and it responded to their personal needs. Patients were satisfied with the healthcare professionals because of the personal help and support that received from telemonitoring professionals. This approach helped them to avoid the barriers that they faced in the usual care, such as visiting a GP (Fairbrother et al., 2012).

Nissen and Lindhardt (2017) presented the results of semi-structured interviews with 14 participants. Patients with COPD who used telemedicine they submitted their readings weekly instead of visiting hospital as outpatients. This study aimed to determine whether patients were satisfied with their participation in the Net-COPD programme, which was a video consultation programme for monitoring patients with severe COPD. The participants were satisfied with the programme, as they found it improved the treatment for patients and they obtained more control over their condition. Furthermore, they had enhanced wellbeing and had a sense of security as they knew that someone was there to take care of them. They felt less stressed as they did not need to visit hospitals, and, in the video consultation, they saw the same nurses that they saw in the hospital. Patients stated that they felt secure with the use of the video consultation programme. However, not all the patients felt the same way, as one patient mentioned that the pulse oximeter did not agree with the measurements taken during hospitalisation. This created uncertainty about the pulse oximeter equipment for that patient (Nissen and Lindhardt, 2017).

Sanders et al. (2012) presented the perspective of patients who decided not to participate in or withdrew from a telehealth or telecare programme. Twenty-two people were interviewed, 19 of whom decided not to participate in the telehealth programme and three of whom withdrew from the programme. Those who were interviewed in that study were patients with diabetes, COPD, heart failure and social care needs. They stated that the reasons they decided to not participate in the programme were that these programmes required technical competence and the operation of equipment. They stated that it was difficult for them to engage with technological requirements. They had doubts about whether they would be able to understand the operational requirements of the equipment. In addition, one of them said that English was not his first language, and therefore he lacked confidence in the use of English. Another reason was patients felt that this programme threatened their independence and self-care. They wanted to distance themselves from implications of old age, sickness and dependence on the system. Specifically, some of the patients stated that they did not want to participate in the programme, while others stated that they are not old enough to need to monitor their condition. Other patients stated that they were not able to be independent. Some stated that this type of treatment makes them more worried about themselves, while others wanted distance from medical details, and the wife of a patient stated that this programme would make patients hypochondriacs. Regarding the three patients who withdrew from the programme, two had difficulties in making the equipment work and one withdrew because of false alarms due to faulty readings (Sanders et al., 2012).

From the studies discussed above, it can be concluded that patients were generally overall satisfied with the telehealth programme they used, as they felt that someone was taking care of them and they received more integrated and personalised treatment. The main problem that COPD patients had was that they had many exacerbations and in some cases, acute exacerbations. If they did not receive early

interventions, then they needed to visit the hospital. Furthermore, the study conducted by Sanders et al. (2012) mentioned some barriers, concerns and fears of some patients, and these patients decided to withdraw or did not participate. Identifying those barriers is essential, and they should be taken into consideration when developing other interventions.

### 4.2.2 Clinician perspectives

The perspectives of healthcare professionals on the various telehealth programmes are discussed below. Healthcare professionals have the knowledge to determine whether a programme provides an actual outcome for patients and the healthcare system.

MacNeill et al. (2014) conducted a qualitative survey to investigate telehealth care for patients with long-term conditions from the perspective of frontline health professionals. Their study was conducted in three different areas of the UK and included semi-structured interviews with 32 frontline health professionals. The results were that the nursing staff were supplemented in the telehealth programme and not substituted as they are in the usual care. However, GPs had mixed views on the programme. Most of them were in favour of the programme although they had concerns about the workload. They also believed that the telehealth programme and related programmes undermined their autonomy (MacNeill et al., 2014).

Odeh et al. (2014) investigated the views of nurses who worked in a telehealth programme . Telehealth programme provided on patients with COPD and heart failure for 22 months in order to present the perspectives that nurses had for that programme,Although the nurses were satisfied with the programme, they stated that there was a lack of resources to run the project appropriately. Nurses stated that the programme was beneficial for the patients but increased their workloads. Generally, the patients were satisfied with this programme; however, some patients considered it a chore and felt that they needed a more focused follow-up. The patients who participated in the telehealth programme were patients after hospital discharge. They were satisfied with the technical side of the programme and they found it easy to use and trustworthy. GPs were not in favour of telehealth, as they believed it increased their workload. The telehealth programme included the provision that patients could contact a GP in an emergency. However, it was difficult for them to get an appointment and they ended up visiting A&E. Moreover, the nurses stated that they were not asked if they wanted to participate and the GPs they worked for ordered them to attend training sessions for telehealth. The training varied among nurses as some of them undertook a two-hour programme while others undertook a one-day programme (Odeh et al., 2014).

Fairbrother et al.'s (2012) study was conducted in Lothian, Scotland, in 2009 to explore the views of patients and healthcare professionals on the telemonitoring programme for COPD known as TELESCOT. They conducted 70 interviews, of which 38 were with patients who participated in a monitoring programme and patients who used the usual care treatment and 32 were with professionals such as service managers, information technology suppliers and support staff, as well as nurses and GPs who did not participate in the programme. Professionals mentioned operational difficulties such as a lack of communication, procurements installation and IT support. There was limited information between teams and practices of other telemonitoring colleagues. Furthermore, many GPs mentioned their concerns about overtreatment. Some GPs felt that this programme took the pressure off GPs and hospital services, whereas other GPs stated that working and sharing information for patients with no medical healthcare professionals was intrusive, unwelcome and unhelpful. Finally, healthcare managers focused on the potential savings that they could gain with the telemonitoring programme (Fairbrother et al., 2012).

Ure et al. (2012) investigated the perspectives of professionals on a pilot implementation of the COPD telemonitoring programme before and after its installation. Twenty-five semi-structured interviews with healthcare professionals were conducted and a focus group was used. This study highlighted the concerns of the healthcare professionals and managers about providing clinical support to patients through the telehealth programme. Clinicians stated that the healthcare treatment improved, but they worried about overtreatment of exacerbations. They also stated that they had concerns about their workload being increased and about the use of technology (Ure et al., 2012).

From the studies above, it was concluded that not all healthcare professionals are in favour of the use of these programmes although nurses stated that these programmes were beneficial for patients.

### 4.2.3 Technologies

Four studies that explored the challenges that patients faced when using the technology for monitoring their conditions are discussed below. Patients who have COPD are mainly older adults who do not always have extensive experience in using technology and gadgets, which can makes them concerned about participating in telehealth programmes.

Patel et al. (2016) investigated how patients who participated in a longitudinal study used an electronic diary to monitor, record and transmit their health status. The focus group aimed to investigate how much individuals used their electronic diary and how it helped them with self-management. The result of the study was that the patients were satisfied with this programme, as it increased their self-efficacy and improved their knowledge of their conditions, which enhanced their wellbeing, and there was a

reduction in hospital admissions. Therefore, this was a successful and effective self-management model (Patel et al., 2016).

Vatnøy et al. (2016) investigated the views of ten patients on the telemedicine programme that explored how patients with COPD follow-up with the use of telemedicine and how the technology supported and improved patients independence. The patients were satisfied with the programme, as it was easy to set up and to learn and use. Patients felt comfortable using the pulse oximeter device and confirming their health condition. Patients had reduced stress levels and could have a healthy life. They felt satisfied as they gained independence and self-managed their condition. However, some difficulties were mentioned regarding the use of technology. Two patients stated that they had some difficulties turning on the tablet and hitting points on the touchscreen because of weak and trembling hands. Two patients were not satisfied as they were reliant on and bound by the measured values. In addition, there was a lack of opportunity to give feedback on improved health conditions in self-evaluation. Telenurses guided patients on how to monitor their disease alone at home and explained the impact this programme could have on their health. Therefore, patients were satisfied with this programme as it enabled them to manage their daily life (Vatnøy et al., 2016).

Williams et al. (2014b) explored how an mHealth app could affect the wellbeing of people and help them to manage their conditions. This study investigated whether the apps used by telehealth programmes were suitable for unfamiliar users to use to self-manage their conditions. The study involved conducting interviews with patients from various NHS services. Initially, the patients were unsure whether they would be able to self-manage their condition. The patients received more integrated continuous care with the programme and were more willing to discuss the variability of their symptoms. This study found that the app was easy to use. Patients using this app could clearly understand the variability of their symptoms and be more engaged in self-management (Williams et al., 2014b).

### 4.2.4 Self-management of Chronic Obstructive Pulmonary Disease

Another aspect of the management of COPD is that the patients are able to self-manage their condition and to detect the symptoms of deterioration at an early stage. The studies discussed below explored how patients detected the symptoms of deterioration, what patients did when they realised that they had an exacerbation, and what those patients should have done when they used self-management telehealth programmes.

Huniche et al. (2013) conducted 22 semi-structured interviews with COPD patients and nine interviews with the patients' spouses. The study explored how the patients could detect the symptoms of exacerbation when they used the self-monitoring programme. Self-management meant that patients

could detect an exacerbation and make a judgement about their symptoms regarding whether it was necessary to contact a GP or a nurse. Knowledge is useful in self-management, as patients can understand when they have an exacerbation. Self-management is not a solution for everyone, as programmes of this type require people to change their behaviour and be more careful. However, self-management is a valuable solution if healthcare professionals support patients in the self-management process. Some of the patients decided not to participate in these programmes and others withdrew from them because of their fears and the uncertainty they felt (Huniche et al., 2013).

Walter et al. (2012) investigated whether there was a change in the behaviour of patients with moderate or severe COPD when they used the telephone health-mentoring programme. Ninety people participated in this programme and 44 patients participated in the interviews. Of these, 33 had moderate COPD and 11 had severe COPD. Most of the patients found the telephone health-mentoring programme valuable. They believed that it helped them to define new goals, activities and strategies to manage their COPD and increase their wellbeing. The majority of the patients made a change in their behaviour. Fourteen patients made a health behaviour change, 18 showed willingness to make small changes, and 12 were more resistant to making changes. The most frequent changes were adding physical activity in their daily life, reducing or stopping smoking, changing their diet and managing their symptoms. However, it should be mentioned that the behavioural change was not achieved in patients with severe COPD (Walters et al., 2012).

Williams et al. (2014a) investigated how patients detected whether they had an exacerbation and how they controlled it by conducting interviews with 44 patients. The patients described an exacerbation as a combination of visible and invisible symptoms. When they detected that they had an exacerbation, patients used various techniques, such as self-medication, which involved taking steroids and antibiotics to control their exacerbation, and then monitored their recovery. If they could not control their exacerbation with self-medication, then they contacted their GPs and healthcare professionals when they felt that they were not able to manage their disease. Clinicians stated that an ‘expert patient’ could detect an early exacerbation and treat it (Williams et al., 2014a).

Wortz et al. (2012) conducted in-depth interviews with patients who had COPD to identify the gaps in the self-management process. Self-management requires them to change their behaviour to obtain a better quality of life. The interviews focused on how the patients could improve their goals for the future, their individual needs, and their learning for the future. In this way, they would overcome the losses and the fears they had and the desire for improved care. Regarding the losses, patients stated that they were afraid that they would lose their normal functioning since they had comorbidity. Therefore, they were afraid that they would not be able to stay active and perform normal daily activities. They were concerned about the progression of the disease and how they could prevent it and about the severe

breathlessness they had. Patients wanted to learn about their condition and how they could give themselves better treatment. Self-management could help patients with COPD to focus on how to improve their health with the use of new medication and new methods and to overcome their fears about the uncertainty and the progression of the disease (Wortz et al., 2012).

### 4.2.5 Better Clinical Results

Two observational studies that investigated whether telehealth programmes could provide better clinical results are discussed below.

In an observational study, Hamad et al. (2016) followed 183 patients who used a telemonitoring programme for four months to determine whether it was possible to detect exacerbations of COPD. They found that 30 people from a group and 68 from the community COPD group needed hospital admission. In the first group, there were 30 episodes. Following those episodes, six patients did not have any change in their health. This means that 80% of the patients did not feel well; they had shortness of breath, cough, sputum production, sputum colour change, ankle swelling, reduced oxygen saturation and high temperature. In the community group, there were 68 episodes. Twelve patients did not present any symptoms, while 82% had some symptoms such as those mentioned above. This indicated that there was a need to develop more accurate methods to detect the symptoms of an exacerbation of COPD. The telehealth programme was not efficient in detecting clinical deterioration on a day-to-day basis (Hamad et al., 2016).

Sanchez-Morillo et al. (2015) conducted a pilot study to investigate whether a mobile health system could detect early acute exacerbation for patients with COPD on a day-to-day basis. The study was conducted in Spain over six months and included 16 patients. The study was observational and a specialist contacted the patients to confirm a past exacerbation. Furthermore, some occasional contacts were made for minor technical issues. Of the 16 patients, 15 completed the trial. Five of them did not have exacerbations, while ten of them had 51 non-programmed medical attention episodes, of which 33 were acute exacerbations and 18 were non-recorded acute exacerbations. The results showed that an average of 2.1 to 1.7 patients had acute exacerbation episodes, six patients needed nine hospital admissions, and the average inpatient hospital stay was 13 to 18.9 days. Moreover, 31 of the 33 acute exacerbations were detected early. The acute exacerbation were detected between 4.5 and 2.1 days earlier (Sanchez-Morillo et al., 2015).

Although the two studies discussed above demonstrated that telehealth programmes are not perfect solutions for detecting deterioration earlier, both studies concluded that there is a possibility that the

telehealth programme can provide better monitoring of patients, as it is possible that an exacerbation can be detected several days earlier.

## 4.3 Summary

From the qualitative studies that are discussed in this chapter, it was found that patients were generally satisfied with telehealth programmes, as they provided them with more integrated care with a less intense need for hospitalisation or a visit to their GP. Patients could monitor and manage their health at home themselves. However, the problem is that not all patients are able to do so, and some patients stated that they were afraid to do it, as is mentioned in the study conducted by Sanchez-Morillo et al. (2015).

It was also found that telehealth programmes can provide a better monitoring system than usual care, which possibly leads to fewer hospital admissions, but this was an imperfect solution. Patients should be able to self-manage their condition and the programme should be able to detect the deterioration earlier to enable patients to manage it effectively. Patients in the control groups had fewer hospital admissions than those in the usual care groups. There is a possibility that the telehealth programme can detect exacerbations a couple of days earlier. This would enable patients to receive the appropriate medication to control it. However, the monitoring system needs to be improved to be able to achieve a better outcome as a result of the monitoring. Furthermore, studies that examined different technology programmes were mentioned, such as the telenursing programmes, mobile apps and longitudinal studies. All these methods received positive feedback as they are generally perceived as easy to use, make the patients more comfortable with their disease, and help them to learn more about their condition and how to detect their symptoms.

The key findings derived from reviewing the qualitative studies on telehealth interventions have been outlined above. The findings suggested that telehealth might be a useful intervention that could help patients receive more integrated care compared to the usual care. Their condition should be managed carefully, and healthcare professionals should play an active role in this. All these studies have demonstrated that telehealth could improve the healthcare that patients receive from the NHS. Therefore, telehealth should be used on a larger scale.

# Chapter 5: Methodology and Methods Used

The purpose of this thesis was to conduct a cost-benefit analysis (CBA) for the Home and Mobile Health Monitoring (HMHM) programme used by patients with chronic obstructive pulmonary disease (COPD) in order to examine if this intervention could provide economic benefits for the NHS. CBA was chosen because it is the only method that calculates costs and benefits in monetary terms. A mixed methods approach was used in this thesis as there was a need for both quantitative and qualitative analysis (Wisdom and Creswell, 2013) of these costs and benefits. Using these combined methods leads to a better understanding and examination of the research problem (Creswell and Plano Clark, 2011). Quantitative analysis involves testability (examining a case study), and qualitative analysis explores the context of the topic (Kaplan and Duchon, 1988). The need for both methods was essential here because HMHM was a new programme, little was known about the costs and benefits, but there was enough information available if collated to conduct a CBA evaluation (quantitative analysis).

Both quantitative and qualitative data were needed to find and estimate the costs and the benefits of the HMHM programme. The mixed methods approach provided an in-depth examination of the topic because quantitative analysis was used to complete the CBA evaluation while qualitative analysis was used to collect and verify all the missing information. Chapter 6 presents data from the secondary sources and Chapter 7 explores data from the primary sources (derived from interviews and online survey with key informers of the HMHM programme).

The multi-methods approach is used when a research study employs different methods but there is no combination between them, whereas the mixed methods approach combines both quantitative and qualitative methods. Therefore, the multi-methods approach was not appropriate for this study. This thesis used a combination of both quantitative and qualitative methods.

The qualitative analysis was necessary to describe the HMHM programme and to collect of the costs and benefit information which was needed to conduct the CBA evaluation. Experts on the topic provided their perspective and verified the data from the published sources collated in chapter 6. Interviews and online survey were designed and conducted together. The purpose of the online survey was to collect data from those involved in the programme on how often patients visit hospitals, General Practitioners (GPs). The interviews were designed to gain further insight into people's opinions as to what the HMHM programme is and how it worked. People who agreed to participate in the interviews were sent a table with the data collected from published sources (see Appendix C: Topic Quide for

Interviews) to provide their perspective on whether they considered that data to be close to reality. Participants discussed this table during the interviews, and they agreed that the data was accurate (see Chapter 6: Table 3: Data and resources for the CBA evaluation).

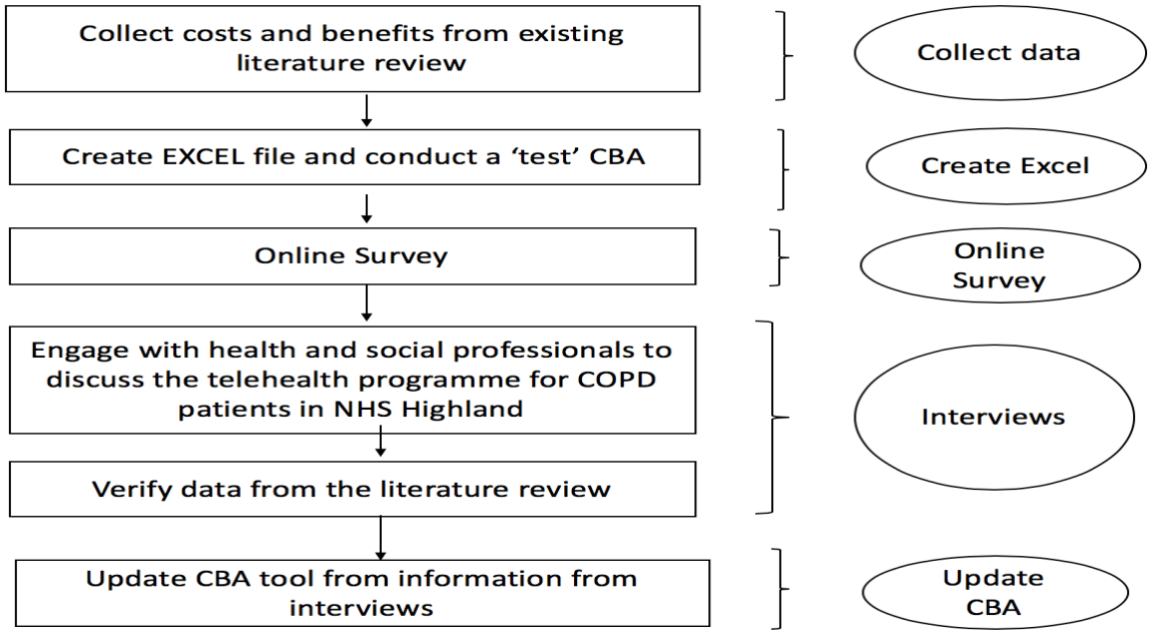
This thesis asked the following research question: "What were benefits for the NHS from the HMHM programme for COPD patients?" The costs and benefits have to be compared to answer this question, but there were many difficulties in calculating these. Challenges arose in terms of completing an economic evaluation on health and assigning values to health outcomes. In terms of the HMHM and Florence programmes not much information was available regarding what those programmes are and how they work. During the interviews, experts attempted to discuss the benefits that the Florence programme provided, but they also described the difficulties of implementing it in NHS Highland and Scotland.

The findings are presented in three chapters. Chapter 6 presents a quantitative analysis (the cost–benefit analysis) evaluating the HMHM programme in NHS Highland to determine whether it was a beneficial solution. Chapter 7 presents qualitative research describing the programme's benefits. Participants were asked what their protocols were and what perspectives clinicians had on the Florence programme and the HMHM intervention (survey and interviews). Chapter 8 presents the challenges of implementing both the Florence programme in NHS Highland and the HMHM programme in Scotland (interviews).

## 5.1 Quantitative Methods: Cost-Benefit Analysis

In this thesis, a CBA evaluation was conducted on the HMHM programme for COPD patients in NHS Highlands. The CBA was used to determine whether the benefits of this programme would exceed the cost, thereby making it a worthwhile solution for patients (Tolley and Rowland, 1995). Figure 1 below demonstrates the steps that were conducted during the CBA evaluation for patients who had severe COPD and needed to continuously monitor their condition. The steps outlined below were taken to assess if the programme provided economic savings for NHS Highlands.

**Figure 1: Methodology**




The NHS and local authority in NHS Highlands has limited information on the HMHM programme, meaning that the data used in the CBA evaluation had to be gathered from both primary and secondary sources. The following sources were used:

1) Information Services Division (ISD) Scotland, which is a part of NHS Scotland, and data from ScotPHO. ISD Scotland provides health information and statistical services while supporting the NHS in improving the quality of healthcare (ISD Scotland, 2018), and ScotPHO is a website that provides Scotland's public health information (ScotPHO, 2020).
2) Interviews conducted with experts on the topic to obtain an in-depth view of the HMHM and Florence programme and to verify some of the missing data collected from the published sources. In the Interviews 7 critical experts on the HMHM programme and Florence programme or other relevant programmes participated. The participants included the following: a nurse from NHS Highlands, two service managers, two experts on the Florence programme, and two academics who are experts on the HMHM programme as well as other relevant programmes. Health and social care professionals who participated in the study received a table (See Appendix C: Topic Quide for Interviews) with the data from the secondary sources to verify if the information was accurate and to give their assessment of what information the researcher might need.
3) Publications regarding healthcare in Scotland or England, such as "Units and Costs of Health and Social Care for 2017" (Curtis and Burns, 2017). This publication is a guideline that provides

information regarding GPs' and nurses' wages and the average number of minutes they spend with each patient.

4) A technical report provided by NHS Highlands about how patients with asthma, COPD, and heart failure used the HMHM programme to monitor their conditions (Wolters, 2018). This report has gathered information on the patients who participated in the HMHM programme on how they monitor their conditions if they have COPD, Asthma or heart failure. For the report, each disease was examined separately, and information on the participating patients was provided. This information included their number of hospital bed-days before and throughout the intervention, the average number of times they visited a GP before, during, and after the programme, and other relevant information. This report is now available at the Scottish Centre of Telehealth and Telecare (SCTT). The researcher received this report from the participant of the sixth interview during the research period. Therefore, the researcher decided to use the data from the report and not from the online survey, as the former provided more accurate data.

### 5.1.1 Costs and Benefits Formulas

The following section presents the costs and the formulas used to calculate them for COPD patients who used the HMHM in NHS Highland. It also presents the benefits and the formulas used to calculate those, which were derived from the reduced number of admissions, the reduced bed-days and the reduced occupancy of nurses and GPs. These reductions were expected to lead to positive results in the economic evaluation. The following equations did not use the query formulas, which are formulas prepared by Excel. The equations used in this thesis were prepared by the author of the thesis in order to calculate the costs and benefits.

Costs - Formulas

The costs were straightforward, and calculating them was more straightforward than measuring the benefits. Several elements determined the cost of the telehealth programme, including the following costs: equipment, texting, monitoring the nurses' data, admissions, visiting GPs, nurses' appointments, and visiting the hospital as outpatients. The CBA included an hourly wage for clinical nurse specialists who monitored the HMHM programme and how many times they spoke with patients over the phone. It also included the hourly wage for practice nurses who met with patients face-to-face. Table 1 below mentions the costs and the formulas used to calculate them.

Table 1: Costs and Formulas

| *No. Equation* | *Costs* | *Formulas* |
|---|---|---|
| **(1)** | **Total cost of equipment** | **Number of COPD patients who used the HMHM *cost of equipment per patient** |
| **(2)** | **Cost of texting on the Florence** | **Cost of texting per patient* Number of patients who used the HMHM in NHS Highland for COPD** |
| **(3)** | **Cost of admission** | **Number of patients with COPD who used the HMHM and get admission *cost of bed day per patient** |
| **(4)** | **Cost of outpatients** | **Number of patients with COPD who used the HMHM *cost of outpatients visits per patient** |
| **(5)** | **Cost of speaking on the phone with the nurse** | **(average hourly wage of nurse /60) * average number of minutes that they speak on the phone** |
| **(6)** | **Cost of visit GP** | **Number of patients with COPD who used the HMHM * (average hourly wage of GP/60 minutes * minutes that GP spent with them) * number of times that they visited the GP per year** |

Benefits - Formulas

The benefits of the HMHM programme were derived from the reduction in expenses. The estimation of the reduction of hospital admissions, visits to GPs, and visits to practice nurses was more challenging to calculate. It is impossible to know how many hospital admissions were avoided because of the at-home treatment patients used to control their COPD exacerbations. For this estimation, the researcher used the number of COPD patients' hospital bed-days before and during the HMHM programme, which is considered an acceptable way to calculate the reduction of bed-days.

Information from usual care was used to compare it with telehealth services and calculate the reductions of hospital admissions and outpatients who visited the hospital. These reductions could lead to savings for the NHS. Most of the benefits were derived from estimations – GPs spending less time seeing people with long-term conditions, including COPD patients using the HMHM programme. The formulas used to calculate the benefits of HMHM are shown below in Table 2.

Table 2: Formula for estimation of the HMHM for COPD patients

| No. equation | Benefits | Formulas |
|---|---|---|
| **(7)** | **Savings from reduced admissions** | **(Number of bed days that patients who had COPD before started using the HMHM minus Number of bed days that patients with COPD started using during the HMHM) * price of bed day per day** |
| **(8)** | **Savings from outpatients' visits** | **(Number of patients with COPD who visited the hospital as outpatients before the HMHM minus Number of patients with COPD who visited the hospital as outpatients during the HMHM) * cost of visiting hospital as outpatients** |
| **(9)** | **Savings from GPs appointment per year** | **[(GPs hourly wage/60) * minutes per appointment] * (number of times that patients visited their GP patients with the HMHM- the number of times that they visited their GP patients before the HMHM)** |
| **(10)** | **Savings from nurse time per year** | **[(nurses hourly wage/60) * minutes per appointment] *(number of times that patients visited the nurse during the HMHM programme minus the number of times that patients visited their nurse before the HMHM)** |

### 5.1.2 Cost-Benefit Analysis Tool

The software used for the CBA evaluation was Microsoft Excel. All the calculations were conducted in one Excel sheet, and all the data gathered was organised in another. There is also a third sheet, in which the sensitivity analysis was done. All the estimations mentioned in Section 6.2 "Economic Analysis: Cost-Benefit Analysis of the Home and Mobile Health Monitoring Programme for Chronic Obstructive Pulmonary Disease Patients in Highland" were calculated in this Excel file. It was deemed appropriate to use Excel as it was hoped that the cost-benefit calculation tool could be used by other telehealth programme leads for other CBAs for other telehealth programmes beyond this thesis.

After the interviews (Chapter 7), the CBA evaluation was updated with the information collected from the health and social care professionals. This led to a more accurate evaluation of the HMHM programme in NHS Highland. This evaluation was used to determine whether the HMHM programme for patients with severe COPD was a beneficial solution for the NHS. The Net Present Value (NPV) and the Benefit–Cost Ratio (BCR) are the two most common indicators that determine if an intervention is worthwhile. The NPV is a measure of monetary units – if it is higher than zero, the intervention is considered effective. The BCR is the ratio of benefits to costs; it indicates the relationship between the

costs and benefits of the project. The BCR should be higher than one: the higher the ratio, the more beneficial the intervention is (Guinness et al., 2011).

Sensitivity Analysis

A sensitivity analysis is used when the results of a project are uncertain, and it evaluates the relationship between different factors (Pandey et al., 2017). On the sensitivity analysis, different assumptions are considered to check the strength of the project. The assumptions used are judgemental (Chin and Lee, 2008). Therefore, a sensitivity analysis was conducted as part of the CBA evaluation. It indicates how input values affect the output values in a model (Chin and Lee, 2008; Tolley and Rowland, 1995). The sensitivity analysis does extreme-case analysis, which includes the best-case scenario and the worst-case scenario for the intervention. Making extreme assumptions is not useful when the value is between the best-case and worst-case scenarios, but doing so indicates the economics of the programme. The best-case scenario is optimistic, and the worst-case scenario is pessimistic (Brent, 2014). The sensitivity analysis examines what happens to NPV and the BCR when there is a change in one factor. This analysis indicates which factors offer better results (Brent, 2014).

## 5.2 Qualitative Methods: Interviews

The interviews in this research were held to:

(1) Verify the cost and benefit information taken from existing academic resources
(2) Obtain additional information about the HMHM programme in NHS Highland (such as the average number of times a patient needs to visit the hospital and how many minutes a nurse typically spends per outpatient visit) [OB1, OB2]
(3) Discover what the health and social care professionals' perspectives were in relation to the HMHM intervention (in terms of factors that influence costs and benefits) [OB3]
(4) Explore the common challenges of implementing the HMHM programme in NHS Highland and Scotland [OB4]
(5) Explore the barriers and facilitators in collecting the required cost and benefit data for the telehealth COPD programme (HMHM) in NHS Highland [OB5] and
(6) Discuss the gaps in the current routine data collected for costs and benefits associated with the HMHM programme [OB6].

This information would provide an in-depth view of the programme and the existing data gaps.

In order to conduct the interviews and the online survey, the researcher gained approval from the Ethics Committee in the Department of Computer and Information Science. The approval was received on

27/11/2017, and the application ID was 630. The ethics approval application was titled "Exploring the Costs-Benefits of Home and Mobile Health Monitoring in Edinburgh". That was the first title of the thesis, since exploring the costs and the benefits were the initial goal of the thesis. Originally, Edinburgh was chosen as the research region, but during the study NHS Highland proved to be more relevant, as they have conducted research studies for the Florence programme for COPD patients and they have collected some data.

The change in region occurred after the researcher participated in a symposium for the HMHM programme, where it became clear that the HMHM and specifically Florence programme were used for COPD patients in Highlands rather than in Edinburgh. The NHS Highland district had already collected data on this programme. The information they collected provides a clear idea of how this programme works. This information for NHS Highland was received during the last interview as well as some of the additional costs needed to collect such data. For that reason, it was considered by experts to be a more appropriate region to get respondents from. HMHM was a new programme and there was not enough information on it.

The Ethics Committee was contacted in order to receive an amendment for the change in geographical area, but the committee responded by saying that an amendment was not needed because that change in region did not affect the research as the recruitment and methods remained the same. In the approved ethics application, nothing was modified but the region; the research questions, the interviews, and the online survey remained the same.

Each participant completed a consent form (see Apendix G) and received an information leaflet (see Appendix F) explaining that the purpose of the study was to examine if the HMHM programme for patients with severe COPD was a more cost-effective solution than the usual care. Through the interviews, the researcher tried to collect information needed to conduct the economic evaluation of the programme. By signing the consent form, participants agreed that they had read and understood the participation information. They were informed that they could ask questions and that the study was part of a research project; their information would only be used for research, statistical, and audit purposes. They were also assured that their information would be protected by the Data Protection Act of 1998 (see Appendix E: Ethics application).

Interviewees were selected either from the online survey respondents or through emails. From the HMHM symposium mentioned above, the researcher received a list with the contact emails of all people who work on the HMHM programme in Scotland. Some of the critical interviewees were contacted through email, where they were asked to respond to an online questionnaire and if they would like to be interviewed. The rest of the interviewees were contacted by the author of this thesis after having

been notified by SCTT staff that these people were appropriate to answer the research questions. The interviews were audio-recorded, or notes were taken during the interviews. These interviews were then transcribed word for word and the transcribed text became the data to be analysed.

Six semi-structured interviews were conducted with seven participants; two stakeholders participated in the first interview. These seven participants were familiar with the the HMHM programme, the Florence programme, and the usual care system for COPD patients. People who participated in the interviews were professionals, such as nurses, service managers of the HMHM programme, experts on the Florence programme, and telehealth and telecare academics. The interviews were semi-structured and split into two parts. The first part focused on questions about the Florence programme and how patients self-managed their condition, the patients' and healthcare professionals' perspectives on the programme, and its benefits. The second part of the interviews focused on asking the participants about the difficulties they faced while implementing the programme in NHS Highland and Scotland, as well as the challenges in measuring the costs and benefits of the HMHM programme. The results from the second part of the interviews is discussed in more detail in Chapter 8.

The interviews lasted 30–50 minutes and all took place over the phone. Five out of six interviews were audio-recorded and transcribed for the data analysis. Only the first one was not audio-recorded, but notes were taken during the interview. In the interviews, participants were asked about the differences between usual care and the telehealth programme: What are health and social care professionals' beliefs about the programme? Is it useful? Has telehealth reduced their work? Does it provide patients with better treatment than usual care? Are the patients satisfied with the programme? What are the patients' and professionals' fears about the telehealth programme? In addition, the interviewees were asked to describe the usual care programme and to provide information regarding the Florence programme. For example, in which situations do patients meet with a GP when visiting a hospital? The same questions were not asked in all the interviews. The interviews were semi-structured, so only questions relevant to each participant's knowledge were asked. The Topic Guide for the Interviews is available in the Appendix section (see Appendix C: Topic Guide for Interviews).

In interviews the professionals also discussed (by proxy) patients' perspectives of telehealth programmes, but interviews with patients were not conducted. Patient interviews were not part of the research. The purpose of this thesis was to indicate whether HMHM was a cost-effective solution for the NHS in monetary units from the organisational perspective. The qualitative analysis was used to understand how this programme works and what its potential costs and benefits would be. It was not intended to be a discussion with patients; the patients' views that were examined were provided only by proxy and by published sources in order to provide some of their perspectives on these kinds of programmes.

Thematic analysis was used for the qualitative analysis. It was used to present, analyse and identify themes related to the data from the interviews (Maguire & Delahunt, 2017). The qualitative analysis process includes the analysis, making judgements about coding, identifying themes, and connecting and interrelating data to interpreter data (Maguire & Delahunt, 2017; Nowell et al., 2017). The thematic analysis followed a six-phase process. The first phase in analysing the interviews was to read the transcripts a couple of times to become familiar with the interview content. Next, the sections that seemed relevant to the research question were highlighted and titled. The titles were HMHM Programme, Patients' Perspectives, Clinicians' Perspectives, Benefits and Self-management. The themes of the thematic analysis emerged from the interviews. That is how the following seven interview themes were derived: (1) Home and Mobile Health Monitoring programme, (2) the patient's perspective, (3) the clinician's perspective, (4) self-management and (5) the benefits. Two additional themes were (6) the challenges of implementation and (7) the challenges of measuring the programme's costs and benefits. These two are analysed in the Chapter 8.

The first three themes (HMHM, patients' perspectives, and healthcare's perspectives) were applied in order to obtain knowledge of the programme; what is it and how does it work? The following two themes regarding the implementation challenges and measurement of costs and benefits were applied to further describe the programme. These themes help to understand the HMHM and Florence programme better. Moreover, they help indicate the benefits that there are from the HMHM programme, for patients' and clinicians'. It is also useful to identify what the different types of challenges in identifying and calculating costs and benefits.

## 5.3 Quantitative and Qualitative Methods: Online Survey

Online survey was another method of collecting data used in the estimation of the HMHM programme's costs and benefits (see Chapter 6). It provided additional insights into the programme: if clinicians were satisfied with the use of HMHM, which clinicians supported patient reporting on that programme, and if the equipment was easy to use.

The online survey also received ethics approval from the Ethics Committee; it was also included in the same ethics approval application that was used for the interviews (see Appendix E: Ethics Application). This survey was distributed through the Scottish Centre for Telehealth and Telecare (SCTT) to collect information that would be used in the calculation of the programme's costs and benefits in NHS Highland for COPD patients (see Appendix D: Questionnaire of Online Survey). It was sent to people who had worked with COPD patients using this programme as well as to those who had worked with COPD patients in the usual care. The survey was sent to people who had knowledge of this field such

as service managers, specialised physicians, nurses, GPs, and pharmacists. These were contacted by the HMHM group from the SCTT (SCTT, 2020) and asked to participate in the online survey.

The online survey was designed on Qualtrics, which is a simple online survey tool, which is easy to be used (Qualtrics, 2019a) to collect and analyse data (Qualtrics, 2019b). The online survey included multiple-choice questions, open questions, and free-text questions (see Appendix D: Questionnaire of Online Survey). At the beginning of the online survey, information was provided as to the kind of data the survey would collect, and what the purpose of the survey was. In addition, participants were informed that their participation was voluntary, and that they would probably spend around five to ten minutes completing the survey.

The online survey was useful in collecting data from people who had experience with that programme. The results from the online survey were aimed to be used in the evaluation of the HMHM programme for COPD patients in NHS Highland (Chapter 6). The ideal number of responses was 20 to 30, because the participants were experts on that field, but only eight responses were collected. The survey was open from the middle of December 2017 until the end of February 2018.

Some of the qualitative responses from the online survey are discussed in Chapter 7, which focuses on the qualitative analysis of the six interviews with the seven key informers, as the first interview was conducted with two people who worked in the same company. In the online survey, patients reported that they were satisfied with the HMHM programme and that the Florence programme was easy to use (six of the responders mentioned that they received training on how to use it). This topic is discussed in more detail in Chapter 7 during the second interview where the clinical nurse specialist explained the type of training the NHS Highland provides to patients.

## 5.4 Summary

This chapter presented the overall methodology and approach for this thesis and presented an overview of the methods used in this thesis. In Chapter 6, the CBA for the HMHM programme was conducted, which used data from all the methods mentioned above. However, there were various data gaps which needed to be filled. For that reason, interviews and an online survey were used. The information collected from interviews was used in the CBA evaluation, as it provided a comprehensive view of the programme and closed some data gaps that were present. However, given the small number of answers to the online survey, it was considered more reasonable to use data from Wolters (2018) and Curtis and Burns (2017) instead. Only eight people answered the online survey, and many questions were not answered at all. As a consequence, the online survey could not be used to provide results with certainly,

as the results were not significant, although the participants were GPs, community GPs, nurses, service managers and researchers who had specific knowledge of the HMHM programme.

# Chapter 6: Cost-Benefit Analysis of the Home and Mobile Health Monitoring Programme for Chronic Obstructive Pulmonary Disease in NHS Highland

This chapter explains the conducted simulated economic evaluation of the Home and Mobile Health Monitoring (HMHM) programme in NHS Highland for patients who used the programme to monitor their condition – chronic obstructive pulmonary disease (COPD). To the best of the researcher's knowledge, this evaluation has never been done. The purpose of the evaluation is to indicate if this intervention could provide economic benefits for the NHS. The NHS operates according to a budget, and the expenses made for patient treatment need to be justified, so an economic evaluation of the outcomes of the NHS's programmes could be helpful for the NHS.

## 6.1 Data Sources

### 6.1.1 Data for the Home and Mobile Health Monitoring Evaluation for Chronic Obstructive Pulmonary Disease in NHS Highland

The COPD patients who were introduced to the HMHM programme were patients who were in severe (68 patients) and very severe (1 patient) situations. Information that was deemed valuable for the cost-benefit analysis (CBA) of NHS Highland was collected from various sources. Table 3 below includes the data collected from existing published sources and from the interviews with key informants on the topic, which are examined in Chapter 7. In the data collection below, valuable information collected by the report 'Service Evaluation of Three Telehealth Services for Monitoring Patients with Asthma, COPD, and Heart Failure' by Wolters (2018) is outlined. Furthermore, the CBA used data from ISD Scotland for the year 2016-2017 in NHS Highland, and Curtis and Burns (2016, 2017) and Curtis (2013) provided in their guidelines evidence based on the GPs and nurses' salaries; minutes per appointment; and how often patients visit a GP and nurse as well as data from ScotPHO (2016) for COPD patients. This was the best available data. Table 3 below explains in detail what kinds of data were required and which data and resources were used.

Table 3: Data and resources for the CBA evaluation

| ***Description*** | ***Data*** | ***Sources*** |
|---|---|---|
| Number of patients who had COPD in Scotland | 122,960<br>2.32 per 100 patients who were registered in the GP and the population in Scotland was around 5,300,000 people | (ScotPHO, 2016) |
| Number of patients who had COPD in NHS Highland | 6400<br>2 per 100 patients who were registered in the GP and the population in NHS Highland was around 320,000 people | (ScotPHO, 2016) |
| Number of patients who had COPD in NHS Highland and used the HMHM | 69 patients (exclude 1 patient) = 68 patients | (Wolters, 2018) |
| ***Costs*** | | |
| Cost of bed days in NHS Highland | £613.4 per day | (ISD Scotland, 2017b) |
| Cost of A&E in NHS Highland | £136 per visit | |
| Visit as an outpatient in NHS Highland | £114 | |
| ***GPs*** | | |
| Time a GP spend in an appointment with a patient | 9.22 minutes | (Curtis and Burns, 2017) |
| GP-led cost per hour of face-to-face contact excluding 'other costs' (including set up costs) | £242 per hour | |
| Average GPs appointment per year usual care | 1.08 appointments with GP | (Wolters, 2018) |
| GP appointments with the HMHM patients | 0.48 per year | |
| ***Cost of equipment*** | | |
| Cost of equipment | £25 pulse oximeter | Verified from Participants Interview No. 4 and No. 6 |
| Cost of the annual license of Florence programme and support cost | £10,000 annual cost,<br>The cost per patient is £25 for 12 weeks for texting from Florence | Interview No. 6 |
| ***Nurse*** | | |
| Speak on the phone a nurse with HMHM patients | Twice per year | Online survey (from an answer from a GP) |
| Meet a nurse face-to-face | 15.5 minutes | (Curtis, 2013) |
| Cost per intervention by nurses | £6.10 | (Curtis and Burns, 2016) |
| Average time per intervention (minutes) by nurses | 6.56 | |
| Practice nurse per hour of face-to-face contact excluding 'other costs' (including set up costs) | £36 | (Curtis and Burns, 2017) |
| Average time a practice nurse meets a COPD patient per year | 2.13 times | Calculation from data (ScotPHO, 2016) and (Wolters, 2018) |

| | | |
|---|---|---|
| ***Outpatients*** | | |
| Outpatient appointment before the HMHM for the COPD patients | 52 appointment (29 of them are not relevant to the COPD, and 23 were relevant) | (Wolters, 2018) |
| Outpatient appointment after the HMHM for the patients | 35 appointment (20 of them were not relevant with COPD, and 15 were relevant) | |
| ***Hospital admissions*** | | |
| The average number of days COPD patients stay in hospital in 2016/17 | NHS Highland: 6.4 days for the respiratory medicine | (ISD Scotland, 2017d) |
| | NHS Scotland: 6.2 days for respiratory medicine | |
| Number of bed days that COPD patients used the HMHM and stayed in Hospital | 80 days | (Wolters, 2018) |
| Number of bed days for the same COPD patients who stayed on Hospital before the HMHM | 183 days | |

### 6.1.2 Data from the Online Survey

An online survey was conducted in order to collect primary data from people who had worked on and had knowledge of the Florence programme, and they gave information about it. Those people were healthcare professionals, service managers, academics, and other relevant experts. The online survey was disturbed through the HMHM group in Scotland (Scottish Centre Telehealth and Telecare) among people who had worked with COPD patients in the HMHM programme, ideally in the Florence programme. The online survey tried to gather information in order to identify and/or verify the costs and benefits of usual care and telehealth programmes (See Appendices D: Questionnaire of Online Survey). Table 4 below indicates the questions used in the online survey, the answers that were received, and how many times each answer was received.

Table 4: Questions and Answers from the Online Survey

| **Questions on Online Survey** | **Answers from Online survey** |
|---|---|
| How often do patients/service users who use the usual care visit Accident and Emergency (A&E)? | Once per month (N=1) |
| How often do patients/service users who use HMHM visit A&E? | Twice per year (N=2) |
| How many times per year do patients/service users with COPD (receiving usual care) get readmitted to the hospital? | Twice per year (N=1) |
| How many times per year do patients/service users with COPD (receiving HMHM) get readmitted to the hospital? | Very few readmissions |
| How many minutes is spent by a GP with a COPD patient? | 10 minutes (N=3)<br>17 minutes (N=1)<br>20 minutes (N=2) |
| How much time is spent by a nurse with patients / service users with COPD who visit hospital for a check-up? | 30 minutes for a check-up (N=1)<br>Varies 5-10 minutes (N=1)<br>10 minutes (N=1)<br>"depends on the type of visit-oxygen clinic visit will be 1-2 hours" (N=1) |
| How much time is spent by a nurse on a phone call with patients / service users with COPD who use HMHM? | 4 minutes (N=2)<br>around 6 minutes (N=2)<br>15 minutes (N=1) |
| How often does a healthcare professional speak on the phone with a COPD patient / service users?" | once per month (N=1),<br>twice per year (N=1),<br>as identified through Flo (N=1),<br>TEC delivery can be every day or only if no alerts (N=1) |
| How much time healthcare professionals spend on monitoring the data? | 1 minute per patient per day to check their data (N=3)<br>2 minutes per patient (N=1)<br>another 30 seconds (N=1)<br>and "respond to amber and red alerts as they come in" (N=1) |
| How many times patients who use the usual care visit hospital for a check-up? | once per year in the primary care, not the secondary care (N=1) |
| How many times patients who use the HMHM visit hospitals for check-ups? | they would still attend their GP for a once-yearly check-up (N=1)<br>that they do not attend (N=1) |
| What are the percentage reductions on GPs appointment because of the HMHM? | 95% (N=1)<br>74% (N=1)<br>30% (N=1) |

Based on the online survey, it can be concluded that there is no standard procedure, and each patient's response to the treatment was different. The most common answer to the questions was that each patient is different. The questions concerning the admission and readmission of patients with COPD indicated that the HMHM is a programme that provides patients with better monitoring of their condition, as they have less of a need for hospitalisation. Furthermore, nurses responding 'to amber and red alerts as they come in' (Participant No. 8 on the online survey) was also mentioned for NHS Highland. Therefore, nurses speak with the patient on the phone when Florence identifies alarms. The information about

nurses speaking with each patient on the phone twice per year was used in the CBA. This information was mentioned in the online survey. This could be considered reasonable, as some patients would need to speak with a nurse more frequently, and others less frequently, or not at all. In addition, due to the programme, patients did not have false alarms, and they did not visit the hospital without experiencing symptoms of deterioration.

## 6.2 Economic Analysis: Cost-Benefit Analysis of the Home and Mobile Health Monitoring Programme for Chronic Obstructive Pulmonary Disease Patients in NHS Highland

In this section, an economic evaluation of the HMHM programme for COPD patients in NHS Highland was conducted using the CBA method. Applying the CBA method, the costs and benefits of the HMHM programme were compared, which indicated whether the programme was worthy in monetary units. The CBA was examined from the NHS's perspective.

### 6.2.1 Calculations of the Costs of the Home and Mobile Health Monitoring Programme

The costs that were calculated for the CBA evaluation were as follows.

**Cost of bed days:** The cost of inpatients per week in 2017 in NHS Highland was £4,294 (ISD Scotland, 2017b). This number was divided by seven to find the daily cost, which was £613.40 per day. The costs of bed days for COPD patients in NHS Highland were calculated as **£49,072**. The total number of bed days for COPD patients who used the HMHM programme was 80 days (Wolters, 2018) and this was multiplied by the cost of the bed days in the hospital, which was £613.40 (ISD Scotland, 2017b).

**Cost of outpatients:** This cost was dertermined by calculating costs of a patient attending a consultant or other medical clinic or of their arranging meeting with a consultant or a senior member of the programme. The cost for an outpatient was £114 per visit in NHS Highland (ISD Scotland, 2017b). According to an estimation of the NHS Highland, they had 35 outpatient appointment from the HMHM monitoring patients, with 20 thereof not being relevant to their condition and 15 being relevant (Wolters, 2018). This data was included in order to examine the programme of how often these patients needed to visit the hospital in a more complete way. The total cost of the outpatients who used the HMHM programme, in that case, was **£3,990**. This number was derived by multiplying the cost per outpatient visit (£114) with the number of visits (35). In that case, there is a small reduction for outpatient visits, as fewer outpatients than before attended the programme regularly.

**Cost of GP appointments:** The patients who used the HMHM visited their GP 0.48[1] times per year on average (Wolters, 2018). Curtis and Burns (2017) calculated this cost assuming that a GP surgery consultation lasted 9.22 minutes (Curtis and Burns, 2017). These 9.22 minutes were equal to £37.19 per appointment, as the GP has an hourly wage of £242 (Curtis and Burns, 2017). Therefore, the total cost of GP consultations per year for the 68 COPD patients (one patient excluded – see Savings in Bed Days for HMHM Patients) was **£1,213.88**.

**Cost of a nurse speaking on the phone with a patient:** A specialist nurse spoke on the phone with patient twice per year on average (according to the online survey – a GP's response). This is the only information that was used in the CBA based on the online survey. Nurses spent 6.56 minutes per call on average (Curtis and Burns, 2016), and the hourly wage of a specialist nurse was £44 (Curtis and Burns, 2017), which means that the cost of each call was £4.81. Therefore, the cost of speaking on the phone with a nurse was £9.62 per year per patient. For all these patients, the cost was £654.25. This calculation was made by multiplying the annual per patient cost of a nurse speaking on the phone with the number of patients (£9.62* 68 patients). In this included the cost of monitoring, as if a patient has an exacerbation then a nurse will be alerted and speak with the patient on the phone in order to give them instructions what to do, such as visit GP or visit hospital. This figure includes the cost of monitoring, because if a patient experiences a deterioration in their condition, then a nurse is alerted and will speak with the patient on the phone in order to give them instructions about what to do, such as visit a GP or visit the hospital.

**Cost of equipment:** The cost of the necessary equipment, a pulse oximeter, was £25 per patient (users of the Florence programme) (Interview No. 4). An additional cost was the annual licence cost for the hospital to be allowed to use that programme. The cost of the annual licence and support for the Florence programme was £10,000 (Interview No. 4, Interview No. 6), which included 37,000 text messages. In NHS Highland, they used the Florence programme for patients who had asthma, heart failure, COPD, and for various other conditions. The cost of texting each patient per month was estimated as £8.51 (Interview No. 6). The total cost for texting patients over a three-month period was £25.53. Therefore, the total cost of texting Florence patients with COPD was £1,736.04 (£25.53*68 patients) plus the cost of the pulse oximeters, which was £1,700. These two costs amounted to £3,436.04.

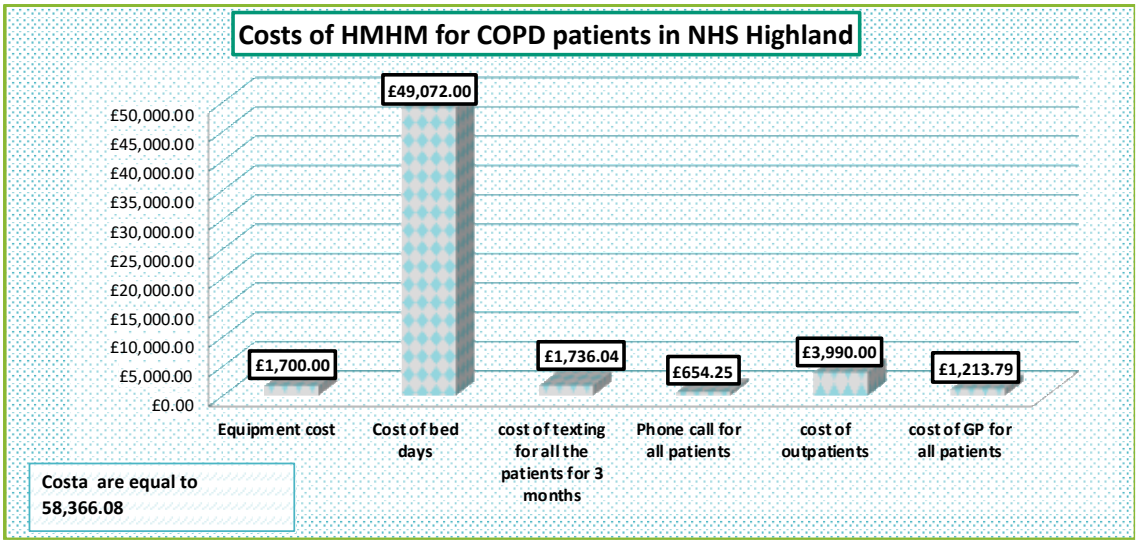
[1] This number is derived from Wolters' (2018) report on the HMHM programme. Data from four different patients who used the Motiva Device (which is part of HMHM) was used for the estimation of the face-to-face GP appointments. Therefore, these patients had 0.48 GP appointments per year.

The total cost of the HMHM programme was £58,366.09 for 68 patients, as one of them was excluded from the data. In the chart below, the primary costs of the HMHM programme for the patients with COPD who used it are outlined. In Graph 1, all the significant costs of the HMHM programme are shown. Below is a picture of the MS Excel file, which was used to calculate all the costs for that evaluation.

**Costs of the HMHM programme for COPD patients in NHS Highland**

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| Equipment cost | £ | 1,700.00 |
| Cost of bed days | £ | 49,072.00 |
| Cost of texting for all the patients for 3 months | £ | 1,736.04 |
| Cost of outpatients | £ | 3,990.00 |
| Cost of GP for all patients | £ | 1,213.79 |
| Phone call for all patients | £ | 654.25 |
| **Total Costs** | **£** | **58,366.08** |

**Graph *1* indicated the costs of HMHM for COPD in NHS Highland**




(Author's own graph. Data sources: ((ISD Scotland, 2017b), (Curtis and Burns, 2017), (Curtis and Burns, 2016), (Wolters, 2018), (Interview No.4) and (Interview No.2)

### 6.2.2 Calculations of Benefits of the Home and Mobile Health Monitoring Programme

The primary benefit that the NHS enjoys from the HMHM programme for COPD patients is cost savings. This benefit was identified due to the continued follow-up of the patients' condition and the programme recognising that they were experiencing an exacerbation of their condition and needed to start to take their "rescue" medication, which could potentially lead to the avoidance of a period of illness and unnecessary visits to the hospital and hospital admissions. Therefore, this intervention provided a critical reduction in the time that the healthcare professionals spent on the patients, as they spoke on the phone with the patients only if an alarm was raised due to their measurements. This could lead to a reduction in unnecessary appointments, offering economic savings to the NHS. These are some simple examples that indicated that the HMHM was a cost-reducing NHS programme. Below, the savings are explained in more detail, as well as an outline of how these benefits were identified.

**Savings in bed days due to HMHM:** The total bed days that these 69 patients stayed in hospital were 183 days before the telehealth programme, and after the telehealth programme, the figure was 186 days. One patient stayed in hospital for 106 days. This patient was excluded from the evaluation as according to the TEC team, which made a comment in the evaluation of Wolters (2018): "the patient who was in hospital for 106 days is known to the specialist respiratory nurses and the length of stay wasn't due to COPD but changing home and social circumstances" (Wolters, 2018). This patient used the Motiva programme (part of the HMHM programme) only for two days, but he did not disenrol from the programme. The 106 days that this patient stayed in the hospital were subtracted from the 186 days, as this one considerable number would affect calculations in a significant way. Therefore, in the evaluation, the admission days were reduced from 183 to 80 days. In the evaluation, all the other costs and savings were calculated for the 68 other patients who used the HMHM programme to monitor their COPD. Therefore, for NHS Highland, it can be asserted that 103 days were saved because of the HMHM programme, and each day cost £613.40. In monetary terms, this means that the NHS saved **£63,180.20** only from the reduction of bed days. The data that was used in the CBA was for COPD patients in NHS Highland who used the HMHM programme, which included the Motiva programme (the old programme) and the Florence programme (the new programme).

**Savings in GP visits:** In NHS Highland, the average number of times that a COPD patient visited a GP was 1.08 times per year (Wolters, 2018).[2] While with the HMHM, the average number that the COPD patients visited their GPs was 0.48 times per year. Therefore, there were savings from 0.60 fewer appointments times per year with each visit cost to be £37.19. The costs saving from GPs appointments for all the patients were **£1,517.35.**

**Savings in nurse time:** A practice nurse spends around 15.5 minutes per patient per appointment (Curtis, 2013), and a practice nurse meets a COPD patient an average of 0.87 times per year. The unit cost per hour of face-to-face contact with a practice nurse was £36 (Curtis and Burns, 2016). This means that the 15.5-minute appointment with a practice nurse cost £9.30. The average number of appointments in which patients met a practice nurse was 0.87 times per year, as shown in Table 3. Savings were made by eliminating these 0.87 appointments per patient, as the patients did not need to meet a practice nurse. If the patients' condition deteriorated, then a specialist nurse could call them and advise them what to do. This means that there were cost savings from the fewer time spent by a nurse with each patient – £8.09 per appointment. The savings for the HMHM programme for these 68 patients amounted to **£550.19.**

The finding that a practice nurse meets a patient 0.87 times per year was derived from calculating different factors, as it was difficult to find an accurate number. However, this was an essential piece of the analysis. Wolters (2018) presented the number of face-to-face appointments with GPs and the average numbers of these four estimations was 1.08 appointments with GP per year. In the ScotPHO (2016), there were 144,390 primary care consultations with GPs for COPD patients in Scotland, 116,530 with practice nurses, and zero with district nurses and health visitors.[3] Using this information, the researcher calculated the number of times that patients visited practice nurses – 0.87 times per year. This means that all these patients, on average, meet their practice nurse almost once per year.

**Savings from the reduction of outpatient appointments for COPD patients:** The HMHM programme observed a reduction in the number of hospital visits by outpatients (patients who were attended to by a consultant or other medical clinician or who had arranged an appointment with a consultant). The savings from reducing outpatient appointments for those 68 patients with COPD who

[2] Wolters (2018) presented four different datasets about COPD patients who participated in the HMHM programme and how many times they visited their GP face to face before, during, and after the programme. She found that patients visited their GP 0.48 times during the programme and 1.08 times before the programme.
[3] This figure is due to the number of GPs being equal to 144,390, the number of appointments per year being 1.08, and the number of nurses being 116,530, and we do not know the number of appointments with nurses. So, we used the rule of three, and we found the number of the appointments (the number of appointments of nurses: (116,530*1.08)/144,390 = 0.87.

used the HMHM programme were 17 appointments. These savings were calculated based on the finding that before the monitoring with the HMHM, these patients had 29 appointments, which were not relevant to their condition, and after they began monitoring their condition, they had 20 appointments that were not relevant to this disease. Hence, considering the appointments they had before the programme started and the appointments that were not relevant, there were nine saved appointments. The fact that such appointments were reduced by nine might be connected with the monitoring from the HMHM programme. It is possible that the programme was alert to something not going well and patients were advised to take their "rescue" medication. This medication probably affects the need for hospital visits.

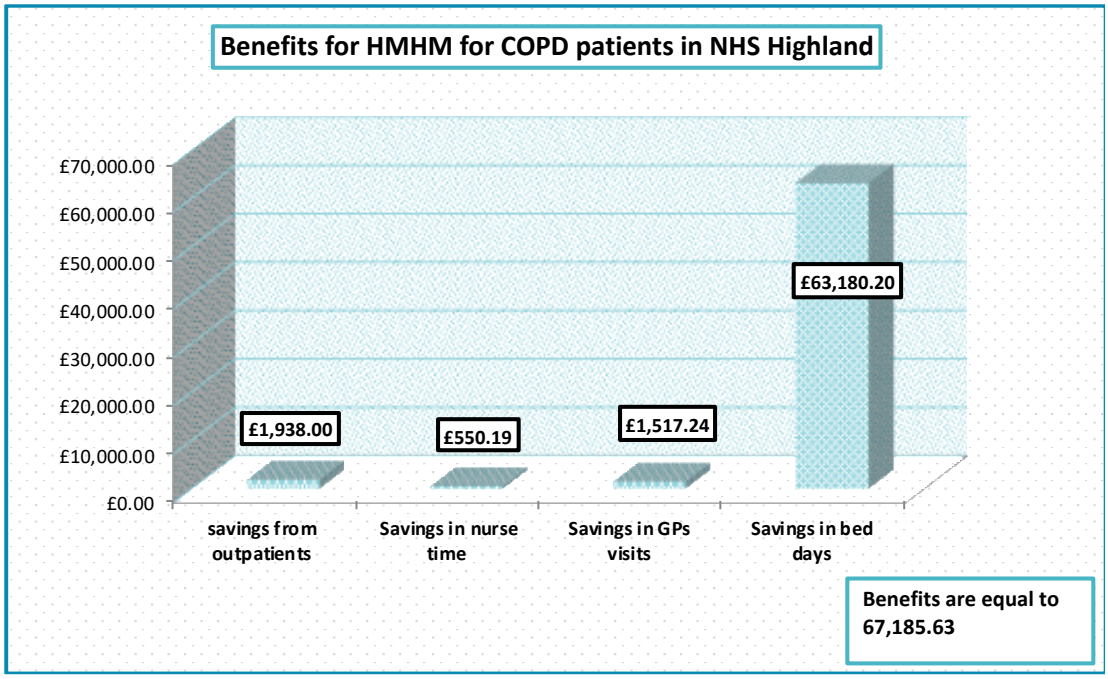
Furthermore, for this group of patients, the appointments before and after the HMHM programmes were compared – those that were relevant to COPD – and there were eight saved appointments. Before the monitoring, there were 23 such appointments, and after, there were 15 appointments (Wolters, 2018). According to the estimation, 17 appointments were saved among the 68 patients who were monitored with the HMHM for COPD. Some appointments that were not relevant to COPD were included in the estimation because those patients participated in the programme. These visits should include, as this group of patients had a problem, which requires to visit the hospital. Each of these appointments cost £114 (ISD Scotland, 2017b). Therefore, the total savings from these 17 appointments amounted to £1,938.

It should be noted that these 68 COPD patients who participated in the HMHM programme were patients with COPD in a severe or very severe situation. Therefore, it can be concluded that they would have a lot of moderate and severe exacerbations. The savings made by the HMHM programme for those 68 patients are demonstrated in Graph 2.

**Benefits of the HMHM programme for COPD patients in NHS Highland**

| ***Benefits of HMHM for COPD patients in NHS Highland*** | | |
|---|---|---|
| **Savings from the reduction of outpatient appointments** | £ | 1,938.00 |
| **Savings in nurse time** | £ | 550.19 |
| **Savings in GPs visits** | £ | 1,517.24 |
| **Savings in bed days** | £ | 63,180.20 |
| **Total Benefits** | **£** | **67,185.63** |

**Graph 2: Indicated the Benefits from the HMHM programme in patients with COPD in NHS Highland**




(Author's own graph. Data sources: ((ISD Scotland, 2017b), (ScotPHO, 2016), (Curtis and Burns, 2016), (Curtis, 2013), (Wolters, 2018), (Interview No.4) and (Interview No.2)))

The savings for these 68 COPD patients who participated in the HMHM programme amounted to **£67,931.88**. The highest savings were from the reduction in hospital admissions, which were estimated at £63,180.20. The second highest saving was due to the reduction in outpatient visits, estimated at £1,938. It was then estimated that the cost savings from GP appointments amounted to £1,517.24 and those from nurse time equalled £550.19.

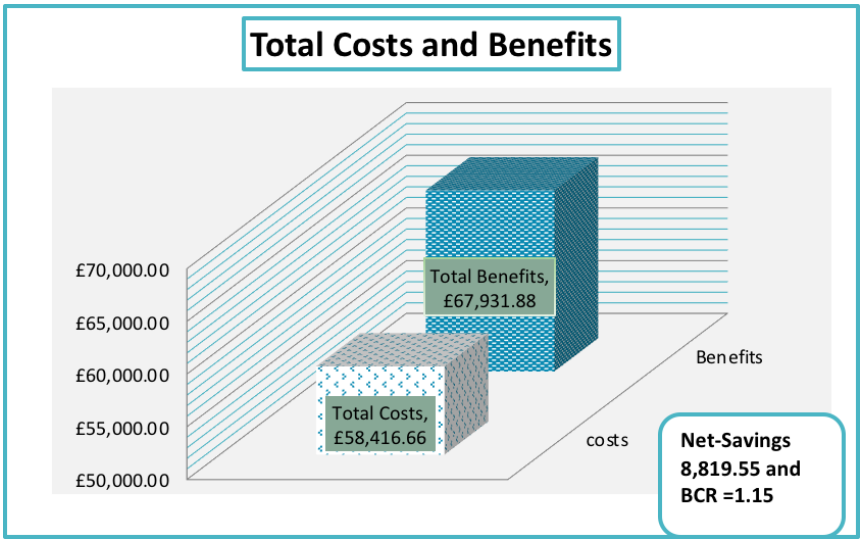
The use of telehealth programmes such as the HMHM could help patients to monitor their conditions much better and take additional medication when they need it in order to manage their exacerbations. Telehealth programmes might be a solution for the exacerbations that COPD patients experience, and this would probably lead to fewer outpatient visits, fewer GP appointments, and fewer hospital admissions.

### 6.2.3 Results of the Cost-Benefit Analysis

This chapter analysed whether the HMHM programme for COPD patients in NHS Highland had more benefits than costs in monetary units. In that case, the HMHM programme was a worthy solution in monetary unis. The results of the simulated CBA are presented in this chapter of the thesis (Chapter 6). The results were promising for the HMHM programme for NHS Highland for COPD patients, as the annual costs were £58,366.09 and the annual cost savings were £67,185.63. Therefore, the net present

value (NPV) were £8,819.55. This means that the benefits outweighed the costs. In this case, the benefit-cost ratio (BCR) (benefit/cost = £67,185.63/£58,366.09) was 1.15; this means that for every £1 that was spent, there were benefits equalling £1.15. This demonstrates that the HMHM programme for COPD patients in NHS Highland was a programme that was worth the money spent. Graph 3 below illustrates that the benefits were higher than the costs in NHS Highland for COPD patients who used the HMHM programme.

**Graph 3 Annual costs and benefits of the HMHM Programme**




(Author's own graph. Data sources: ((ISD Scotland, 2017b), (ScotPHO,2016), (Curtis and Burns, 2016), (Curtis, 2013) (Wolters, 2018), (Interview No.4) and (Interview No.2)

### 6.2.4 Sensitivity analysis

A sensitivity analysis is used when there is uncertainty in the results of an evaluation. Therefore, the researcher examined whether some factors of the evaluation could affect the results thereof. This is a technique that examines the factors that were robust and those that were not. This technique was presented in Chapter 5 (in section 5.1.2).

The sensitivity analysis examined five factors: (i) the cost of equipment, (ii) the number of patients who used the HMHM programme, (iii) the minutes that a GP spent per appointment, (iv) the number of times that patients visited a GP, and (v) the number of bed days that patients stayed in hospital. From these five factors, the researcher tried to determine what happened in the evaluation if each of those factors was changed (one factor at each time). In the base case, the BCR was equal to 1.15, and the NPV was £8,819.55.

Table 5 below demonstrates how changes in a factor affected the CBA. In each of the five rows, there are three columns. In the first and the third sets of columns (representing optimistic and pessimistic

scenarios respectively), the analysis started from the base case (column 2), and one factor was changed at a time, recalculating the net savings. In the first column, the optimistic scenarios are presented. In those scenarios, the patients received comparatively cheaper equipment than the base case; the number of patients who used the equipment is higher than the base case (second column); the minutes that a GP spent per appointment was reduced compared to the base case scenario; the times that those patients visited their GP per year were reduced; and the number of bed days in hospital was reduced to 50 days instead of 80 days. In the three columns, the different pessimistic scenarios are shown. In those scenarios, the patients received comparatively more expensive equipment than the base case; the number of patients who used the equipment is higher than the base case scenario (second column); the time that a GP spent per appointment was increased to 20 minutes instead of 9.22 minutes; the number of times that a patient needed to visit a GP was increased to twice per year; and the number of bed days were increased to 90 days, 94 days, and 100 days.

Table 5: Sensitivity analysis of the evaluation

| | | ***Overoptimistic scenario*** | | | ***Base case*** | | | ***Pessimistic Scenario*** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | ***best case*** | | | ***base case*** | | | ***worst case*** | | |
| | | *value* | *BCR* | *Net savings* | *value* | *BCR* | *Net savings* | *value* | *BCR* | *Net savings* |
| ***1*** | *Cost of equipment for COPD* | 20 | 1.16 | £9,519.55 | 25 | 1.15 | £8,819.55 | 75 | 1.09 | £5,419.55 |
| ***2*** | *Number of patients in HMHM* | 100 | 1.12 | £7,296.41 | 68 | 1.15 | £8,819.55 | 20 | 1.20 | £11,104.24 |
| ***3*** | *times that GP spend per appointment* | 4 | 1.15 | £8,647.75 | 9.22 | 1.15 | £8,819.55 | 20 | 1.15 | £9,179.34 |
| ***4*** | *number of times that they visit a GP* | 0.3 | 1.17 | £9,729.89 | 0.48 | 1.15 | £8,819.55 | 2<br>3 | 1,02<br>0.94 | £1,132.18<br>-£3,925.30 |
| ***5*** | number of bed days | 50 | 1.68 | £27,221.55 | 80.00 | 1.15 | £8,819.55 | 90<br>94<br>100 | 1.04<br>1.003<br>0.954 | £2,685.55<br>£231.95<br>-£3,448.45 |

Table 5 above demonstrates that the net savings for the case study examined were equal to £8,819.55. In the base case (second column), all the values used in those cases are presented: the cost of equipment was equal to £25; the number of patients was 68; the average number of minutes that a GP spent per appointment was 9.22 minutes; the number of times that the patients visited their GPs was 0.48 per year (some patients would not visit their GP even once a year); and the number of bed days was 80 days. Below, it is explained in detail what would happen in each of these five scenarios if we changed one factor at a time and all the other factors remained the same. Table 5 was created based on the calculations in the MS Excel file. Each time, only one factor was changed.

*Cost of equipment*

The first column indicates what would happen to the net savings if only one factor was changed at a time. For instance, in the first column, if the cost of equipment was changed to £20 instead of £25 and all the other factors stayed the same, then the net savings of the programme would be £9,159.55, and the BCR would be 1.16. In the same way, in the third column, if the cost of equipment was changed to £75 instead of £25, then the net savings would be £5,419.55, and the BCR would be 1.09.

*Number of patients using the HMHM*

If it is assumed that the number of patients who used the HMHM was 100 instead of 68 and all the other factors stayed the same, then the net savings of the programme would be £7,296.41, and the BCR would be 1.12. Moreover, if the number of patients who used the HMHM for COPD decreased to 20 instead of 68, then the savings would be £11,104.24, and the BCR would be 1.20.

*Minutes that GPs spend per appointment*

If it is assumed that the number of minutes that a GP spends per patient was changed to 4 minutes instead of 9.22 minutes and all the other factors stayed the same, then the net savings would be £8,647.75, and the BCR would be equal to 1.15. In addition, if the number of minutes that a GP spends per appointment increased to 20 minutes instead of 9.22 minutes, then the net savings would be £9,174.34, and the BCR would be 1.15.

*Number of times that the  patients visited a GP*

If the average number of GP appointments reduced to 0.3 times per year, then the net savings would be equal to £9,729.89, and the BCR would be 1.17. Moreover, if the patients on the HMHM programme need to visit their GP twice per year (for all 68 patients), then the savings would be £1,132.18, and the BCR would be 1.02. In the case that the number of GP appointments was three per year, then the savings would be negative, -£3,925.30, and the BCR would be 0.94, which means that for every £1 that they spend, they would save £0.94.

Number of Bed Days

If the number of bed days was 50 instead of 80 and all the other factors stayed the same, then the net savings would be £27,221.55, and the BCR would be 1.68. Furthermore, if the number of bed days that the patients who used the HMHM programme in NHS Highland needed to stay in hospital were 90 instead of 80, then the net savings would be £2,684, and the BCR would be 1.04. If the patients stayed in hospital for 94 days, then the net savings from that programme would be £231.95, and the BCR would be 1.003. Therefore, after the 94 days, the evaluation would have negative results. If the number of bed days would increase to 100 days, then the HMHM programme would have negative results, and

HMHM would be more expensive, by £3,448, and the BCR would be 0.95, which means that for every £1 that the NHS spends it would save £0.95.

Factors such as the cost of equipment, number of patients, and minutes spent by a GP per patient did not affect the results of the evaluation. Therefore, these factors are considered robust. However, the other two factors, the number of times patients visited a GP and the number of hospital admissions, may affect the results of the evaluation. If all these patients visited their GP up to two times per year and all the others factors remained the same, then the evaluation would still have a positive outcome, but if all the 68 patients who participated in the programme visited their GP three times, then the evaluation would have a negative result. Furthermore, the results concerning bed days indicated that if the bed days were up to 94 days for those 68 COPD patients in NHS Highland, then the results would be positive, but if the patients needed a hospital admission for 95 days or more, then the outcome for those 68 patients who participated in the HMHM programme would be negative. In the Appendix (See Appendix H: Sensitivity Analysis), how the net savings and the BCR are affected if only one factor is changed per time is explained. The affecting factors are those highlighted in green.

## 6.3 Summary

This chapter examined whether the HMHM programme in NHS Highland was a cost-effective programme. To examine that from the NHS's perspective, the CBA method was used. This analysis calculated the costs and benefits from the NHS's perspective in order to discover if the HMHM programme for COPD patients in NHS Highland was a beneficial solution. The calculation of the costs and benefits illustrated that the benefits were higher than the costs. Therefore, this programme could be considered a worthwhile solution for the NHS Highland, as it provided savings – the net savings were £8,819.55. The BCR was equal to 1.15, which means that for every £1 that the NHS spent they were saving £1.15. The sensitivity analysis revealed that the number of bed days and the number of times that patients met a GP could affect the programme's economic performance.

# Chapter 7: Qualitative Research Interviews with Experts on the Florence Programme

This chapter discusses the interviews that were conducted with stakeholders who were experts in the use of the telehealth programmes and Home and Mobile Health Monitoring (HMHM) programme for chronic obstructive pulmonary disease (COPD), of which the Florence programme is a part. The aim of the interviews was to collect further information about the Florence programme and usual care in order to compare these types of care and collect data for the cost - benefit analysis (CBA). They were also conducted in order to identify the challenges facing the HMHM programme especially in relation to monitoring and calculating costs and benefits of such programmes (presented in Chapter 8).

The number of interviews with stakeholders was small – only seven people participated in them. However, all of these people were experts in a specific area, and they provided valuable information for the thesis. There is a risk that those interviews could be considered biased, as they provided a specific perspective (positive), except for the participant in Interview No. 5. The participants in the interviews were people who had knowledge of the HMHM programme for COPD patients, but their knowledge came from different perspectives, as they were clinicians, service managers, and academics. However, in the literature review (Chapters 3 and 4), there were also positive views of telehealth programmes for COPD patients. This indicates that there is a high possibility that the perspectives mentioned in interviews are close to reality.

Each interview was unique, as each had the aim of indicating the type of information that the informants could provide. In Interview No. 1, the Florence programme was explained in detail. In Interview No. 2 and Interview No. 6, the HMHM programme was explained, specifically the Florence programme for COPD patients in NHS Highland, and which factors should be included in an economic evaluation was also discussed. Interview No. 3 and Interview No. 5 were more general discussions: which costs and benefits should be used in economic evaluations, the nature of the challenges in conducting economic evaluations, and what should be included in such evaluations in order for them to be valuable and provide useful results. Moreover, in Interview No. 4, the HMHM programme in the broader context of Scotland was discussed. Table 6 below briefly demonstrates the position of each participant in the interviews and what was discussed during the interviews.

Table 6: Key informants for Interviews

| ***Key Informants Interviews*** | | | |
|---|---|---|---|
| **Interview No.** | **Position of Stakeholder** | **Why Speak with that Person?** | **Duration of the Interview** |
| 1 | Director of Services and Community Simple Shared Healthcare<br>Chairman &Chief Innovation Officer | They explained the Florence programme in depth. | 47 minutes (no audio) |
| 2 | Community Respiratory Nurse Specialist in NHS Highland | They discussed the Florence programme and how it works; mentioned case studies; and outlined the patients' and clinicians' perspectives on the programme as well as the challenges that face it. | 30 minutes (audio-recorded) |
| 3 | Academic | They discussed the benefits and costs of the telehealth programme and the challenges facing economic evaluations. | 40 minutes (audio-recorded) |
| 4 | Service Developer Manager | They discussed the HMHM programme and the Florence Programme. In the interview, they commented on the benefits and challenges that they face. | 47 minutes (audio-recorded) |
| 5 | Academic | They discussed the benefits and costs of the telehealth programme and the economic challenges facing it. | 30 minutes (audio-recorded) |
| 6 | TEC Project Officer with NHS Highland | They discussed the Florence programme in NHS Highland, specifically the benefits thereof and the challenges facing it. | 35 minutes (audio-recorded) |

## 7.1 Interview Findings

Below are the findings of the interview analysis, organised by theme. There were seven themes in total. Five themes are discussed in this chapter and two remaining themes are discussed in the following chapter (Chapter 8).

### 7.1.1 Home and Mobile Health Monitoring Programme

Florence Programme

A fundamental theme, discussed in most of the interviews, was the Florence programme itself. The Florence programme is the latest telehealth technology programme in Scotland. In Interview No. 1, two experts on the Florence programme participated, and they explained the Florence programme in depth. The Florence programme is called a telehealth programme, but the participants in Interview No. 1 admitted that they regretted having called it telehealth, as the Florence programme is slightly different

to a telehealth programme. A telehealth programme monitors patients, and if they do not feel well, then a healthcare professional contacts them. Meanwhile, in the Florence programme, the patients self-manage their condition, and if their readings are abnormal, then they need to take appropriate actions and control their exacerbations (Interview No. 1 and Interview No. 6).

> *"Florence is based much more on self-management and on helping the person to develop their own self-management skills, helping them to understand their condition and, by monitoring their SATs and their other symptoms, to self-manage, with Florence's assistance, to take the right course of action that they need to. It doesn't create anything like so much work for the clinicians because the individual patient is self-managing rather than the clinicians making contact with them if their SATs are low." (Interview No. 6)*

Later, a nurse reviews their data and contacts them in order to check how they are and how they respond to their exacerbation (Interview No. 1). The Florence programme aims to make people change their behaviour and reduce their anxiety. The Florence programme has a standard procedure that patients need to do every morning. In addition, the interviewees mentioned that the patients who participated in the Florence programme had specific behaviours (Interview No. 1). This probably means that they were patients who were able to cope with the self-management of their condition.

The Florence programme provides patients a shared management plan. It reinforces and activates the patient by increasing their confidence (Interview No. 1). According to a nurse, a specialist on the HMHM in NHS Highland, the nurses verbally describe the programme to the patients. They say: "this is your self-management plan", they give them a written leaflet explaining the plan, and they explain what a pulse oximeter is or provide this information in written form on a website. In addition, they give patients a contact number that they can call in case they have any problems. Participant in Interview No. 2 mentioned that a common problem was that

> *"Sometimes we've had issues where people are not able to use the pulse oximeter in their own readings so they might send us the heart rate reading. It's normally quite visible from the Flo data, so we know when that's happening and it's been very rare."* (Interview No. 2).

The participant in Interview No. 6 also discussed the Florence programme in depth and mentioned that they have a protocol to set up the monitoring of with the Florence programme to last for three months. Therefore, patients receive messages from the Florence programme over three months to monitor their condition. The participant in Interview No. 6 commented that

> *"…currently have our protocol set up at three months, so people receive messages over the three-month period. I think there's a good argument for saying that the period should be longer than three months, but currently it's set up for three months."* (Interview No. 6).

The participant in Interview No. 6 described the protocol that NHS Highland uses for COPD patients who use the Florence programme. The patients receive three questions every day. The questions are the following: what their oxygen saturation levels (SATs) reading is, how are their symptoms compared with their usual health status (the same as usual or worse than usual), and whether there have been any changes in their sputum. After a patient responds to these three questions, the Florence programme responds to the patient, telling them which "traffic-light colour" they are. The traffic-light card is a card produced by Chest, Heart & Stroke Scotland, used widely with COPD patients. The colours are green, amber, and red. If the patient is assigned a green traffic-light colour, then the Florence programme tells them, "Just continue with your usual care". If the patients are assigned an amber colour, their condition is getting worse, and they should then take actions in order to feel better, such as rest more, increase the use of an inhaler, drink plenty of fluids, among other steps, and they should continue with their regular medication. If in the following 24-48 hours they do not feel better, then they should check their traffic-light card, and it might be appropriate for them to take their rescue medication, as they are then in the red zone (Chest, Heart & Stroke Scotland, 2015). If they are in the red zone, they are asked to text the word "MEDS" to the Florence programme, so the programme then knows that they have started taking their rescue medication. If the patients are in the red zone, then the clinicians are alerted by the Florence programme, and the same would happen if patients text the word "MEDS". Therefore, clinicians are aware of what is going on. The programme is for patients to monitor themselves, but the clinicians monitor the patients as well to some extent (Interview No. 6).

### The Motiva Device

NHS Highland used the Motiva Phillips system in the HMHM programme before the Florence programme. This programme was a tablet-based system for patients who had COPD and heart failure. The Motiva programme had a "care plan", which consisted of videos, messages, information, and monitoring of different elements. Patients received a Motiva Tablet, an oxygen saturation levels (SATs) monitor, and a blood pressure monitor in order to manage their condition. The patient was required to record their SATS and blood pressure and to answer a small survey about their symptoms regarding if they were feeling the same as or worse than usual. If their SATS were below a certain level, then the clinicians contacted the patient to ask them how they were feeling. The problem was that this system created many alarms, and the clinicians had a large workload. NHS Highland stopped using the Motiva system because it was costly, and they decided to move to something different. Participant in Interview No. 6 supported that

*"We use Florence for both COPD and heart failure patients, but also for a wide range of other patients, including asthma. We have an electronic asthma action plan. We're using Florence for a wide range of other types of conditions"*

### 7.1.2 Self-Management of the Condition

The Florence programme was designed for patients to self-manage their condition. They need to have self-management skills.

*"It creates really a key cornerstone of prevention, supported self-management, and allowing people to be much more actively engaged in their own healthcare"* (Interview No. 4).

The programme aims to make people understand their condition by monitoring their SATs and their other symptoms. Patients learn to self-manage their exacerbations using the Florence Programme and to take actions when necessary (Interview No. 6). Specifically, participant in Interview No. 6 mentioned

*"The system is primarily for patients to self-manage rather than for the clinician to monitor, but of course, the clinicians do monitor to an extent."*

COPD can lead to the rapid deterioration of patients' health, and patients may need to be admitted to hospital. Many community services support people living at home with COPD. In addition,

*"physiotherapy teams will go out and support people, give them education, training. They'll give them advice on how to use their inhalers properly, how to keep fit and well and live with COPD, because it is a chronic condition"* (Interview No. 4).

Self-management is focused on the exacerbations, as most patients with COPD had exacerbations at least once per year, and they had at least one hospital admission per year. Therefore, self-management skills help them to identify what an exacerbation is, how to identify that they are having one, and how to react in such an instance (Interview No. 2). The aim of the self-management plan is that the Florence Programme allows clinicians to have much earlier notice of the early stage of an exacerbation in order to be able to intervene earlier (Interview No. 4).

Big questions about the Florence Programme and similar programmes is whether they have resulted in the improvement of the health of patients, if patients become responsible for the self-management of their condition by using the programme, or whether they should have a combined treatment of independent self-management and the use of technology.

It is also important to consider what happens after the 12 weeks of the Florence Programme pass and the programme ends (Interview No. 6). Patients might be able to maintain the self-management on their own or might need monitoring from a specialist nurse. The programme aims to allow patients to self-manage their condition on their own and to be able to detect their symptoms. The answer to that question relates to the fact that all patients are different. Some of them can gain the skills needed for self-management in one week and others in 12 weeks. The duration of the programme has the aim of making patients adapt the programme to their daily routine as a habit. Furthermore, it should be noted that no patient completed the programme in less than 12 weeks. Generally, patients need someone to monitor and take care of them. They feel reassured by, are able to contact, and have a connection with the programme's nurse (Interview No. 2).

Therefore, according to a specialist nurse in NHS Highland who was interviewed for this research, the costs of that programme are worth it, as this programme helps patients feel reassured. Specifically it reported that

> *"… it's worth cost benefit, the balance and the benefit there. We're going to look at a protocol that helps exactly that core of people who you're talking about, maybe help them to feel reassured." (Interview No. 2)*

Furthermore, the number of patients who can continue the self-management of their condition independently is very small (Interview No. 2). According to the participant in Interview No. 3, the patients do learn to self-manage their condition but only for a while. Then they go back to their old ways. The participant in Interview No. 3 supported this point by commenting that

> *"The risk is then that you assume that the clinical outcome can be sustained, because you don't know. Patients may become complacent, you know, especially after you take away the monitoring, they might very easily slip back into their old ways. That's the world that they're going to usually take with chronic conditions."*

### 7.1.3 Patients' Perspectives

All the participants in the interviews were asked what they believed that patients think of the Florence Programme, and the same question was asked in the online survey. Below are some of the findings from both research methods. According to the health and social care professionals who participated in the online survey and interviews, the patients are satisfied with the Florence Programme.

The views of health and social care professionals on what might be the patient's perspectives of the Florence Programme in the online survey are outlined below.

> "*We have carried out research with them, and the highest percentage of them are happy*". (Online survey, No. 1)

> "*They almost all feel more connected. They like the feeling that someone is seeing their responses. They feel more cared for."* (Online survey, No. 2)

> "*After receiving many patient stories, case studies and evaluation - patients report feeling supported and more confident to manage their own health with Flo's support. Feelings of isolation are reported to reduce with a discreet and personal interaction with Flo. Patients report feeling more confident and motivated to manage their own health with Flo*." (Online survey, No. 3)

A COPD nurse who answered the online survey gave the following answer:

> "*we do have quite a large decline rate. However, those who do engage are happy with the service*". (Online survey, No. 8)

The participant in Interview No. 2 commented that patients like the Florence Programme more than its proponents originally anticipated:

> "*Their feedback has been really positive. They feel reassured, they feel that it helps them to know things, they tell me that they already knew but it reinforces it, and it becomes a habit. So, patients really like it*" (Interview No. 2).

In all the interviews, the patient's perspectives of the Florence Programme and telehealth programmes in general were discussed. It was found that the patients were delighted with that programme. This is clear from the fact that patients had support from experienced healthcare professionals. This helped them feel that they had control of their condition. In addition, technology played an important role in this outcome.

> *"It's all about the technology. Make it simple, easy to use"* (Interview No 4).

It was not complicated and there were no complicated software programs that needed to be used (Interview No 4). The equipment that NHS Highland gave to the COPD patients in order for them to monitor their condition was a simple pulse oximeter, which they used to measure the oxygen levels in

their blood. The patients used their mobile phones to send their measurements to the Florence Programme system. The Florence Programme system is the most straightforward telehealth system, as it requires only the use of text messages. Therefore, it can be used by everyone, and that includes older people who might have difficulties with using more complicated technology with which they are not familiar (Online Survey No. 2 and Online Survey No. 6).

The interview participants mentioned that patients are required to use their own mobile phones. This is beneficial for the project as the NHS does not have extra financial resources for buying devices for the patients, and the patients feel more comfortable with this option as they are familiar with their mobile phones. The patients need to use their mobile phones to send a text message to the system with their measurements. The success factor in such programmes is simple and easy-to-use technology. Patients need to make the technology a part of their daily life (Interview No. 4). Participant in Interview No. 4 mentioned that patients have supported that

> *"technology does make me feel in control. But it's really important that the technology is easy to use, that they see it as part of their daily life."*

It is crucial that patients should be able to use their devices, so these programmes are not particularly complicated systems. Patients are supported initially with the tasks that they need to complete in order that they become confident with the programme (Interview No. 4). Lack of complexity is something that makes patients more than happy to use a programme. This is the benefit of patients using their own device, as they are already familiar with it.

The patients felt that they had sufficient support and were confident in managing their health when they used the Florence Programme. This programme had massive support from the patients' families due to the use of the technology. Especially if the patient was an older adult who lives alone. This is a serious problem for the patient's family. Initially, a lot of patients were concerned and anxious about whether or not they would like to participate in the programme, and they were afraid they would have to do more things, such as taking their pulse oximeter readings and uploading them to the programme. They were worried that this would add a massive amount of things to do daily for the self-management of their condition (Interview No. 4).

> *"They're having to measure their saturation, they're having to do more, but certainly what we've found over time is that if those people are supported and are guided to understand what this means, and they're given a self-management plan, then that does abate, so that does improve"* (Interview No. 4).

### 7.1.4 Clinicians' Perspectives

An essential consideration about the Florence Programme and the HMHM programme in general is how the clinicians view these programmes. Clinicians are fundamental to the success of such interventions. In the beginning of the programme, the clinicians were sceptical about telehealth programmes for various reasons, such as how confident the clinicians felt about the use of technology in the healthcare sector. They were also concerned that such a programme would increase their workload and that the patients would be dependent on the programme and would call the clinicians any time they were anxious or any time that a reading was not good. However, the reality was quite different from what they expected (Interview No. 4). Participant in Interview No. 4 quoted:

> *"I think it's varied amongst clinicians how confident they feel about technology, but the main worries are that it creates more work. Also, I think they are a bit concerned that it creates a bit of a dependency on them, so some people who are anxious and picking up the telephone and worried about a reading"* (Interview No. 4).

NHS Highland, used another type of HMHM programme before the Florence Programme (Motiva Device – see Section 7.1.1), which was more labour intensive. When they moved from the other model to the Florence Programme, the clinicians preferred the Florence Programme, as it was significantly less labour intensive (Interview No. 2). According to the participant in Interview No. 2,

> *"…myself and my colleagues who have most experience with it – and she particularly loves it – particularly because it's not labour intensive"* (Interview No. 2).

The participant in Interview No. 6 mentioned that

> "*Florence does alert the clinicians if the patients are in the red zone and also if they text in the word "meds" so that the clinicians are aware of what's going on with the patient if they want to monitor them. The system is primarily for patients to self-manage their condition rather than for the clinician to monitor, but of course, the clinicians do monitor to an extent*"
> (Interview No. 6).

When a nurse looks at the data, if any issue is identified, then either the nurse sends a message through the Florence Programme system or the nurse contacts and speaks to the patient on the phone (Interview No. 2). The clinicians monitor and respond to these alerts.

> "*Patients are much more proactive, so not all alerts are coming through to clinicians. Patients can see their own alerts, but they take much more responsibility as to when they get in touch with a clinician"* (Interview No. 4).

Before the implementation of the programme, there were concerns that the workload would increase because of the programme. However, the Florence Programme has an 18-month pilot phase in order to explore how this programme should be implemented and maintained. The Florence Programme is just a system. Some guidelines of how the programme works and how to engage clinicians should provide in order to have results. All these considerations are part of the pilot phase. If the pilot phase which recommend it does not follow, then the Florence Programme cannot provide results. In the methodology of the programme, there are instructions on how to make healthcare professionals engage with it, how to do case studies, and more. These elements are part of the methodology, and the Florence Programme is just a tool that is used in the process. Overall, clinicians were satisfied with that programme, as it proved a viable and sustainable programme that provided a full service. It was not only a system (Interview No. 1).

Clinicians were engaged in the Florence Programme, and their engagement became even stronger as they saw how pleased patients were with it (Interview No. 1). According to the participant in Interview No. 4,

> "*Clinicians have really got on board with that type of approach. They believe that this is the future. It isn't about patients just sending in all this data and becoming passive around it. This has to be something where there are triggers in the system that, when certain readings kick in, health professionals do pick up, but until then, patients are sufficiently supported to do it*" (Interview No. 4).

According to the participant in Interview No. 1, clinicians see a difference due to the Florence Programme. They knew that this programme worked and that it had reduced acute and moderate exacerbations. However, clinicians did not evaluate the programme, and if an evaluation would be made, it would be easier to indicate that Florence helped in the reduced number of hospital admissions (Interview No. 1). In addition, it should be mentioned that not all diseases are the same, and when people have an addiction, it is much more challenging to measure the disease, while in other cases, the trajectories are more straightforward (Interview No. 1).

### 7.1.5 Benefits of the Home and Mobile Health Monitoring Programme

The Florence Programme provides various benefits for patients, healthcare professionals, and the NHS. The participant in interview No.1 quote that the beenfits for the patients are that

> *"the patients feel well looked after and well cared for. It may improve their knowledge of the condition. Those are the main benefits that I see."*

Other benefits for patients included that they learned to self-manage their condition and look after themselves. In addition, the patients did not need to travel to visit hospitals, as they received proper healthcare treatment at home and they were able to continuously monitor their condition. The patients who used the HMHM programmes had improved compliance and adherence to their treatment (Interview No. 4).

> "*The idea of Florence is that it should alert people to the fact that they have an exacerbation starting up and they should take their rescue meds accordingly and, therefore, hopefully, that the exacerbation is reduced in severity and caught early enough that they don't end up being admitted to hospital…our results are really quite encouraging"* (Interview No. 6).

This quote indicates that the patients are responsible for the self-manage of their disease and should take care of themselves – if something is not going well then they need to take action for that. The biggest benefit for patients is that they are responsible for themselves, and they do not depend on someone else.

The HMHM programme has created different protocols for each disease, as each condition needs a different treatment protocol system to monitor it. According to the participant in Interview No. 3, the benefits should be measured according to clinical outcomes. If patients have a better clinical outcome, then the NHS would have potential savings. For COPD, the benefits would be fewer hospital admissions (Interview No. 3). Moreover, participant in Interview No. 3 claimed that telehealth programmes can provide benefits even if it did not improve health outcome. Participant in Interview No. 3 supported

> *"if it doesn't improve your health outcomes, even if they have the same rates of admission. It doesn't mean it's a bad idea because it can save GPs time, it can save patients time. If the cost difference is very small in influencing it remotely as opposed to influencing it face to face, going in and doing all these breathing exercises and things like that, then it can still be time saving even if it doesn't prevent exacerbation."*

The participant in Interview No. 6 supported that the Florence Programme makes a positive contribution to patients' lives:

> "*It does look as through Florence is actually making a positive contribution to improving the health of people who have COPD*" (Interview No. 6).

Furthermore, the participant in Interview No. 4 commented that

> "*I believe it was improving patients care because it offered a level of support to patients that they don't otherwise have. They are improving their understanding of their health condition and self-managing of their health conditions*" (Interview No. 4).

From the NHS and healthcare professionals' perspectives, the benefits are that NHS needs to provide fewer outpatient appointments in hospitals and fewer unplanned admissions, and there is quicker access to data by healthcare professionals. This is very important as healthcare professionals can check the clinical situation of a patient in a few minutes and have a good idea of the patient's situation. In addition, there is a reduction in the amount of travel that may be necessary to attend a hospital appointment. These are some benefits for the NHS, which have indicated that this programme could be considered as a cost saving solution for the NHS (Interview No. 4).

Another benefit of the HMHM programme is that it was a regional model. The benefit of a regional model is that patients could connect with their local teams and services; therefore, they get personalised care and meet familiar staff. There needs to be a balance between regionally delivered services and for these services to be localised enough so as to encourage patients to use them. Local teams need to have access to patient's data and to find how to link in with local out-of-hours services (Interview No. 4).

> *"There are serious benefits, I think, to doing a regional model, but what's really struck me, though, with the work that we do nationally is it's really important that we get a balance between a regional delivery service but also that is localised enough to allow people to use it, because I think local teams need access to patient data. They need to look at how they can link in with local out-of-hours services, with our local teams that deliver."*

An additional advantage of using a different regional model could be that after some time, the different projects could be compared in order to identify the best solutions in order for this to be implemented at the national level (Interview No. 6).

## 7.2 Summary

This chapter discussed the HMHM programme; self-management skills; patients and clinicians' perspectives; and the benefits of the programme. The interviews demonstrated that the HMHM programme, specifically the Florence Programme, is a beneficial programme for monitoring COPD patients, for clinicians, and for the NHS. From the patients' perspectives, the HMHM programme helps patients to acquire self-management skills, allowing them to control their condition and be able to recognise and detect symptoms. The clinicians who participated in the interviews reported that the intervention has many benefits for patients and that it does not increase clinicians' workloads. In addition, for the NHS, this programme probably reduced unplanned hospital admissions and outpatient consultations. The savings for the HMHM programme could be considered the result of fewer hospital admissions and fewer GP appointments. The reduction in admissions occurred because whenever a patient experienced any significant deterioration in their condition, the Florence Programme sent them a text message on their phones that told them to take their rescue medication.

All participants – except the participant in Interview No. 5 – had positive views of the Florence Programme, specifically that patients have better control of their condition and there are fewer hospital admissions Participant No. 5 suggested that the Florence programme did not work for COPD patients because it is more expensive than the usual care and there is no evidence that it helped patients. It was reported that patients felt satisfied with the programme because someone was taking care of them, and that makes patients feel important. In addition, the participant in Interview No. 5 mentioned that the patients who participated in the programme had had a hospital admission in the previous year, and they would not have one in the next year. The group of people who used the HMHM programme had fewer hospital admissions during that time, but it could not be proven that this happened because of the HMHM programme. The Florence Programme reduced the number of appointments that patients had with their GPs, nurses, and their visits to the hospitals. Therefore, as shown by the views of the participant in Interview No. 5, there are controversial opinions on the HMHM programme and whether it provides better healthcare monitoring. All the interviewees admitted that this programme is better than usual care.

# Chapter 8: Challenges to Implementation and Measuring the Costs and Benefits of the Home and Mobile Health Monitoring Programme

Another critical part of this thesis has been to identify the challenges that the stakeholders faced based on interviews with them. There are two types of challenges: the challenges facing the implementation of the Florence and HMHM programme itself as well as the challenges specifically around measuring the costs and benefits of the HMHM programme and those like it. By examining the challenges, it is possible to determine if the programme is an appropriate solution or not which contributes to the cost benefit. Another important part of this thesis is to outline the challenges faced in measuring the costs and benefits of the programme (and those like it), specifically concerning the factors that affect an economic evaluation.

## 8.1 Challenges to Implementation

NHS Highland and the NHS National Service Scotland (NHS NSS) faced different challenges.

Challenges in NHS Highland

Some of the challenges that the Florence Programme faced in NHS Highland were due to the geography in the Highland region. In those areas, it is challenging for a mobile phone to be used due to the weak mobile network coverage. People find it difficult to use their mobile phones due to a lack of or inadequate mobile network coverage. This was a critical problem as such patients could not use the Florence Programme effectively. Participant in Interview No. 6 claimed that

> *"there are quite significant pockets in an area where there is no mobile phone signal or the signal is very poor."*

Another challenge that was reported by workers in NHS Highland was that the patients on the programme were elderly (often over 60 years old), and most did not have a mobile phone – if a patient did have one, they used it only for emergencies and not for texting. This creates a challenge. Participant in Interview No. 6 mentioned that

"*the patient group tends to be a fairly elderly patient group. Within this group, quite often they don't have a mobile phone. If they don't have a mobile phone, they can't use Florence."* (Interview No. 6)

In addition, the participant in Interview No. 2 supported that

*"it is the connection sometimes and then often the age group of our patients is that they tend to be over 60 and quite often they'll say that they don't use mobile phones. Even if they use mobile phones they keep it for an emergency and they don't text."*

Before the introduction of the Florence Programme in NHS Highland, they used the Motiva system. This was perceived to be a more suitable system, as it was easier to use by people who are not used to technology at all. They received a tablet device for using the programme. It was more accessible for the patients to use this programme than the Florence Programme, and the device was given to them, while the Florence Programme required the patients to already have a mobile phone and to be able to use text messaging. Participant in Interview No. 6 supported that

"*There are quite a lot of people who could use Florence who actually can not because they have never used text messaging. It is something that is very foreign to them and they're not particularly keen on learning."*

Challenges facing the NHS National Service Scotland

NHS National Service Scotland is a national NHS board, which supports patients to receive their services more efficient and to be a cost-effective solution (NHS NSS, 2020). From the NHS NSS's perspective, there were various challenges related to the telehealth programme in Scotland. The challenges are that there are many different technologies on the market and the short-term investment by government. Participant in Interview No. 4 supported that

*" Our (NHS NSS) ambition in Scotland is to really scale up the use of this remote digital technology for people living with chronic disease* (Interview No. 4). "

One fundamental challenge that the NHS NSS faced was that there is no evidence that the telehealth programme works. The clinicians commented that it is a good programme, but there is no clear evidence (such as Randomised Controlled Trials [RCTs] to support this claim) (Interview No. 4). In addition, Participant in Interview No. 4 claimed that she prefers the observational studies. Below is presented her quote:

> *"I'm much more interested in implementation, science around how we deliver things. I like doing observational studies around seeing how people adopt these things. I think that clinicians continually want to have the goal of evidence, and I just don't think that telehealth is something like that. It isn't like a drug."*

The clinicians mentioned the need for RCTs, observational studies, and the programme itself to be done on a large scale. The patients needed to see the benefits of the programme; if they did not realise the benefits, then they were cautious about it (Interview No. 4). The NHS NSS considered that they needed to make people see the benefits of digital support and monitoring patient health as well as to demonstrate how it could improve clinicians' workloads. Patients should be shown that the programme makes the whole patient experience much better (Interview No. 4). The difficulty in indicating that the Florence Programme resulted in fewer hospital admissions was also confirmed by the participant in Interview No. 5, who commented that the telehealth programme did not provide better care than usual care for COPD patients. The participant in Interview No. 5 reported that he had

> *"yet to be convinced by any study that there's evidence about providing telehealth for COPD improves outcome."* (Interview No. 5).

Another challenge that NHS NSS experienced was that there were many technologies on the market. The problem is that these technologies were not integrated or did not have the capacity to integrate with the NHS systems. Participant in Interview No. 4 supported that

> *"We know that we can't just introduce technology and expect that to transform the system, because it has to be integrated into the service. So often what happens is, at the same time as receiving telemetry monitoring, a patient will also be introduced to a self-management plan. They will also, perhaps, get a bit more training and support, but all of these other really good supports happen at the same time as telememonitoring."*

The NHS NSS wanted to introduce a system that allow for the uploading of the data from the technology to the existing NHS system. They wanted to work with the market in order to create these next-generation technologies (Interview No. 4).

Another challenge that was mentioned in the interviews was the issue of funding sustainability. Many challenges were associated with funding and not with the HMHM programme itself. Funding from the Scottish Government was short term, whereas the programme needed a long-term investment in their technologies. Therefore, the NHS NSS needed to look for a more extended period of funding, and they needed time to deliver these services.

"*It can take up to a year to get services produced and technology procured and be introducing it back"* (Interview No. 4).

These were the challenges that faced the implementation of the programme in the NHS Highland and NHS NSS. They are important challenges that should be investigated in order to take appropriate actions and find solutions.

## 8.2 Challenges to the Evaluation of the Home and Mobile Health Monitoring Programme

In some of the interviews, the challenges facing the estimation of the HMHM programme were discussed, while in other interviews, the Florence programme was discussed. The purpose of the interviews was for the stakeholders to provide information regarding the measured costs and benefits of the HMHM programme and the challenges faced when gathering data, which demonstrate the impact and cost-effectiveness of the programme.

Table 7: The key points of measuring costs and benefits

| ***Challenges in measuring costs and benefits*** | |
|---|---|
| (1) | The chosen population may not be representative of the whole COPD population. |
| (2) | The participants who participated in the Florence Programme may have been admitted to hospital before. |
| (3) | It is difficult to determine an appropriate method that evaluates telehealth programmes → control groups or observational studies. |
| (4) | Did the Florence Programme affect the patients' hospital visits? |
| (5) | What happens to the cost of medication because of "rescue" medications? |
| (6) | There are different tools for each disease and therefore different costs and benefits. |

According to the participant in Interview No. 5, there are two issues in measuring the costs and benefits of the programme. The participants who participated in the HMHM programme do not represent the whole COPD population. This is reasonable, as the patients who participated in the HMHM programme in the NHS Highland were patients who were in a severe situation, and they had had many exacerbations and were not patients in a mild or moderate situation.

The second issue is that the programme was used by people who had been admitted to hospital in the past; thus, considering the costs of the previous year, the comparative costs could be high, as everyone

on the programme probably had been admitted to hospital. Specifically, the participant in Interview No.5 supported that

> *"If you have people who are joining this service because they have been admitted to hospital, then you're going to get the costs from the previous year are going to be high because almost everyone who's joining has been in hospital. The following year they're going to be lower because that group of people are probably not going to be in hospital"* (Interview No. 5).

The following year, the cost probably would be lower, as the number of hospital admissions could possibly be lower (Interview No. 5). Furthermore, if a patient had been admitted to hospital in the past, the possibility of a hospital admission in the following year is 40% (Interview No. 5). Participant in Interview No. 5 mentioned that

> *"these figures they often will present 100% of these people had a hospital admission in 2015-2016. Then we get telehealth. In 2016-2017, only 40% had a hospital admission. Then they claim that that 60% improvement is due to the fact that they had telehealth."*

The participant in Interview No. 5 added that the proportion of telehealth patients who had been admitted to hospital in 2015-2016 was 100%. When the patients were introduced to the telehealth programme in 2016-2017, only 40% of them had a hospital admission, meaning that 60% of them saw an improvement in the number of their hospital admissions due to the telehealth programme.

One interviewee claimed that there is no evidence to support that telehealth programme improve patients life, and it supported that comparable results will be achieved with the following way.

> *"What you really need is to have a group of people as similar as possible to the group that were given the telehealth who did not get given telehealth who were admitted to hospital in the previous year. You look at the pattern of the people who were given telehealth. How many that were admitted in the previous year? You try and find a control at a similar number admitted the previous year and then you follow up both groups"* (Interview No. 5).

According to the participant in Interview No. 4, the challenge was that no RCT studies to indicate when the telehealth programme was incorporated into usual care have been undertaken. Participant in Interview No. 4 expressed a preference for observational case studies, as such studies make it easier to find out how people adapt in these programmes. In addition, the participant in Interview No. 4 mentioned that clinicians always prefer to have evidence of the results of such programmes in the same way as new medications. Participant supported that

> *"It's often compared to something like pharmacy costs, so people are given this new medication, some people aren't, and then they're asked which one worked best. I don't think that's how it is in reality at all. This is about changing systems. It's about giving people much more ownership, so I think we need to really think about different methodologies that we use in our evidence"* (Interview No. 4).

This quote supports the idea that a technological intervention cannot be examined in the same way as medication. These two things (medication and technological intervention) are different. There is no connection between them. Medication is a method of treatment and managing a condition, and a telehealth programme is a way of monitoring a condition.

A challenge in the estimation of the HMHM benefits was that it was difficult to capture the change in the health of people. It was also difficult to answer if the technology, specifically the use of the HMHM programme, helped patients in combination with their usual care. With a telehealth programme, people have fewer emergencies and visited hospitals less often than they had done before. More importantly, the programme led to a reduction in hospital readmissions. All of these indicators suggest there was an improvement in the patients' lives. An important factor was to measure how many times patients took their medication, but this was time-consuming and costly, as it required someone to record when a patient who was in the programme or used usual care has had an exacerbation and visited a hospital as an outpatient (Interview No. 5). Participant in Interview No. 5 mentioned that *"it's difficult to do but it can be done"*. In this way, a database that would record when a patient visited a hospital could be created. Furthermore, the participant in Interview No. 4 mentioned that there had been some changes to the HMHM programme in terms of prescription costs. These changes could be considered a way of changing the model of healthcare delivery in Scotland (Interview No. 4). The increase in the use of medication may have been why hospital admissions reduced. Moreover, the participant in Interview No. 6 noted that in NHS Highland,

> *"there's been an increase in the prescriptions for medication for COPD patients and indeed the asthma patients. That suggests that patients are taking their medication as they need to take it in order to remain healthier. That is looking, again, very, very positive"* (Interview No. 6).

The participant in Interview No. 2 was asked if they had captured data on the admissions and readmissions of patients who used the Florence Programme and the patients who did not use it. The participant claimed that they were in the early stage of the programme, so they had not collected such data. The only data collection that they made was in the evaluation "Service Evaluation of Three Telehealth Services for Monitoring Patients with Asthma, COPD and Heart Failure" by Wolters (2018) (Interview No. 2). In addition, the participant in Interview No. 4 commented that there are gaps in the

data collection, and with the data that they collected, it is not easy to carry out a CBA for the COPD patients who used the Florence Programme. This is because they captured data about Scotland, which covered mostly characteristics such as how many people used the telehealth programme, the patients' ages, where the patients lived, and what their primary diagnosis was. They collected data on the process and not on the costs and the potential savings (Interview No. 4).

The Wolter (2018) evaluation used data such as the number of times that patients who used the HMHM programme visited the hospital as outpatients. If it was related and not related to the monitoring condition before they started to use the HMHM and after the HMHM programme; how many bed days they had had before and after the HMHM programme; and how many GP visits the patients had before, during, and after the programme. All this data is very important for the CBA evaluation. It would also be valuable if they had measured the number of times that patients with COPD visited Accident and Emergency (A&E) before and during the programme in order to know how many A&E visits could be saved because of the HMHM programme and the rescue medication that they had used at home.

In Interview No. 3 and Interview No. 5 with two academic experts, the challenges in doing an economic evaluation were discussed, particularly a CBA. Firstly, it should be noted that each disease is different and there is a need for different monitoring programmes. Therefore, a single tool cannot be created for all conditions; however, each condition needs a different protocol, as each disease needs different treatment to control it. For instance, the COPD patients need to check their blood oxygen, diabetes patients need to check their sugar levels, hypertension patients need to check their blood pressure, and similarly, each disease has its own metrics (Interview No. 3).

The evaluation in this thesis examines the telehealth programme from the NHS's perspective, so it does not include the patients' perspectives. If the CBA included both perspectives (NHS and social perspectives), then added value calculations should be included in the benefits section. These values could be collected from an online survey in which patients with COPD or other diseases (because of the limited number of patients with COPD who used the Florence programme) would answer how much money they would be willing to pay annually in order to continue using the programme. In the survey, they would be asked questions such as how valuable the service is for them and how much money they are willing to give for the benefits that they receive (such as the feeling of reassurance, better understanding of their condition, and being able to recognise their symptoms).

If an online survey had been done asking patients how much money they would be willing to pay to receive the benefits of the programme, then the benefits from the social perspective could be calculated. We could add all the values that were given and divide them by the number of people who participated in the survey. In that way, we could find the average amount of money that patients were willing to pay

in order to continue to have these benefits. According to participant in Interview No. 3, it recommended that in this thesis

> *"need to have access to a patient group to actually issue these surveys, and the time and resources to do it. These are valid reasons why you can't do it in your own study unless you actually have got those skills, resources and patient population, which I don't know what you've got."*

Such surveys are called willingness-to-pay (WTP) surveys. WTP surveys may seem like a controversial approach. First of all, people have a wide range of incomes, so WTP varies depending on the participants' incomes. People who have a higher income find it is much easier to decide to pay money for their healthcare services. In addition, another difficulty in that survey would be that in the UK, NHS services are free for everyone. Participant in Interview No. 3 specifically mentioned that

> *"People do take offence to being asked, "Would they be willing to pay for this service?" That's highly almost a British thing or anyone who's had an NHS-style service for a while, people aren't familiar with how to pay for healthcare."*

Therefore, such a survey would have been complicated to answer by patients. In addition, it would have been difficult to find and contact people who used the HMHM programme in order for them to provide their perspectives on that programme, as there is only a limited number of people who are part of it (Interview No. 3).

Finally, in Interview No. 5, the participant explained that CBA is not a useful technique. According to this interviewee, the method indicates a programme that is expensive and not needed. However, he agreed that a cost-effectiveness analysis (CEA) technique would be appropriate, as this method compares two different programmes (Interview No. 5). The CEA method would indicate that usual care is cheaper than any intervention programme. Telehealth programmes are more expensive programmes than usual care, as they include the cost of equipment and monitoring the patients, but if they add all the additional costs and benefits, then the outcome of the evaluation could be different. For that reason, this thesis examined the telehealth programme by means of a CBA to demonstrate if the programme could provide economic benefits to the NHS.

## 8.3 Conclusions

An essential part of the interviews was reporting the challenges facing the HMHM programme and the Florence Programme. Each new programme has difficulties in implementation. If the NHS knew in advance the challenges that would arise, it could be easier to face them. Clinicians recognised that there were challenges in the implementation of the programme and that they needed to find ways to resolve them. In addition, during the interviews, the factors that make it difficult to measure costs and benefits were explained (for example which method is appropriate to examine a telehealth programme - control groups or observation studies, telehealth programme affect the hospital admissions). Finding resolutions to these challenges is essential because if such resolutions were found, then the evaluations of the programmes could be done more easily.

# Chapter 9: Discussion and Conclusions

This study focused on exploring the costs and benefits of the Home & Mobile Health Monitoring (HMHM) Programme, particularly the Florence Programme in NHS Highland for chronic obstructive pulmonary disease (COPD) patients. A mixed-method approach was used to explore the potential savings that NHS Highland could make in monetary terms (quantitative analysis) because of the HMHM programme for COPD patients. Semi-structured interviews and an online survey were also used (qualitative analysis), which looked at the feedback that patients provided for clinicians on that programme, to what extent clinicians were engaged with that programme, and what the benefits and costs of the programme were.

These were the fundamental factors that were used to examine if the HMHM programme was beneficial for the NHS services. Patients could stay at home and receive more integrated monitoring of their condition, and the NHS made savings due to the reduced number of hospital admissions. With the Florence Programme, it is possible for patients to detect a deterioration earlier, and they can react on that in an early stage of the exacerbation. Therefore, it is possible to avoid hospital admissions and outpatient visits. The conclusion is that if the Florence Programme (or the HMHM in general) were implemented on a larger scale, then the cost savings would be higher for the NHS. According to feedback from the interviews, more patients would have greater independence, better access to services, and they would not need to visit hospitals as much.

In Chapter 6, the cost-benefit analysis (CBA) evaluation for that programme was outlined. The essential factors considered in this thesis were calculations of the total costs and benefits of the HMHM programme for COPD patients and explanations thereof. The costs were the costs of monitoring patients with COPD, while the benefits were the cost savings that NHS made because patients used that programme instead of only having their usual care. Therefore, the costs were calculated at £58,336.09 and the benefits were £67,185.63. The net savings were £8,819.55 for the 68 patients (one patient was excluded). This means that the cost savings per patient from that programme were £129.70.

The results of evaluation were that the HMHM programme was a worthy solution for COPD patients in NHS Highland. The BCR is equal to 1.15, which means that for each £1 that was spent on the programme, the savings were equal to £1.15. This number indicated that the HMHM provided savings for NHS Highland with respect to the COPD patients who used it. In addition, a sensitivity analysis was conducted to examine if the factors were robust or not. Examining five factors, it was found that the

number of bed days and GP appointments were the factors that could affect the results of the evaluation. All the other factors have a small contribution to the evaluation, so they did not affect the results of the CBA.

Chapter 7 analysed the findings of the interviews with experts on the programme and COPD. The interviews aimed to obtain information on what exactly the programme is, how it works, and what its benefits are. The conclusions from the interviews with seven experts on the topic were that clinicians received positive feedback from patients when they used the Florence Programme. The patients felt comfortable with the programme, as it was easy for them to use it and their measurements could be monitored easily. In addition, the clinicians felt engaged in the programme, as monitoring patients became more efficient compared to usual care. The clinicians contacted patients only in the case that their measurements were out of the usual range. Therefore, by using the Florence Programme, the clinicians had less of a workload than they did using the previous Motiva Device monitoring programme.

The Florence Programme provided various benefits. The benefits for the NHS were the reduced number of hospital admissions, as the patients could control mild and moderate exacerbations at home with the increased use of antibiotics or steroids. Some additional benefits were that the patients felt more secure as they monitored their condition every day (they took measurements with their pulse oximeter, which measures their blood pressure). If their measurements were not good, then a nurse would contact them and advise them to take their rescue medication and advise them if there is a need for them to visit their GP or hospital.

## 9.2 Limitations

One problem experienced in preparing this thesis was the difficulty in finding data to conduct a robust CBA, as the Florence Programme was relatively new at the time, and only limited information was available. The aim of this study was to identify the costs and potential benefits of the programme.

Gathering the data for all the necessary estimations for the CBA was challenging. Data was collected from multiple sources, such as an online survey, interviews, and secondary data from existing published resources. Qualitative research, interviews and an online survey, was undertaken to collect more data. Interviews were conducted in order to obtain an integrated description of the programme and to determine the costs and the benefits thereof. Then, the study identified what factors affect each cost and benefit. The patients who participated in the HMHM programme were experts on the HMHM programme, but the number of participants was small.

The online survey had the same problem. Through the online survey, the researcher tried to collect data on the average number of visits to hospitals, the number of emergencies, the reduction in the proportion of emergencies, and the number of GP appointments. Some data gaps were expected, as some data is not collected. Some factors are not standard in the health sector, such as how many times patients with COPD visit their GPs and practice nurses and how many exacerbations they experience. Each patient is different, needs different treatment, and reacts differently to the same treatment. Therefore, healthcare professionals avoided answering such questions, saying that each patient is different. For that reason, the researcher collected information in order to find generally accepted average numbers in order to carry out the CBA. The online survey information was not used in the CBA evaluation, as the online survey answers were not considered valuable for use in the evaluation because of the small number of responses.

Another important limitation was the lack of estimations of the number of Accident and Emergency (A&E) visits. This factor was not included in the CBA, as the number of A&E visits that were avoided in NHS Highland because of the HMHM programme was not known. If this factor was estimated so as to be included in the CBA, this could affect the result of the evaluation, and it could possibly provide a different result in the evaluation. This factor (how many times patients did not visit A&E because of the HMHM programme) is not easy to estimate. It is not known if an A&E visit or hospital admission has been avoided due to the use of continuous monitoring or with the use of "rescue" medication at home, which helped patients to control moderate exacerbations.

With respect to A&E visits, the online survey provided the following figures. A patient with COPD who used the HMHM programme would need to visit the A&E once every six months because of an exacerbation (on average), while a patient who used usual care and was in a severe or very severe situation would therefore be experiencing an emergency and would need to visit A&E once a month (on average). Those are some estimations made by the participants of the online survey. The problem with these numbers is that they were hypotheses made by just a few people, so they cannot be considered valuable. For that reason, those numbers were not included in the estimation. However, the researcher demonstrated them in order to indicate some data that was provided by people who worked in that field. This indicates that people who worked on that programme believed that it is a valuable programme that provides patients with better control of their condition, and they could possibly avoid having acute exacerbations. All these are estimations made by the participants in the online survey and interviews. As mentioned above, those numbers were not included in the evaluation, as they are estimations.

In addition, the number of interviews and the number of participants in the online survey were limited. This was probably because the research design required the participants to have some knowledge of the HMHM, specifically the Florence programme for COPD patients. Therefore, many people considered

that they were not appropriate for participation, as they did not know if they should answer the online survey or to appropriate to participate in the interviews. For that reason, only seven people participated in the interviews and only eight people responded to the online survey.

Some essential limitations of this thesis are the small number of participants in the online survey and the small participation in the interviews; the non-inclusion of the number of A&E visits; and the reduction in the number of the A&E visits, which could have been included in the CBA evaluation. The CBA that was conducted is comprehensive, as it presents all the essential costs and benefits of the HMHM programme for patients with COPD in NHS Highland. It demonstrated that the programme was a valuable solution for the NHS Highland for COPD patients, as it provided a cost-effective solution compared to usual care. Patients received more integrated care, and they could manage their conditions alone at home.

## 9.3 Originality of the Thesis

The two key original contributions of this thesis are its CBA, presented in Chapter 6, and the outcome of the interviews, presented in Chapter 7. The CBA estimated the costs and benefits of the HMHM programme in NHS Highland for COPD patients in monetary units. In order to fill the data gaps in the estimations, interviews with stakeholders were conducted. The interviews were intended to provide more in-depth information about the HMHM programme, particularly the Florence programme.

This thesis is original research, as in the knowledge of the researcher there are no other studies that put monetary value on the economic benefits of a telehealth programme for the NHS for patients with COPD. This study is essential, as it indicated that the telehealth programme that was used in NHS Highland could reduce the costs incurred by the NHS from this common and expensive disease if alternative ways of monitoring it can be used. All the studies estimated the costs in monetary units and measured the benefits in terms of other outcomes, like those presented in the Scoping Review in Chapter 3.

In addition, from Chapter 7 it was derived that clinicians and patients were satisfied with the programme. Patients received a more integrated monitoring of their care, and the clinicians' intense workload reduced. This thesis indicated that such programmes should continue on a larger scale, as this programme provides benefits to the NHS, to patients, and to clinicians.

## 9.3 Recommendations for Further Studies

This thesis recommends five different scenarios of how this programme and others like it could be examined in the future. Five different scenarios for economic evaluations, specifically the CBA of telehealth programmes for COPD patients, are presented as well as how these evaluations could happen and how more data could be collected.

One scenario for another research study is the following. The limited number of economic evaluations of telehealth programmes for COPD patients indicated that there was a gap in the economic appraisal of such telehealth programmes, especially in the evaluations, which calculated costs and benefits purely in monetary terms. Some evaluations demonstrated the potential benefits that hospitals experienced from such interventions. The problem in performing an evaluation is the existence of various data gaps, with only limited available data that could be used. In the following years, a study like that could be done if more data were available. It would be ideal, if there were sufficient information, to examine how many times patients visited A&E, how many times patients took their rescue medication, and cost information such as the cost of hospital admissions, costs of A&E visits, and costs of outpatient hospital visits for COPD patients. All these costs could be different for each disease, as each condition needs different treatment and monitoring. It is recommended that this data should be routinely collected or accessed for telehealth evaluations.

Another scenario for doing a full CBA evaluation could be a comprehensive survey of patients who participated in the programme. Patients could be asked to answer questions regarding how valuable they found the programme and how much money they would be willing to pay for such a service. Such a survey would be more appropriate for patients who had used the programme, who knew whether they liked it, and what the benefits of such a programme were. A full CBA evaluation should include both the private and social benefits of those interventions. Collecting such patient benefit data should be considered for all future telehealth evaluations.

To support future research, researchers need to have access to all the relevant databases and to be able to collect data on the number of hospital admissions, the number of visits to A&E, the number of hospital visits as outpatients, the number of GP visits, and the number of nurse consultations (face to face or over the phone). All this information is difficult to collect, and possibly the best way to do so is to request that patients answer an online survey and provide all that information themselves. The number of answers in the survey should be substantial.

Another recommendation for a more extensive study could be to examine two different diseases that have been monitored using a telehealth programme in order to determine whether a telehealth programme is beneficial or not more generally. Such a research project would examine the potential benefits for the management of each disease and how the protocols and procedures that the NHS uses are different between the conditions. In addition, such a project could examine if the result was the same for both diseases and if not, then which factors could affect the result.

Another recommendation could be to examine telehealth programmes supporting the same condition in two or more areas in Scotland. By examining different programmes, it could be shown which was the best solution from an effectiveness and efficiency perspective. In this way, different interventions used in different NHS regions in Scotland could be examined. This could be considered as relevant research, as different areas in Scotland used different interventions such as Medvivo, Florence, and the Motiva Philips Device. They used a regional model, and each area had different programmes and different protocols for each of them. The choice of the regional model is relevant because the NHS tried to find the most effective way of delivering these programmes.

## 9.4 Conclusions

HMHM is an essential programme for patients with COPD, who are in a severe or very severe situation and who need intense monitoring of their conditions. COPD is characterised by progressively worsening lung capacity. Patients with COPD often need hospital admission. Studies like this help significantly in understanding the value of interventions like the HMHM programme. Such studies indicate if the technological interventions (telehealth in that case) could provide patients with a complete method of managing their conditions much better. The general conclusions are that patients find participation in these programmes feasible, as it is a combination of usual care with technology.

The use of a mixed-method approach indicated that the HMHM programme is beneficial for the NHS. A mixed-method approach was necessary for this study in order to collect the necessary information for the CBA and to provide a better perspective on the project. The primary method was CBA, while the qualitative analysis was a supplementary method used to fill the data gaps in the evaluation.

The fundamental research question in this thesis was whether the HMHM programme in NHS Highland for COPD patients is a worthy solution for the NHS. This question was examined with the use of a CBA. The CBA calculated the costs and benefits in monetary terms, examining them from the perspective of the NHS. The results were that the CBA evaluation that took place in this thesis indicated that the HMHM programme was a worthy solution, as the costs were less than the benefits in monetary

terms. From the sensitivity analysis, it was found that the number of hospital admissions can affect the results of the evaluation as well as the number of times that patients visit their GP. In particular, if they visit their GP more than three times per year (with all other factors being unchanged), then the evaluation has a negative result.

The data used in this thesis led to the conclusion that there was a reduction in the number of appointments with GPs and that the number of hospital admissions reduced because whenever patients did not feel well, a nurse would contact them and advise them to take their rescue medication. Therefore, there is a need for economic evaluations, as they could indicate the possible savings that the NHS had (as shown in the quantitative analysis) and the better healthcare management that patients received (as shown in the qualitative study) from the HMHM programme.

Another important part of the thesis was the qualitative analysis – interviews and an online survey with stakeholders. The data used for the CBA for the HMHM programme was for the Florence programme and the Motiva Device Programme (used before the Florence programme). Based on the interviews, it was found that patients were pleased with that programme, as they could control their condition, they felt reassured, and they had the feeling that someone was caring for them. Those were some essential issues for patients. In addition, the clinicians felt satisfied with the Florence programme, as it helped them to monitor patients easily without devoting a great deal of time to them. This programme provided patients with continued monitoring due to the use of technology. In conclusion, the Florence Programme was useful, as patients and clinicians were pleased with it and it provided various benefits, such as better clinical outcomes. Patients have better control of their condition and clinicians could monitor the patients more easily than before.

This programme could be considered as an improvement in the health-related quality of life for patients. Patients could control their exacerbations, as it is was possible to detect acute exacerbations and to receive their “rescue” medication in order to avoid acute exacerbations. In addition, clinicians were pleased and engaged with the programme, as it provided them with a more effective way of working and of monitoring their patients. Moreover, it is a cost-effective solution for the NHS compared to usual care.

# REFERENCES


Achelrod, D., Schreyögg, J. & Stargardt, T. (2016). Health-economic evaluation of home telemonitoring for COPD in Germany: evidence from a large population-based cohort. The European Journal of Health Economics**,** 1-14.

Bentley, C. L., Mountain, G. A., THOMPSON, J., Fitzsimmons, D. A., Lowrie, K., Parker, S. G. & Hawley, M. S. (2014). A pilot randomised controlled trial of a Telehealth intervention in patients with chronic obstructive pulmonary disease: challenges of clinician-led data collection. Trials, 15**,** 313.

Bergmo, T. S. (2014). Using QALYs in telehealth evaluations: a systematic review of methodology and transparency. BMC Health Services Research, 14**,** 332.

Brent, R. J. (2014). Cost-Benefit Analysis and Health Care Evaluations. 2nd ed ed. Cheltenham, UK: Edward Elgar.

British Lung Foundation (2018). Chronic obstructive pulmonary disease (COPD) statistics [Online]. Retrieved from: https://statistics.blf.org.uk/copd

Boardman, A. (2015). Cost–Benefit Analysis. International Encyclopedia of the Social & Behavioral Sciences.

Ceri, P. (2009). What is cost-effectiveness? [Online]. Retrieved from: http://www.bandolier.org.uk/painres/download/whatis/Cost-effect.pdf

Chest, Heart & Scotlands, (2015). Traffic Lights for COPD. Retrieved from: https://www.chss.org.uk/documents/2015/11/copd-traffic-lights-pdf.pdf

Chin, R. & Lee B.Y. (2008). Principles and Practice of Clinical Trial Medicine. Elsevier

Creswell, J. W. & Plano C. V. L. (2011). Designing and conducting mixed methods research (2nd ed.) Thosuand Oaks, Calif: SAGE Publications.

Curtis, L. (2013). Unit Cost of Health & Social care 2013. Personal Social Services Research Unit, University of Kent, Canterbury.

Curtis, L. & Burns, A. (2016). Unit Costs of Health and Social Care 2016. Personal Social Services Research Unit, University of Kent, Canterbury.

Curtis, L. & Burns, A. (2017). Unit Costs of Health and Social Care 2017. Personal Social Services Research Unit, University of Kent, Canterbury.

Drummond, M. F., Sculpher, M. J., Torrance, G. W., O'Brien, B. J., & Stoddart, G. L. (2005). Methods for the Economic Evaluation of Health Care Programmes. Third edition. Oxford: Oxford University Press.

Fairbrother P, Pinnock H, Hanley J, McCloughan, L., Sheikh, A., Pagliari, C. & McKinstry, B. (2012). Continuity, but at what cost? The impact of telemonitoring COPD on continuities of care: a qualitative study. Primary Care Respiratory Journal, 21(3), 322-328.

Farrugia, P., Petrisor, B. A., Farrokhyar, F., & Bhandari, M. (2010). Practical tips for surgical research: Research questions, hypotheses and objectives. Canadian journal of surgery. Journal canadien de chirurgie, 53(4), 278–281.

Fitzsimmons, D.A., Thompson, J., Bentley, C.L. & Mountain, G.A. (2016). Comparison of patient perceptions of Telehealth-supported and specialist nursing interventions for early stage COPD: a qualitative study. BMC Health Services Research, 16, 420.

Flynn, T.N. (2006). The Dictionary of Health Economics. Anthony J Culyer. Cheltenham: Edward Elgar Publishing Ltd, 2005, pp. 390. ISBN 1-84376-208-0. International Journal of Epidemiology, 35, 806-806.

Guinness, L., Wiseman, V., & Wonderling, D. (2011). Introduction to Health Economics. Maidenhead: McGraw-Hill/Open University Press.

Hamad, G.A., Crooks, M. & Morice, A.H. (2016). The value of telehealth in the early detection of chronic obstructive pulmonary disease exacerbations: A prospective observational study. Health informatics journal, 22, 406-13.

Hamine, S., Gerth-Guyette, E., Faulx, D., Green, B.B., & Ginsburg, A.S. (2015). Impact of mHealth chronic disease management on treatment adherence and patient outcomes: a systematic review. Journal of medical Internet research, 17(2), e52.

Healthcare Improvement Scotland (2016). What is the clinical effectiveness, cost effectiveness and safety of home health monitoring compared with usual care for patients with moderate to severe chronic obstructive pulmonary disease? Retrieved from: http://www.healthcareimprovementscotland.org/our_work/technologies_and_medicines/shtg_-_evidence_notes/evidence_note_60.aspx

Henderson, C., Knapp, M., Fernández, J.L., Beecham, J., Hirani, S. P., Cartwright, M., Rixon, L., Beynon, M., Rogers, A. & Bower, P. (2013). Cost effectiveness of telehealth for patients with long term conditions (Whole Systems Demonstrator telehealth questionnaire study): nested economic evaluation in a pragmatic, cluster randomised controlled trial. BMJ: British Med J, 346.

Hirth, R.A., Chernew, M.E., Miller, E., Fendrick, A.M. & Weissert, W.G. (2000). Willingness to pay for a quality-adjusted life year: in search of a standard. Med Decis Making, 20, 332-42.

Hofer, F., Achelrod, D. & Stargardt, T. (2016). Cost-Utility Analysis of Telemonitoring Interventions for Patients with Chronic Obstructive Pulmonary Disease (COPD) in Germany. Applied Health Economics and Health Policy, 14, 691-701.

Hughes, A. (2016). COPD patient avoids A&E and acute admissions through self-management with Flo [Online]. Retrieved from:

http://www.simple.uk.net/home/casestudies/casestudiescontent/copd-patient-avoids-a-e-and-acute-admissions-through-self-management-with-flo

Hughes, R. (2008). Patient safety and quality: An evidence-based handbook for nurses. Retrieved from: https://www.ncbi.nlm.nih.gov/books/NBK2651/

Huniche, L., Dinesen, B., Nielsen, C., Grann, O. & Toft, E. (2013). Patients' use of self-monitored readings for managing everyday life with COPD: a qualitative study. Telemedicine and e-Health, 19(5), 396-402.

Hutton, G., Rehfuess, E., Tediosi, F., & Weiss, S., (2006). Evaluation of the costs and benefits of household energy and health interventions at global and regional levels. Retrieved from: http://apps.who.int/iris/bitstream/handle/10665/43568/9789241594790_eng.pdf?sequence=1&isAllowed=y

ISD Scotland (2017b). R025: HOSPITAL RUNNING COSTS BY PATIENT TYPE –NHS BOARD LEVEL (APRIL 2016-MARCH 2017))

ISD Scotland. (2017d). Inpatient and Day Case Activity [Online]. Retrieved from: http://www.isdscotland.org/Health-Topics/Hospital-Care/Inpatient-and-Day-Case-Activity/

ISD Scotland (2018). About ISD [Online]. Retrieved from: http://www.isdscotland.org.

ISD Scotland National Statistics Publication (2017). Average length of stay in the hospital, by admission type and specialty, Scotland, 2012/13 - 2016/17p. Retrieved from: http://www.isdscotland.scot.nhs.uk/Health-Topics/Hospital-Care/Publications/2017-11-07/Average-Length-of-Stay-by-Health-Board-and-Specialty-Nov17.xlsx

Jodar-Sanchez, F., Ortega, F., Parra, C., Gómez-Suárez, C., Bonachela, P., Leal, S., Pérez, P., Jordán, A. & Barrot, E. (2014). Cost-utility analysis of a telehealth programme for patients with severe chronic obstructive pulmonary disease treated with long-term oxygen therapy. Journal of Telemedicine and Telecare, 20, 307-16.

Kaplan, B. & Duchon, D. (1988). Combining qualitative and quantitative methods in information systems research: a case study. MIS quarterly, 571-586.

MacNeill, V., Sanders, C., Fitzpatrick, R., Hendy, J., Barlow, J., Knapp, M., Rogers, A., Bardsley, M. & Newman, S. P. (2014). Experiences of front-line health professionals in the delivery of telehealth: a qualitative study. British Journal of General Practice, 64, e401-e407.

Maguire, M. And Dehalunt, B. (2017). Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. AISHE-J: The All Ireland Journal of Teaching and Learning in Higher Education, Vol 9, No.3 3351-33514.

Maiolo, C., Mohamed, E. I., Fiorani, C. M. & De Lorenzo, A. (2003). Home telemonitoring for patients with severe respiratory illness: the Italian experience. Journal of Telemedicine and Telecare, 9, 67-71.

McDowell, J. E., McClean, S., Fitzgibbon, F. & Tate, S. (2015). A randomised clinical trial of the effectiveness of home-based health care with telemonitoring in patients with COPD. Journal of telemedicine and telecare, 21**,** 80-7.

McCurdy B.R. (2012). Hospital-at-home programs for patients with acute exacerbations of chronic obstructive pulmonary disease (COPD): an evidence-based analysis. Ontario health technology assessment series, 12(10), 1–65.

McKinstry, B. (2013). The use of remote monitoring technologies in managing chronic obstructive pulmonary disease. QJM: An International Journal of Medicine, 106**,** 883-885.

McLean, S., Hoogendoorn, M., Hoogenveen, R.T., Feenstra, T.L., Wild, S., Simpson, C.R., Mölken, M.R. & Sheikh, A. (2016). Projecting the COPD population and costs in England and Scotland: 2011 to 2030. Scientific Reports, 6**,** 31893.

McPake, B. & Normand, C. (2008). Health Economics: An International Perspective, London: Routledge.

Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., Mcarthur, A., Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Medical Research Methodolog 18, 143. https://doi.org/10.1186/s12874-018-0611-x

My Diabetes My Way, (2016). My Diabetes My Way: May 2016 Update. Retrieved from: https://www.mydiabetesmyway.scot.nhs.uk/ContentNews.aspx?id=70

NHS Highland (2017a). About NHS Highland [Online]. Retrieved from: http://www.nhshighland.scot.nhs.uk/AboutUs/Pages/AboutUs.aspx

NHS Highland (2017b). 'Florence' signs up to Reach Out campaign [Online]. Retrieved from: http://www.nhshighland.scot.nhs.uk/News/Pages/'Florence'signsuptoReachOutcampaign.aspx

NHS Highland. (nd). Service by Region. Retrieved from: http://www.nhshighland.scot.nhs.uk/Pages/welcome.aspx

NHS NSS (2020). Retrieved from: https://nhsnss.org/how-nss-works/

Nissen, L. & Lindhardt, T. (2017). A qualitative study of COPD-patients' experience of a telemedicine intervention. International Journal of Medical Informatics, 107**,** 11-17.

Nowell, L., Norris J., White D., A & Moules N. (2017). Thematic Analysis: Striving to Meet the Trustworthiness Criteria. International Journal of Qualitative Methods, 16(1), 1-13.

O' Connell, H. (2018). Focus on COPD: Improving quality of life in the Highlands [Online]. Retrieved from: http://www.simple.uk.net/home/casestudies/casestudiescontent/focus-on-copd-improving-quality-of-life-in-the-highlands

Odeh, B., Kayyali, R., Nabhani-Gebara, S. & Philip, N. (2014). Implementing a telehealth service: nurses' perceptions and experiences. Br J Nurs, 23**,** 1133-7.

Odeh, B., Kayyali, R., Nabhani-Gebara, S., Philip, N., Robinson, P. & Wallace, C. R. (2015). Evaluation of a Telehealth Service for COPD and HF patients: Clinical outcome and patients' perceptions. Journal of telemedicine and telecare, 21**,** 292-7.

Palmer, S., Byford, S. & Raftery, J. (1999). Types of economic evaluation. BMJ, 318**,** 1349-1349.

Pandey, P., Bharadwaj, R., Chen, X., O'connor, T., Yang, X., Tian, G., Chatterjee, S., Lee, S., Dubey, A., Michrafy, A., Zavaliangos, A., Cunningham, J., Chaudhury, A., Barrasso, D., Pohlman, D., Litster, J., Ramachandran, R., Gupta, R., Bilgili, E., & Waghmare, Y., (2017). Predictive modeling of pharmaceutical unit operations. 10.1016/B978-0-08-100154-7.00018-1.

Paré, G., Poba-Nzaou, P., Sicotte, C., Beaupré, A., Lefrançois, É., Nault, D. & Saint-Jules, D. (2013). Comparing the costs of home telemonitoring and usual care of chronic obstructive pulmonary disease patients: A randomized controlled trial. European Research in Telemedicine / La Recherche Européenne en Télémédecine, 2**,** 35-47.

Paré, G., Sicotte, C., St-Jules, D. & Gauthier, R. (2006). Cost-minimization analysis of a telehomecare program for patients with chronic obstructive pulmonary disease. Telemedicine journal and e-health : the official journal of the American Telemedicine Association, 12**,** 114-21.

Patel, N., Jones, P., Adamson, V., Spiteri, M. & Kinmond, K. (2016). Chronic Obstructive Pulmonary Disease Patients' Experiences of an Enhanced Self-Management Model of Care. Qual Health Res, 26**,** 568-77.

Pinnock, H., Hanley, J., McCloughan, L., Todd, A., Krishan, A., Lewis, S., Stoddart, A., Van Der Pol, M., Macnee, W., Sheikh, A., Pagliari, C. & McKinstry, B. (2013). Effectiveness of telemonitoring integrated into existing clinical services on hospital admission for exacerbation of chronic obstructive pulmonary disease: researcher blind, multicentre, randomised controlled trial. BMJ : British Medical Journal, 347.

Polisena, J., Tran, K., Cimon, K., Hutton, B., Mcgill, S., Palmer, K., Scott, Re. (2010). Home telehealth for chronic obstructive pulmonary disease: a systematic review and meta analysis. Journal of Telemedicine & Telecare;16(3):120-7.

Qualtrics, (2019a). Retreived from: https://www.qualtrics.com/research-core/survey-software/

Qualtrics, (2019b.) What is Qualtrics? Retreived from: https://www.qualtrics.com/uk/what-is-qualtrics/

Robinson, R. (1993). Cost-benefit analysis. BMJ : British Medical Journal, 307**,** 924-926.

Rudmik, L. & Drummond, M. (2013). Health Economic Evaluation: Important Principles and Methodology. Laryngoscope, 123**,** 1341-1347.

Sanchez-Morillo, D., Fernandez-Granero, M.A. & Jimenez, A.L. (2015). Detecting COPD exacerbations early using daily telemonitoring of symptoms and k-means clustering: a pilot study. Medical & biological engineering & computing, 53**,** 441-51.

Sanders, C., Rogers, A., Bowen, R., Bower, P., Hirani, S., Cartwright, M., Fitzpatrick, R., Knapp, M., Barlow, J., Hendy, J., Chrysanthaki, T., Bardsley, M. & Newman, S. P. (2012). Exploring

barriers to participation and adoption of telehealth and telecare within the Whole System Demonstrator trial: a qualitative study. BMC Health Services Research, 12**,** 220.

SCOTPHO. (2016). Chronic obstructive pulmonary disease (COPD): NHS board data [Online]. Retrieved from: http://www.scotpho.org.uk/health-wellbeing-and-disease/chronic-obstructive-pulmonary-disease-copd/data/nhs-board-data/

ScotPHO (2020). Retrieved from: https://www.scotpho.org.uk

Scottish Government (2018). Technology Enabled Care Programme: Data Review and Evaluation Options Study: Summary Report. Scottish Government. Retrieved from: https://www.gov.scot/binaries/content/documents/govscot/publications/research-and-analysis/2018/05/technology-enabled-care-programme-data-review-evaluation-options-study-summary/documents/00535760-pdf/00535760-pdf/govscot%3Adocument/00535760.pdf

SCTT (2017). A National Service Model for Home and Mobile Health Monitoring, Scottich Centre for Telehealth and Telecare. Retrieved from: https://tec.scot/wp-content/uploads/2019/08/A-National-Service-Model-for-HMHM-v1.1.pdf

SCTT (2020). Retrieved from: http://sctt.cadrecreative.co.uk

Shah, A. S., Velardo, C., Farmer, A. & Tarassenko, L. (2017). Exacerbations in Chronic Obstructive Pulmonary Disease: Identification and Prediction Using a Digital Health System. Journal Medical Internet Research, 19(3), e69.

Snoswell, C., Smith, A.C., Scuffham, P.A. & Whitty, J.A. (2016). Economic evaluation strategies in telehealth: obtaining a more holistic valuation of telehealth interventions. Journal of Telemedicine and Telecare**,** 23(9), 792-796.

Stoddart, A., Van Der Pol, M., Pinnock, H., Hanley, J., McCloughan, L., Todd, A., Krishan, A. & McKinstry, B. (2015). Telemonitoring for chronic obstructive pulmonary disease: a cost and cost-utility analysis of a randomised controlled trial. Journal of Telemedicine and Telecare, 21(2)**,** 108-118.

Taylor, L., Poole, C. & Maslen, J. (2016). RCNi Primary Health Care; Enabling supported self-management of wound care [Online]. Retrieved from: http://www.simple.uk.net/home/casestudies/casestudiescontent/rcniprimaryhealthcareenablingsupportedself-managementofwoundcare

Taylor, S. J., Sohanpal, R., Bremner, S. A., Devine, A., Mcdaid, D., Fernández, J.-L., Griffiths, C. J. & Eldridge, S. (2012). Self-management support for moderate-to-severe chronic obstructive pulmonary disease: a pilot randomised controlled trial. British Journal of General Practice, 62**,** e687-e695.

The King's Fund (2019). Long-term conditions and multimorbidity. Retrieved from: https://www.kingsfund.org.uk/projects/time-think-differently/trends-disease-and-disability-long-term-conditions-multi-morbidity

The Scottish Government (2012). A National Telehelath And Telecare Delivery Plan For Scotland to 2015: Driving Improvement, Integration and Innovation. Scottish Government Publications.

The Scottish Parliament (2018). Technology and innovation in health and social care. Scotland: Scottish Parliamentary Corporate Body. Retrieved from: http://www.parliament.scot/S5_HealthandSportCommittee/Reports/HSS052018R01(1).pdf

Thomas, D.R. & Hodges I.D. (2010). Designing and managing your research project: core skills for social and health researchers. London : SAGE Publications doi: 10.4135/9781446289044.

Tolley, K. & Rowland, N. (1995). Evaluating the Cost-effectiveness of Counselling in Health Care, London: Routledge.

Udsen, F.W., Lilholt, P.H., Hejlesen, O. & Ehlers, L.H. (2014). Effectiveness and cost-effectiveness of telehealthcare for chronic obstructive pulmonary disease: study protocol for a cluster randomized controlled trial. Trials 15**,** 178.

United4Health (2015). Universal solutions in Telemedicine Deployment for European Health Care. Retrieved from: http://united4health.eu/wp-content/uploads/2017/04/D7.6-v1.0-United4Health-Intermediate-Trial-Report-COPD.pdf

Ure, J., Pinnock, H., Hanley, J., Kidd, G., Smith, E.M., Tarling, A., Pagliari, C., Sheikh, A., Macnee, W. & McKinstry, B. (2012). Piloting tele-monitoring in COPD: a mixed methods exploration of issues in design and implementation. Primary Care Respiratory Journal, 21(1)**,** 57-64.

Vatnøy, T.K., Thygesen, E. & Dale, B. (2016). Telemedicine to support coping resources in home-living patients diagnosed with chronic obstructive pulmonary disease: Patients' experiences. Journal of Telemedicine and Telecare, 23(1)**,** 126-132.

Vitacca, M., Bianchi, L., Guerra, A., Fracchia, C., Spanevello, A., Balbi, B. & Scalvini, S. (2009). Tele-assistance in chronic respiratory failure patients: a randomised clinical trial. European Respiratory Journal, 33**,** 411-418.

Walters, J. A., Cameron-Tucker, H., Courtney-Pratt, H., Nelson, M., Robinson, A., Scott, J., Turner, P., Walters, E. H. & Wood-Baker, R. (2012). Supporting health behaviour change in chronic obstructive pulmonary disease with telephone health-mentoring: insights from a qualitative study. BMC Fam Pract, 13**:** 55.

Williams, V., Hardinge, M., Ryan, S. & Farmer, A. (2014a). Patients' experience of identifying and managing exacerbations in COPD: a qualitative study. npj Prim Care Resp Med 24, 14062.

Williams, V., Price, J., Hardinge, M., Tarassenko, L. & Farmer, A. (2014b). Using a mobile health application to support self-management in COPD: a qualitative study. British Journal of General Practice, 64**,** e392-e400.

Wisdom J., And Creswell J.W. (2013) Mixed Methods: Integrating Quantitative and Qualitative Data Collection and Analysis While Studying Patient-Centered Medical Home Models. Rockville, MD: Agency for Healthcare Research and Quality. AHRQ Publication No. 13-0028-EF.

Witt Udsen, F., Lilholt, P. H., Hejlesen, O. & Ehlers, L. (2017). Cost-effectiveness of telehealthcare to patients with chronic obstructive pulmonary disease: results from the Danish 'TeleCare North' cluster-randomised trial. BMJ open, 7(5)**:** e014616.

Wodskou, P. M., Høst, D., Godtfredsen, N. S. & Frølich, A. (2014). A qualitative study of integrated care from the perspectives of patients with chronic obstructive pulmonary disease and their relatives. BMC Health Services Research, 14**,** 471.

Wolters, M. (2018). Service Evaluation of Three Telehealth Serviecs for Monitoring Patients with Asthma, COPD and Heart Failure. Retrieved from: https://tec.scot/wp-content/uploads/2019/08/NHS-Highland-HMHM-Evaluation.pdf

Wortz, K., Cade, A., Menard, J. R., Lurie, S., Lykens, K., Bae, S., Jackson, B., Su, F., Singh, K. & Coultas, D. (2012). A qualitative study of patients' goals and expectations for self-management of COPD. Primary care respiratory journal: Journal of the General Practice Airways Group, 21(4)**,** 384-391.

# APPENDICES

## APPENDIX A: TABLE WITH REFERENCES CHAPTER 3

The table below lists studies that included economic evaluation methods for telehealth for COPD patients referred to in Chapter 3.

| *Author* | *Methods* | *Outcome* |
|---|---|---|
| Stoddart et al., 2015 | CUA | Usual care is more cost-effective than telehealth |
| Hofer et al., 2016 | CUA | Telemonitoring is a cost-effective solution, as it increased the incremental cost but also the incremental QALYs |
| Jódar-Sánchez et al., 2014 | CUA | The telehealth programme is a not a cost-effective solution, but it is effective for patients who do not have comorbidity |
| Paré et al., 2013 | CMA | The home telemonitoring programme was a cost-effective solution, as it saved $1,613 per patient per year compared to the usual care programme |
| Paré et al., 2006 | CMA | Telemonitoring provides significant savings from lower hospitalisation and fewer home visits by nurses |
| Vitacca et al., 2009 | CMA | The TA programme is an effective way to avoid hospitalisation, acute home exacerbation, and urgent GP calls. It could be a cost-effective solution |
| Maiolo et al., 2003 | Simple cost analysis | In the telemonitoring service, there is an observed was a 50% reduction in the expenses by 50% in cost of hospital admissions and a 55% reduction of 55% in acute home exacerbations. |
| Udsen et al., 2014 | CEA | According to CEA, the QALY is expected to increase compared to the usual practice. No difference in mortality and higher health-related QoL. Expect reduced number of admissions and readmissions and 30% reduction in outpatients |
| Henderson et al., 2013 | CEA | The QALY gained from telehealth is almost the same as with the usual care, but the costs are higher in telehealth. Therefore, it is not considered a cost-effective solution |
| Achelrod et al., 2016 | CEA | COPD telemonitoring is a viable strategy to reduce mortality and healthcare cost.costs |
| Pinnock et al., 2013 | CEA | No statistically significant effect on monitoring between postponing hospital admissions and improved QoL |
| Udsen et al., 2017 | CEA | Telehealth is more expensive than the usual care but the ICER is €55,327 per QALY, so it is cost-effective |
| Taylor et al., 2012 | CEA | There is a 75% possibility that the telehealth will be cost-effective as the ICER was £11,710 per QALY gained. Society is willing to pay £20,000 for every additional QALY gained |
| Bentley et al., 2014 | CEA | Usual care is more cost-effective than telehealth. Telehealth is not cost-effective because of hospital admissions. Without considering these, it becomes cost-effective |
| McDowell et al., 2015 | CEA | Telemonitoring is effective in improving QoL and anxiety levels, but it is not cost-effective |

## APPENDIX B: TABLE WITH REFERENCES FOR CHAPTER 4

The table below provides a summary of the results of the qualitative studies on telehealth for COPD patients analysed in Chapter 4.

| ***Sources*** | ***Technique*** | ***Results*** |
|---|---|---|
| ***Patients' perspective*** | | |
| Fitzsimmons et al., 2016 | 9 Semi-structured interviews, 17 semi-structured self-administered questionnaires, and interviews with 3 clinicians | Telehealth is an accepted alternative method to a nurse home visit. Patients in both programmes feel safe, as these are integrated programme |
| Odeh et al., 2015 | 27 patients agreed to participate in a survey | Patients are satisfied with the telehealth programme, as it improved their life. There is a reduction in A&E visits and hospital admissions |
| Wodskou et al., 2014 | 7 focus groups and 5 individual interviews with 34 patients with severe and very severe COPD and 2 focus groups with 8 relatives | Patients were satisfied with the programme and had few criticisms of it. Patients with a severe condition identified more problems with the programme. |
| Nissen and Lindhardt, 2017 | Semi-structured interviews with 14 participants on Net-COPD | Enhanced wellbeing and sense of security, as there is someone to look after them and it is less stressful than visiting the hospital as an outpatient |
| Patel et al., 2016 | 3 focus groups with 15 patients but 5 withdrew because they were ill | Patients' awareness and monitoring of their personal symptoms improved and they gained a better understanding of their condition. A reduction in the cost of hospital admissions was observed |
| ***Healthcare professionals' perspective*** | | |
| MacNeil et al., 2014 | Semi-structured interviews with 32 front-line health professionals (13 community matrons, 10 telehealth monitoring nurses and 9 GPs) | This programme was supported by nurses as long as it supplemented rather than substituted their role in patient care. GPs held mixed views; some gave it a cautious welcome, but most saw telehealth as increasing their workload and potentially undermining their professional autonomy |
| Odeh et al., 2014 | Semi-structured email interviews with 9 nurses to obtain their views | Nurses stated that their experience in telehealth was positive. Barriers: lack of resources, organisational support, patient selection criteria and technical support |
| ***Patients' and Clinicians' perspectives*** | | |
| Ure et al., 2012 | In-depth interviews with 27 patients and 25 professionals and one focus group before and after the installation of the equipment | Patients: positive about technology<br>Clinicians: concerns about false positive symptom difficulties, which leads to overtreatment and an increase in workloads |
| Fairbrother et al., 2012 | Semi-structured interviews with 38 patients and 32 healthcare professionals and managers | Patients and healthcare professionals considered that continued care was important for the telemonitoring services. Managers emphasised how to reduce healthcare costs. Healthcare professionals mentioned operational challenges from telemonitoring |

| | | |
|---|---|---|
| ***Self-management*** | | |
| Williams et al., 2014a | Interviews with 44 patients with a moderate to the very severe condition | Patients have the knowledge to detect and manage exacerbations. This means that they can detect an exacerbation early and obtain treatment for exacerbations |
| Huniche et al., 2013 | Semi-structured interviews with 22 COPD patients and 9 spouses of interviewees | Self-management is beneficial depending on the personal circumstances. Health professionals should support patients in the self-management process |
| Walters et al. 2012 | Interviews with 44 patients who have COPD<br>• 33 with a moderate condition<br>• 11 with a severe condition | Feedback on whether the telephone health monitoring programme changed their behaviour |
| ***Technology*** | | |
| Vatnoy et al., 2017 | 10 semi-structured interviews with patients | Telemedicine helps patients to reduce their stress. Patients are positive about technology and telemedicine as they feel more independent and they are more able to self-manage their condition |
| Williams et al., 2014b | The use of the mHealth application by 19 patients (aged 50–89) with varying computer skills | mHealth was perceived to be easy to use by patients. From the use of the mHealth application, it became clear that patients increased their awareness of the variability of their symptoms and their reassurance through monitoring |
| ***Concerns, fears and barriers*** | | |
| Wortz et al., 2012 | In-depth interviews with patients | Examines factors related to concerns, fears, learning needs, barriers and goals |
| Sandres et al., 2012 | Semi-structured interviews with 22 people who declined to participate in the telehealth and telecare programme | Reasons patients withdrew from or refused to participate in the programmes, such as concerns about unique skills required to use the equipment |
| ***Can detect early exacerbations?*** | | |
| Hamad et al., 2016 | Observation study to determine whether it is possible for COPD patients to detect an exacerbation | More research needed to develop methods for identifying exacerbations earlier. Telehealth was not an efficient way to indicate whether someone will experience deterioration |
| Sanchez-Morillo et al., 2015 | To determine whether a mobile health system could enable early detection of an AECOPD on a day-to-day basis | This system was able to detect 31 out of the 33 acute exacerbations |

## APPENDIX C: TOPIC GUIDE FOR INTERVIEWS

The structure of the interviews is the following:

Thank you very much for agreeing to participate on the interviews, which will discuss the HMHM for COPD patients and will compare that with the usual care in order to indicate which of these programmes a more cost-effective solution is. The purpose of the interview is to collect data in order to conduct the CBA evaluation for HMHM and usual care programme. The questions for the interviews are the following:

(1) What is included in the usual care programme for COPD patients?
(2) What is included in the HMHM programme for COPD patients?
(3) What are the patients/service user's perspective about the HHM programme?
    i. Are they satisfied with that?
    ii. Do they face any difficulties?
    iii. Some patients withdraw from the programme, do you know why?

b. What are the health and social care professionals perspectives about the HMHM programme?
    i. Are they satisfied with the programme?
    ii. What are the problems for them?
    iii. Do they have more workload?

(4) What if anything do you believe about patients treatment is better with the HHM programme than usual care?
    i. Do they experience better health related quality of life?
(5) Who can participate in the HMHM programme?
(6) Patients who participate in the HMHM programme receive some equipment from the NHS. What kind of equipment?
(7) Do the patients receive training about the equipment?
(8) How many times do patients with COPD who use the usual care visit hospital as outpatients per month?
(9) How many times do patients with COPD who use HHM programme visit hospital as outpatients per month?
(10) How often do patients/service users using the usual care visit A&E per year?
(11) How often patients/service users use the HHM programme visit A&E per year?
(12) How many times patients with COPD who use the HHM get readmission per year?

(13) How many times patients with COPD who use the usual care get readmission per year?

(14) Are there difference between the average length of stay that HHM patients and usual care patients stay on hospital when they have an acute exacerbation and they need admission?

(15) In which case a COPD patient can meet a GP?

(16) How often patients/ service users who use the HMHM call to speak on the phone with a healthcare professional?

(17) And which are the average minutes that a healthcare professionals spend to talk on the phone with a patient who have an emergency?

(18) How much time is spend by a nurse to patients with COPD who visit hospital for a check-up?

(19) How often patients/ service users who use the HMHM visit A&E per year?

In addition, I would like the healthcare professionals to verify if the data from the table below are response to the reality.

| ***Paper*** | ***Description*** | ***Costs or Benefits*** | ***Reference*** |
|---|---|---|---|
| Telemonitoring for chronic obstructive pulmonary disease: a cost and cost-utility analysis of a randomised controlled trial | Cost of equipment | £1000<br>It can be used for 4 years. Therefore the cost per day is £0.73 | (Stoddart et al., 2015) |
| | Installation and maintenance cost | £25 | |
| | Initial training | £27.30 | |
| | Time to spend for monitoring the data | 1 minute per patient | |
| *Unit Costs of Health and Social Care 2010* | Time a nurse spent in a phone call | 6.56 minutes | (Curtis, 2010) |
| | Time a GP spend in an appointment | 17.2 minutes | |
| Unit Costs of Health and Social Care 2016 | Annual salary for district nurse and hourly wage | £31,828<br>£20.23 | (Curtis and Burns, 2016)<br>(Curtis and Burns, 2016) |
| | Nurse-led cost per hour of face-to face contact excluding 'other costs' (including set up costs) | £56 | |
| | GP-led cost per hour of face-to face contact excluding 'other costs' (including set up costs) | £216 | |
| | Average time per intervention (minutes) by nurses | 6.56 | |
| | Average time per intervention (minutes) by GPs | 4 | |

| | | | |
|---|---|---|---|
| | Cost per intervention by nurses | £6.10 | |
| | Cost per intervention by GPs | £14.40 | |
| *Annual Acute Hospital Activity and NHS Beds Information in Scotland* | Average number of days COPD patients stay in hospital | 4 days | (ISD Scotland, 2016a) |
| *'R025: HOPSITAL RUNNING COSTS BY PATIENT TYPE –NHS BOARD LEVEL' (APRIL 2015-MARCH 2016)) Excel file for NHS Lothian* | Total day care cost | £202 | (ISD Scotland, 2016c) |
| | Cost of check-up for outpatients | £69 | |
| | Cost per A&E | £101 | |
| | Cost per admissions | £3853 per case | |
| Telehealth benefits evident | Reduction in admissions | 80% | (ehealth, 2016) |
| | Reduction in GPs appointment | 27% | |
| | Reduction on home visits | 90% | |
| | Reduction on out of hours contact | 40% | |
| Whole System Demonstrator Programme: Headline Findings – December 2011 | Reduction in A&E attendance | 15% | (Department of Health, 2011) |

## APPENDIX D: QUESTIONNAIRE OF ONLINE SURVEY

Below is the online survey that was available to professionals who had experience of chronic obstructive pulmonary disease (COPD) and ideally from people who had experience of the telehealth programme for COPD patients.

Preview Survey

# Data gathering HMHM

Are patients/ service users happy with Home & Health Monitoring intervention?

Welcome to our survey!
Thank you for agreeing to take part in this survey gathering data for the Home & Mobile Health Monitoring (HMHM) programme for Chronic Obstructive Pulmonary Disease (COPD) patients. The purpose of the survey is to estimate whether HMHM is a more cost-effective solution of the usual care.

This survey should take around 5-10 minutes to complete. Be assured that all answers you provide will be dealt with the strictest confidentiality.

Participation in this survey is entirely voluntary. For any questions, please contact to the researcher (Eftychia Dania) or her supervisor (Marilyn Lennon) and email: eftychia.dania@strath.ac.uk, marilyn.lennon@strath.ac.uk

Please click 'Next' to begin.

Page Break

**Q1** What is your current job role?

**Q2** How long have you been in this role?

**Q3** Can you describe what you do in the HHM programme?

Page Break

**Q4** Are patients/service users happy with the Home & Health Monitoring intervention?

- Yes
- No
- I do not know

**Q5** Patients who participate in the HMHM programme receive equipment from the NHS. Do patients /service users find it easy to use the equipment given to them by the NHS?

- Yes
- No
- I do not know

**Q6** Are the patients/ service users receiving HMHM training?

- Yes
- No
- I do not know

Page Break

**Q7** How many years can the equipment that the NHS gives to the patients /service users of HMHM be used?

- 1
- 2
- 3
- 4
- other, please specify
- I do not know

**Q8** How often do patients /service users need to have the equipment returned for maintenance or replacement?

- Once per year
- Once per two years
- Once per three years
- I do not know

Page Break

**Q9** How often do patients/service users who use the usual care visit A&E?

- once per month
- once per 3 months
- once per 6 months
- once per year
- Other, please specify

**Q10** How often do patients/service users who use HMHM visit A&E?

- Once per month
- Once per 3 months
- once per 6 months
- once per year
- Other, please specify

Page Break

**Q11** How many times per year patients/service users with COPD who use the usual care system they get readmitted?

- Once per year
- Twice per year

- Three times per year
- Other, please specify

**Q12** How many times per year patients/service users with COPD in HMHM get readmitted in hospital?

- Once per year
- Twice per year
- Three time per year
- Other, please specify

Page Break

**Q13** How many times patients who use usual care visit hospital for a check-up?

- Once per year
- Twice per year
- Once per month
- Twice per month
- Other, please specify
- I do not know

**Q14** How many times patients who use HMHM visit hospitals for check-ups?

- Once per month
- Twice per month
- Once per year
- Twice per year
- Other, please specify
- I do not know

Page Break

**Q15** How much time does a GP spend in an appointment with someone with COPD?

- 17 minutes
- 20 minutes
- Other, please specify
- I do not know

**Q16** How much time is spent by a nurse for patients/ service users with COPD who visit hospital for a check-up?

- 13 minutes
- 15 minutes
- 30 minutes
- Other, please specify
- I do not know

Page Break

**Q17** How often does a healthcare professional speak on the phone with COPD patients/service users?

- Once per month
- Twice per year
- Other, please specify
- I do not know

**Q18** How much time is spent by a nurse in a phone call for patients/service users with COPD who use HHM?

- 4 minutes
- 6 minutes

- 10 minutes
- 15 minutes
- I do not know
- Other, please specify

Page Break

**Q19** How much time a healthcare professional needs to check the data from HMHM patients per day?

- 1 minute per patient
- 30 seconds per patient
- 2 minutes per patient
- I do not know
- Other, please specify

Page Break

**Q20** How much has HMHM reduced GPs appointments?

- Please provide a percentage:
- I do not know

Page Break

**Q21** What is the percentage of patients/service users who have COPD and use HMHM and who get readmission in hospital?

- Please provide a percentage:
- I do not know

**Q22** How much have the percentage of people who get readmissions in hospitals been reduced?

- Please provide a percentage:

I do not know

Page Break

**Q23** What was the percentage of people who have false alarms and who visit hospitals as a result of that?

Please provide a percentage:

I do not know

**Q24** How much have the number of false alarms for patients with COPD been reduced because of HHM?

Please provide a percentage

I do not know

Page Break

This was the questionnaire of the online survey that sent on people. The aim of that questionnaire was to collect data for the telehealth / HMHM programme for patients with COPD in order to find answers for the data gaps.

## APPENDIX E: ETHICS APPLICATION

## Application ID: 630

## Title of research:
## Exploring the Cost-Benefits of Home and Mobile Health Monitoring in Edinburgh

**Summary of research (short overview of the background and aims of this study):**

This study examines the costs and the benefits from the Home & Mobile Health Monitoring (HMHM) programme in Edinburgh for patients with COPD and compares it with the costs and benefits of the usual care. In addition, it will examine the challenges associated with collecting and using routinely collected cost and benefit data for conducting benefits analyses for telehealth interventions and usual care service.

HMHM is an intervention programme that takes place in Scotland in order to help people who have long-term conditions avoid visiting hospital whilst managing their condition. These patients receive equipment from the NHS in order to monitor their conditions every day from home and talk with a health and social care professional if they have an exacerbation and only visit hospitals in the case of an emergency. The aim is for them to receive better or equally good monitoring of their conditions and the NHS will save money by helping reduce costs associated with hospital stays and GP visits.

The first objective of this study is to collect and analyse the costs and the benefits of HMHM for people with COPD in Edinburgh. This will be done by (i) collecting data reported in the public domain on costs and benefits of HMHM and usual care for patients with COPD in Edinburgh and (ii) collecting primary data from people involved in the programme via interviews and online survey. The interviews have the aim to collect information about the HMHM programme and the usual care, to collect data for the CBA evaluation regarding the costs and benefits calculations, and to identify the challenges and the opportunities that there are with regards to the HMHM programme. This relates to meeting the third aim of this study (which is shown below). The online survey aims to collect information which will be used in the evaluation of the HMHM programme for the COPD patients in Edinburgh. The information from the interviews will be more qualitative and will allow interviewees to respond with more in-depth responses, as some of the questions will be open-ended. The information from the online surveys will be more quantitative, as the respondents will be asked to pick answers from a potential list, along with an opportunity to provide written responses. The responses are expected to be more suitable to be organised and presented as quantitative data.

The second objective is to develop a simple tool (in Excel) that would assist those commissioning and delivering telehealth to more easily capture the cost and benefit data for their intervention and conduct a simple CBA comparison with the usual care programme for their service to indicate which of these two programmes are more cost-effective solution.

The third aim of this study is to collect qualitative data on the challenges associated with the collection and use of cost and benefit data for these types of telehealth interventions / programmes. This will be done via interviews with people involved in evaluating and implementing telehealth programmes in Scotland.

The research questions that this research tries to answer are:

1) What are the identifiable and measurable costs for managing COPD in Edinburgh with and without telehealth?
2) What are the identifiable and measurable benefits for managing COPD in Edinburgh with and without telehealth?
3) Does HMHM for patients with COPD offer more benefits than costs in monetary units than usual

care?
4) What methods are currently used for economic evaluations of telehealth for COPD?
5) Do current data collection practices support simple CBA techniques for telehealth interventions such as HMHM in Edinburgh?

**How will participants be recruited?**

The first thing (objective 1) is to conduct a simple economic evaluation using the method of cost-benefit analysis (CBA) for the first year of the HMHM project. This CBA evaluation will be done via collecting costs and benefits data from already available secondary resources, online surveys, and interviews with professionals involved in the programme. The interviews and the online survey will be done/sent to health and social care professionals who have worked in that programme in Edinburgh or in the usual care for COPD patients and who can provide information about the costs and benefits (for example minutes that GPs and nurses spend per COPD patient and the minutes that patients speak on the phone with the healthcare professionals etc).

The second element (objective 2) to develop a CBA tool relies on data collection from objective 1.

The third element (objective 3) is to conduct a small sample (N=3-5) unstructured interviews with people who run the HMHM programme, which will help for a more in-depth view of the problem in order to describe the challenges that the HMHM programme has with regards to measuring the costs and benefits.

**What will the participants be told about the proposed research study? Either upload or include a copy of the briefing notes issued to participants. In particular this should include details of yourself, the context of the study and an overview of the data that you plan to collect, your supervisor, and contact details for the Departmental Ethics Committee.**

**PDF File:** None.

Participant information leaflet:
Title of the proposed study
Exploring the Costs-Benefits of Home & Mobile Health Monitoring in Edinburgh

Description of the proposed study
This thesis examines if the HMHM programme for COPD patients, who are in a severe situation, is a more cost-effective solution than the usual care. With the use of the interviews try to obtain information about the collection useful information in order to be done the economic evaluation for the HMHM programme which is compared the HMHM and the usual care.

The consent form also requires a “fair processing” Notice.

Participants will not be paid for their time.

Confidentiality/anonymity and data security
Your data will be treated as anonymous and/or confidential.
Participants should be told who will have access to their data and for what the data will be used. Data storage and disposal arrangements may also be mentioned.
Results of the study Information should be provided about the intended use and dissemination of the results arising from study, and about any feedback that will be provided to participants.

Contact details
Researcher: (Eftychia Dania)
MPhil student in Computer and Information

University of Strathclyde
Email: eftychia.dania@strath.ac.uk

Supervisor: Dr Marilyn Lennon
Senior Lecturer in Computer and Information
University of Strathclyde
Email: marilyn.lennon@strath.ac.uk

This study has been approved by the Departmental Ethics Committee.
In the case of any queries please contact:
The Secretary to the Ethics Committee
Department of Computer and Information Sciences
University of Strathclyde
Livingstone Tower
Richmond Street
Glasgow
G1 1XH
enquiries@cis.strath.ac.uk

Consent form:
Title of the proposed study
Exploring the Costs-Benefits of Home & Mobile Health Monitoring in Edinburgh
Fair Processing Statement
This information is being collected as part of a research project concerned with (objective of the research) by the Department of Computer and Information Science in the University of Strathclyde. The information which you supply and that which may be collected as part of the research project will be entered into a filing system or database and will only be accessed by authorised personnel involved in the project. The information will be retained by the University of Strathclyde and will only be used for the purpose of research, and statistical and audit purposes. By supplying this information you are consenting to the University storing your information for the purposes stated above. The information will be processed by the University of Strathclyde in accordance with the provisions of the Data Protection Act 1998. No identifiable personal data will be published.

Statements of understanding/consent
As appropriate to the study, for example these may include:
- I confirm that I have read and understand the participant information leaflet for this study. I have had the opportunity to ask questions if necessary and have had these answered satisfactorily.
- I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason. If I withdraw my data will be removed from the study and will be destroyed.
- I understand that my personal data will be processed for the purposes detailed above, in accordance with the Data Protection Act 1998. - Based upon the above, I agree to take part in this study.
Name, signature and date
Name of participant……..…… Date……
Signature……..
Name of researcher/ individual obtaining consent……..... Date……
Signature……..
A copy of the signed and dated consent form and the participant information leaflet should be given to the participant and retained by the researcher to be kept securely on file.

Please also add the following to the information leaflet:
This study has been approved by the Departmental Ethics Committee.
In the case of any queries please contact:
The Secretary to the Ethics Committee
Department of Computer and Information Sciences
University of Strathclyde
Livingstone Tower

Richmond Street
Glasgow
G1 1XH
enquiries@cis.strath.ac.uk

**How will consent be demonstrated? Either upload or include here a copy of the consent form/instructions issued to participants. It is particularly important that you make the rights of the participants to freely withdraw from the study at any point (if they begin to feel stressed for example), nor feel under any pressure or obligation to complete the study, answer any particular question, or undertake any particular task. Their rights regarding associated data collected should also be made explicit.**

**PDF File:** View document

The following text will be adapted for emails targeted at relevant health and telehealth professionals identified via the supervisors existing telehealth networks. Participants can take part by agreeing to a face to face interview or telephone interview of by agreeing to fill in an equivalent online survey with the same questions.

The aim of the online survey and interviews is to:
(i) Identify costs associated with the provision of the telehealth programme as well as cost associated with treatment of patients via usual care
(ii) Identify benefits from telehealth programmes and benefits from usual care
(iii) Identifying challenges and benefits of conducting CBA

The interviews will take around 30-45minutes. We do not anticipate that there are any risks associated with your participation, but you have the right to stop the interview or withdraw from the research at any time. The online survey should take around 15 minutes to complete.

"You are being invited to participate in a research study titled 'Exploring the Costs-Benefits of Home Health Monitoring in Edinburgh'. This study is conducted by Eftychia Dania and supervised by Dr Marilyn Lennon both from the University of Strathclyde.

Thank you for agreeing to be interviewed/fill in a survey as part of the above research project. Ethical procedures for academic research undertaken from UK institutions require that interviewees explicitly agree to being interviewed and how the information contained in their interview will be used. This consent form is necessary for us to ensure that you understand the purpose of your involvement and that you agree to the conditions of your participation. Would you therefore read the accompanying information sheet and then sign this form to certify that you approve the following:
-• the interview will be recorded and a transcript will be produced
-• the transcript of the interview will be analysed by Eftychia Dania as research investigator
-• access to the interview transcript will be limited to Eftychia Dania and academic colleagues and researchers with whom she might collaborate as part of the research process
-• any summary interview content, or direct quotations from the interview, that are made available through academic publication or other academic outlets will be anonymized so that you cannot be identified, and care will be taken to ensure that other information in the interview that could identify yourself is not revealed
-• the actual recording will be kept but never used to identify you or shared with anyone else for any other purpose other than that described above" Estimating that the interviews will take around 30-45 minutes and the online survey to 10-15 minutes.

Online survey For the first online survey (conducting a CBA)
"You are being invited to participate in a research study titled 'Exploring the Costs-Benefits of Home Health Monitoring in Edinburgh'. This study is conducted by Eftychia Dania and supervised by Dr Marilyn Lennon both from the University of Strathclyde.

The purpose of this research study is to collect data from health and social care professionals in order to help determine if the HMHM programme for COPD patients is a cost-effective solution. It will take you approximately 10-15 minutes to complete the survey. Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any question. We believe there are no known risks associated with this research study; however, as with any online related activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential."

**What will participants be expected to do? Either upload or include a copy of the instructions issued to participants along with a copy of or link to the survey, interview script or task description you intend to carry out. Please also confirm (where appropriate) that your supervisor has seen and approved both your planned study and this associated ethics application.**

**PDF File:** View document

**PDF File:** None.

I would like to confirm that my first supervisor (Dr Marilyn Lennon) has seen and approved both my planned study and this associated ethics approval.

**What data will be collected and how will it be captured and stored? In particular indicate how adherence to the Data Protection Act and the General Data Protection Regulation (GDPR) will be guaranteed and how participant confidentiality will be handled.**

The data collected will be about how many times patients have an episode and visit A&E, or do readmissions. Other data to be collected are: how many minutes a healthcare professional spends to speak on the phone with a patient; how much time a nurse spends with the patient when he/she visits hospital; how often patients with COPD who use usual care visit hospitals and how often patients who use HMHM; how many check-ups are done for patients with COPD who use usual care and how many for those who use HMHM.

The collection of the information will be done with interviews and online survey with health and social care professionals and through secondary resources from the academic papers in order to conduct the CBA evaluation. The interviews will be recorded and then transcribed in order for the answers to be used in the evaluation. In addition, the data from the online survey will be analysed using Qualtrics to do Data & Analysis.

All the data that are collected and stored from the interviews and online survey will be anonymised. Data will be stored electronically and will be protected with a password in a protected computer. These data will be accessed by Eftychia Dania, her supervisors and academic colleagues and researchers with whom she might collaborate as part of the research process.

**How will the data be processed? (e.g. analysed, reported, visualised, integrated with other data, etc.) Please pay particular attention to descibing how personal or sensitive data will be handled and how GDPR regulations will be met.**

The methods that will be used in the interviews will be tape recording and taking notes during the interviews. Then these will be transcribed word for word and then the transcribed text becomes the data that will be analysed. From the online survey will use the data that will be collected.

**How and when will data be disposed of? Either upload a copy of your data management plan or describe how data will be disposed.**

**PDF File:** None.

The data will be kept for 3 years after the graduation and then they will be destroyed, both in their physical and digital form.

# APPENDIX F: PARTICIPATION FORM THAT INTERVIEWERS RECEIVED BEFORE INTERVIEW

**Participant information leaflet:**

Title of the proposed study

Exploring the Costs-Benefits of Home Health Monitoring for COPD patients

Description of the proposed study

This thesis examines if the HMHM programme for COPD patients, who are in a severe situation, is a more cost-effective solution than the usual care. With the use of the interviews try to obtain information about the collection useful information in order to be done the economic evaluation for the HHM programme which is compared the HMHM and the usual care.

The consent form also requires a "fair processing" Notice.

Participants will not be paid for their time.

Confidentiality/anonymity and data security

Your data will be treated as anonymous and/or confidential.

Participants should be told who will have access to their data and for what the data will be used. Data storage and disposal arrangements may also be mentioned.

Results of the study Information should be provided about the intended use and dissemination of the results arising from study, and about any feedback that will be provided to participants.

Contact details

**Researcher:** (Eftychia Dania)

MPhil student in Computer and Information

University of Strathclyde

Email: eftychia.dania@strath.ac.uk

**Supervisor:** Dr Marilyn Lennon

Senior Lecturer in Computer and Information

University of Strathclyde

Email: marilyn.lennon@strath.ac.uk

# APPENDIX G: CONSENT FORM THAT PARTICIPANS RECEIVED BEFORE THE INTERVIEW

## Consent form

Title of the proposed study
Exploring the Costs-Benefits of Home & Mobile Health Monitoring for COPD patients

Fair Processing Statement
This information is being collected as part of a research project concerned with (objective of the research) by the Department of Computer and Information Science in the University of Strathclyde. The information which you supply and that which may be collected as part of the research project will be entered into a filing system or database and will only be accessed by authorised personnel involved in the project. The information will be retained by the University of Strathclyde and will only be used for the purpose of research, and statistical and audit purposes. By supplying this information you are consenting to the University storing your information for the purposes stated above. The information will be processed by the University of Strathclyde in accordance with the provisions of the Data Protection Act 1998. No identifiable personal data will be published.

Statements of understanding/consent
As appropriate to the study, for example these may include:
- I confirm that I have read and understand the participant information leaflet for this study. I have had the opportunity to ask questions if necessary and have had these answered satisfactorily.
- I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason. If I withdraw my data will be removed from the study and will be destroyed.
- I understand that my personal data will be processed for the purposes detailed above, in accordance with the Data Protection Act 1998. - Based upon the above, I agree to take part in this study.

Name, signature and date
Name of participant……..…… Date……
Signature……..
Name of researcher/ individual obtaining consent:…… Date:..……..
Signature……..
A copy of the signed and dated consent form and the participant information leaflet should be given to the participant and retained by the researcher to be kept securely on file.

This study has been approved by the Departmental Ethics Committee.
In the case of any queries please contact:
The Secretary to the Ethics Committee
Department of Computer and Information Sciences
University of Strathclyde
Livingstone Tower
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Glasgow
G1 1XH
enquiries@cis.strath.ac.uk

## APPENDIX H: SENSITIVITY ANALYSIS

Below is an explaination of the numbers derived in Table 5: Sensitivity analysis on page 66 on Chapter 6. In the sensitivity analysis, one factor was changed in each scenario and all the other factors remained the same. The factors that are affected in each scenario are highlighted in green.

### Equipment cost

In this scenario, only the equipment cost was changed and all the other factors remained the same.

→ If the equipment cost was 20 instead of 25 and all the other factors remained the same, the net savings would be £9,159.55 and the BCR would be 1.16.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,360.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 1,213.79 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **58,026.09** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | £ | 1,517.24 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **67,185.63** |

→ If the equipment cost was 75 instead of 25 and all the other factors remained the same, the net savings would be £5,419.55 and the BCR would be 1.09.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 5,100.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 1,213.79 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **61,766.09** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | £ | 1,517.24 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **67,185.63** |

## Number of patients who participated in the HMHM programme

Many factors were affected by the number of patients who participated in the HMHM programme. Those factors are equipment cost, cost of texting for patients and cost of visiting GP, and the savings are from nurse time and GP appointments.

→ If the number of patients who participated in the HMHM programme was 100 instead of 68 and all the other factors remained the same, the net savings would be £7,296.41 and the BCR would be 1.12.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 2,500.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 2,553.00 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 1,784.99 |
| **Phone call for all patients** | £ | 962.13 |
| **Total Costs** | **£** | **60,862.13** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 809.10 |
| **Total savings from GPs appointment** | £ | 2,231.24 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **68,158.54** |

→ If the number of patients who participated in the HMHM programme was 20 instead of 68 and all the other factors remained the same, the net savings would be £11,104.24 and the BCR would be 1.20.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 500.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 510.60 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 357.00 |
| **Phone call for all patients** | £ | 192.43 |
| **Total Costs** | **£** | **54,622.03** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 161.82 |
| **Total savings from GPs appointment** | £ | 446.25 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **65,726.27** |

## GP appointment

This case examines the minutes that a GP spends per appointment with the patients. The factors that were affected are the cost of visiting GPs, and the savings from GPs are derived from GPs spending less time per appointment.

→ If the GP spent 4 minutes per appointment per patient instead of 9.22 minutes and all the other factors remained the same, the net savings would be £8,647.75 and the BCR would be 1.15.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,700.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 526.59 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **57,678.88** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | £ | 658.24 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **66,326.63** |

→ If the minutes of GP appointments was 20 instead of 9.22 minutes and all the other factors remained the same, the net savings would be £9,174.34 and the BCR would be 1.15.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,700.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 2,632.96 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **59,785.25** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | £ | 3,291.20 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **68,959.59** |

## Number of times patients visit their GP

This case examines the number of times that patients visit their GP. The factors that were affected are the cost of visiting GPs, and the savings from GPs are derived from GPs spending less time per appointment.

→ If patients visited their GP 0.3 times instead of 0.48 times per year and all the other factors remained the same, the net savings would be £9,729.89 and the BCR would be 1.17.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,700.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 758.62 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **57,910.91** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | | £1,517.24 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **67,185.63** |

→ If patients visited their GP 2 times instead of 0.48 times per year and all the other factors remained the same, the net savings would be £1,132.18 and the BCR would be 1.15.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,700.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 5,057.48 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **62,209.77** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | | -£2,326.44 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **63,341.95** |

→ If patients visited their GP 3 times instead of 0.48 times per year and all the other factors remained the same, the outcome would be negative, as the net savings would be –£3,925.30 and the BCR would be 0.94.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,700.00 |
| **Cost of bed days** | £ | 49,072.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 7,586.22 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **64,738.51** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | | -£4,855.18 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **60,813.21** |

## Number of bed days in hospital

This case examines the number of bed days that patients needed to stay in hospital. The factor that was affected is cost of bed days.

→ If patients stayed in hospital for 50 days instead of 80 days and all the other factors remained the same, the net savings would be £27,221.55 and the BCR would be 1.68.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,700.00 |
| **Cost of bed days** | £ | 30,670.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 1,213.79 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **39,964.08** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | £ | 1,517.24 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **67,185.63** |

→ If the patients stayed in hospital for 90 days instead of 80 days and all the other factors remained the same, the net savings would be £2,686 and the BCR would be 1.04.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,700.00 |
| **Cost of bed days** | £ | 55,206.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 1,213.79 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **64,500.08** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | £ | 1,517.24 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **67,185.63** |

→ If the patients stayed in hospital for 100 days instead of 80 days and all the other factors remained the same, then the outcome would be negative as the net savings would be -£3,448 and the BCR would be 0.94.

| *Costs of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Equipment cost** | £ | 1,700.00 |
| **Cost of bed days** | £ | 61,340.00 |
| **Cost of texting for all the patients for 3 months** | £ | 1,736.04 |
| **Cost of outpatients** | £ | 3,990.00 |
| **Cost of GP for all patients** | £ | 1,213.79 |
| **Phone call for all patients** | £ | 654.25 |
| **Total Costs** | **£** | **70,634.08** |

| *Benefits of HMHM for COPD patients in NHS Highland* | | |
|---|---|---|
| **Savings from outpatients** | £ | 1,938.00 |
| **Total savings from nurse time** | £ | 550.19 |
| **Total savings from GPs appointment** | £ | 1,517.24 |
| **Savings from hospital admissions** | £ | 63,180.20 |
| **Total Benefits** | **£** | **67,185.63** |