Using Forensic Science in Major Crimes Investigation: A Preliminary Review of Limiting Factors

By

Chimdia Nwanneka Adaeze Edo

Centre for Forensic Science

Department of Pure & Applied Chemistry

University of Strathclyde

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Centre for Forensic Science

Department of Pure & Applied Chemistry

University of Strathclyde

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CHIMDIA NWANNEKA ADAEZE EDO

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Abstract

The utilization of forensic science in the investigation of criminal activities has been shown to have increased over the years especially with the discovery of DNA profiling and the creation of various databases such as the NDNAD and CODIS. Notable advancements in science and technology have contributed to the way forensic science aids criminal investigations. In spite of the increased potential of the use of forensic science in criminal investigations, certain factors such as insufficient forensic training, knowledge and resources appear to limit its effective and efficient use.

Major crimes investigations receive more attention in terms of investigative resources due to their severity and the effect they have on the public. These characteristics result in the prioritisation of allocation of resources compared to volume crime investigations. Previous research on the effective and efficient use of forensic science in volume crime investigations identified recurring themes that appeared to hinder the use of forensic science. This research considers these themes and others in relation to major crime investigation. It was found that in addition to themes previously identified in volume crime investigations; information management in major crime investigation appears to impact on the effective and efficient use of forensic science.

The CJS is made up of actors such as the police, the courts and other agencies such as the Home Office in the United Kingdom. During investigation of criminal activities especially in major crimes, these actors communicate and collaborate in the bid to achieve effective justice outcomes. However, certain factors seem to hinder effective and efficient communication and collaboration such as organisational cultures and behavioural economics. These factors are explored in terms of their impact on the use of forensic science in major crimes investigations.

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Abbreviations

ASCLD/LAB	American Society of Crime Laboratory Directors/Laboratory Accreditation Board
CJS	Criminal Justice System
CODIS	Combined DNA Index System
CSE	Crime Scene Examiner
DA	District Attorney
FSL	Forensic Science Laboratory
FSS	Forensic Science Service
GC-MS	Gas Chromatography-Mass Spectrometer
ILP	Intelligence-Led Policing
LCN DNA	Low Copy Number Deoxyribo-Nucleic Acid
MDTs	Mobile Digital Terminals
MIRSAP	Major Incident Room Standardised Administrative Procedure
NAFIS	National Automated Fingerprint Identification System
NAS	National Academy of Sciences
NCRS	National Crime Recording Standard
NDNAD	National Deoxyribo-Nucleic Acid Database
NIBIN	National Integrated Ballistic Information Network
PACE	Police and Criminal Evidence Act
SEM	Scanning Electron Microscope (SEM)

SOCO	Scene of Crime Officer
UNODC	United Nations Office on Drugs and Crime

CHAPTER ONE: INTRODUCTION

1.0 THE CRIMINAL JUSTICE SYSTEM

The report of a suspected criminal activity usually marks the beginning of the process of criminal investigations [2-4] (Figure 1).These criminal investigations are carried out in different ways and are influenced by various factors such as the application of forensic science to the investigative process [5, 6]. In addition to forensic science, other methods employed in criminal investigations include eyewitness interviews and medical evidence[7-9]. The criminal justice system consists of intrinsically complex activities and processes involved in determining if a crime has been committed and the subsequent trial of an offender. According to Dammer and Albanese, the criminal justice system primarily involves "*all of the agencies whose goal is to control crime*"[10] by encouraging and enforcing *"compliance with the law, judg[ing] alleged breaches, and punish[ing] offenses"[11].* Typically, a CJS is composed of the police, courts and correction agencies[10]. There are two major forms of CJSs in operation all over the world; the adversarial and the inquisitorial systems [12-14].

The adversarial system is the system of justice that bestows the responsibility of presenting evidence to court relating to a criminal matter upon the two parties (the prosecutor and the defendant) involved in a dispute while the inquisitorial system of justice bestows the responsibility of evidence finding upon the judge or investigator[14].In the former system of justice, the responsibility of finding a person either guilty or not guilty by the impartial arbitrator (the judge) or jury depends on the opposing parties arguing their case either in the presence or absence of a jury whereas the later system of justice allows the arbitrator to investigate. The adversarial system of justice is operational in common law countries such as the United Kingdom (UK), many of its former colonies and the United States of America(USA) whereas the inquisitorial

system is operational in countries within continental Europe[13] such as France.

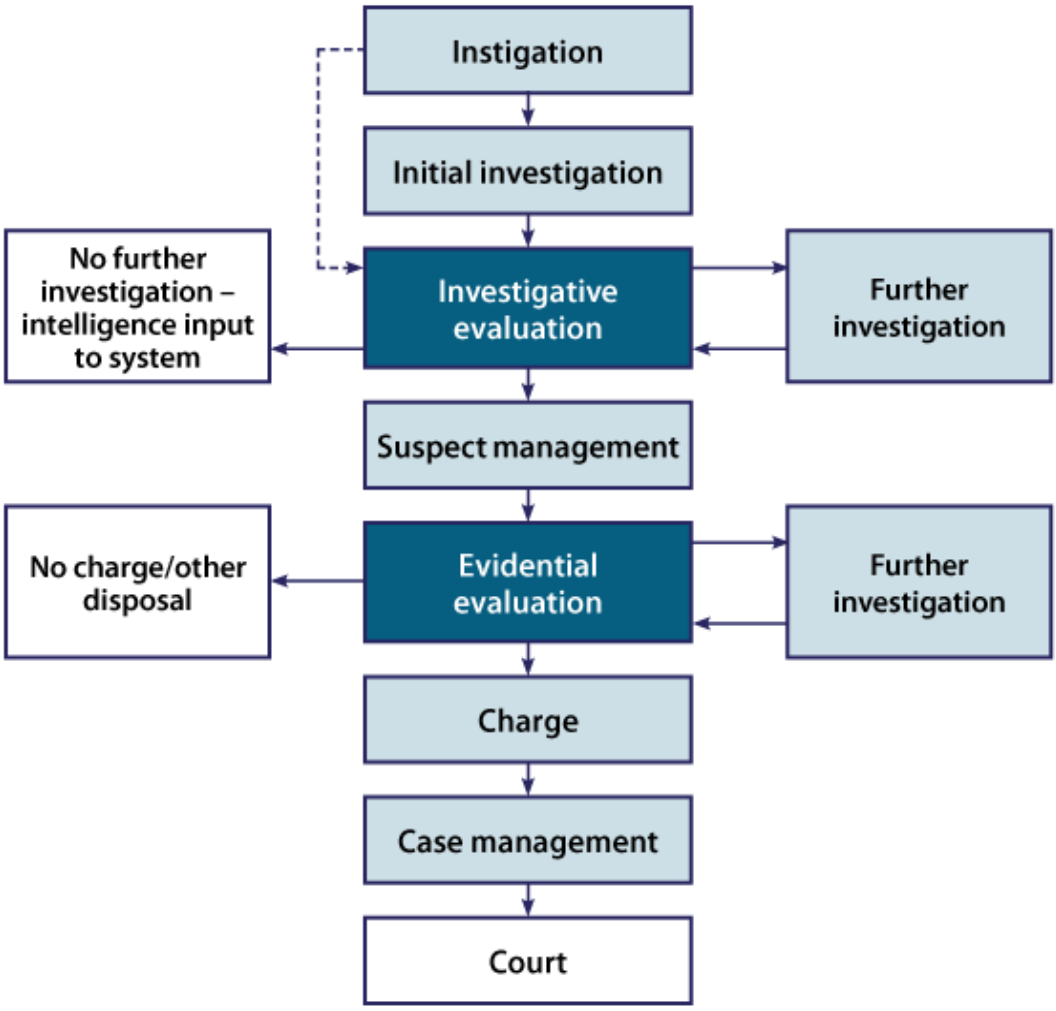

Figure 1: Criminal Investigative Process Highlighting Different Stages of Investigation[1]

CJSs all over the world have evolved in different ways [10, 15]. In England and Wales for example, the codes of practice of the Police and Criminal Evidence Act (PACE) of 1984 has been modified over the years[16, 17]. PACE was enacted to

> "govern the major part of police powers of investigation including, arrest, detention, interrogation, entry and search of premises,

personal search and the taking of samples. Also part of this legislation are the PACE Codes of Practice which police officers should take into consideration and refer to when carrying out various procedures associated with their work"[18].

The way each CJS has evolved has to an extent been as a result of historic, social, economic factors and to a lesser degree by scientific and technological developments[19, 20]. In developed economies such as the UK and the USA, developments in science and technology have appeared to impact considerably on the way investigations are carried out in the CJS especially when compared to other jurisdictions such as South Africa [21-24].

From the discovery of a criminal activity to its adjudication in the courts, many processes are carried out by the various actors in the CJS. The police employ forensic science as an investigative and intelligence tool[25, 26] (Figure 2). The police and sometimes in collaboration with scientists collect physical or trace evidence from the crime scene to be scientifically analysed to produce information that could eliminate or generate suspects[27].The use of forensic science by the police when viewed in relation to particular criminal cases appears to have had significant impact on justice outcomes for various crimes such as armed robbery and homicide[27, 28]. Cold cases have been revisited and victims of miscarriages of justice have been exonerated using DNA evidence [29-31].Samples which could not be analysed due to their quantity are now being analysed with such methods as Low Copy Number (LCN) DNA [32-34].

However, Horvath *et al* observed that the use of forensic science in criminal investigations has:

> "not been accompanied by a corresponding improvement in investigative effectiveness, except, perhaps in the most visible but

relatively infrequent situations. Thus, while technology is playing an increasingly influential role in the criminal investigation process, it for the most part remains supportive of and reliant upon the relationship between the public and the police in solving crime"[35].p.8

This statement captures what appears to be the current position versus the actual impact of the potential of forensic science in the investigative process. This also shows that despite the potential of any given technology, in this case forensic science, its impact is not entirely dependent on its own efficiency but on other factors such as how its users understand and apply it. The impact of DNA databases for example has been affected to a degree by objections to their scope as expressed by some commentators[36]. Objections relating to infringement of human rights have resulted in the reductions of DNA profiles contained in these databases.

Commenting on a general note, forensic science plays significant roles in criminal investigations. However, forensic science providers[1] seem to be *'flying blind' in terms of the true impact of [their] work[37].* This is to say that there is paucity of empirical evidence on the impact forensic science makes on individual criminal cases. For example in sexual assault cases, Johnson et al stated that "*there has been little empirical research evaluating the actual contribution of forensic testing to successful case solution and adjudication"[38].*Feedback on cases where forensic science plays a role in the investigative process is also rarely given especially where such impact led to elimination of suspects rather than producing suspects[39].

[1]This term 'Forensic science providers or suppliers' is used throughout this document to include all forensic scientists either working at the scene collecting samples or at the laboratory analysing samples and writing expert statements for court purposes.

1.1 FORENSIC SCIENCE AS AN EVIDENCE AND INTELLIGENCE TOOL IN INVESTIGATIONS

Some scholars have observed that structure and approach of forensic science since its inception has been non-systematic [40, 41]. Lucas explained this non-systematic concept in the sense that "*it was never planned or developed as a system*"p.8[40]. Although it can be argued that not all systems were planned from inception, this author's view may be explained in terms of non-uniformity in the way the use of forensic science started in different jurisdictions. Despite the fact that this view originated from a study of how forensic science is run in the USA, it also describes how the use of forensic science began in the UK[42] and probably in other countries. Forensic science services may be delivered through the police department laboratory or any other laboratories usually accredited to offer such services[41, 43]. For example, until 2012 forensic science in England and Wales was primarily delivered ('near monopoly'[44]) by the Forensic Science Service in England and Wales but have now moved fully to an in-house and outsource systems[44].

In-house here implies that the analysis of physical evidence is carried out by a laboratory run by the police department whereas outsourcing implies delivery of forensic science by laboratories not run by the police e.g. independent private laboratories[44]. Authors such as Gallop and Brown[44] have made recommendations for proper marketing of forensic science delivery while critically analysing its present state in England and Wales. Basically, "*forensic science develops and is constrained by the jurisdiction within which it operates" p.386[6].*

The society in which we live in has steadily increased its dependency on scientific and technological advances in so many areas especially in communication and health care[45, 46]. In like manner, the investigative processes in the CJS have also been influenced to a degree by changes in science and technology [47-50]. The extent to which these scientific and

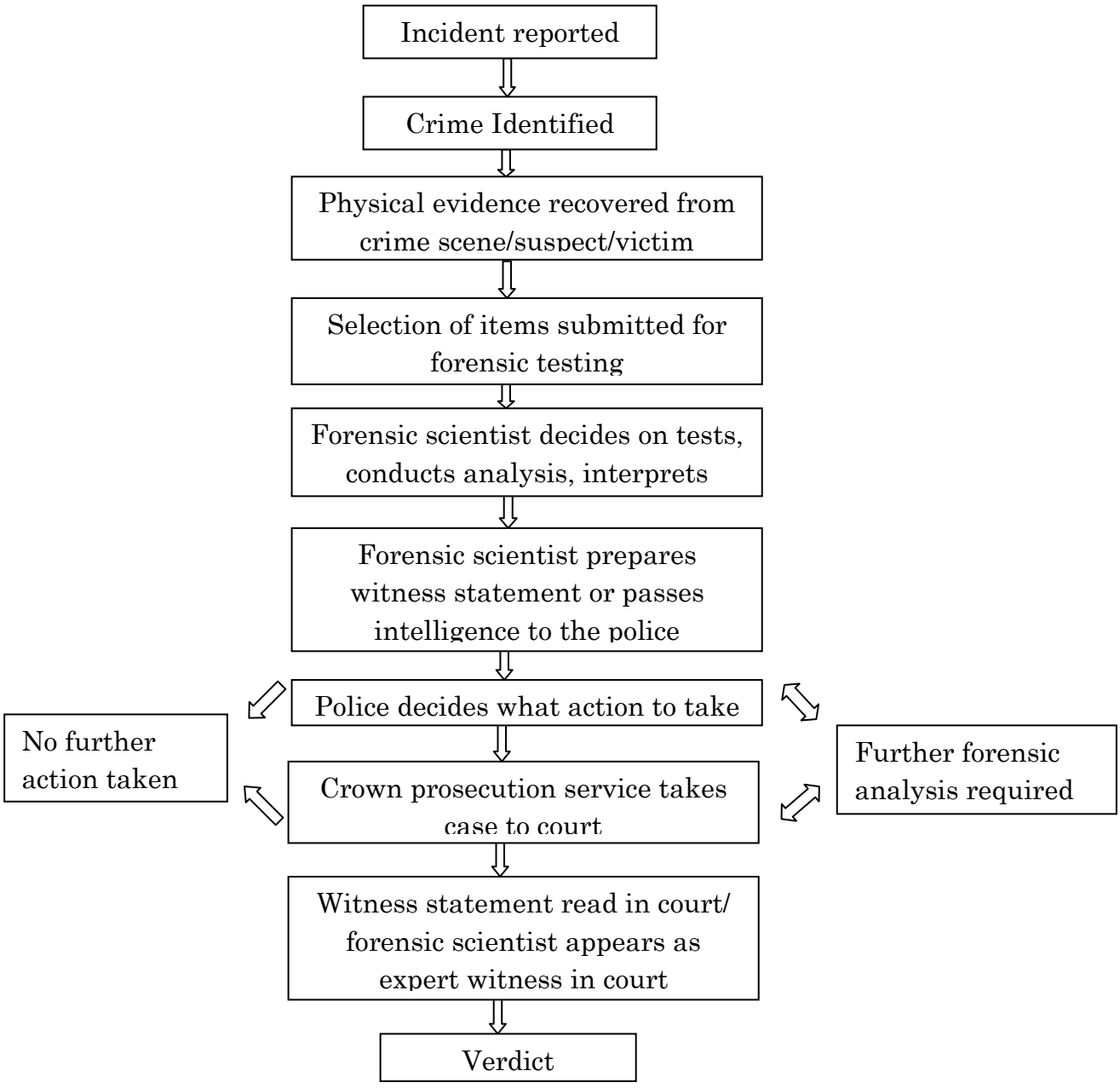

Figure 2: Forensic Science in Criminal Investigation[51]

technological advances have impacted on criminal investigations are based on the expectations that they will "*improve effectiveness and efficiency, [...] satisfy the demands [...] and meet the requirements of new forms of police management and accountability"[50].* Forensic science as an investigative tool employs these advancements in assisting the

criminal justice process. This area of practice which primarily involves the recovery, analysis and interpretation of evidence found at or related to scene of crimes for assisting investigative processes has served as an investigative tool for police investigations for many years[52]. As the Touch Ross report predicted in 1987, "*technological developments including major breakthroughs such as DNA profiling [has] enhance[d] the contribution that can be made"* through forensic science[53].

According to the American Society of Crime Laboratory Directors/ Laboratory Accreditation Board (ASCLD/LAB)[40],forensic science is composed of the following specialised units; biology (serology and DNA analysis), controlled substances, crime scene, digital and multimedia evidence(computer forensics, forensic audio, video analysis, image analysis), firearms/tool marks, latent prints(development and/or comparison), questioned documents, trace evidence (explosives, fires, fire debris, glass, gunshot residue, hair, paint, soil), and toxicology. Other specialised units include forensic accounting[54], forensic anthropology[55] and forensic entomology[56]. The forensic scientist/examiner specialises in one or more areas of forensic science which involves the analysis of physical evidence to produce forensic intelligence and or evidence for the police and the courts respectively[42].According to the United Nations Office on Drug and Crime (UNODC), physical evidence refers to *"anything from massive objects to microscopic items, generated as part of a crime and recovered at the scene or at related location"[57]* while forensic evidence has been defined as *"facts or opinions proffered in a criminal case that have been generated or supported by the use of one, typically by more than one, of the corpus of forensic sciences routinely used in criminal prosecutions"[58].* The impact that can be made by the use of physical evidence in criminal investigations is usually limited by the knowledge and context interpretation of its users[9].

Historically, forensic science was used in a more reactive rather than proactive manner [9] in criminal investigations. Reactive, in that it was used only when a crime had been committed while proactive here implies that the use of forensic science in investigation is not limited to use after a crime had been committed but used to prevent the commission of crime. The application of forensic intelligence [26, 59] is an example of proactive use of forensic science. Forensic intelligence has been defined as *"the accurate, timely and useful product of logically processing (analysis of) forensic case data (information) for investigation and/or intelligence purposes"[26]*. Bell[60] in an attempt to describe how forensic intelligence could be used in determining effectiveness and efficiency in the use and delivery of forensic science in criminal investigation classified it into two parts; intelligence delivery in forensic casework and business intelligence (*information required to manage the business of delivering forensic services, particularly at an operational and strategic level*). Ribaux et al[26] argued that the use of forensic science is limited by utilising it only as an evidence producing tool for court purposes. The following statement captures the crux of the matter;

> [T]here is evidence that forensic case data could contribute more valuably to the provision of intelligence: it is recurrently discovered retrospectively, that all the information needed was previously in the files and could have been proactively used in order to solve the case earlier. p.171

Although commentators in the field of forensic intelligence have shown the potential of applying forensic intelligence to criminal investigations[26, 60], Ribaux *et al[61]*noted that;

> The difficulties in measuring the efficiency of forensic science in terms of intelligence-led policing may be a reason why the delivery of integrated forensic intelligence has failed to find its place within

> economical models that tend to drive most organisations: the creation of useful intelligence products based on traces may be an illusion in most sub-disciplines of forensic science. p.15

Advancements in science and technology have contributed to the way forensic science aids criminal investigations by police forces internationally with noticeable impacts in jurisdictions such as the UK, the USA and Australia[37, 42, 62]. Police forces increased employment of forensic science in criminal investigations following these technological and scientific advancements such as the discovery of DNA profiling in the mid-1980s and subsequently the developments of DNA databases such as the CODIS[63] and the NDNAD in 1995[64]. The NDNAD for example since its discovery has undergone a number of changes and advancements (such as the PoFA[2] in 2012 that requires destruction of a DNA sample within six months of its collection[65]), from its management by the Forensic Science Service (FSS) long before its closure in 2012 to its current management by the Home Office through the Home Office NDNAD Delivery Unit in order to improve and maintain its effective and efficient use in criminal investigations[66].Other databases include NAFIS (fingerprint) and NIBIN (ballistics).

However, more than five years after the introduction of DNA profiling, a report by the Audit Commission showed that *"the level of recorded crime in England and Wales rose by 74% in the decade to 1992"* with a *"decline in clearance rate by the police to 26% from 37%"*. Almost a decade after the creation of the database, the range of detection rates between 2003 and 2012 seemed to appear similar: 2012/13 (27%), 2011/12 (27.3%), 2008/09 (28.5%), 2003/04 (18.4%). These statistics appears not to differ so much to an Australian research in2001[67].Despite the assumption that technological advancements could increase detection rate, the available

[2] Protection of Freedom Act was enacted in 2012 in the United Kingdom. This act consists of seven parts of which regulation of biometric data is one.

statistics appear to contradict this assumption. However, it is important to state here that certain factors also influence these statistics such as changes in how crime is being recorded. For example,

> [T]he implementation of the NCRS[3] in April 2002 is thought to have had an inflationary effect on recorded crime and the assumption is that it has depressed detection rates since additional recorded crimes are generally less serious and possibly harder to detect. p.31[68]

In addition to the changes in the recording system, the general complexity of the CJS poses a difficulty in robustly relating these statistics with how much impact forensic science plays generally in the criminal investigative process[27, 69]. As Bradbury *et al* rightly opined *"understanding the actual contribution of forensics to detections is [...] complex"[70]* and *"the value of forensic science relative to the work involved and the outcome of cases [is yet] to be established"[37].* This appears to be an international phenomenon where forensic science is used in criminal investigations[71].

In a broad context, effectiveness here refers to *"the degree to which objectives[*set by forensic science providers and users*] are achieved and the extent to which targeted problems*[exonerating the innocent and conviction the guilty within the ambit of the law*] are solved"[72]* whereas efficiency *is "the comparison of what is actually produced[*criminal justice outcomes*] or performed with what can be achieved with the same consumption of resources (money, time, labour, etc.)"[73].* For example, "*quality investigation [*all available resources put into use including forensic evidence*] is a fundamental component of effective policing[74].*The important issues are therefore to what degree forensic

[3]National Crime Recording Standard is a standard for recording crimes in accordance to the law which was introduced in England and Wales in 2002. It is geared towards maintaining consistency in the recording of offences across forces.

science is used in different jurisdictions, for what purpose and what impact it makes at different stages in the investigative process[75].

In general terms however, scientific and technological advancements (previously mentioned) have led to a greater awareness of the potential of forensic science amongst the criminal justice actors who are involved in criminal investigations. In spite of the increased awareness of forensic science, certain factors such as poor and insufficient forensic training appears to impact on its effective and efficient use[70, 76]. A review by Ludwig and Fraser concluded that certain factors appear to recur in volume crime investigations[77]. The review which consisted of reports published from 1986 to 2011 indicated that these recurring themes appeared to hinder effective use of forensic science in volume crimes despite technological advancements[77]. Having acknowledged the complexity of criminal investigations within the CJS, the authors identified seven main factors that appear to hinder the effective use of forensic science in volume crime investigations.

In the context of this research, the effective and efficient use of forensic science in criminal investigation entails various factors. Firstly, that forensic science resources (e.g. forensic methods or techniques) are used in criminal investigations to apprehend offenders and generate intelligence[26]. Secondly, that these resources are employed in such a manner that their cost is minimised whilst maximising time and resources. This is achieved by identifying where, when and how forensic science may be applied in the process of criminal investigations[37]. This also implies that all the actors involved in the criminal investigative process are made aware of what forensic science is and its potential in criminal investigations [6, 9, 57].

It is important to emphasize, moreover, that despite the many advances in technology and the forensic sciences that have

> occurred in recent years, clearance rates, whether at the individual agency or the state and national levels, remain relatively stable. For certain violent crimes, moreover, those rates are declining in some locations, even in the face of more and better technological improvements and personnel enhancements[35]p.7.

This present research reviews both academic and non-academic literatures in light of the recurring themes discussed in Ludwig and Fraser[77] as it relates to the use of forensic science in major crimes investigations. Despite the paucity of literature on this topic, research so far has shown that some of these factors appear to occur in major crimes investigations [76, 78, 79] but the question of recurrence would be addressed in the following chapters. However, in relating the findings of Ludwig and Fraser to major crimes investigations, the differences between volume and major crimes are considered.

1.2 INVESTIGATING VOLUME AND MAJOR CRIMES

Forensic science in the investigation of minor or volume crimes was underutilised until in recent times[70, 80, 81]. Since its increased use, a report has shown by Bradbury[70]that forensic science contributes *"to a greater proportion of volume crime detections"* in the UK. These crimes are termed 'volume' because they occur more frequently whereas major or serious crimes as the name implies reflect the severity of these criminal activities [82]. Severity in this case does not only describe the activity or harm done but it is determined also by the criminal act of the given jurisdiction[82, 83]. In the UK (except Scotland) for example, the following crimes have been classified as volume crimes; street robbery, burglary – dwelling, burglary non-dwelling, theft (including shoplifting), vehicle crime - theft of, vehicle crime - theft from, criminal damage and drug trafficking (link with acquisitive crime)[84]. In contrast, murder and rape are examples of major/serious crimes[42, 78]. Due to the severity and high profile nature of major crimes enquiry, the police are usually

faced with pressure from the public[85]. The urgency associated with these crimes was captured in Becker's statement *"offences like murder and rape should be solved more frequently and punished more severely than milder offences like auto theft and petty larceny"p.44[86].* Homicide for example "*consistently receives extensive criminological and public attention. It also commands intensive police attention"[87].*

The use of forensic science in criminal investigations for volume and major crimes differ in operation. In major crimes, forensic science is applied in a case by case method and therefore in great detail. The investigation of major crimes are generally characterised by the *"use of ...structured assessment in the selection and submission of evidence for testing and recovery"[88].* Due to the greater number of cases associated with volume crimes, applying a case by case approach would not be cost effective bearing in mind the limited resources available[42, 85]. This entails therefore that frameworks for selecting and prioritising cases are put in place. High levels of expertise must be employed in the investigation of major crimes. This is largely to the fact that *"major crime[s] comprise[] the most serious incidents of violence and death investigated by the police"[89]* and are complex in nature[78]. Major crimes investigation may involve complex collaborations between teams of detectives, crime analysts, forensic scientists, pathologists, behavioural experts and Scene of Crime Officers (SOCOs) who require investigative knowledge of forensic evidence [76, 78, 89].

> The more serious the matter [...] the more likely the personnel involved will be multi-disciplinary (police, medicine, law, forensic science), and multi-organisational (Health, Justice, private legal/medical, police) p.8[90].

Ideally, every criminal investigation is apportioned relevant resources to achieve expected justice outcomes however "t*he investigation of crime, in*

*particular major and serious crimes, is a dynamic process that requires structured management to ensure the effective use of resources, to manage risks and to optimise outcomes p.144[91].*On the contrary, volume crime investigation is characterised with an underlying assumption by *"officers that volume crime offences are less serious, difficult to detect and that merely recording the details of them is sufficient"[84].* In England and Wales for example, guidelines for the investigations of volume crimes have been set out by the Association of Chief Police Officers (ACPO) in order to guide allocation of relevant resources and achieve expected outcomes. However, as mentioned earlier in this discussion, there appears to be less use of scientific support in volume crimes investigations in practice although improvements have been made over the years [47, 70, 80].

1.3 SUMMARY OF THEMES IDENTIFIED IN LUDWIG AND FRASER**[77]**

In this section, six major themes identified by Ludwig and Fraser[77] to recur in volume crime investigations are summarised. The review of major crimes investigation in chapter three is based on these themes while due consideration is given to the differences in dynamics between the two crime classifications.

1.3.1 POOR COLLABORATION

Barclay's assertion that "*the power of forensic science to facilitate the administration of justice is [...] entirely dependent on the ability of the police and the others to use it effectively*"[78] implies that there ought to be effective collaboration between actors in the CJS. The CJS is made up of actors such as the police, forensic science providers and prosecutors [10, 19, 77, 92]. Successful activities within the CJS are achieved when the various actors collaborate in achieving the aim of the CJS[77, 93]. Contrary to this expectation, Ludwig and Fraser[77] discovered that

collaboration between the police and forensic science providers was found to be insufficient. One of the major reports reviewed showed that poor collaboration affected case turnaround times, interpretation of result and how efficiently cases progressed to the court[94]. Better collaborations appear to facilitate the processes that lead to detection and prosecution of offenders thereby giving closure to victims[77].

1.3.2 POOR COMMUNICATION

Communication between the police and forensic science providers was found to be poor in volume crime investigations[77]. For example, investigators did not always update the forensic scientist in the laboratory with new information regarding cases being worked on[77]. This was evidenced in one of the statistics published from a major police force that *"30% of cases which no longer required work were still being worked on by scientists"[95].* Poor communication was also discovered to impact on the number of work referred to forensic providers by the police. Feedback was mostly given in cases where forensic evidence helped in apprehending the offender either by identification or providing intelligence. However, limited feedback was given on forensic evidence which did not play such roles as a result of use of other investigative methods. This form of feedback has got its limitations in that the full impact of forensic evidence in criminal investigations cannot be robustly examined[77]. Tilley and Ford observed that *"feedback on cases is currently poor"* and also recommended that scientist should *"strengthen links with the legal profession"[96].*

1.3.3 POOR FORENSIC KNOWLEDGE AND LIMITED TRAINING

Regardless of the increased use of forensic science in volume crime investigations, the reports reviewed by Ludwig and Fraser showed that there was poor forensic knowledge amongst forensic science users i.e. the police investigators and crime scene examiners (CSEs)[77]. Poor knowledge exhibited by these actors could be attributed to the forensic

training which was also suggested to be poor by the authors[77]. Length of training and course content varied amongst agencies both for refresher and beginners courses. Proper and sufficient forensic training would help provide forensic users with the forensic knowledge needed for criminal investigations [9, 77, 94]. For example, CSEs would be better informed on what type of evidence to collect as quickly as possible to avoid degradation, loss or contamination such as in the case of a 'DNA' sample[81, 97]. Most of the information the officers had on forensic science was either from external formal course work, Forensic Science Service (FSS) publications, 'on the job experience' or personal study[98].

1.3.4 LIMITED RESOURCE ALLOCATION AND TASKING OF CRIME SCENE EXAMINERS (CSEs)

Ludwig and Fraser stated that *"appropriate deployment and utilisation of resources is an essential aspect of an effective investigation"[77].* Providing adequate resources such as deploying CSEs to a crime scene could impact on the outcome of the investigation[99, 100]. Police forces task their CSEs differently and this did not always reflect peak crime times or size of the police force[77].For standardisation purposes, HMIC recommended the employment of blanket or discretionary methods of tasking CSEs to scenes of crimes[52, 94].The human resources required for effective investigations were found to be insufficient[77].

1.3.5 POOR TIMELINESS

Timing is an essential component in all stages of the investigation. Here, the authors discussed the impact of quick attendance to crime scenes and turnaround times for laboratory results. Some studies have shown for example that crimes reported while in progress had a higher chance of being detected[77, 101]. The time between when a crime was committed and when it was reported and the scene subsequently examined has a significant impact on the value of forensic evidence that may be recovered[27, 57]. This factor addressed the *"importance of timeliness for*

the utility of forensic evidence and the value of the intelligence for police investigations"[77]. In essence, the quick recovery of physical or trace evidence from the scene and subsequent laboratory analysis determines the value or role forensic science plays in the criminal justice process. For instance, receipt of a DNA result after an offender has been apprehended by one or more investigative methods such as eye witness and confession.

1.4 POLICE AND TECHNOLOGY

The dynamic and flexible nature of technology has resulted in great advancements through the 19th century to this present time[45, 46]. Advancements in technology have come with expectations of increased effectiveness and efficiency in different fields of life[45, 102]. Unfortunately, with the advantages came also increase in technology assisted crimes[103] and because *"police work is determined by the conditions of our society and its people"* p.11[102], police use of technology increased such as in the use of Computer Aided Dispatch and Mobile Digital Terminals(MDTs) technologies. As far back as the mid 1960's, the use of technology by the police had already been recorded to have increased. However, by the late 1970's, it was observed that this growth in usage was slower than previously predicted[102]. This may be explained by the fact that *"despite these advances, investigators are frequently required to practice the art of investigation, that is, to rely on skills acquired by experience, study and observation rather than on scientific principles"[2].*

Police use of technology has been studied by various scholars [24, 48, 49, 104, 105]. These authors agree that technology has impacted on policing in certain ways which have resulted in visible changes although Koper *et al* observed that *"research on police technology is not well developed"[106].* These changes however are seen in varying degrees depending on individual police forces studied. As one of the major actors in the CJS, the police are by far the main users of forensic science in the investigative

process[84, 107]. The bulk of impact on how forensic science is or not utilised within the investigative process lies on the police[42]. The police have been observed to *"spend[] vast sums on technology [including forensic] in the hopes of improving their efficiency and effectiveness"[106]* and this appears to be as a result of the *"strong belief (among both police and citizens) in its potential to enhance policing"[106].* The police have employed scientific and technological tools to;

> identify and monitor offenders; facilitating the identification of places and conditions that contribute disproportionately to crime; speeding the detection of and response to crimes; enhancing evidence collection; improving police deployment and strategies; creating organizational efficiencies; enhancing communication between police and citizens; and strengthening the ability of law enforcement to deal with technologically sophisticated forms of crime[106].

However, *"greater forensics capabilities […] does not seem to have improved clearance rates for criminal investigations"[106].*In practice, factors such as complexities associated with changes in technologies or adapting to new ones and the tendency to favour technologies that support reactive policing have inhibited maximal utility[106]. Best practices would likely involve agencies modelling their use of particular technologies on the context of their environment through pilot studies and rewarding of officers/staff who employ technologies for proactive policing[106].

According to Chan, technology has *"created new cultures of policing"*[50]. Despite the creation of these *'new cultures',* a greater consensus of scholarship agree that existing police cultures have hindered technological implementation [48, 102, 108]. In an interview conducted by Colton, an officer opined that *"the result of the computer may be to take*

*our minds off what are the more important issues"*p.18[102].With such a mind-set, it would be unsurprising to encounter 'resistance' among police officers to the use of technology in carrying out their duties. Technologies that aided clear up rates rather than proactive policing have been found to be readily embraced by officers[50]. Factors that have been observed to promote the use of technology include; ease of use and usefulness[108]. Timeliness and information quality were also observed to influence acceptance of a particular technology [108]. For example, any technology that produced information in real time that leads to apprehending offenders in the very act was optimally maximised. It is important to note that "*factors beyond the technology itself, such as the influence of peers and involvement of operational officers in technology investment decisions, must be considered to accommodate the strong cultural barriers in policing[49].*

Information regarding what a particular technology does, how it works and why it ought to be used in the context of policing should be effectively communicated to police officers if positive results are to be achieved because "*technology both shapes and is shaped by organisational routines and structures"[105, 108].* In this regard, for effective and efficient use of forensic science by the police in criminal investigations, it is paramount to consider ways in which these 'organisational routines' and 'structures' can be manipulated in order to communicate the potential of forensic science. This research does not discuss this in details but attempts to make recommendations in terms of police use of forensic science in major crimes investigations.

1.5 RESEARCH AIMS

This research aims to explore the factors affecting the use of forensic science in major crime investigations by;

- Comparing major and volume crimes investigations with regards to the recurring factors found in Ludwig and Fraser[77]. Bearing in mind the different dynamics in the two types of crime classifications, different outcomes are expected with regards to these limiting factors. For example, in earlier discussions, it has been suggested that more resources are channelled to major crimes investigations due to their severity. However, does this imply that adequate resources are deployed in major crimes investigations?
- Reviewing existing literatures (predominantly in UK and USA) to determine if the recurring factors found in Ludwig and Fraser apply to the use of forensic science in major crimes investigations. Exploring literatures beyond one jurisdiction (country) could also create a platform for comparison in order to determine best practices.
- Identifying (if any) recurring factors which affect the use of forensic science in major crimes investigations which appear inapplicable to volume crimes investigations. The difference in investigative processes between major and volume crimes investigations would entail differences in challenges encountered. This could therefore result in factors which would affect major crimes investigations and insignificant or nonexistent in the use of forensic science in volume crimes investigation.
- Exploring the relationship between the police and the use of technology as it applies to major crimes in investigations. This would attempt to discover the factors which either hinder or encourage police to employ forensic evidence in major crimes investigations. This is important as it may shade some light on the perspective of the police on the use of forensic science. Do they view forensic science as an asset in the scheme of things or a liability?

CHAPTER TWO: METHOD

2.0 SCOPE OF REVIEW

This section outlines the methods utilised in the search and appraisal of the literature included in the review. The limitations of the review are also discussed. The inclusion and exclusion criteria for the studies selected for the review were defined based on the recurring themes discussed by Ludwig and Fraser[77] in the context of major crimes investigation. Due to variations in the definition and classification of crimes within jurisdictions, the major crimes investigations considered in the discussions contained in this review are limited to homicide, armed robbery, sexual assault and rape.

Due to the paucity of robust literature on the impact of the use forensic science in major crime investigations, the criteria were selected to include as wide a range of potential sources as possible. As van Asten opined "*interestingly not many […] publications can be found in recent scientific literature discussing and proposing challenges, strategies, missions and visions for forensic science*"[109]p.17. The articles chosen for this review covered a 40 year period (1975 to 2015). This timeline was considered in order to explore the impact of technological and scientific advancements as it relates to the use of forensic science in criminal investigations. Over 90% of the articles reviewed were research carried out in the UK and USA. These comprised of both academic and non-academic sources. The feasibility of comparing data across countries is due to '*strong consistencies*' in the way forensic evidence is employed internationally[9].

> "increasing internationalisation of crime and policing, the avowedly universal character of scientific knowledge and the increasing rate of knowledge transfer across national boundaries" p.2[42].

2.1 SELECTION CRITERIA AND STRATEGIES

The studies[4] chosen for the review were therefore based on the following criteria:

- Studies that discussed the use of forensic science in volume crimes investigations which included specific mentions of the use of forensic science in any type of major crimes investigations.
- Studies that examined the use of forensic science in the criminal justice process in general (i.e. its use in both major and volume crimes investigation).
- Studies that focused only on the use of forensic science in major crimes investigations.

Furthermore, the articles chosen for the review were not limited to research based on primary data but also included sources that discussed the use of forensic science criminal investigations based on secondary data. In addition to the outlined criteria, the articles chosen for this review were also streamlined based on themes discussed by Ludwig and Fraser[77]. This is to say that, only articles that discussed one or more of the themes found in Ludwig and Fraser[77] were included in the review.

2.1.1 EXCLUSION CRITERIA

Further analysis was carried out on the available literature to exclude the following;

- Studies on any of the four major crimes listed earlier which did not contain at least one of the factors suggested by Ludwig and Fraser.
- Studies from jurisdictions where the forensic science has reportedly been employed in criminal investigations.

2.1.2 SEARCH TERMS AND DATABASES

- Criminal investigation+
    - Major crimes

[4] Studies here refer to all literature employed in the review and these include academic research articles, government reports and reviews.

    - Homicide
    - Murder
    - Rape
    - Robbery
    - Assault
    - Volume crime
- DNA +
    - DNA database + Innocence Project
- Forensic +
    - Collection
    - Evidence
    - Investigation
    - Science
- Evidence types
    - DNA, fingerprints e.t.c
- Forensic Science Service
- Impact of Forensic Science/ Evidence
- Police + forensic science

Information sources:

- Academic Journals
    - Forensic Science International
    - International Journal of Police Science & Management
    - Journal of Forensic Science
    - Science & Justice
- Athens: ISI Web of Knowledge
- Home Office
    - Police Research
    - Science & Research
    - House of Commons
- Internet search engine – Google and Google scholar.

- National Institute of Justice (NIJ)
- Science Direct
- University of Strathclyde Library

2.2 DEFINITION OF THEMES

For the purpose of this review, the themes discussed in Ludwig and Fraser are examined in light of major crimes investigation based upon the following definitions:

- Insufficient Communication

  Communication in its simplistic form is a "*meaning-making process*" [60]. For the purpose of the discussion on the use of forensic science in major crimes investigation, the theme 'insufficient communication' encapsulates lacking , improper or underutilisation of effective communication channels between the forensic science users (the police in particular) and forensic science providers.
- Insufficient Collaboration

  This theme addresses how well these personnel and agencies interact and combine resources during investigations for effective justice outcomes.
- Poor Timeliness

  Poor timeliness here refers only to turnaround times for laboratory result. The time taken for evidence to be analysed in the laboratory and the police receipt of results for investigation to be used as evidence or intelligence .
- Insufficient Resourcing

  This addresses the issue of how much funds, staff and scientific/technological resources are available for the investigation of major crimes.
- Insufficient Knowledge

The level of knowledge in terms of 'forensic awareness' amongst the users of forensic science. This includes specialist or general knowledge on the potential and role forensic evidence plays in the investigative process.

- Insufficient Training

  The question addressed by this theme borders around how much forensic training forensic science users are exposed to, how structured and relevant they are to criminal investigations.

2.3 LIMITATIONS OF THE REVIEWED LITERATURE

Literature on the use of forensic science in criminal investigations appears somewhat readily available. The major setback being that majority lack detailed statistical analysis. Furthermore, an estimated fifty percent of these readily available literatures do not address the quantifiable impact of forensic science out criminal justice outcomes. Most of the academic research which is statistically robustly sound addresses uses of forensic evidence and not their measured impacts on case outcomes. This is to say for example that robust data is easily available on how DNA can be used in criminal investigation rather than on the impact it makes on case outcome.

The corpus of the reviewed literature when put together compliments each another. However, some of these studies reviewed as part of this research contained a number of limitations. The research carried out on some of these studies was carried out on small sample sizes, selected police forces[27, 52, 110] and particular agencies such as the FSS[53, 111].In some cases, the conclusions drawn were not based on research specifically designed for the investigation of major crimes. Most available literature such as in homicide investigation are based on the "*subjective experience of the author"[67],* i.e. not based on sound empirical methodology[112, 113].

The sample size of reviewed literature is small. However, certain factors appear to be significant. First and foremost, about 85% of the reviewed literatures in the United Kingdom are policy/government research/report. This could indicate that academic researchers do not have access to CJ personnel and data for analysis on the impact of forensic science on criminal investigations (See Table 1). The likely limitation being that academic researchers who are equipped with robust statistical methods are not afforded adequate opportunity to fill the vacuum in the research of forensic science impact. Beyond the literature reviewed, academic researchers have contributed more to analysing and expanding the scope of the uses of forensic evidence especially DNA, fingerprint and bloodstain pattern analysis. This also appears to be the case in the literature reviewed in the United States.

Having selected four types of major crimes, the possibility of comparing the degree of employment of forensic science in their investigations are considered although bearing in mind that caution must be taken in making conclusions due to the small sample size analysed. See conclusion chapter for more discussions.

CHAPTER THREE: REVIEW OF LITERATURE

3.0 INTRODUCTION

Advancements in scientific and technological processes and methods appear to impact on the way criminal investigations are carried out. *Yet what appears to be missing from the literature is how often such technologies and procedures are used and under what circumstances such methods may be most fruitful[99].* Forensic science in particular has played important roles in notable major crime cases such as the James Lloyd case (shoe rapist)[114] in the UK and Sara Lynn Wineski murder in 2005 (USA)[115]. Increased use of forensic evidence in the criminal justice process has also been linked to a particular type of policing model; intelligence-led policing[116]. In Ratcliff's definition;

> Intelligence-led policing is a business model and managerial philosophy where data analysis and crime intelligence are pivotal to an objective, decision-making framework that facilitates crime and problem reduction, disruption and prevention through both strategic management and effective enforcement strategies that target prolific and serious offender p.3[117].

With its emergence in the early 1990s, intelligence led policing has been geared towards improving the effectiveness and efficiency of policing in the CJS[118, 119]. Although research indicates that its full impact in the criminal justice process has been hindered in part by historical and cultural effect of environments where it is being adapted[120].

The first convictions based on a DNA evidence happened in 1987 both in the UK and USA[121]. The perceived impacts made by forensic science in criminal investigations have been widely recorded[25]. From providing evidence or intelligence used in the *"conviction of the guilty and exculpation of the innocent"[122]*to the reconstruction of crime scenes[123], forensic science has to a degree influenced the way criminal

investigations are carried out. Attempts have been made by different authors to examine its impact [27, 76, 124]. At the time of writing, a five year project had been initiated in Australia to study the value of forensic science in criminal investigations[37].

Following 'landmark' studies such as Greenwood and Petersilia [101] in the USA and the Touche Ross report[53] in the UK, robust and systematic research into the impact of the use of forensic science in major crimes investigations are few and scarce across readily available literature databases. In a directive given by the United State of America's Congress in 2005, a team was employed to review the impact of forensic science on the criminal justice system[62]. This research has been widely cited across both academic and government research literature [27, 125, 126]. The research highlighted issues affecting the use of forensic science in the USA CJS which included poor training and poor knowledge of forensic science amongst its users. In concluding remarks, they opined that "*substantial improvement"* was imminent in the use of forensic science. Another study carried out in the USA around the mid-2000s also showed that contrary to popular perception of the use of forensic science in serious crimes investigation,

> Forensic evidence not only goes unexamined in unsolved cases, but in the vast majority of all assault, burglary, rape, and robbery incidents. Only a small fraction of available forensic evidence present at scenes of serious crime is submitted to forensic crime laboratories and undergoes examination p124 [27].

Pre- DNA profiling era studies such as Greenwood and Petersilia[101] and Chaiken *et al[7]* showed that major crimes investigations such as homicide and rape received more resources both scientifically and otherwise as it were when compared to volume crimes. However, the clearance of these cases was mostly as a result of traditional investigative

methods rather than scientific evidence. This included eye witness identification or an offender being caught in the very act. However, both research papers showed that physical evidence was usually collected by the police but were more than can be "productively processed"[101].The physical evidence collected consisted mostly of latent fingerprints and were usually matched to suspects in 4 to 9 percent of the time[101]. Chaiken *et al[7]* observed that the collection of physical evidence from criminal activities did not automatically help in clearing of cases unless evidence process capabilities were adequate. They however, believed that there was potential in the use of fingerprint evidence and recommended more training and collaboration between fingerprint examiners and investigators. Another research study in the USA was carried out by Peterson *et al[28]* few years after these earlier studies. Peterson collected data between 1980 and 1982 on 1,600 cases where physical evidence was collected and subsequently examined and 1,100 were physical evidence had not been employed in the investigation. Peterson *et al* showed that scientific evidence played significant roles in cases of robberies when traditional investigative methods could not play any role i.e. no witnesses or suspects available to be interviewed. Despite the improvement in the use of scientific evidence in criminal investigation, it was observed that there was poor scientific knowledge amongst the police investigators. Apart from fingerprints, blood analysis to determine genotype were commonly used as scientific evidence in the investigation of cases[127].

The Touche Ross report[53] in the UK also observed that more time and resources are allocated to the investigation of major crimes than volume crimes. According to this report, 80 to 90percent of laboratory time is dedicated to analysing evidence from major crimes especially in murder enquiries. Due to the policy by the forensic science laboratory to encourage restriction to number of items submitted for examination, police prioritised evidence from major crimes. Available resources to

crime investigations were insufficient as crime rates were shown to be on the increase. Expectation was high for the advent of DNA technology in criminal investigation as its technology was being developed at the time Touch Ross report was published.

However, post DNA profiling and database era, studies continue to show that more resources are allocated to the investigations of major crimes when compared to volume crimes investigations[70, 76] especially in murder cases[128, 129]. In practice, murder of all the major crimes receives more attention in terms of investigative resources. For example, Peterson *et al[27]* in their research found that32% of reported rape cases had forensic evidence submitted to the lab while 89% of reported homicide cases had forensic evidence submitted to the lab for analysis[25].

3.1 IMPACT OF FORENSIC EVIDENCE

Forensic science has contributed to crime reconstruction by giving information on source and activity levels[109]. Source level describes the origin of forensic evidence while the activity level seeks to infer what action(s) could have led to the production of such forensic evidence. For instance, a DNA profile match between a swab sample collected from the neck of a strangled victim and buccal swab from a suspect shows origin of the DNA (source level). The location of the evidence indicates the kind of activity (contact with victims neck) that could have resulted in the deposition of the evidence between the victim and offender (activity level).As far back as the 1990s, application of forensic science in criminal investigations was observed to increase clearance and convictions rates on burglary and robbery[9]. Although these publications were based on published crime statistics in the USA, similar results have also been observed in other jurisdictions where forensic science is used[70, 130].

Forensic evidence has been shown to impact on charges and sentencing of offenders. It has been shown that "*laboratory examined forensic evidence increased the odds of DA[5] charges by over five times [27].* Peterson *et al* also showed that "*the conviction rate for the cases with linking forensic evidence was significantly higher than cases without such evidence. Furthermore, conviction rates were higher for offenses with two or more forms of individualizing evidence that associated offenders with crime scenes[27].* However, "*forensic science analysis and police secured evidence have little effect upon a prosecutor's decision to charge a suspect unless courtroom savvy scientists or witnesses possess the skill to compel others that the information they have is reliable and can play a leading role toward the conviction of a suspect"p.47[131].*

3.2 COMPLEXITY OF INVESTIGATION

The paucity of literature associated with the impact of forensic science use in the investigation of crimes could stem from the complexity of the investigative process as a whole. The processes involved in criminal investigations are entwined in a 'matrix' of complex activities and interactions especially in major crimes investigations. In an attempt to explain this complex process, Innes divided the investigative process into three categories which he called 'movements'. 'Identifying and acquiring', 'interpreting and understanding' and 'ordering and presenting[3]. In terms of research, more emphasis has been laid on the investigation of less serious crimes due to their volume and also there seem to be higher detection rates in major crimes investigation when compared to the volume crimes.[3]

> "We [...] presume that the policies, processes and practices that are employed in homicide investigations are reasonably effective- although, of course, it does not follow that they are efficiently run" p.272 [3].

[5] District Attorney

Based on the recurring themes identified in the review carried out by Ludwig and Fraser[77], this section reviews the literature which addresses the use of forensic science in the investigation of major crimes. In addition to these, one more theme is discussed which appears to impact on the effective and efficient use of forensic science in major crime inquiry specifically.

3.3.1COMMUNICATION

Effective communication amongst police officers and other actors within the CJS is a crucial element to the effective and efficient use of forensic science in criminal investigations [69, 90, 93]. However, sufficient communication between the police and forensic science providers appear to be more important. This is because not all cases end up in court or offenders in prison therefore not involving all other actors in the CJS. Tilley and Ford[96] observed insufficient communication between the police and forensic science providers which was not limited to volume crime investigations alone but criminal investigations in general. Although another instance by the authors involved the infrequent informal contact between the Crown Prosecution Service (CPS) and forensic supplier[96], this area does not fall under the remit of present review. Forensic scientists and Officer in Charge (OIC) interaction was observed in 44% of 150 cases studied by Tilley and Ford which was less than half of the cases studied[96].

Nicol*et. al[76]*observed also that internal (within the criminal justice system) and external (the media, public, victims) communications were found to be areas of weakness in a significant number of reviews. This observation was based on the result of their research into the reviews carried out on 34 unsolved homicide cases. The type of model adapted by forces in the supply of forensic science impacts on communication. For example, the model used in New Zealand as shown by Briody[132] highlighted the limitations associated with the police working alongside

an independent and autonomous laboratory which resulted in limited communication and collaboration.

> The tremendous variation in death investigation systems also impedes interagency and interjurisdictional communication and the development of standardized best practices both in death investigation and in the performance of medico legal autopsies[62].

Cronin *et al* suggested that *foster[ing] a balanced relationship between labs and police … ensure[s] greater case management of evidence and open communication.[121].*However, some commentators are of the opinion that there should be a distinct distance between the forensic scientist and the investigator. Evidence of contextual bias in the interpretation of results has been shown to be a result of unfiltered information received by forensic scientists from investigators [133, 134]. In response to this limitation, sequential unmasking[135, 136] and the use of case managers[133] are two of the recommendations for reducing such bias. In this approach, the case manager *"maintains a global view on a specific case and distributes tasks to specialised forensic analysts, by shielding them away from contextual influences and knowledge emanating from other pieces of evidence"[133].*The role of a Specialist Advisor[6] has also been created in the UK to bridge the gap between the investigators and laboratory scientists[78].

In a recent study in Australia by Kelty *et al*[90] into a phenomenon they described as 'silo effect', they observed that partial silo effect existed amongst some criminal justice actors involved in the investigation of homicide and sexual assault cases. This silo effect was described by the authors as *"an absence of meaningful and regular communication between the forensic sciences, forensic medicine, law and police"*[90]. They made a

[6] The Specialist Advisor was a role pioneered in the late 1990s by the then Forensic Science Service but was updated to Major and Critical Incident Investigator around 2010. This role primarily involves formulating forensic strategies in major inquiries.

number of recommendations for better practice amongst criminal justice actors which include; a clear purpose for any group to meet, having defined roles and responsibilities, commitment and support backed up by inter-agency agreement, clear and adequate recording and dissemination of information[90].

3.3.2 COLLABORATION

Improved collaboration among criminal justice actors such as the police and forensic science providers has been suggested as a means to improving the forensic knowledge of forensic science users[9]. According to Peterson *et al*

> An effective practice is when the scientific examiner and investigator collaborate and make a mutual decision as to the order in which cases should be examined and the types of information which should be sought[28].

Barclay observed that one of the serious constraints in major crime investigations is *"a lack of understanding of investigative practice by experts, especially laboratory scientists"*[124]. As Ludwig and Fraser opined, collaboration among actors facilitates understanding of the roles and expectations of each other, this lack of understanding by the experts[124]could be an indication of insufficient collaboration in major crime investigation highlighted by Barclay[77, 78].

More effective collaboration ensures that the views of every party involved are put into consideration and decisions are not made independent of one another. One of the methods that have been recommended to foster collaboration between actors is visualisation[133]. Visualisation is a process which incorporates methods that help in memorising, exploring, evaluating and communicating complex ideas, activities or ideas[137, 138] such as criminal investigation[133]. This process has been observed to promote teamwork which is an essential

component in the concept of collaborative interaction[133]. It is able to accomplish these through structuring of information, supporting reasoning and promoting collaborative work[133]. In a case study[139], it was shown that visualisation technique reduced crime analysis time when compared to traditional paper-based method. However, its limits and risks in terms of investigative process have been recently discussed by Rossy and Ribaux[133].Collaboration also fosters *'a joint known purpose for the group, motivation of skilled group leaders, organisational support, value to the organisation and clear dissemination of information and decisions made in the groups[90].* Problems associated with interagency collaboration include groupthink, context bias, tunnel vision and group conformity[90].Furthermore, a model has been developed to help enhance collaboration in the investigation process[133]. This model integrates the concepts of coordination and cooperation. In practice, these various forms of interactions are expected to exist in the investigative process in varying degrees.

Factors limiting effective collaboration include organisational culture, organisational structure and personal networks whereas effective leadership, effective communication, and adequate resources promote collaboration [140].Although few citations have been made regarding insufficient or poor collaboration, it is important to keep encouraging effective collaboration amongst the team assigned to investigate major crimes. The need for effective collaboration cannot be overemphasised because;

> ...Collaboration is about sharing information, sharing knowledge and sharing expertise... Collaboration [does] not happen by itself, or as a result of mentioning it in strategic documents and plans. A working environment is needed which supports and promotes a culture of information sharing and collaboration.p.23[141]

3.3.3 TIMELINESS

In the early assessment of the FSS by Touche Ross report, a general observation was made on turnaround times of results from the lab[53]. Although specific mention was not made to what crimes suffered from poor turnaround times, it can be inferred from the report that this involved major crimes. This delay however was attributed to the ratio of low staff number to the increasing crime rate[53]. Saulsbury *et al* in the interview with police officers of different ranks found out that almost half of their sample was dissatisfied with result turnaround from the lab[98]. Evidence of the impact of backlogs in the laboratory resulting in the delay of DNA results was shown by Briody[132]. This delay in turn resulted in court delays. Although there appears to be a consensus across the literature of improved turnaround times in major crimes investigations compared to volume crime, there is still evidence for the need to improve[62].In their 2010 paper, Peterson *et al* discovered that "*laboratory results were unavailable at the time of charging. This was particularly true in sexual assault cases"[27].*Due to "*delays in receiving laboratory results because of long turnaround times"[27],* police officers were discouraged from submitting evidence to the lab.

In a study of one of the forces in the United States (the New York Police Department), in nearly 40% of the cases (230 or 38.8%), DNA evidence was collected and submitted for analysis, but the results were not available during the course of the detective's investigation[79]. Due to this time lag between submission of sample and production of result, 93% of homicides were investigated without the benefit of DNA evidence[79]. Nicol*et. al* observed that the long-time taken for documents to be processed[76] affected investigation of major crimes. Causes of delayed turnaround times include the caseload from cold cases and re-opened cases[121]. Cronin *et al* opined that *'delays of months or even years in the*

analysis of forensic evidence can have a significant impact on the [police] department's ability to solve cases and bring offenders to justice[121].

In one of the major high profile cases, the Damilola Taylor murder investigation , foot wear evidence during the review of the case was discovered not to have progressed in a timely way[129].Backlog of cases involving DNA testing, firearms and trace evidence have also been observed[110].The need to collect and analyse forensic evidence in a timely manner influences how effective its input would be in an investigation. The production of forensic result or intelligence after an offender has been apprehended would be inefficient and less helpful in a criminal investigation unless for corroborative purpose [123].

3.3.4 FORENSIC TRAINING

The need for adequate training for forensic science users is necessary for forensic science to be used effectively and efficiently. The need to "*get the basics right"[52]*cannot be overemphasised. Getting the basics right entails that the users are made aware of the potentials of forensic evidence or intelligence and interpretation based on the particular context of the crime being investigated. As the NAS report rightly noted "*lack of standards and proper training at the crime scene can contribute to the difficulties of drawing accurate conclusions once evidence is subjected to forensic laboratory methods"*[62].Although evidence suggests that high ranked police officers involved in homicide and other major crimes are "*much better trained"[122]* when compared to the average police force. However, there appears to a need for more and specialist training in general.

> […]shortage of resources and the lack of consistent educational and training requirements prevent investigators from taking full advantage of tools […]that the health care system and other scientific disciplines offer[62].

In the 1987 article, Touch Ross observed that "*many officers appear[ed] unaware of some areas of forensic science capability and may have a need for more forensic science training"[53].*In the same year, Peterson suggested that "*police, prosecutors, and defence attorneys must also strive to increase their understanding of forensic results and take a more systematic approach to its use"[25].* After more than two decades, Innes observed that in homicide investigation, *"investigators were not always fully aware of what could be tested and what precisely was required to conduct different types of test"[128].*Prior to Innes' observation[128], Saulsbury *et. al* also noted that some managers in their sample, appeared "*to know less about the usefulness of different kinds of evidence*"p.48[98]. Keel *et. al* in their study also found out that agencies with formally trained detectives had high clearance rate for homicide cases compared to less trained ones[99]. Poor training and lack of refresher training courses was found to be weaknesses in major crimes investigations[76].

More recently, Smith and Bull[142] carried out an online survey on 398 experienced police officers from various countries (80% respondents from Australia while 20% responded from the USA, UK and other European countries). More than 50% of the sample included officers who have interviewed suspects in murder and sexual assault cases. The average year of experience was 13.57 years. One of the conclusions drawn from their study was that an *"overwhelming lack of training in the area of forensic science"[142]*appeared to be evident across their sample. Although their sample size constrained them from making comparisons between countries, this is an indication that more strategic and specialised training ought to be emphasized and implemented.

3.3.5 FORENSIC KNOWLEDGE

Williams and Weetman opined that there was;

need for investigative actors with sufficient contextual and general knowledge to identify what crime-relevant information is required at what stage of the investigation, what forensic resources are likely to provide this information and the ability to interpret the results of scientific tests carried out by other experts p.381[75].

Peterson et al. (1984) found clearance rates of offences with evidence scientifically analysed were about three times greater than in cases where such evidence was not used. When the Touche Ross report was published in the late 1980s, one of the observations made was the reluctance in submission of physical evidence to the laboratory. This was attributed in part to poor knowledge of physical evidence which could have aided an investigation[53].In the early 1990s, Saulsbury *et al* in their survey of various rank of officers, found that almost 50% of the sample size accepted that their knowledge of forensic science was at least occasionally insufficient[98]. For example, 46% acknowledged insufficient knowledge of body fluid grouping as forensic evidence. In their review of the use of physical evidence in criminal investigations, Horvath and Meesig[9]suggested that insufficient knowledge and skill limited the police use of scientific evidence especially in its contextual interpretation. They stated that *"investigators and judicial personnel who are not familiar with the potential value of scientific evidence are less likely to use it effectively in their work"[9]p968.*The follow up on the thematic inspection of the scientific and technical support in England and Wales[52] showed that there was "*lack of [forensic] awareness at all levels[52]* and there was also "*difficulty in managing the transformation of forensic intelligence into detections"[52].*

In 2006, the National Institute of Justice funded research into the role and impact of forensic evidence in criminal investigations[27]. Peterson *et*

al selected five jurisdictions[7]. The employment of limited range of forensic evidence from the vast options available did indicate limited knowledge of their potential to criminal investigations[27]. Patrol officers have been shown to have the least forensic knowledge[39, 98].Patrol officers may be the first at the scene[27] of a major crime and therefore should poses adequate knowledge of forensic science in order to help preserve the crime scene. The need to preserve the crime scene is crucial as contamination, loss or damage of physical evidence may impact on how much value forensic science brings to a criminal investigation[42, 57, 112]. In view of the use of advanced technologies in forensic science, extra care ought to be exercised in preserving, packing and storing evidence due to high sensitivity of these techniques for example low template DNA analysis. When evidence is deteriorated or damages, *"the information value that can be added through forensic investigation of that evidence is limited irrespective of the methodology used"[109].*In a 2002 review paper on undetected homicides in the 1990s, Gaylor highlighted the need for good scene practices in homicide investigations which is still relevant. He opined stated that;

> The advance in forensic technology, together with future potential, requires the police service to examine in detail their methods for handling exhibits and property in major crime investigations, particularly undetected homicides. p ii

Gaylor also emphasized the need for the role of a forensic specialist adviser[8][143].

[7](Los Angeles County; Indianapolis, IN; and the Indiana State Police Laboratory System (Evansville, IN; Fort Wayne, IN; and South Bend, IN)). Cases included from the time of police incident report to final court disposition

[8] According to Gaylor, Forensic specialist advisers are able to assess not only forensic material, but also its relevance as evidence.

3.3.6 RESOURCE ALLOCATION

A review of the literature indicates that a degree of limitedness to effectiveness and efficiency in the criminal justice system is a result of insufficient resources [9, 10, 53, 76, 109].Nicol *et al* stated that

> The constraining effect of [lack of] resources on the investigation was a key cause of problems highlighted within reviews. In many investigations there will be a discrepancy between the resources required in order to investigate the case as suggested by MIRSAP[9], or based on the judgement of the SIO, and the resources actually available. Staffing was the main resource issue raised, with the lack of suitably trained personnel the most sensitive issue[76]p.36.

Peterson *et al* noted also that despite the availability of new and advanced technologies in *DNA typing, physical evidence databases, related scientific instrumentation […] due to limited resources, are not utilized in most criminal investigations[27].*

Although it appears that resources are more readily available in major crime investigations compared to volume crime, research shows that more resources should be allocated[27]. The size of police agencies usually determine the amount of resources allocated to them and this sometimes leads to insufficient resources that hinder homicide case clearance in smaller forces[99]. Major crimes such as 'whodunit'[10][3] apart from facing the pressure of solving the case are also sometimes faced with limited resources[113] and lack of adequate exhibit storage facilities[76].

The problem of securing appropriate resources is potentially becoming more pronounced as elements of the investigative system become more technically advanced and specialist skills are increasingly required[3] p.273. In his review, Gaylor observed the difference in availability of

[9] MIRSAP stands for Major Incident Room Standardised Administrative Procedure

[10] Whodunit is a term used to describe complex murder inquiries in which it takes protracted investigation by the police to identify a prime suspect.

resources in the UK and the USA and the impact it makes on investigation.

> In the USA law enforcement agencies follow a similar pattern of investigation. They work to the same principles of fast-track actions; investigative theory and a planned method of investigation. Numbers of homicide investigations in that country far exceed the United Kingdom and therefore the number of resources available for each investigation is less. Although they follow the team concept of investigation the teams are smaller[143]p.5

He also observed that the ratio of homicide offences *"to available resources restricted the length of time inquiries were fully resourced"[143].* The more available resources are made, the better the chances of solving the crime[67]. During the Damilola Taylor Murder Investigation Review, the Oversight Panel observed that *"pressure on resources was intense. As a consequence, most of the inquiry team were re-deployed to meet the demands of [other] murder investigations[129].* According to Peterson *"there are a range of other research studies that are needed to resolve […] key questions and controversies such as proper allocation [of resources]"[126].*

3.3.7 INFORMATION MANAGEMENT IN MAJOR CRIME ENQUIRIES

Through observations and study, it has been suggested that one of the most routinely encountered problems in criminal investigations especially major crimes is information management and the attendant issue of information overload[3, 48, 128, 144-146].In 2001, Mouzos presented a paper at the 4th National Outlook Symposium on Crime in Australia convened by the Australian Institute of Criminology where she stated that;

> In recent years, homicide investigations such as Ivan Milat "Backpacker Murders" and the "Snowtown or Bank Vault Murders" […] have had to organise and sift through a wealth of information. At one stage during the Backpacker Murder Investigation it was estimated that the holdings of information increased from around seven to ten thousand pieces of information to around 1.5 million in just 12 weeks. Given the complexities associated with major homicide investigations, especially in dealing with large volumes of data, information management appears to be a major challenge[147].

In the earlier distinction of major crimes investigation from volume crimes, it was stated that these kinds of inquiries are characterised by a team of law enforcement agencies and experts. Each is tasked with generating information and therefore leading to the influx of information. The problem associated with the bulk of information generated from major inquiries has been referred to some as "volume challenge"[11][144]. One of the difficulties in dealing with high volumes of information is that "key nuggets of information essential to identifying a suspect or impending event are often identified in retrospect which frequently is too late"[144]. Another issue regarding the influx of information is that it *"result[s] in an overload of time consuming and unnecessary enquiries"[67].*

Julian *et al* discussing issues on the management of major crime scenes suggested that "*management of complex crime scenes [are] critical in […] forensic investigation"[116].*This then implies that if information is poorly or insufficiently managed due to its volume, it could impact negatively on the value of forensic evidence and in some cases not used at all[76]. The need to interpret forensic evidence in the context of any given criminal

[11] Coined by CIA director, George Tenent used to describe the ubiquity of information associated with criminal investigation.

investigation entails that wrong lines of enquiry (due to too much information) are to be avoided.

> Strong leadership and good management skills are necessary if a complex crime scene is to be processed effectively and efficiently (especially where personnel from numerous agencies and the public are present)[116].

It is also important that *"more systematic framework upon the collection of information"[148]*be put in place.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.0 RESULTS FROM LITERATURE REVIEW

In his research into wrongful convictions, Giannelli agreed that [forensic] scientific evidence is *"frequently better than other types of evidence"[149]*such as eyewitness identification in criminal investigations. However, "*current knowledge regarding the application of forensic science, particularly its effectiveness in criminal investigations and judicial outcomes, is limited"[37].* This has been attributed to several causes such as *"lack of standardization in the collection of data across forensic laboratories"[37],* complexity of the criminal investigation process[2, 4, 6, 77] and access to police information amongst others (funding and communication gaps as a result of fragmentation)[150].

Amongst the available literatures on the factors affecting the effective and efficient use of forensic science in criminal investigations include the work of Ludwig and Fraser[77] upon which this present research has been carried out. Although their work was based on volume crimes investigations, the literature reviewed in this research was based on the recurring themes they identified. However, these themes have been slightly modified in such a way to allow their use for major crimes investigations (See chapter two). Tables 1, 2 and 3 show the themes identified in thirty published papers and reports between 1975 and 2015 (40-year period). In these tables, the factors which appear to impact on how effectively and efficiently forensic science is used in major crimes investigations are shown to recur. Figure 3 shows the percentage occurrence of the recurring themes in the literature reviewed(Sample size (n) =30).

1. **Insufficient Communication and Interagency Collaboration**
   Insufficient communication appeared to impact on the use of forensic science in major crime investigations only in about 26% of

the literature reviewed while 10% addressed insufficient collaboration. Greater interagency communications and collaborations have appeared more integrated into homicide investigations compared to other major crimes like sexual assault [27, 78, 90, 121]. In one of the interviews carried out by Kelty *et al,* one of the participants was quoted as saying;

> "Look, sex assault is pretty specific in terms of the disciplines that are involved. Homicides are dealt with individually; sex assault does not need to be dealt with like that all the time. We've got a group that deals with sex case issues that are raised"p.11[90].

This view expressed by the interviewee indicates that though there appears to be collaboration in the investigation of sexual assault cases, more attention is however always placed on homicide cases. Prioritization of homicide cases as evidenced in the quote above is consistent across literature as homicide appears to have greater effect on victim's family, friends and the society at large[151, 152].

The issue with poor communication seems to go beyond interagency relationship but extends to internal relationship within the police department. In their 2002 article based largely on a field experiment in the mid-1990s, Keily and Peek[153] observed that a poor communication existed even amongst police officers. The 2013 research article by Kelty et. al[90] though limited by its sample size (103 criminal justice actors drawn from seven Australian States and Territories) highlighted the need for effective communication and collaboration practices. Another issue raised across the literature regarding communication between forensic scientist and investigators is the clarity of scientific report. Recent articles by Howes et al have shown evidence of the impact

of scientific report on effective communication within the CJS [154, 155].The major recommendations of these articles being that scientists endeavour to make their report readable while *"retaining scientific integrity[154]"*. These they opined would help "*enhance efficiency and effectiveness of the criminal justice system"[155].*It is important to bear in mind the "*complexity associated with achieving effective communication of forensic science in this multidisciplinary arena"[69].*Although the effect of contextual bias has impacted on the communication between forensic scientists and investigators to an extent, methods such as use of blind testing and evidence line-ups[90, 156]have been recommended to remedy the situation. Despite the pitfalls that may be associated, the pros associated with efficient interagency communication and collaboration outweighs the cons[90]. Ineffective communications result in conflicting perspectives between forensic providers and users on the roles of forensic science in criminal investigations[9]. Lack of effective communication and poor coordination of resources have the tendencies of creating *"system-wide effect"*[157].

2. **Poor Timeliness**

More than 40% of the reviewed literature (Figure 3) indicated that one of the factors impacting on how effectively and efficiently forensic science was used in major crimes investigation is poor timeliness. Though advancements in science and technology has decreased the time taken to analyse some physical or trace evidence, the bulk of work sent to the labs hinder quick results except in urgent cases[158]. This increase in workload has resulted in part due to increase in the use forensic science in volume crime investigations and largely to insufficient resources [47, 62, 76, 110, 111, 131, 132]. [106].

Backlogs contribute in hindering the timely processing of physical and trace evidence submitted to the laboratory for analysis[157]. Efforts have however been made to reduce these backlogs through targeted funding[159] but it appears that the such efforts have not accompanied the increased submission of evidence in certain jurisdictions[157]. Backlogs here may be referred to as delayed analysis of evidence submitted to the laboratory[157, 160]. In the USA for example, evidence is considered backlogged if it remains untested for more than 30 days[160, 161].

Increase in laboratory workload has also been attributed to the increase in the number of analytical processes available in the laboratory for the analysis of evidence[157]. This implies that an item of evidence would take up more time for analysis as more analytical methods are available to be carried out on it compared to decades ago.

TABLE 1: Recurring Themes that Limit the Effective Use Forensic Science in Major Enquiries (United Kingdom)

Source & Date	Recurring Themes							
			Flow of Information		Management		Forensic Awareness	
	Type of Literature	Research Method and limitation	Insufficient Communication	Poor Collaboration	Timeliness	Insufficient Resourcing	Insufficient Knowledge	Insufficient Training
Touch Ross Report (1987)[53]	Home Office Review	Review of police forces in England and Wales. However, this excluded the metropolitan police. The review lacked detailed statistical analysis			☑	☑		
Saulsbury *et. al*(1994)[98]	Research Report[12]	320 personnel involved in the operational decision of physical evidence collection and submission in 8 forces in England and Wales were interviewed. The research also contained survey and some statistical analysis which were limited by small sample size.			☑	☑	☑	
Tilley & Ford (1996)[96]	Home Office Police Research	Interview of less than 200 individuals within 12 police forces in England and Wales. Focus was on investigation and not how it affects the CJS as a whole	☑	☑			☑	☑
Using Forensic Science Effectively (1996) [107]	Research study[13]	Review of 14 police forces in England and Wales through interviews. Limited	☑				☑	☑

[12] An FSS/ACPO joint initiative

		statistical analysis.						
Blakey, D. (2002)[52]	Home Office Research Report[14]	Self assessment questionnaire was administered to 10 police forces in England and Wales.					☑	☑
National Audit Office (2003)[162]	National Audit Office Report	Semi-structured interviews , review of documentation from the forensic science service and meta-analysis of various documents.	☑		☑	☑	☑	☑
Fiest, A. and G. Newiss (2004)[163]	Home Office Report	Described the overall processes at work within hard to solve homicide investigations, with focus on actions undertaken, information received and decisions made.	☑					
Nicol, C., et al. (2004)[76]	Home Office Report	Review of academic literature, survey data from an inspection conducted, qualitative analysis of data contained in 34 review documents and interviews with six senior officers. Potential for bias due to self-administered review.	☑		☑	☑	☑	
House of Commons (2005)[122]	House of Commons [15] Report	five oral evidence sessions and over 30 written submissions received in response to a call for evidence and requests for supplementary information.					☑	☑
Bradbury, S.A and Feist, A(2005)[70]	Home Office Review Report	Literature review of fifty previously published work. No primary data to support findings.					☑	
Fraser, J. (2012)[125]	Text Book	Literature Review and analysis of secondary data relating to the application of forensic science to criminal investigation. Lacked robust statistical					☑	☑

[13] FSS & ACPO Steering Group
[14] follow up to 2000 report
[15] Select Committee on Science and Technology

		analysis.						
Fraser and Williams (2013)[112]	Text Book	Literature Review and analysis of secondary data as relating to forensic science and the criminal justice system. Lacked robust statistical analysis.					☑	☑
Monckton-Smith et al (2013)[164]	Text Book	Literature Review and analysis of secondary data on forensic science application to criminal investigation. Lacked robust statistical analysis.					☑	☑
Smith and Bull (2014)[142]	Research Paper	Questionnaire was administered to 398 experienced police interviewers on the impact of forensic evidence during suspect interviews.					☑	☑

TABLE 2: Recurring Themes that Limit the Effective Use Forensic Science in Major Enquiries (United States of America)

Source & Date			Recurring Themes					
			Flow of Information		Management		Forensic Awareness	
	Type of Literature	Research Method and limitation	Ineffective Communication	Poor Collaboration	Timeliness	Insufficient Resourcing	Insufficient Knowledge	Insufficient Training
Greenwood & Petersilia (1975)[101]	Research Report	Survey and Interview of over 25 police agencies. Data was based on only police forces in the United States.				☑	☑	☑
Peterson et al (1984)[28]	National Institute of Justice Research Report	Data review from 2,700 cases. Analysis based on secondary data.					☑	
Peterson et al (1987)[47]	Research Paper	Surveys and Interviews on laboratory personnel. Hypothetical case scenarios. Review of felony case files.			☑	☑	☑	
Horvath and Meesig (1996)[9]	Research Paper	Review of previously published work (secondary data) on the use of forensic evidence in criminal investigation, No primary data for statistical analysis.	☑	☑		☑	☑	☑
California Task force (2003)[110]	Agency Report	Review of forensic services in the state of California. Data limited to just one state.			☑			
Rossmo, D.K.	Text Book	Results and Conclusions based mostly on				☑	☑	

(2008)[165]		secondary data.						
Stevens, D.J (2008)[131]	Research Report	Research data based on survey carried out on 444 American prosecutors. Lacked robust statistical analysis.			☑			
Keel, T. G., et al. (2009)[99]	Agency Research[16]	Survey based analysis of homicide cases across 81 law enforcement agencies in the United States. However, there was 67.9% response rate from the survey and lacks detailed statistical analysis.				☑		☑
Schroeder, D. A. & M. D. [79]White (2009)	Academic Research	Homicide cases from one police department (NYPD) between 1996 and 2003 were examined. Some case files were missing resulting in reduced data for robust analysis.					☑	
National Academy of Sciences (NAS)(2009)[62]	Agency Research Report[17]	Research based on review and expert consultation. Very critical of the state of forensic science in the United States.	☑		☑	☑	☑	☑
Peterson et.al (2010)[27]	Agency Research Report[18]	Analysed official records from various criminal justice agencies (police, crime scene investigators, and court files e.t.c) to determine the role played by forensic evidence in different crime types.			☑		☑	
McEwen, T NIJ (2011)[166]	Agency Research Report[19]	Interview, case studies and surveys in three American states to examine the role and impact of forensic evidence on major crimes.			☑	☑		
Peterson, J.L. (2014)[126]	Academic Research	A literature review of documents relating to use and impact of forensic evidence in criminal investigations.			☑	☑	☑	☑
Carter and Carter (2015)[167]	Agency Research	Qualitative research based on document analysis and interviews of seven different police agencies		☑	☑	☑		

[16] Federal Bureau of Investigation
[17] National Research Council
[18] National Institute of Justice
[19] National Institute of Justice

TABLE 3: Recurring Themes that Limit the Effective Use Forensic Science in Major Enquiries (AUSTRALIA)

Source & Date	Type of Literature	Research Method and limitation(s)	Recurring Themes					
			Flow of Information		Management		Forensic Awareness	
			Ineffective Communication	Poor Collaboration	Timeliness	Insufficient Resourcing	Insufficient Knowledge	Insufficient Training
Briody, M. (2005)[132]	Academic Research (PhD Thesis)	750 cases (sexual offences, homicide, serious assaults and property crimes) which were past appeal stage were analysed using advanced statistical methods. These cases were collected from one Australian state.	☑	☑	☑	☑		
Kelty et. al (2013)[90]	Academic Research	Interviews and focus groups on 103 criminal justice personnels including police, forensic scientists, pathologists e.t.c in seven Australian states.	☑				☑	

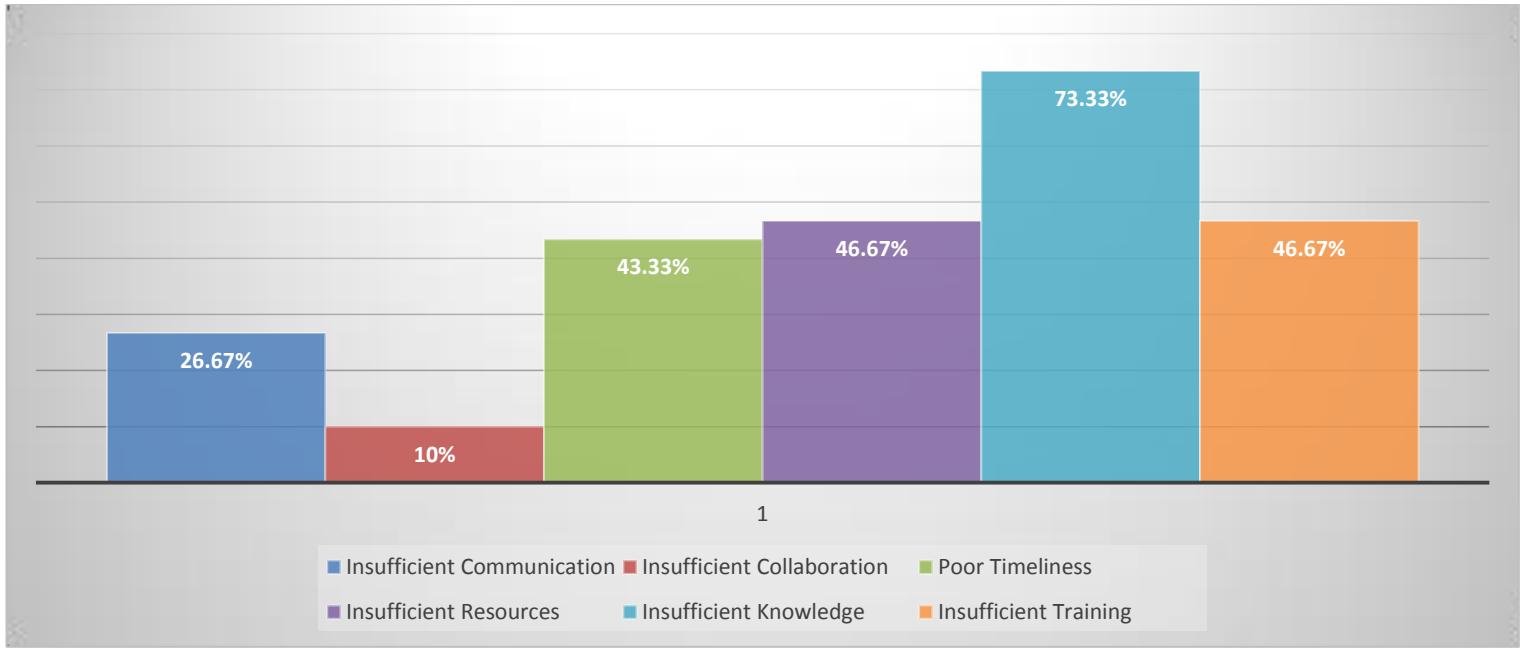

Figure 3: Percentage Distribution of Themes in Reviewed Literature

3. Insufficient Resources, Knowledge and Training

In the documents reviewed, almost half identified the impact of insufficient resources, insufficient training and insufficient knowledge on the effective and efficient use of forensic science in criminal investigations (Figure 3). Insufficient forensic knowledge among police officers from the sample reviewed appeared to be the most significant factor. Although detectives and investigators are more trained and knowledgeable in the potential of forensic evidence compared to other police officers, they still appear not to have sufficient knowledge in terms of interpreting evidence in the context of individual cases[9, 142]. The relevance of forensic evidence is best employed in the context of individual cases. For example, finding a DNA match between a suspect and a sample collected from a rape victim where the suspect is a sexual partner to the victim. This would make little or no difference due to the nature of their relationship.

Insufficient forensic training, one of the factors limiting effective use of forensic science in major crimes investigation involves inconsistencies in standards and length of training[94].In certain police forces such as in Scotland, it appears that as the number of years of service increases, the amount of training given decreases[39]. Increased awareness of the potential impact of forensic science in criminal investigations appear not to have significant impact on forensic training as recent publications still indicate that forensic training is insufficient[112, 126, 142].

Although there has been an increase in resources dedicated to forensic scientific testing, budget allocations for laboratory resources have not increased in direct proportion to the number of items submitted for testing[126]. Limited resources in the

laboratory also appear to influence the decision of investigator to submit fewer amounts of samples for forensic science testing[126]. Insufficient resources and knowledge also limit the range of analysis that can be carried during investigations [123].

Shortage of well trained staff have also be shown as a factor that hinders the effective use of forensic science in major crimes investigations[76].

4.1 OTHER FACTORS AFFECTING THE USE OF FORENSIC EVIDENCE

4.1.1. POLICE OCCUPATIONAL CULTURE

In an attempt to comprehend the nature of culture and its influence, a number of definitions have been put forward depending on researcher's point of view[168, 169]. For the purpose of explaining organisational culture here, Schein's definition of culture was adopted. In this regard, organisational culture may be defined as;

> "a pattern of shared basic assumptions learned by a group as it solved its problems of external adaptation and internal integration, which has worked well enough to be considered as valid and therefore to be taught to new members as the correct way to perceive, think and feel in relation to those problems" p.18[170].

This therefore implies that the longer an organisation shares these basic assumptions, the more difficult it becomes to change them. Although organisational cultures evolve or may be changed, it has been found that this change does not happen easily if at all[168, 171]. One of the reasons for change not occurring being that *"vested interests within the organisation can foster or hinder the change process"* p.51[168]. When people are taught to *perceive*, *think and feel* in a certain way which is assumed to be correct, contrary opinions would be met with opposition. This sometimes lead to what is observed when "*we explain in detail why*

something different must be done, yet people continue to act as if they had not heard us" p.6[170]. The values of an organisation plays important role on how its culture is shaped and how it subsequently evolves. *"Organisations with focus on control emphasise stability and cohesion* [e.g. police] *while organisations with a focus on flexibility emphasise adaptability and spontaneity* [e.g. forensic scientist providers]*" p.128*[171]. Here, the focus on flexibility and emphasis on adaptability is described in terms of the forensic scientist ability to interpret scientific results based on the particular contexts of a various cases.

The complexity of culture stems from the fact that there are various categories of culture within a culture i.e. micro and subcultures[168, 170]. Organisations are usually made up of subunits or departments and these subunits or departments in turn develop their own cultures because they each face different tasks or problems and therefore would have different ways of solving them. For example, patrol officers and detectives though police officers would develop different subcultures as a result of their task and work environment. The culture of an organisation has been shown to hinder or promote organisational effectiveness. The fact that culture is developed over time makes its study and management cumbersome. However, certain factors have been observed to change organisational cultures such as rewarding activities that promote a desired culture[106].

Police culture is characterised by an unwillingness *"to implement reforms that they perceived correctly would ultimately undermine their own positions"[172].* Research has shown that there are similarities between police cultures in an international scale[153].The impact of police culture on the use of forensic science by the police for investigative purposes is quite significant. The awareness of this impact implies therefore that the police ought to '*create an institutional framework in which creativity and innovation will be accepted as basic cultural norms in the midst of technological […] changes*"[173]. However, there is hope for improvement

in the current state of affairs because "*police culture […] is slowly but surely evolving from its strong roots[153]*" of rigidity to adaptability and openness to new ideas. The need to*" improve understanding and aid the development of effective working practices and policies in criminal justice systems"[77]*also involve understanding to effectively and efficiently use forensic science in criminal investigations.

4.1.2 BEHAVIOURAL ECONOMICS

Every stage of an investigation requires decision making processes which affect some factors afore mentioned such as allocation of resourcses. Every investigative action depends on decisions made by actors in the criminal justice system. In neoclassical economics, it is assumed that humans are rational thinkers and therefore make rational decisions[174, 175]. This rational human is

> "[a]ssumed to have knowledge of the relevant aspects of his environment which, if not absolutely complete is at least impressively clear and voluminous. He is assumed also to have a well-organised and stable system of preferences and a skill in computation that enables him to calculate for the alternative courses of actions that are available to him, which of these will permit him to reach the highest attainable point on his preference scale"p.99[176].

Yet, significant deviation from this assumption has been observed in the way humans make decisions when faced with uncertainties. This phenomenon has been explained in terms of various forms of boundedness or limitation[177, 178]. Poor or insufficient forensic knowledge could affect decision making even when the decision maker intends to be rational. For example, a police officer whose goal is to arrive at an effective justice outcome would not be able to employ the best forensic science has to offer due to insufficient knowledge of its potential

in particular cases. Lack of well defined preferences can result due to insufficient knowledge[179].Behavioural economics is a branch of economics that attempts to explain the observed deviation from the theories of rational thinking [174, 175, 180].

Every process involved in criminal investigation is shaped by the decisions of one or more actors in the criminal justice system. Until recently, the concept of behavioural economics had not been specifically utilized in understanding how the criminal justice system works[181]. Behavioural economics is a field of study that gives explanations as to why human choices deviate from expected economic utility theory in certain circumstances [175, 181, 182]. In economic utility theory, humans are assumed to be rational whereas the behavioural economics assumes otherwise [174, 175, 182]. Although behavioural economics can be considered a relatively new field [175, 181], most of its ideas are not new and can be traced to neoclassical economics[175]. Behavioural economics help to describe certain human behaviours. These behaviours in turn help to explain human relationships and thus can be applied to actors in the criminal justice system. Jolls, Sunstein and Thaler in 1998 published an article[183] which has been asserted as "*the first paper to try to relate behavioural economics as a whole to economic analysis of law as a whole*"[174]. Behavioural economics explains why human decision making deviates from rationality as expected. It gives insight on why people are unable to make changes or reluctant to change. In terms of the relationship between forensic science providers and users, behavioural economics could explain why the police are not easily aligned to applying forensic science in their investigative process[181]. There are different theories in behavioural economics that explain further the factors that result in organisational and occupational cultures which in turn influences the relationship between the actors in the criminal justice system.

Bounded Rationality

In human decision making, it has been observed that various limitations are evident in how rational humans can be. According to Simon;

> Bounded rationality is simply the idea that the choices people make are determined not only by some consistent overall goal and the properties of the external world, but also by the knowledge that decision makers do and don't have of the world, their ability or inability to evoke that knowledge when it is relevant, to work out the consequences of their actions, to conjure up possible courses of action, to cope with uncertainty (including uncertainty deriving from the possible responses of other actors), and to adjudicate among their many competing wants p25[184].

This implies that for example, the forensic knowledge which actors in criminal investigations posses and their ability to evoke the knowledge in case contexts influence how effectively forensic science can be used. Since the early 2000s, many studies have been carried out on how bounded rationality affect decisions people make[177, 184]. Decisions people make are usually dependent on self-interest even when it's rational to do otherwise. For example, this might explain why criminal law and punishment do not generally deter offenders from committing crimes[185].

The Endowment Effect

The value of goods increase when they become part of a person's endowment[181]. Forensic techniques and services are endowments to forensic practitioners and this affects the way they offer their services so also methods employed by the police. Each actor's practices and occupational culture become an endowment resulting in an unwillingness to part with. As Roberts explained in his article on renegotiating cultures, there is an invisible battle line drawn between the cultures of forensic

science and law [186]. One actor sees their culture as better than the culture of the other. This invariably affects the way the actors interact with one another. This impact interaction could limit the flow of information needed in a particular criminal investigation. The result of preferring one's endowment over another's would also impact on how resources are allocated. For example, the police would readily make available funding to projects that promote their traditional methods rather on scientific analysis.

Loss Aversion and Status Quo Bias

People react to losses more than they react to an equivalent magnitude of gain. This is to say that *"all things [being] equal, people weigh losses more heavily than gains"[187].* With regards to the use of forensic science in criminal investigations, actors would choose to avoid losing a traditional method of investigation rather employ new scientific methods. People also tend to hold unto status quo (the familiar). Rational theory expects decision makers to make choices based on best alternatives in uncertainties. However, decision makers are usually bias towards known outcomes even if they are not the best choices[179]. This phenomenon is referred to as status quo bias. For example, an experienced investigator who has effectively employed interrogation of suspects as a means of identifying an offender would be biased towards the method even in a situation where a scientific method would be more efficient.

4.2 RESULTS OF INEFFECTIVE AND INEFFICIENT INVESTIGATIONS

Miscarriages of Justice

According to Walker and Starmer, a miscarriage of justice

> "is defined as whenever individuals are treated by the state in breach of their rights; whenever individuals are treated adversely

by the state to a disproportionate extent compared with the need to protect the rights of others; or whenever the rights of others are not properly protected or vindicated by state action against wrongdoers" [188]

This breach of right could be in the form of a wrongful conviction[29, 189]or the acquittal of a guilty person. Whatever be the case, several factors have been identified as influential in miscarriages of justice. False confessions, prison informants, false testimonies, ineffective defence and false or misleading expert witness testimony amongst others [29-31, 189]. Of all these factors, false or misleading expert witness deals directly with the role of forensic science in the trial process. Backlog of evidence in forensic laboratories have also been cited as contributing to justice delayed and justice denied which are forms of miscarriages of justice[157].

Recurring Themes in Miscarriages of Justice

Reviews of the literature [29-31, 189] and a number of cases have shown some recurring themes in terms of the role of forensic science plays in miscarriages of justice. These themes are; poor knowledge of forensic evidence and procedure (interpretation and scope of evaluation of evidence), tunnel vision and invalidated methods and techniques (limited research).

Poor Knowledge of Forensic Evidence and Procedure

Poor knowledge of forensic evidence amongst the actors in the courtroom (judge, jury, lawyers etc.) contributes to cases of miscarriages of justice. This is evidenced by what appears to be an inability on their part to question the reliability of certain forensic methods and results presented in court .A number of wrongful convictions[20] have been as a result of false or misleading expert witnesses which may have been avoided or

[20] This term is used across certain literatures to describe miscarriages of justice

discovered in time if the court actors possessed sufficient forensic knowledge[131, 190-192]. Unfortunately, insufficient forensic knowledge has been observed also not just among investigators with less experience but investigators who have been in the system for a number of years[39, 193]. Poor knowledge of forensic evidence could be seen by lack of proper processing of a crime scene[194]. This is sometimes reflected in the way potential trace or physical evidence is lost because of wrong packaging which could eventually lead to degrading of the evidence. Issue of contamination in Meredith Kercher's murder serves as an example of how poor knowledge of forensic evidence could affect a case[195, 196]. According to Balk, "*the Knox trials show the potential that contamination events have to wreak havoc in the judicial system; even a few cells can be the deciding factor in a conviction[195]*".

Poor knowledge of procedure is evidenced in the way examiners especially crime scene examiners deal with physical evidence and attitude to taking contemporaneous notes. According to the Stephen Lawrence Case Inquiry, it was observed that records and notes were not made or retained[197]. In other reviews, it was discovered that there were *'initial mistakes at the murder scene'*[198]. In Damilola Taylor's case, best practices were not employed in certain procedures such as testing for the presence of blood on items of clothing. This resulted in bloodstains being missed earlier in the investigation[129, 199, 200].

Validation of Scientific or Technical Methods/Techniques and Quality Assurance

Invalidated forensic methods and techniques have been cited by a number of commentators as leading to miscarriages of justice[149, 201, 202].Fraser and Williams opined that;

> "[T]he seeming absence of a commonly agreed methodological basis for the assessment of the validity and reliability of specific –

sometimes long standing forensic practices, the deployment of faulty reasoning or faulty procedures can surely lead to wrongful convictions or at least unsafe convictions" p.7[42]

The case of R v Reed and Reed [2009] ECWA Crim 2698 exemplifies the issues associated with validation and standardization of methods. In the case of R v Reed and Reed, the evidence of DNA transfer which was admitted in court was challenged due to the paucity of robust empirical research on DNA transfer mechanisms[203, 204].

Tests and trials with monitoring to ensure that quality is assured[205] needs to be encouraged especially in the forensic laboratory. This is to ensure that best practices are employed in order to achieve the objectives of forensic science service in the CJS. It has been observed that forensic sciences "...do *not currently possess-and absolutely must develop-an adequate research culture*." [206]. This is an important observation because "*research that is deeply methodologically flawed should be given no credence*" [206].

Tunnel Vision

Tunnel vision describes the situation whereby a person reaches a conclusion without thorough explorations of alternatives thereby having a limited view. Tunnel vision has been cited as one of the factors resulting in miscarriages of justice[207] such as in the case of the Schiedam Park murder[208] and [R V. Gilfoyle]**.** As complex as other factors associated with criminal investigation, tunnel vision may not be entirely removed but measures that reduce its effect have been suggested. These measures include creating awareness of its impact and encouraging investigators to be 'open-minded' while investigating[208]. However, Snook and Cullen has argued that absence of empirical results renders such recommendations 'premature'[207]. They also argue that tunnel vision is important to investigations as it helps investigators remain focused.

Regardless of these arguments, it's important that all forms of biases be reduced in the course of investigations.

CHAPTER FIVE: CONCLUSIONS AND FURTHER WORK

5.0 CONCLUSIONS

Almost two decades ago, Horvath *et al* asserted that "[…] *what is known about who solves crimes and how they solve them is based on research that is both limited and outdated"p.1*[35]. Years after this assertion, Williams and Fraser observed once again that;

> "[...]we can safely assert that the systematic knowledge and understanding of how forensic science is actually deployed (as opposed to the many espoused and anecdotal accounts) in the investigation of crime and the preparation and the presentation of courtroom evidence remains fundamentally lacking" p.613[42]

Unfortunately, these statements appear to hold true even at the time of writing this research. A review of the literature has shown that debates, commentaries and discussions are ongoing in the area of criminal investigations in general but there is paucity of robust and empirical research in the specific area of the use of forensic science in criminal investigations [8, 35, 133]. However, there are notable studies and research which have been carried out in the effective use of forensic science in criminal investigations [37, 77, 107, 123]. This research has attempted to contribute to the ongoing discourse in the use of forensic science in criminal investigations by reviewing the literature based on recurring themes identified in Ludwig and Fraser[77].

A few conclusions have been drawn from this review but caution must be applied to the scope of interpretation and understanding due to the lack of robust statistical methodology. In some cases, inferences had to be made where the limiting factors were not mentioned specifically with regards to major crimes investigations but affecting criminal investigations in general. However, the outcome of this research serves as a 'litmus test' in the sense that it has indicated that there are recurring

limiting factors in the use of forensic science in major crimes investigations. Almost all of the recurring themes that have been suggested to hinder the effective use of forensic science in volume crimes investigations[77]appear to recur in the use of forensic science in major crimes investigations (Tables 1,2 and 3). However, certain issues such as resource allocation differ significantly between volume and major crimes investigations. Due to the nature of criminal activities and media attention more resources are employed in the investigation of major crimes compared to volume crimes investigation[70, 76, 112].Despite the greater allocation of resources in major crimes when compared to volume crimes investigations, these resources are insufficient for investigations[124, 126].

In addition to the recurring themes discussed in Ludwig and Fraser, this research indicates that information management in major crime investigations appears to impact on the effective and efficient use of forensic science. Research has shown that information management affects firm's performance by *"enabling valuable organisational capabilities"[209]*. This implies that maximizing tools that help in information management during the investigation of major crimes must be encouraged in order to achieve effective justice outcomes in the CJS.

Thirdly, the police being the major user of forensic science seem not to have totally embraced and understood the potential of maximising forensic science in their roles of crime prevention and control. As opposed to the popular idea of the CSI effect, it appears that the police still struggle with the idea of wholly inculcating forensic science in routine investigative processes. The apparent 'resistance' which has been attributed to factors such as organisational cultures and behavioural economics show that relationship between police and technology is a long standing issue. Darroch and Mazerolle in addressing this issue opined that *"by far, the most challenging reform is embracing strategic change,*

with wide-ranging implications for organizational arrangements and external relationships[118]. It may be a long shot in realising the full potential of forensic science in criminal investigations as long as the police perceive forensic science as a tool that undermines their skill and exposes the weakness in some traditional method rather than something to aid them carry out their roles more effectively and efficiently.

Due to the small sample size, comparisons could not be made between jurisdictions. However, this research indicates that these factors limiting the effective use of forensic science in major crimes occur in an international scale. This agrees with previous research by Ludwig and Fraser[77].

The police makes effort to direct resources efficiently [in major crimes] but, as in most organisations, there is room for improvement p.1[93]. As Ludwig and Fraser rightly observed, "*an important issue appears to be that the processes required to effectively use forensic science in the investigation of crime are more complex than generally recognised*'[77]. Although forensic science has been said to be "*critical to the efficiency and effectiveness of the criminal justice system*"[122], it however appears that *"things are improving but [...] too slowly"[52].*

Finally, it is important to bear in mind that the CJS and the whole process involved in criminal investigations are intricate. It ranges from the readily controllably factors (e.g. allocation of resources) to less controllably factors such as human biases (behavioural economics) and therefore would require consistency and dedication to identify problems and proffer feasible solutions.

More interagency communications were found to be more in effective in homicide cases in Australia[210]. Homicide is viewed as the most serious of crimes and therefore receives more police resources[167] Staffing and training improved competency of clearing homicide cases.

5.1 PRELIMINARY INDICATIONS

Preliminary review of the literature discussed in the previous chapter indicates that some factors that appear to hinder the use of forensic science in major crimes investigation differ in degree in different jurisdictions. Some factors appear to be more prevalent in some jurisdictions than others. Of the 30 sources reviewed, 14 originated from the UK, 14 from the US and 2 from Australia. In the UK jurisdiction, it appears that the major hindering factors are insufficient knowledge and insufficient training. More than 70% of the literature reviewed indicated that these two factors have persisted over the years. The question to be considered is "Is insufficient knowledge a result of insufficient training or are there other factors such as police culture, availability of resources e.t.c that play significant roles"?

In the US, three factors appear to hinder effective use of forensic science in major crimes investigation. These include timeliness, insufficient resources and insufficient knowledge. The issue of backlog has significantly impacted on timeliness in the use of forensic science [157, 159, 211]. Only 2 research papers were reviewed from the third jurisdiction therefore no indications could be suggested here. These indications ought to be treated with caution because of the limitations associated with small sample size such as missing data and under or over representation of reality [212-214]. However, small sample size is not always a limitation in determining the true state of affairs[214].

5.2 THE WAY FORWARD

A number of factors have been highlighted from this review which has shown potentials for further research especially in the application of robust statistical methods to support finding. Nonetheless, various factors have been highlighted which ought to be implement in view of current findings.

- Priority ought to be given to the area of research funding. This funding ought also to extend to making the implementation of research into casework feasible.
- Resources are important in ensuring that materials and policies are put in place to standardize training of personnel involved with collecting, analysing and presenting forensic evidence in criminal investigation process.
- The impact of organisational and professional cultures cannot be overemphasised. Therefore, policies should be put in place to encourage forces and individuals who utilise forensic evidence in criminal investigations.
- Best practices should be encouraged and adapted which could serve as template for jurisdictions like Nigeria where forensic science is yet to be formally integrated to criminal investigations.

5.3 FURTHER WORK

This research has only been able to highlight factors that indicate that improvement is needed in the area of major crimes investigations in terms of the application of forensic science. These highlighted themes therefore warrant further research in order to better understand and proffer necessary solutions.

1. Surveys and interviews (focus groups) should be carried out amongst actors involved in the investigation of major crimes in order to verify the highlighted themes that have been identified. Surveys are one of the most widely used methods of data collection. This could be attributed to the fact that they are cheap to carry out and serve as an easy means of getting specific information from participants in relation to the research [215, 216].
- It encourages data collection from a very large sample size unlike other forms of data collection methods.

- It reduces any form of bias from the participant which could arise as a result of the researcher's presence.
- The researcher is privileged to receive the specific answers needed to answer the research questions since the questions are structured by the researcher.

However, it is important that the researcher bears in mind the limitations associated with this method of data collection. These limitations include;

- Participants may be reluctant to participant in the research if the researcher does not formulate a means to ensure that they fill the questionnaire.
- Participants may not understand the questions if not properly framed by the researcher.
- Respondents do not have an opportunity to elaborate on answers.
- There is a greater risk of missing data as some questionnaires may be partially filled.
- Low response rates are usually recorded.

Interviews and Focus Group

As a qualitative research strategy, it helps to understand why people do what they do or what shapes the decisions they make. This therefore makes it a good tool to observe and identify the relationships between actors in the CJS. It is expected that the focus groups would be made up of police, forensic scientist and legal practitioners. Reasons for employing the focus group in this research include;

- Naturalistic**:** Apart from ethnographic studies, focus group is another method that helps in acquiring data from an environment that is as close as natural everyday life. This focus group will include participants from different arms of the CJS. Interaction

between these participants would help show what they think of their roles and those of each other.

- This method allows the researcher *"to develop an understanding about why people feel the way they do"[216].*
- In relation to this specific research, it would offer the researcher the opportunity to study the ways in which individuals in the CJS collectively make sense of the use of forensic science in criminal investigations.

Limitations[216]

When compared to individual interviews, the interviewer in this method has less control over proceedings. Due to the fact that a number of people would talk at the same time at some point, transcribing and analysis of the data can be difficult and also time consuming. Organising a time that is suitable for all the participants to meet for the interview can be tasking and group effect may occur where the actions of one or more participants affect the whole group.

2. The review suggests that more attention is being paid to the investigation of homicide. Other types of major crimes ought to be studied specifically and the use of forensic science examined.

3. Robust and systematic methodology should be further developed to understand the influence of the concept of behavioural economics on the use of forensic science in major crimes investigations.

4. The result of this preliminary review indicates that these themes which appear to recur are an international phenomenon. Due to the limited number of literature chosen for the review, country comparison could not be feasible. Therefore, more research should

be carried out across countries in order to enable comparison of result. Best practices can be highlighted and recommended.

5. Police culture appears to continually inhibit the maximum utility of forensic science (and other technologies). Although a lot of discussions have been across the literature regarding this relationship, more robust methods should be developed in order to identify ways to restructure police cultures to aid acceptance of innovative methods such as forensic science.

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