London South Bank University

AN EXAMINATION OF THE DEVELOPMENT OF STANDARDS, PROTOCOLS AND STANDARD OPERATING PROCEDURES IN FORENSIC RADIOGRAPHY

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Mark Donald VINER

An Examination of the Development of Standards, Protocols and Standard Operating Procedures in Forensic Radiography

Abstract

Forensic Radiography has seen a rapid development over the last 20 years with the evolution of new technologies, but perhaps more significantly development of policy and guidelines for radiographers, the adoption of standards and standard operating procedures and changes in education and training.

This thesis explores the author's contribution to the body of knowledge in this discipline through the use of participatory action research which was undertaken through a sequence of iterative cycles over time. The author, as practitioner-researcher, examined the practice of forensic radiography through these cycles of data gathering, studying a number of different operational situations, each of which presented specific organisational issues requiring resolution.

Practitioners and service users as members of the organisational system were active participants in the cyclical process of planning, taking action and evaluating the actions. Longitudinal, cross sectional and case study research designs employed observation and reflection, focus groups and multidisciplinary group discussions, questionnaires and semi-structured interviews. These led to collaborative findings and the development of new knowledge that was applied to subsequent situations, which were then further examined and refined within an overarching action research model.

The thesis highlights the author's new contributions to the body of knowledge from the respective studies and resultant publications with specific reference to the development of standards, protocols and standard operating procedures in forensic radiography.

Contents

Glossary of Abbreviations

AAFS	American Academy of Forensic Sciences
AFR	Association of Forensic Radiographers
ACPO	Association of Chief Police Officers
BAFM	British Association of Forensic Medicine
CIFA	Centre for International Forensic Response
CoR	College of Radiographers
CRFP	Council for the Registration of Forensic Practitioners
CSFS	Chartered Society of Forensic Sciences
DVI	Disaster Victim Identification
FEMA	Federal Emergency Management Agency (USA)
IAFR	International Association of Forensic Radiographers
ICC	International Criminal Court
ICTY	International Criminal Tribunal for the Former Yugoslavia
INFORCE	International Forensic Centre for the Investigation of Genocide
ISFRI	International Society of Forensic Radiology and Imaging
JoFRI	Journal of Forensic Radiology and Imaging
NAI	Non-Accidental Injury
PTSD	Post Traumatic Stress Disorder
SCoR	Society and College of Radiographers
SOPs	Standard Operating Procedures
SORSA	South African Society of Radiographers
SPA	Suspected Physical Abuse
TIG	Trauma Imaging Group
TIG(FR)	Trauma Imaging Group (Forensic Radiography Sub-Committee)
UN	United Nations
UK DVI	United Kingdom Disaster Victim Identification Team

1. Background and Context

1.1 Background

Forensic radiography, defined as "the appliance of the science of diagnostic imaging to questions of law" (CoR, 2014), has developed rapidly over the last 20 years with evolution of technology, changes in education and training for radiographers, and adoption of standards and standard operating procedures (SOPs) (CoR, 1999; Beck, 2011; Thali et al., 2011; Baglivo et al., 2013).

Brogdon (1998a), showed that most forensic radiology techniques originated within months of Roentgen's discovery but that few of these techniques had been developed and applied systematically within forensic medicine. In the 1980s and 90s, several events raised awareness of the need to establish guidelines and protocols and to train radiographers in forensic imaging.

Between 1980 and 1995, 185 terrorist incidents occurred on the UK mainland, with many causing death and injury from explosions (HC deb, 4th March 1996), and radiographers dealt with forensic issues as they examined casualties in hospital emergency departments. Investigative techniques became more sophisticated and it was important to identify and retrieve shrapnel from victims for forensic analysis - a task in which radiographers, as emergency practitioners, played a crucial role (Meserve, 1992; Green, 1993). As a superintendent radiographer in London, the Principal Researcher co-ordinated hospital and forensic responses to some of these incidents which provided opportunities to observe, reflect and analyse preparedness, protocols and procedures. It was not just within hospitals that radiographers undertook forensic imaging. Radiographers responded to mass fatality incidents such as the Lockerbie bombing - for which they were unprepared, untrained and ill equipped, and which left them with emotional and psychological consequences (Gillespie, 1992).

On 26th February 1994, over 400 radiographers attended a Trauma and Forensic Imaging study day in London, organised by the Principal Researcher. This provided a forum for the discussion of issues, and identified the need for guidance, research and training. As a result, the Principal Researcher and others formed the Trauma Imaging Group (TIG) which aimed to develop standards and training in trauma and forensic imaging (Society of Radiographers, 1994). In the same year, the College of Radiographers also commissioned a study into forensic radiography provision (Baker and Hughes, 1997).

In 1995 the world became aware of "ethnic cleansing" during the war in the former Yugoslavia, (Bell-Fialkoff, 1993) and the United Nations (UN) established the UN International Criminal Tribunal for the Former Yugoslavia (ICTY) to investigate and bring to justice those responsible for

the genocide estimated to have claimed the lives of over 35,000 civilians in Bosnia alone (Zwierzchowski and Tabeau, 2010). In 1996, the ICTY established an international forensic team to locate, exhume and examine victims from several mass graves. This investigation was the largest of its kind since the Second World War, the first in which forensic science played a key role and in which radiology was integral to the investigation (Rainio et al., 2001).

The Principal Researcher, as lead radiographer for the UN ICTY, recruited, formed, led and developed a multi-national team of radiographers who worked on the team from 1996-2002. From the literature review conducted at the outset it was apparent that there were no guidelines, either at international level or in any nations represented. In many countries forensic imaging was undertaken by untrained personnel without knowledge of basic radiographic procedures, supporting Brogdon's observations (Brogdon, 1998a). The Principal Researcher worked in close cooperation and consultation with the senior forensic pathologist, anthropologist, odontologist and senior members of the investigating team. This offered a unique opportunity to develop new knowledge and implement, observe, analyse, discuss and modify protocols and standard operating procedures (SOPs) for forensic radiography investigation.

As a result of experience with ICTY and TIG, the Principal Researcher advised the College of Radiographers, the UK Government Home Office and Government Office for London, the International Criminal Tribunal (ICC), the International Centre of Excellence for the Investigation of Genocide (INFORCE) and several universities in the UK and abroad. Earlier work was refined and developed, resulting in development of guidelines and protocols for forensic radiography, the integration of an organised radiography response for both the ICC Forensic Team and the United Kingdom Disaster Victim Identification (UK DVI) Team, and several education and training programmes.

In 2006 the Principal Researcher undertook an international review of the role and development of forensic radiography, analysing the role of the forensic radiographer in a variety of settings and jurisdictions and facilitating further development of standards and guidelines. Discussing and reflecting upon new knowledge from this research with others in the field, the Principal Researcher published a number of texts defining the scope of practice of forensic radiography, identifying underpinning knowledge and competencies required by radiographers, developing policy and devising protocols and SOPs. The Principal Researcher co-founded the International Association of Forensic Radiographers (IAFR) in 2005, the International Society of Forensic Radiography and Imaging (ISFRI) and the Journal of Forensic Radiology and Imaging (JoFRI) in 2012 with the aim of promoting research and development.

Through examination of the literature and the author's contribution of new knowledge in this rapidly developing area, this thesis will explore the growth in the radiography evidence base with specific reference to furthering the understanding of the role of the radiographer in forensic imaging and the development of standards, protocols and SOPs in forensic radiography.

1.2 The Knowledge Gap

1.2.1 Scope of Practice

The literature was reviewed over many stages. An initial literature review was conducted at the start of the first research cycle, with further targeted reviews during subsequent cycles (Figure 1, p16-17). A more comprehensive review was subsequently conducted for this thesis to present this work within an overarching action research model (Appendix 1, p68).

The initial review of literature published by the mid to late 1990s showed that, although forensic applications of radiology had been in use for over 100 years, there was widespread ignorance amongst radiographers regarding the scope of practice of forensic radiography. Most believed that this term referred only to examination of the deceased and areas of forensic practice involving live subjects were loosely referred to as "medico-legal" with no generally understood concept of what this entailed. Radiographers had little awareness of their role and responsibilities with respect to these examinations.

This lack of knowledge also extended to those users of the service: pathologists, dentists, anthropologists and others who were largely ignorant of the potential benefits afforded by modern radiological imaging. Although radiographs had proved indispensable in investigation of mass fatality incidents since 1949, there was little advance planning for the use of radiology in such incidents and no national co-ordinated resource to respond to calls for assistance.

Subsequent reviews of the forensic pathology service (Home Office, 2003), and the report of the public enquiry into the Marchioness disaster (Clarke, 2001), highlighted the continued divergence of forensic pathology away from required support services such as radiology and the need for more reliance on non-invasive methods of post-mortem investigation.

1.2.2 Medico-legal Implications

The literature (Appendix 1, Section A1.4, p80) demonstrated that radiographers were largely unaware of the standards of evidence that apply to forensic examinations and of the procedures for documenting continuity of evidence to be followed.

In addition, investigation of Non Accidental Injury (NAI, now referred to as Suspected Physical abuse - SPA) and examination of patients who had suffered non-fatal injuries following assault, motor vehicle incidents, medical negligence, industrial injury, etc., was part of normal clinical work for many radiographers and yet there was no understanding that these patients may form part of the incident "crime scene", and that standards of evidence should be applied in these cases.

Whilst few radiographers were involved in examining non-human subjects, such examinations were occasionally performed for investigative purposes but again there was little information available to radiographers regarding the organisational or procedural issues necessary.

1.2.3 Policy, Guidelines, Protocols and SOPs

The few guidelines and protocols that did exist at that time were based on a poor understanding of the scope of forensic radiography and the nature of forensic investigation and were limited in their application (Appendix 1, Section A1.5, p81). There was little technical and procedural information to assist the radiographer in the conduct of examinations or to assist those responsible for managing forensic investigations and emergency response in the planning of facilities.

1.2.4 Underpinning Knowledge and Competencies, Training, Education and CPD

The literature (Appendix 1, Section A1.6, 82) showed that most radiographers involved in forensic work had not received any specific training and were largely ignorant of the technical, organisational and procedural issues pertinent to those examinations of a crime scene, relying instead on ad hoc and on-the-job training. Not only were they ill-prepared in terms of training and education, there appears to have been no consideration given to preparing them mentally or physically for the hazards that they would be exposed to.

1.3 Addressing the Knowledge Gap

This thesis will demonstrate how the Principal Researcher addressed these gaps and contributed new knowledge to the body of literature through:

- Advancing the understanding of the role of the radiographer in forensic imaging by defining the scope of practice (Publications I, II, IV, V, IX, X, Sections 3.1, 3.2, 3.3) and the medico-legal implications (Publications I, VI, VIII, X, Sections 3.1, 3.3)

- Developing policy, guidelines, protocols and SOPs (Publications I, II, III, VI, VII, VIII, IX, X, XI, XII, XIII Sections 3.1, 3.3, 3.4)

- Identifying the underpinning knowledge and competencies required by those undertaking forensic radiography (Publications I, IV, VII, IX, X, Sections 3.1, 3.3).

2. Aim, Objectives and Methodology

2.1 Aim and Objectives

2.1.1 Aim

This thesis will evaluate the author's contribution to the growth of understanding of forensic radiography within the medical imaging professions and the development of practice, policy and guidance in this field.

2.1.2 Objectives

To:

a) Examine the drivers for change, evaluating the research and publication activity and determine the author's contribution to:
   - Advancing the understanding of the role of the radiographer in forensic imaging
   - Defining the scope of practice of forensic radiography
   - Identifying the underpinning knowledge and competencies required by forensic radiographers.

b) Evaluate the author's contribution to:
   - Developing policy and guidance for forensic radiography
   - Developing protocols and standard operating procedures in forensic radiography.

c) Explore and assess the perceived impact, influence and reach of the author's research and publications.

2.2 Research Methodology

This thesis will detail the use of action research undertaken over a period of time in the field of forensic radiography, highlighting new contributions to the body of knowledge in this discipline from the respective studies. This methodological approach is detailed more fully in Appendix 2, p85.

It will demonstrate an application of participatory action research in which the practice of forensic radiography was examined by the Principal Researcher through the study of a number of different situations over a period of time, each of which presented specific organisational issues requiring resolution. The research framework detailed below (Section 2.3, p14) and discussed in Appendix 2, (Section A2.4, p 99) has been retrospectively applied to show how a sequence of iterative

cycles of data gathering (Figure 1, p16-17) was used to address specific organisational issues within an overarching research model. These were studied by the Principal Researcher as a practitioner- researcher involving the active participation of practitioners and service users as members of the organisational system in the cyclical process of planning, taking action and evaluating the actions. This participative approach led to collaborative findings and the development of new knowledge which was applied and further examined and refined in subsequent situations:

- The Principal Researcher worked as part of multidisciplinary, multinational forensic teams undertaking forensic investigations of mass graves for the UN. The new knowledge developed from systematically applying forensic radiography as part of these large-scale criminal investigations was adjusted and refined through several feedback loops and group discussions and demonstrated in publications VI-VIII (Section 3.3, p43).

- Publications II,III,VI-X and XI-XIII show how new knowledge gained from development and co-production of protocols and procedures for the investigation of human remains from mass graves was then applied and further refined within the context of other mass fatality events (Section 3.1, p28; Section 3.3, p43; Section 3.4, p47).

- Publications I, IV, V and X show how new knowledge arising from the development and co-production of protocols and procedures forensic radiography in the large-scale investigations described above was developed into a series of underlying principles to be applied to a range of routine circumstances faced by the radiography practitioner (Sections 3.1, p28; Section 3.3, p 43).

2.3 Theoretical Framework

The theoretical framework used in this thesis is discussed in Appendix 2 (Section A2.4, p99) and is summarised diagrammatically in Figure 1 (Page 16-17). It maps the cycles of research activity against the respective publication outputs.

2.4 Publications and Research Methods

The Principal Researcher's publications discussed within this thesis present a coherent theme demonstrating new knowledge. These publications and the corresponding research methods

utilised are detailed in Table 1 (Page 18-27). Methods are further discussed in Section 3 (p28) and in Appendix 2, (p 85) .

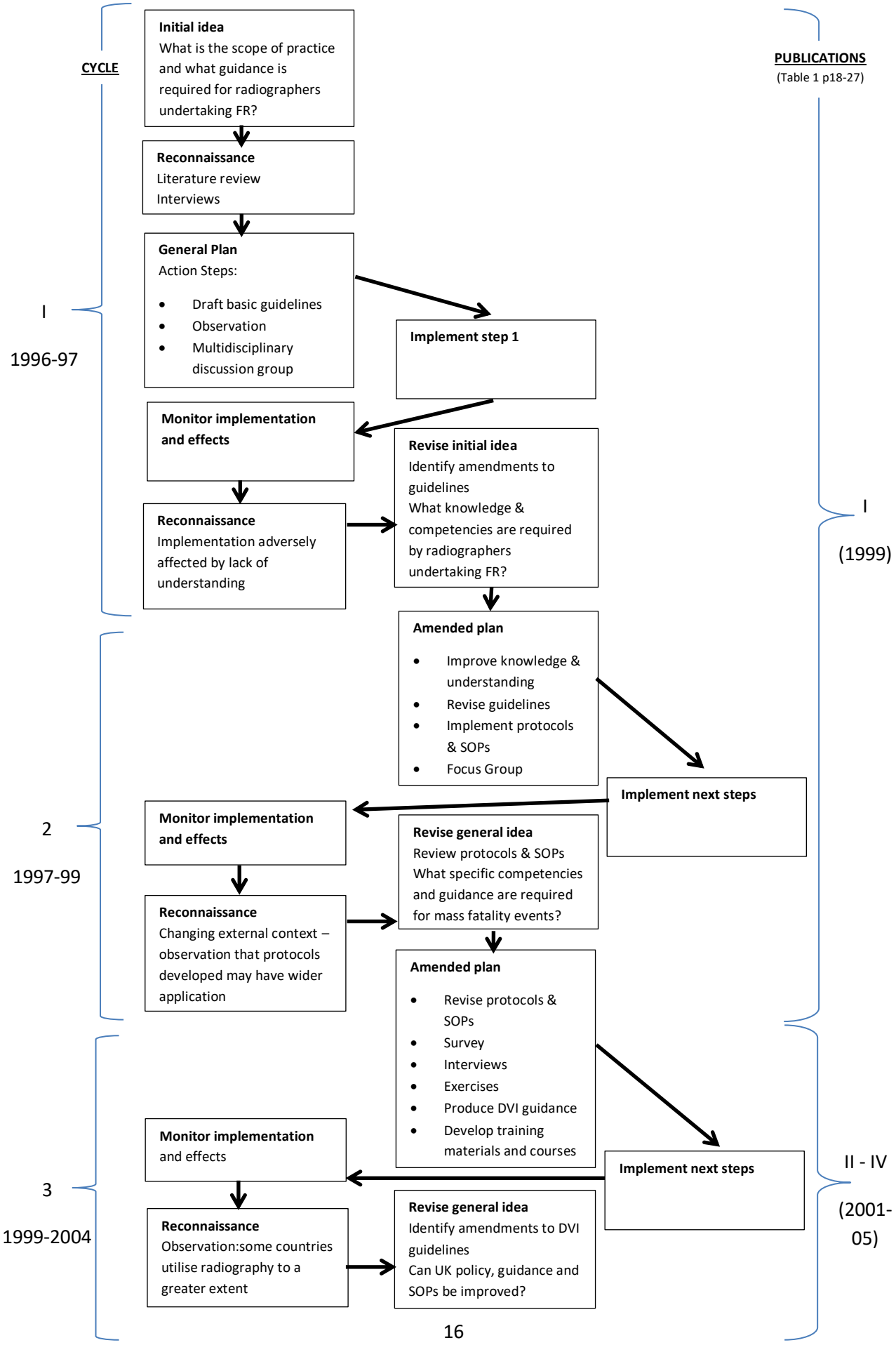
2.5 Limitations of the Study

It is acknowledged that there are a number of limitations of the methodology and methods employed in the study. These are discussed further in Appendix 2, Section A2.5 (p102).

2.6 Ethics and Ethical Issues

Ethical principles have been applied to the design and conduct of this research study. The principles applied are discussed further in Appendix 2, Section A2.6 (p104).

Figure 1 **Theoretical Framework** *(Adapted from Elliot's Action Research Model, p98)*



Theoretical Framework *(ctd)*

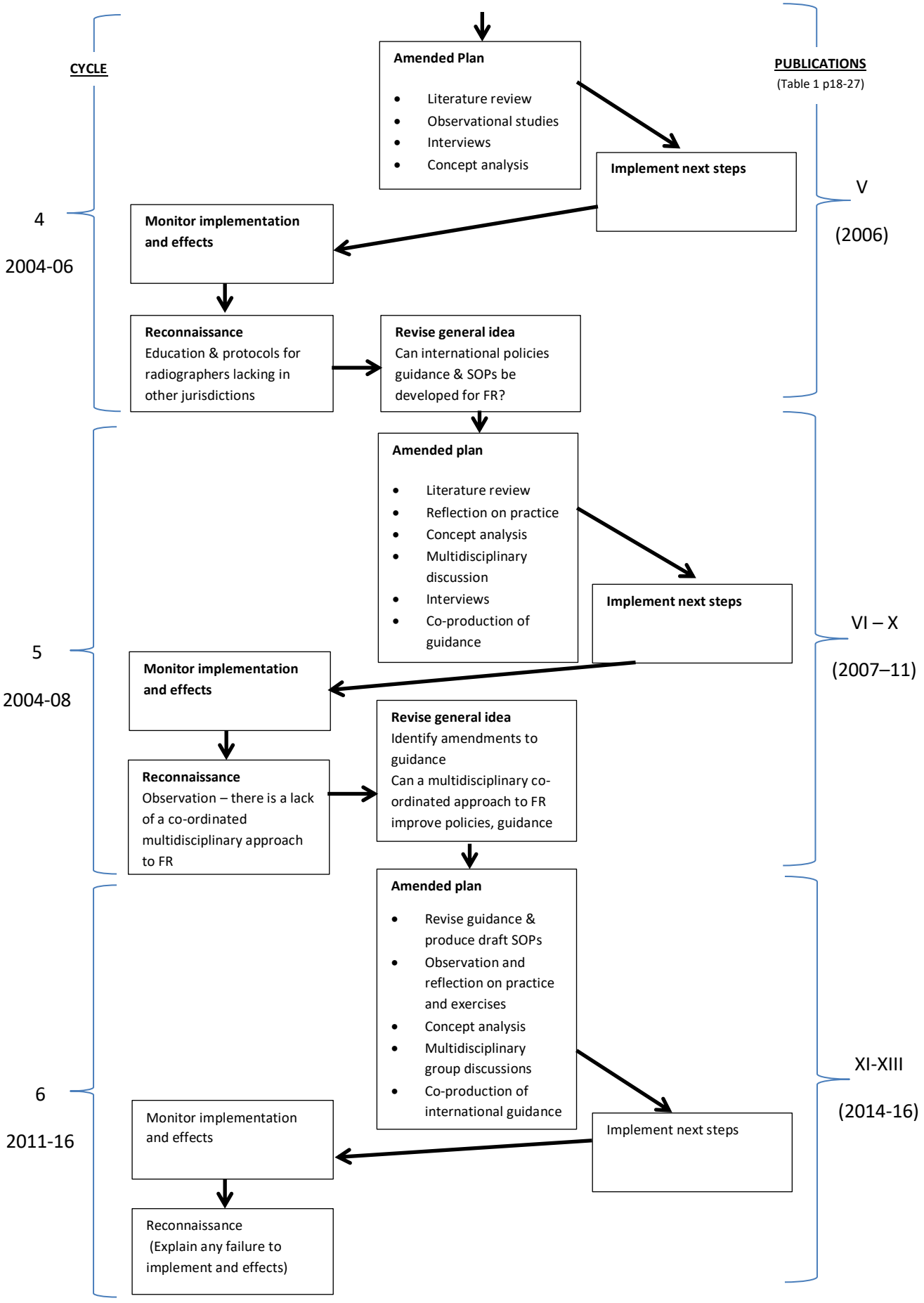


Table 1 Publications showing research methods and contribution of Principal Researcher

ID	Title	Research Methods	Contribution[1]	Areas of Impact
I	College of Radiographers 1999: *Guidance for the Provision of Forensic Radiography Services*, College of Radiographers, London	• Literature Review • Observation • Multi-disciplinary discussion group • Co-production of draft guidelines, procedures and recording forms • Longitudinal sampling - guidelines evaluated in practice during several investigations over two years. • Multi-disciplinary interviews • Radiography focus group • Testing against existing knowledge.	Joint author and group chair (50%)	Advanced understanding of the role of the radiographer, defined the scope of practice, identified required knowledge and competencies, clarified the legal framework and rules of evidence. Set out CoR policy and guidance and provided a framework for development of practice.
IIa	*Provision of Radiology Facilities within Temporary Mortuaries in the event of a Mass Disaster*, 2001, Trauma Imaging Group – Forensic Committee	Development of new paradigm: applied new knowledge from large scale criminal investigation to a DVI incident • Observation and reflection: recognised the need for a forensic radiography process for DVI (Viner et al., 1998) Co-production of draft plan • Literature review • Multi-disciplinary focus group and discussion- incorporation of trauma management principles • Cross-sectional sampling: questionnaire, interviews and multi-disciplinary discussion groups.	Principal author (80%)	Defined the scope of practice of forensic radiography in mass fatality incidents, advancing understanding of the role of the radiographer. Developed a new paradigm for use of radiography in DVI and set out planning guidance for the use of radiography in DVI and a detailed framework for development of SOPs.

Table 1 (ctd)

ID	Title	Research Methods	Contribution[1]	Areas of Impact
IIb	*Temporary Mortuary Exercise RAF Northolt 13/4/2003: Review of Facilities and Requirements*, 2003, Trauma Imaging Group – Forensic Committee	Testing in action -Exercise at RAF Northolt- • Observation • Multidisciplinary feedback and discussion • Interviews: coroner, pathologist, dentist, emergency planner, radiographer, mortuary manager, police DVI commander • Table-top exercise[2] and simulation exercise.	Principal author (70%)	Advanced understanding of the role of the radiographer in DVI incidents and set out planning guidance for the use of radiography and a framework for development of SOPs.
III	*London Mass Fatality Plan*, 2005, London Resilience Forum, Government Office for London, Crown Publication – Restricted	Results from II(b) further evaluated and refined through: • Discussion groups • Concept analysis of correspondence • Co-production of multi-disciplinary emergency plan • Table-top exercies[2]**.**	Sole author of radiography sections	Defined policy and guidance for radiography in the management of DVI incidents in London. UK Government subsequently adopted planning & resourcing recommendations for UK DVI.
IV	Hines, E., Rock, C., Viner, M.D., 2006, "The Role of Radiology" in *Human Identification,* Thompson T., Black, S., CRC Press, Boca Raton pp221-228 ISBN 978-0849339547	Discussed and evaluated the scientific application of forensic radiography methods to human identification and the underlying principles involved in I-III • Literature review • Concept analysis of correspondence • Interviews • Group discussions – inter and intra-professional • Observation and reflection on practice (Viner et al., 2006c).	Joint Author – co-ordinating (50%)	Defined the scope of practice of radiography in DVI and advanced understanding of the radiographers' role. Adopted as standard text for training of police officers for UK DVI team.

Table 1 (ctd)

ID	Title	Research Methods	Contribution[1]	Areas of Impact
V	Viner, M.D., 2006, *Radiography and Forensic Medical Investigation – A study of forensic radiography in South Africa, Argentina and the USA*, Winston Churchill Memorial Trust, http://www.wcmt.org.uk/public/Reports//671.pdf	Aimed to evaluate role and development of forensic radiography internationally - cross sectional sampling • Literature review • Observation visits • Targeted interviews • Concept analysis of correspondence.	Sole Author	Advanced understanding of the role of the radiographer amongst the wider forensic community. Clarified the legal framework across a range of legal and organisational contexts internationally and developed knowledge and competencies required by radiographers across differing models of service provision.

Table 1 (ctd)

ID	Title	Research Methods	Contribution[1]	Areas of Impact
VI	Anderson, A., Cox, M., Flavel, A., Hanson, I., Hedley, M., Laver, J., Perman, A., Viner, M. and Wright, R., 2007. "Protocols for the Investigation of Mass Graves". *In:* Cox, M., Flavel, A., Hanson, I., Laver, J. and Wessling, R., eds. *The Scientific Investigation of Mass Graves: Towards Protocols and Standard Operating Procedures.* Cambridge University Press, pp. 39-105. ISBN: 978-0521865876	Observation and reflection on practice: applying radiography knowledge and experience to large multidisciplinary forensic projects in Bosnia, Croatia, Kosovo and Sierra Leone over 7 years from 1996-2002 (Viner, 2001; Viner et al., 2003) • Literature review • Concept analysis of correspondence, feedback and notes from cycles 1-3 (figure 1, p16-17) • Multidisciplinary discussion • Co-production of protocols and procedures. Simulation training exercises for Inforce Foundation/ Bournemouth University - training of forensic radiographers for the Iraq Special Tribunal in 2004: • Observation • Targeted Interviews • Multidisciplinary feedback group discussions. • Co-production of policy, guidance and SOPs.	Sole author of radiography sections	Developed policy and guidance for the organisation and use of forensic radiography in temporary mortuaries. Identified the knowledge and competencies required by forensic radiographers working in multidisciplinary forensic teams investigating mass graves and defined for the first time, policy protocols and SOPs for the use of radiography in these investigations. Policy and SOPs subsequently adopted by the International Criminal Court, International Red Cross and Commonwealth War Graves Commission.

Table 1 (ctd)

ID	Title	Research Methods	Contribution[1]	Areas of Impact
VII	Anderson, A., Hanson, I., Schofield, D., Scholtz H., Velema, J., Viner, M 2007. "SOPs for the Investigation of Mass Graves. 3. Health and Safety" *In:* Cox, M., Flavel, A., Hanson, I., Laver, J. and Wessling, R., eds. *The Scientific Investigation of Mass Graves: Towards Protocols and Standard Operating Procedures.* Cambridge University Press, pp. 109-147. ISBN: 978-0521865876	Observation and reflection on practice: applying radiography knowledge and experience to large multidisciplinary forensic projects in Bosnia, Croatia, Kosovo and Sierra Leone over 7 years from 1996-2002 (Viner, 2001; Viner et al., 2003) • Literature review • Concept analysis of correspondence, feedback and notes from cycles 1-3 (figure 1, p16-17) • Multidisciplinary discussion • Co-production of protocols and procedures. Simulation training exercises for Inforce Foundation/ Bournemouth University - training of forensic radiographers for the Iraq Special Tribunal in 2004: • Observation • Targeted Interviews • Multidisciplinary feedback group discussions. • Co-production of policy, guidance and SOPs.	Sole author of radiography sections	Developed policy and guidance for the organisation and use of forensic radiography in temporary mortuaries. Identified the knowledge and competencies required by forensic radiographers working in multidisciplinary forensic teams investigating mass graves and defined for the first time, policy protocols and SOPs for the use of radiography in these investigations. Policy and SOPs subsequently adopted by the International Criminal Court, International Red Cross and Commonwealth War Graves Commission.

Table 1 (ctd)

ID	Title	Research Methods	Contribution[1]	Areas of Impact
VIII	Anderson, A., Scholtz, H., Vellema, J. and Viner, M., 2007. *SOPs for the* "Investigation of Mass Graves. 6. Mortuary Procedures I – Pathology, radiography and the role of the anatomical pathology technologist." *In:* Cox, M., Flavel, A., Hanson, I., Laver, J. and Wessling, R., eds. *The Scientific Investigation of Mass Graves: Towards Protocols and Standard Operating Procedures.* Cambridge University Press, pp. 268-294, plus recording forms (Appendix) ISBN: 978-0521865876	Observation and reflection on practice: applying radiography knowledge and experience to large multidisciplinary forensic projects in Bosnia, Croatia, Kosovo and Sierra Leone over 7 years from 1996-2002 (Viner, 2001; Viner et al., 2003) • Literature review • Concept analysis of correspondence, feedback and notes from cycles 1-3 (figure 1, p16-17) • Multidisciplinary discussion • Co-production of protocols and procedures. Simulation training exercises for Inforce Foundation/ Bournemouth University - training of forensic radiographers for the Iraq Special Tribunal in 2004: • Observation • Targeted Interviews • Multidisciplinary feedback group discussions. • Co-production of policy, guidance and SOPs.	Sole author of radiography sections	Developed policy and guidance for the organisation and use of forensic radiography in temporary mortuaries. Identified the knowledge and competencies required by forensic radiographers working in multidisciplinary forensic teams investigating mass graves and defined for the first time, policy protocols and SOPs for the use of radiography in these investigations. Policy and SOPs subsequently adopted by the International Criminal Court, International Red Cross and Commonwealth War Graves Commission.

Table 1 (ctd)

ID	Title	Research Methods	Contribution[1]	Areas of Impact
IXa	Viner, M.D., 2008 "The Role of Radiology in Mass Fatality Incidents" in *Recovery, Analysis And Identification of Commingled Human Remains*, Adams, B., Byrd, J., Humana Press, Totowa, NJ. pp 145-184 ISBN: 978-1588297693	Evaluated the scientific application of forensic radiography methods to human identification through observation and reflection on practice in previous cycles 1-4 (figure 1, p16-17). Further developed principles set out in previous publications and applied survey principles used in the imaging of major trauma • Literature review • Observations and reflection on practice • Concept analysis of correspondence • Group discussions: inter- and intra-professional.	Sole Author	Defined the scope of practice of forensic radiography in mass fatality incidents and advanced understanding of the role of the radiographer in DVI amongst a wider international professional community. Detailed scientific principles underpinning the development of protocols & SOPs and set out a systematic method of applying the new paradigm in DVI (Publication II) in a flowchart process for radiography survey model within a multi-disciplinary investigation. Protocols for application of radiography surveys subsequently incorporated in international guidance position statements (publications XI-XIII).
IXb	Viner M.D., (2014) "The Role of Radiology" in *Commingled Human Remains: Methods in Recovery, Analysis and Identification*, Adams, B.J., Byrd, J.E., (eds), Academic Press 2014 pp 87-122 ISBN: 978-0124058897	Further evaluated the scientific application of forensic radiography methods to human identification through observation and reflection on practice. • Literature review • Observations and reflection on practice • Concept analysis of correspondence • Group discussions: inter- and intra-professional. Testing in action – Commonwealth War Graves Commission project: radiography of archaeological remains from a WWI mass grave. (Loe et al., 2014; Viner et al., 2018) • Observation • Targeted interviews • Group discussions.	Sole Author	

Table 1 (ctd)

ID	Title	Research Methods	Contribution[1]	Areas of Impact
X	Thali M., Viner M.D., Brogdon B.G., 2011 *Brogdon's Forensic Radiology, Second Edition,* Boca Raton, CRC Press ISBN: 978-1420075625 Viner M.D., Lichtenstein J.E., *Radiology in Mass Casualty Situations* Chapter 13 pp 177-198 Viner M.D., Laudicina, P. F., *Organisation and Management of Forensic Radiology,* Chapter 33 pp 493-504	Themes arising from earlier research cycles 1-3 (figure 1, p16-17; Section 3.1, p28) and cycle 4, (figure 1, p16-17; Section 3.3.1, p43) were further developed in an international context to bring together organisational processes behind II- VIII • Literature review • Observations and reflection on practice • Concept analysis of correspondence • Group discussions – inter and intra-professional • Co-production of publications.	Joint editor (30%) of volume, principal author of 3 chapters and joint author of 3 chapters. (75%) (90%)	Advanced understanding of the role of the radiographer in FR amongst the wider forensic community. Clarified the legal framework across a range of legal and organisational contexts internationally and further developed the knowledge and competencies required by radiographers across differing models of service provision in an international context. Recognised as the essential text in forensic radiology across the forensic professions. Used as standard course material for courses at a number of universities worldwide.

Table 1 (ctd)

ID	Title	Research Methods	Contribution[1]	Areas of Impact
Positional statements of the members of the DVI working group of the International Society of Forensic Radiology and Imaging:				
XI	Morgan B., et al. Use of post-mortem computed tomography in Disaster Victim Identification. *Journal of Forensic Radiology and Imaging* July 2014, Volume 2, Issue 3, Pages 114–116 ISSN: 2212-4780	Further developed, tested and evaluated guidance produced in earlier cycles 1-3 and 5 (figure 1, p16-17), publications II-IV, VI-VIII,IX,X) within an international context • Literature review • Observations from practice (Viner et al., 1998; Viner et al., 2006c; Viner, 2010; Viner and Robson, 2017; Viner 2017; Viner et al., 2018) • Concept analysis of interview notes following simulation exercise in cycle 5, (figure 1, p16-17) and correspondence Further experimental testing in action- a series of training exercises for Inforce Foundation/ Bournemouth University - training of multi-disciplinary forensic teams 2006-10 (Hutchings et al., 2008) • Observation • Multi-disciplinary feedback • Group discussions. • Group discussions – inter and intra-professional • Co-production of international professional guidelines.	Joint author (15%)	Developed internationally agreed policy and guidance, protocols & SOPs for the use of radiology in mass fatality incidents. Principles applied in DVI incidents including the Grenfell Tower disaster and the MH17 plane crash. (Rutty et al., 2019. Radiography now recognised as a key component of the international DVI process (INTERPOL, 2018).
XII	Viner, M. D. et al., 2015 Use of Radiography and Fluoroscopy in Disaster Victim Identification; *Journal of Forensic Radiology and Imaging* June 2015, Volume 3, Issue 2, Pages 141–145 ISSN: 2212-4780		Principal author (80%)	
XIII	Middleton A., et al. 2016, Forensic odontology radiography and imaging in disaster victim identification: *Journal of Forensic Radiology and Imaging*, September 2016, Volume 6, Pages 28-30 ISSN: 2212-4780		Joint author (25%)	

Table 1 (ctd)

Notes

[1] Contribution
The included publications present a coherent theme which addresses the knowledge gaps underpinning the objectives (p 13), as identified within the literature review. In some cases, whilst these have not been published in peer-reviewed journal articles, they have been co-produced, reviewed and published by the professional body or recognised professional interest groups. In other cases, these publications have a multi-disciplinary focus, having been co-produced by multi-disciplinary teams. Whilst the radiography component of some of these publications represents a small percentage of the overall text, they have been selected on the basis of the Principal Researcher's contribution as sole author of these components and the significance of the impact of the publications within a multidisciplinary context.

[2] Table top exercises
Table top exercises are a widely used tool in governmental organisations to test and evaluate plans, particularly in emergency planning. They are based on simulation, usually involving a realistic scenario and a timeline, which may be real-time or accelerated.

The exercises are run in a single room or in a series of linked rooms to simulate the divisions between responders who need to communicate and be co-ordinated. Players are expected to know the plan and are invited to test how the plan works as the scenario unfolds. This type of exercise is useful for validation purposes, particularly for exploring weaknesses in procedures. Table-top exercises are relatively cheap to run, except in the use of staff time, but demand careful preparation (FEMA, 2010; Cabinet Office, 2014).

3. Results – Publications and Contribution of New Knowledge

By applying action research methodology within a number of forensic contexts, the Principal Researcher gained understanding of the role of the radiographer in forensic imaging, clarifying scope of practice and formulating the basis for standards. This was developed, evaluated and refined through iterative cycles of implementation, observation and reflection within a multi-disciplinary environment, gaining insight into the most effective contribution of radiography (Appendix 2, Section A2.4, p99).

Between 1999 and 2006 the Principal Researcher, developed, co-produced and published a number of key texts (Table 1, p18-27; I, II (a and b), IV, V, IX (a and b), X), demonstrating the unique contribution of the Principal Researcher's work in defining scope of practice and creating a structure for standards in forensic imaging. They advanced understanding of the radiographer's role and identified the underpinning knowledge and competencies required by radiographers, developing policy and guidance for managers, educators, service users and allied professionals. Further publications (Table 1, p18-27: III, VI, VII, VIII, XI, XII, XIII (2005-2016) added knowledge by defining policy and guidance for forensic radiography following mass fatality events.

3.1 Action Research Cycles 1 -3 (Figure 1, p16-17) - Publications I-IV (1996-2004)

As lead radiographer for the UN forensic investigations in the former Yugoslavia from 1996-2001, the Principal Researcher gained extensive first-hand experience of large-scale international criminal investigations and the essential role that radiography and radiographers played within the forensic process.

Recognising the need to establish a framework and procedures for radiography (Figure 1, cycle 1, p16-17), the Principal Researcher first conducted a review of the literature and available guidelines and protocols from national and international radiography organisations and found only one document (CoR, 1985), which simply provided basic procedural information.

The Principal Researcher was uniquely placed to examine the role of the radiographer within the context of a complex forensic investigation from crime scene to mortuary. Working closely with the senior pathologist, anthropologist, odontologist, mortuary manager, investigators and scenes of crime officers, the Principal Researcher studied and evaluated the roles and procedures of each profession involved in the investigation. This gave greater understanding of forensic procedures and enabled evaluation of the potential contribution of radiography, when undertaken by suitably qualified radiographers, to the investigation.

During discussions with other disciplines it became apparent that the lack of understanding amongst radiographers regarding the role of imaging within forensic investigation also extended to other professions.

The Principal Researcher used longitudinal and cross-sectional designs to examine the role of radiography across the disciplines of forensic pathology, forensic odontology and forensic anthropology (Figure 1, cycle 2, p16-17) and develop protocols and SOPs for radiographers (UN ICTY, 1998). These were reviewed and discussed with other lead professionals to ensure consistency of approach and tested, reviewed, fine-tuned and their impact evaluated over the initial three-year period (1996-98) by observation and targeted interviews with experts in each field.

These included:

- forensic anthropologists experienced in human identification and in the analysis of trauma in homicide and human rights investigations in Latin America and SE Asia
- pathologists from developed and developing countries with experience of trauma, gunshot wounds, narcotics trafficking and SPA
- pathology technologists working in a range of physical environments in developed and developing countries
- police investigators from differing judicial systems in Europe, North America, Africa and Asia.

This inclusive approach enabled the fullest possible understanding of the range of forensic investigation to determine the potential scope of forensic radiography.

A total of 16 targeted interviews were conducted over a two year period from 1997-98, eight in the first year and a further eight in the following year after revision and fine-tuning of the protocols and SOPs. Four participants (two in each year) from each of the above four professional groupings were selected from within the UN ICTY forensic team to ensure a mix of representation from developed and developing countries. Participants were selected from those who had worked on the investigation for periods in excess of four weeks on the basis of their level of prior experience of forensic caseload in which radiography had the potential to provide a significant contribution, as defined by the literature review.

Each tranche of interviews was conducted face-to-face by the Principal Researcher over a two week period towards the end of each forensic investigation phase during September/October of each year. Interviews were conducted in accordance with the ethical principles discussed in

Appendix 2 (Section A2.6, p104). They were designed to be semi-structured, with a number of pre-determined open questions to explore subject areas identified in the initial literature review: to establish the extent to which radiography had been utilised by the interviewee during the investigation, the degree to which it had proved useful, operational difficulties encountered in accessing radiography during the investigation, types of imaging that could be obtained versus that which would normally be required, evaluation of workflow, quality and consistency of imaging examinations, continuity of evidence and record keeping , suggestions for improvements that could be made, etc..

The average time for each interview was 30-40 minutes with some outliers. Interview notes were taken at the time by the Principal Researcher. These were transcribed and checked for accuracy with interviewees prior to evaluation of qualitative findings using the process described in Appendix 2 (Section A2.4, p99).

Having developed understanding of the role of the radiographer, the Principal Researcher led a focus group of radiographers who had been deployed to the UN teams in 1996 and 1997 to define the knowledge and competencies required by radiographers, establish criteria for selection of radiographers to work within the team, develop induction and training material, and the design of training events.

A single focus group was comprised of five radiographers who had worked with UN investigating teams in 1996 and 1997. As a small group made up of individuals of a high level of expertise, this can be considered to be a mini focus group (Hague, 2002). The group met three times during March and April 1998 in London. The Principal Researcher acted as facilitator for the focus group discussions and notes were taken by a radiographer colleague who also observed non-verbal interactions and group dynamics (Burrows and Kendall, 1997; Nyumba et al., 2018). The group discussed their experiences of working with the forensic teams and their opinions regarding the knowledge, competencies, experience and personal attributes that they considered were required by radiographers working within the teams. In the latter meetings the group were asked to give opinions and attitudes on draft induction and training material and the design of training events.

Focus group meeting notes were documented and qualitative findings evaluated following the process described in Appendix 2 (Section A2.4, p99).

Knowledge gained during further investigations from 1999 to 2002 in Bosnia, Croatia, Kosovo, Sierra Leone and the Republic of Ireland enabled procedures, guidance and training material to be drafted, reviewed and edited through further cycles of review (Figure 1, cycles 2-3, p16-17).

In 1997 the Principal Researcher approached the College of Radiographers to suggest that their existing guidelines be revised. This occurred at the same time that results of a study into forensic radiography by Baker and Hughes of the University of Central England (1997) were submitted which made similar recommendations. In 1998, the Principal Researcher was appointed to chair and lead a working group comprising radiographers from the Trauma Imaging Group, the Society and College of Radiographers, University of Central England and an advisor from the British Association of Forensic Medicine. During 1998-99 this group drafted guidelines for forensic radiography and tested and refined its recommendations with senior pathologists and coroners.

3.1.1 Publication I, (1999)

Guidance for the Provision of Forensic Radiography Services (I) is recognised as the first comprehensive professional policy document for forensic radiography, defining radiographers' scope of practice and setting out guidelines for the development of local policies and procedures.

It defines the term "forensic medicine" and makes clear that it relates to both living and deceased subjects. It characterises forensic radiography as one of the most commonly used methods for collecting evidence and identifies four principal areas of practice: human identification, identifying skeletal trauma e.g. in cases of non-accidental injuries, determination and/or confirmation of the cause of death, and locating hidden foreign bodies. The guidelines are now in their fourth edition, having been reviewed and updated to reflect developments in practice, with the later and most recent versions (CoR/IAFR, 2014) going a step further in defining the term forensic radiography as "the application of the science of diagnostic imaging to questions of law". The four principal areas of practice have been refined as: investigation of non-fatal injuries, location of other forensic evidence, cause of death, and human identification.

A significant section is devoted to discussing the importance of correctly authenticating evidence produced in the course of a radiography examination and ensuring documentation of the provenance and continuity of the evidence throughout the process with detailed recommendations on how this should be achieved. As shown by the literature (Appendix 1, p68), this was the first attempt by the radiography profession to evaluate and apply the principles of evidence collection to its own practice and to detail the requirements in a manner that could be understood and applied by practitioners.

It also sets out the underpinning knowledge and competencies required by radiographers, stressing the need for training and CPD in this area of practice which had been hitherto largely overlooked by undergraduate and post-graduate programmes (Baker and Hughes, 1997).

The guidelines set out a structure for written protocols recommending that these be developed within every organisation undertaking forensic radiography.

In the course of the work to define the knowledge and competencies required for forensic radiographers in UN teams described above, the Principal Researcher corroborated the findings of Baker and Hughes (1997) – namely that radiographers possessed little knowledge of forensic investigation and procedures, testing this through interviews and a questionnaire targeting the main stakeholders.

The Principal Researcher subsequently led a small team of radiographers from TIG(FR) to develop and deliver CPD events and short courses in forensic imaging for radiographers, and worked together with a pathologist and forensic anthropologist as advisors to the University of Central England to establish the first postgraduate course in forensic radiography in the UK. The CoR guidance document formed the basis of the syllabus for this course commencing in 1999 and for subsequent courses.

Contribution of New Knowledge

This publication addressed the identified gaps in knowledge and understanding by providing information and guidance for radiographers and radiography service providers in an accessible, single document. Uniquely amongst the Principal Researcher's publications cited in this thesis, it addresses all the major objectives of this study and demonstrates contribution of new knowledge by:

- Defining the scope of practice of forensic radiography
- Identifying the underpinning knowledge and competencies required by forensic radiographers
- Advancing understanding of the role of the radiographer in forensic imaging
- Developing policy and guidance for forensic radiography
- Developing a structure for protocols and SOPs in forensic radiography.

3.1.2 Publication IIa (2001), IIb (2003) and Publication III (2005)

The Principal Researcher gained first-hand experience of a mass fatality incident (Viner et al., 1998), observing the procedures used to examine and identify the deceased (Figure 1, cycle 2, p16-17), and recognised that the principles developed for forensic examination of bodies

exhumed from mass graves could equally be applied in any mass fatality incident, however caused. This led to greater understanding of the role of the radiographer in such incidents.

A series of interviews and inter-professional focus group discussions[1] with pathologists, odontologists, anthropologists, coroners and emergency planners determined that there was a lack of awareness regarding the significant contribution that radiography could make or how it could be integrated within the mass fatality response.

To investigate this further (Figure 1 cycles 2-3, p16-17), the Principal Researcher undertook a survey of emergency preparedness in England and Wales which aimed to determine the existing levels of planning for use of radiology in the event of mass disasters. This survey employed two postal questionnaires, targeting the following professions (Viner and Hoban, 2001):

- radiology service managers/superintendent radiographers
- emergency planning officers / health emergency planning advisers
- coroners and forensic pathologists.

These professions were divided into two groups, each of which received a different questionnaire, worded to reflect their particular perspective. Those which were identified as potential users of the forensic radiology service (coroners, forensic pathologists and local authority emergency planning officers) received a Type A (service user) questionnaire, whilst those who were identified as potential providers of the service (radiology services managers/superintendent radiographers and health emergency planning advisers) received a Type B (provider) questionnaire.

Participants were selected on the basis of geographical location based upon coroners' areas. A total of 30 Coroners' areas were selected ensuring at representation from within each of the eight NHS regions of England and Wales. Purposive sampling was used to give a sample of both urban and rural environments and to include those that covered major cities, airports, transport hubs and large industrial zones. Type A (service user) questionnaires were sent to each of the 30 coroners and 17 forensic pathologists covering those areas drawn from the British Association for Forensic Medicine (BAFM) database.

Responsibility for emergency planning within these coroners' areas lay with the respective local authorities. A total of 34 local authorities were identified as having responsibility for the identified coroners' areas, (some coroners covering more than one local authority area), and Type A questionnaires were distributed to each of the 34 local emergency planning officers.

[1] Interviews and focus groups were conducted using a similar methodology to that described on pages 29-30. However, due to the extended time period of this research, the precise details of the participants and dates of these interviews and focus group discussions are no longer available.

As local authorities liaise closely with health services for emergency planning, Type B (provider) questionnaires were sent to health emergency planning advisors for each of the corresponding eight NHS regions. All major hospitals with emergency departments located within the selected Coroners areas were identified from the TIG database. Type B questionnaires were sent to all 69 identified hospitals and addressed to named superintendent radiographers with responsibility for the emergency department where known. Where individuals were not known, questionnaires were addressed to the radiology services manager.

The aim of the survey was to test the extent of the knowledge gaps identified within the literature review (Section 1.3, p12) as they related to the use of forensic radiography in disaster victim identification: to identify the level of understanding of the scope of practice, potential contribution of forensic radiography and the role of the forensic radiographer, develop greater understanding of the knowledge and competencies required by radiographers and the extent to which radiography was incorporated within plans, policy and guidance. Questions were designed using a mix of closed questions to measure attitudes between the different groups, with open questions to identify areas for further exploration via targeted interviews. They addressed five key areas:

- Demographics – to gather data regarding the status of the respondent, the size of the area covered, population, degree of urbanisation and any significant potential for mass disaster events
- Radiology response – to determine the level of understanding of the potential scope of practice of radiography in the management of DVI incidents, the role of the radiographer and the understanding of where responsibility lay for providing equipment and staff
- Planning –to determine the extent to which available guidance and emergency plans included the use of radiography and availability and provision for deployment of the necessary staff and equipment
- Field experience – to identify those with prior experience of managing DVI incidents and gain understanding of the degree to which guidance had existed or been sought, the facilities deployed, problems encountered and any changes to plans that had resulted from this. To elicit recommendations for guidance, provision of equipment and improving co-ordination between agencies
- Training – to examine the degree to which training, exercising and co-ordination between agencies existed

Questionnaires were sent by post and a stamped return envelope was provided in order to encourage response. A total of 81 questionnaires of Type A and 77 of Type B were distributed. The overall response rate was 43% with 35 Type A and 33 Type B questionnaires returned.

Response was highest amongst emergency planners (53%) and lowest amongst radiology service managers/ superintendent radiographers (36%) - a response rate well below the average of 67% for such a postal survey (Asch et al. 1997).

The questionnaire was followed up by targeted semi-structured interviews with some respondents to explore some of the emergent themes. Purposive sampling was used to target those respondents with prior experience of responding to DVI incidents. In total two pathologists, two coroners, three emergency planners and two superintendent radiographers were interviewed. Interviews were conducted in February 2001, either as face-to-face or as telephone interviews by the Principal Researcher. Interviews were conducted in accordance with the ethical principles discussed in Appendix 2 (Section A2.6, p104) and were designed to be semi-structured, with a number of pre-determined open questions to explore the identified themes.

Some interesting anomalies were revealed. Almost all coroners, pathologists and emergency planners who responded, indicated that plans were in place for radiology and that these relied on local hospitals providing equipment and staff. However, only 28% of radiology managers who responded were aware of any such plans. Of those who responded, 85% of coroners, pathologists and emergency planners supported the need for a co-ordinated national approach and many requested information and assistance.

The Principal Researcher was instigator and principal author of *Provision of Radiology Facilities within Temporary Mortuaries in the event of a Mass Disaster* (IIa), which outlined the potential contribution of radiography, introducing for the first time the concept of “primary and secondary” radiography surveys for radiographic triage within mass fatality investigation.

The document was circulated to local and central government representatives and was widely used as the basis of local and regional emergency mortuary plans in the UK.

Significantly it was used by Hammersmith and Fulham Council to revise plans for the West London Coroner’s area in 2003. The Principal Researcher tested the practicality and applicability of the recommendations through multidisciplinary simulation exercises. A table top exercise (p27), of existing DVI procedures and temporary mortuary plans was undertaken to evaluate capacity to include radiological analysis. This was followed by a simulation exercise organised by HM Coroner at RAF Northolt. Observations made by the Principal Researcher and a radiographer colleague

were followed by targeted interviews and multidisciplinary discussions between forensic specialties to gain feedback.

A total of seven targeted interviews were conducted with the key stakeholders. Interviewees comprised HM Coroner for West London, the senior forensic pathologist, senior forensic odontologist, the police senior identification manager, mortuary manager and local authority emergency planner and senior radiographer.

Each interview was conducted face-to-face by the Principal Researcher on the day immediately following the simulation exercise. Interviews were conducted in accordance with the ethical principles discussed in Appendix 2 (Section A2.6, p104). They were designed to be semi-structured, with a number of pre-determined open questions formulated to test the practicality and applicability of the recommendations made in Publication IIa, and to elicit suggestions for improvements that could be made. Other questions sought to address knowledge gaps identified in the literature review and gain further understanding of the scope of practice of forensic radiography in DVI and the knowledge and competencies required by forensic radiographers (Section 1.3, p12).

The average time for each interview was 30 minutes. Interview notes were taken at the time by the Principal Researcher's radiography colleague. These were transcribed and checked for accuracy with interviewees.

A multi-disciplinary feedback meeting of all exercise participants was held immediately following the event. This meeting was facilitated by the Police Senior Investigation Manager as an open discussion on the organisation of the mortuary and identification procedures, workflow, data recording methods, etc.. Notes of themes and issues arising that were pertinent to radiography provision and organisations were recorded at the time by both the Principal Researcher and radiographer colleague.

Focus group meeting notes were documented and qualitative findings evaluated following the process described in Appendix 2 (Section A2.4, p99).

Recommendations arising from this analysis are contained within *Temporary Mortuary Exercise RAF Northolt 13/4/2003: Review of Facilities and Requirements* (IIb). Guidance was further refined following a multi-disciplinary meeting of radiographers, coroners, emergency planners, pathologists, odontologists and HM Government representatives at the College of Radiographers in June 2004.

The West London plan was activated in December 2004 for the forensic identification of the deceased repatriated following the South East Asia Tsunami. Following the incident the implementation of the plan was reviewed by a multi-disciplinary team and the plan amended to take account of lessons learned. The review process highlighted the value of a co-ordinated forensic radiography service integrated within the DVI processes and as a result the Government Office for London asked the Principal Researcher to assist with development of a pan-London mass-fatality plan.

The Principal Researcher was the sole radiographer working as part of a group of emergency planners, police officers, coroners, pathologists, anatomical pathology technologists, odontologists, anthropologists and forensic scientists to compile an integrated DVI plan. Through discussion groups, table top exercises (p27), and concept analysis of correspondence, the Principal Researcher refined and developed the principles and recommendations set out in publications IIa and b, testing these against the logistics plan and procedures employed by the other specialists.

Two table-top exercises (p27) were held during 2004 to test and evaluate the developing resilience plans for London. These were based on two different realistic scenarios involving potential (exercise 1) or actual (exercise 2) activation of the mass fatality mortuary plans following a major incident in London. Both exercises were run on an accelerated timetable in a series of linked rooms at the Government Office for London. Exercises were designed to test robustness of call out response processes of both staff and equipment for the emergency mortuary (exercise 1) and DVI procedures within the mortuary (exercise 2). Both exercises were prepared and facilitated by the emergency planners from the Metropolitan Police Service and British Transport Police Force who subsequently held feedback discussion groups following each exercise. A summary and report of the outcome of each exercise and feedback meeting was made available to all participants[2].

The Principal Researcher also made detailed notes following both exercises and discussion groups. Qualitative findings from these, together with the exercise reports were evaluated following the process described in Appendix 2 (Section A2.4, p99).

Radiography was integrated into the mortuary workflow plan at each stage and requirements for radiography equipment and radiation safety were compiled and detailed. The Principal Researcher worked with a consultant physicist to devise and compile a radiation plan and local radiation rules for application within varying emergency mortuary configurations. *The London*

[2] Due to the classification of these planning exercises as “Restricted”, precise information regarding participants, scenarios and management of the exercises cannot be further detailed.

Mass Fatality Plan (III) was published in June 2005 and put into action on 7th July 2005 following the London Suicide Bombings.

Contribution of New Knowledge

The Principal Researcher co-produced the first integrated DVI mass fatality plan incorporating the systematic use of radiography in the UK, suitable for implementation in a variety of different emergency mortuary environments. This, together with publication II (a and b), has contributed new knowledge by:

- Defining the scope of practice of forensic radiography in mass fatality incidents
- Advancing understanding of the role of the forensic radiographer in these incidents
- Developing policy and guidance for the use of forensic radiography in mass fatality incidents
- Developing protocols and SOPs in forensic radiography for use in such incidents.

3.1.3 Publication IV (2006)

Using training material developed for radiographers working with the UN teams (Section 3.1, p28-31), the Principal Researcher led a group of experienced radiographers to develop material for CPD events and short courses to equip radiographers with the necessary knowledge and competencies required when responding to mass fatality incidents (Figure 1, cycle 3, p16-17). These were identified by previous research and defined within the CoR guidelines (I, Section 3.1.1, p31) and the TIG(FR) guidance document (IIb, Section 3.1.2, p32). Courses were first delivered in 2003, with radiographers who successfully completed the training joining the TIG(FR) Mass Fatality Response Register. Course design and material was reviewed and revised following each course in response to course evaluation.

Following the Tsunami of 2004 and London Suicide Bombings in 2005, the UK Home Office set up the multidisciplinary UK DVI team. The forensic radiography response team was a key component of UK DVI from the outset and government planning for the use of radiography adopted the principles set out in the *London Mass Fatality Plan* (III). It was agreed that specific education and training would be required for all members of UK DVI, including medical, dental and scientific specialists, police officers and emergency planners and that a new textbook on human identification would support this.

The Principal Researcher was invited to author the forensic radiology chapter within this textbook, *"Human Identification"*, edited by Thompson and Black and published in 2006 (IV), and

invited two radiographers who had participated in earlier phases of the research to co-author the text.

Material was developed by review of the literature, the guidance set out in publications IIa and IIb and by reflecting upon the effectiveness of the radiography response to the Tsunami and London Bombing incidents. Concept analysis of correspondence and feedback was undertaken together with observations and reflections on practice through targeted interviews with members of the multi-disciplinary forensic team (Viner et al., 2006c).

A total of six targeted interviews were conducted with the key members of the multidisciplinary team. Interviewees comprised a consultant forensic pathologist, the senior forensic odontologist, a forensic anthropologist, mortuary manager, local authority emergency planner and senior radiographer, all of whom had participated in the response to one or both events. Interviews were conducted in November 2005, either as face-to-face or as telephone interviews by the Principal Researcher.

Interviews were conducted in accordance with the ethical principles discussed in Appendix 2 (Section A2.6, p104). Interviews were designed to be semi-structured, with a number of pre-determined open questions to explore the subject areas identified through the concept analysis; to establish the extent to which radiography had been utilised by the interviewee during the investigation(s), the degree to which it had proved useful, operational difficulties encountered in accessing radiography during the investigation(s), types of imaging that could be obtained versus that which would normally be required, evaluation of workflow, quality and consistency of imaging examinations, continuity of evidence and record keeping , suggestions for improvements that could be made, etc.

The average time for each interview was 45 minutes. Written notes were taken at the time by the Principal Researcher and then transcribed and shared with the interviewee for verification and amendment in order to ensure accuracy and test understanding. Qualitative findings were evaluated following the process described in Appendix 2 (Section A2.4, p99).

The chapter summarised scientific principles for human identification using radiological methods and applying knowledge gained from the research undertaken to support publications I to III, discussed their practical application, and set out a simple scheme of work. Although basic when evaluated against later studies, this contained essential elements which underpinned the later

development of detailed protocols and SOPs by the Principal Researcher (Section 3.3.2, p45). It emphasised the role of the radiographer, referring to the 1999 guidelines (I) and Ionising Radiation legislation, and whilst it stressed the importance of involving appropriately educated, trained and experienced radiographers, it failed to adequately detail reasons for this and the knowledge and competencies that they should possess.

Somewhat prescient, the chapter foresaw the increasing use of newer modalities such as CT and MRI scanning and digital radiography, and challenged the forensic community to develop this potential and apply them within a multi-disciplinary approach to human identification.

Contribution of New Knowledge

As shown by the literature review (Appendix 1, p68), many forensic disciplines had limited knowledge of radiology and there were applications of radiology within forensic science of which imaging professionals were ignorant. This chapter addressed this issue in the field of human identification, being unique at that time as a text authored by radiographers on this subject aimed at a multi-disciplinary audience. Through this publication, the Principal Researcher has contributed new knowledge in the field of forensic radiography in human identification by:

- Defining the scope of practice of forensic radiography in this area
- Advancing understanding of the role of the radiographer in forensic imaging amongst the wider forensic community.

3.2 Action Research Cycle 4 (Figure 1, p16-17) - Publication V (2004-2006)

3.2.1 Publication V (2006)

In preceding research cycles the Principal Researcher applied new knowledge gained within the context of radiography in the UK. Through observation, reflection and discussion arising from work with international forensic teams in cycles 1 and 3 (Figure 1, p16-17), the Principal Researcher was aware that legal, organisational and educational differences existed elsewhere.

Between December 2005 and March 2006 the Principal Researcher undertook a three month study in Argentina, Australia, South Africa and the USA to examine the role and development of forensic radiography internationally and apply knowledge gained to develop the research objectives. Cross-sectional sampling across a variety of systems, working environments and professional groups was used, contrasting the findings against the UK position established during previous research cycles.

Using a combination of literature reviews, observation visits and targeted interviews, the current and potential level of forensic radiology usage, equipment and staff provision, training and experience, and systems of organisation were investigated.

A total of 20 centres undertaking forensic radiography were visited across the four countries; South Africa (6), Australia (1), Argentina (3) and USA (10). Countries and centres were selected in order to evaluate the effect of a range of different factors which would potentially affect the levels of demand for and provision of forensic radiography. Observation of facilities and operating procedures was undertaken in each centre by the Principal Researcher. Notes, photographs and some video recordings were made at the time using Microsoft Note ® and a tablet PC.

A total of 46 interviews were conducted across a range of professions. Participants were: radiographers (11), radiography educators (9), forensic pathologists and medical examiners (17), forensic anthropologists (6), forensic radiologists (3).

Interviews were conducted in accordance with the ethical principles discussed in Appendix 2 (Section A2.6, p104). Interviews were designed to be semi-structured, with a number of pre-determined open questions to explore identified subject areas identified within cycles 1-3 (Figure 1, p16-17) to establish, within the different operational contexts: the extent to which radiography was currently utilised by the interviewee during investigations, the degree to which it proved useful, operational difficulties encountered in accessing radiography during investigations, types of imaging that could be obtained versus those which would normally be required, evaluation of workflow, quality and consistency of imaging examinations, continuity of evidence and record keeping across number of different legal systems, standards of education and training, existence and content of emergency plans, suggestions for improvements that could be made, etc.

The average time for each interview was 45 minutes with a number of outliers in excess of one hour. Written notes were taken at the time by the Principal Researcher using Microsoft Note® and a tablet PC and were subsequently transcribed and shared with the interviewee for verification and amendment in order to ensure accuracy and test understanding. Qualitative findings were evaluated following the process described in Appendix 2, A2.4, p99).

Radiography and Forensic Medical Investigation – A study of forensic radiography in South Africa, Argentina and the USA (V) was written to meet the requirements of the Winston Churchill Memorial Trust which funded this research. It was an interim report, descriptive in nature, focussing upon organisational aspects of the study, and presenting initial findings to a lay audience.

The Principal Researcher continued to evaluate the results of this study (Viner, 2006b), reflecting upon the information gained and applying, testing and refining this in subsequent research cycles (Figure 1, cycles 5, 6, p16-17). This led to further publications VI-XIII (Section 3.3, p43; Section 3.4, p47), intended for an international audience.

Contribution of New Knowledge

This is a unique study of the role and development of forensic radiography at an international level across a range of legal, cultural, medical and educational systems.

Through this publication, the Principal Researcher has contributed new knowledge by:

- Further defining scope of practice of forensic radiography across a range of legal and organisational contexts
- Identifying underpinning knowledge and competencies required by forensic radiographers practising in different jurisdictions
- Advancing understanding of the role of the radiographer in forensic imaging amongst the wider forensic community.

3.3 Action Research Cycle 5 (Figure 1, p16-17) - Publications VI-X (2004-08)

3.3.1 Publications VI-VIII (2007)

In 2001, the Principal Researcher joined an international team of experts as sole radiography advisor on the Scientific Advisory Board of the International Centre for the Investigation of Genocide (INFORCE) Foundation.

The Foundation aimed to document the knowledge accumulated by the forensic team of the UN ICTY, a key element of which was the compilation of protocols and SOPs. The Principal Researcher built upon work undertaken in earlier stages (cycles 1-3, figure 1, p16-17), defining the scope of practice and adapting protocols and procedures (Section 3.1, p28 and Section 3.2, p40). These were evaluated against observations and reflections by the Principal Researcher in the course of forensic investigations of mass graves with the UN in Sierra Leone in 2000, clandestine graves in the Republic of Ireland from 2000-2001, training courses for forensic radiographers in Kosovo in 2002, and through concept analysis of feedback correspondence received from multi-disciplinary teams during and following these studies.

These protocols and SOPs were tested, fine-tuned and evaluated during simulation exercises as part of a training programme for Iraqi radiologists and radiographers during 2004. Training, devised and led by the Principal Researcher was delivered by a team of radiographers from the IAFR. Through multi-disciplinary feedback, targeted interviews with lead practitioners and subsequent refinement and testing, robust SOPs and recording forms for use of radiography, dental radiography and fluoroscopy in such incidents were developed.

A total of six targeted interviews were conducted. Interviewees comprised the senior forensic archaeologist, a forensic anthropologist, the training programme manager, an experienced forensic investigator, a mortuary manager and a radiographer.

Each interview was conducted face-to-face by the Principal Researcher on the day immediately following one of the simulation exercises. Interviews were conducted in accordance with the ethical principles discussed in Appendix 2 (Section A2.6, p104). They were designed to be semi-structured, with a number of pre-determined open questions formulated to test the practicality and applicability of the protocols and SOPs and to elicit suggestions for improvements that could be made. Other questions sought to address knowledge gaps identified in the literature review and concept analysis and gain further understanding of the scope of practice of forensic radiography in the forensic investigation of mass graves and the knowledge and competencies required by forensic radiographers. The average interview time was 30 minutes. Written notes

taken at the time by the Principal Researcher were transcribed and shared with the interviewee for verification and amendment in order to ensure accuracy and test understanding.

A single focus group was comprised of nine radiographer members of the IAFR who had participated in the delivery of the training programme. In addition six of the members of this group had prior experience of working with UN ICTY forensic teams in the former Yugoslavia. The group met three times during the period October 2004 to April 2005 in Bournemouth and London. The Principal Researcher acted as facilitator for the focus group discussions and notes were taken by a radiographer colleague who also observed non-verbal interactions and group dynamics (Burrows and Kendall, 1997; Nyumba et al., 2017). The group discussed their experiences, both of working as members of forensic teams and in delivery of the training programme, regarding the the scope of practice and required elements of protocols and procedures, competencies, experience and personal attributes that they considered were required by radiographers working within the forensic teams on the investigation of mass graves. In the later stages, the group were asked to give opinions and attitudes on draft protocols, SOPs and recording forms.

Qualitative findings were evaluated following the process described in Appendix 2, A2.4, p99). Protocols were then evaluated against the findings of cycle 4 (Section 3.2, p40) to develop procedures applicable across a wide range of jurisdictions, with varying levels of equipment provision, taking account of differences in radiography education.

The Scientific Investigation of Mass Graves: Towards Protocols and Standard Operating Procedures was published in 2007 and contains a number of chapters with radiography specific content which were authored by the Principal Researcher (VI, VII, VIII).

Contribution of New Knowledge

This volume is recognised as the first and, to date, only comprehensive text regarding the forensic examination of mass graves, and these chapters define, for the first time, protocols and SOPs for the use of radiography in these investigations. The Principal Researcher has contributed new knowledge by:

- Advancing the understanding of the role of the radiographer in forensic imaging for the investigation of mass graves and exhumed remains
- Developing policy and guidance for the organisation and use of forensic radiography in temporary and emergency mortuaries
- Developing forensic radiography protocols and SOPs for the forensic investigation of mass graves.

3.3.2 Publications IXa (2008) IXb (2014) and X (2011)

Themes arising from earlier research cycles 1-3 (Figure 1 p16-17; Section 3.1, p28) together with those arising from publications VI-VIII (Section 3.3.1, p43) were further developed and shared with an international audience in a series of publications. Impetus for this arose from research undertaken by the Principal Researcher in 2005-6 (Figure 1, cycle 4, Section 3.2.1, p40) which concluded that issues of a lack of standards and protocols, first recognised in the UK, were equally apparent in other countries.

The study of the role and development of forensic radiography in South Africa, Australia Argentina and the USA (publication V, Section 3.2.1, p40) concluded that, whilst radiography was recognised as a useful tool in forensic investigations, the levels of utilisation differed greatly from country to country owing to demographic epidemiological and social variations. Moreover, significant variations were found between sites in each country with levels of utilisation of radiography within forensic investigation ranging from 5% to 55% of cases.

In some situations this was due to lack of physical resources in terms of equipment but in many there appeared to be a correlation between the level of training given to those undertaking radiography examinations and the levels of utilisation and perceived benefit to the investigation.

Forensic investigation was usually pathology driven, often unaware of the potential of imaging and having little input from imaging professionals. The approach was often unsystematic and there were few protocols and standard operating procedures to refer to. As a result there was little integration as part of any regional and national DVI response.

Whilst more forensic mortuaries had on-site imaging equipment, the situation in many parts of the countries visited was that forensic imaging was not being undertaken by trained personnel, supporting Brogdon's observations (Brogdon, 1998a). In such places standards of imaging technique, image processing, quality control, radiation safety and health and hygiene were compromised and it is almost inevitable that the forensic investigations was less thorough as a result.

However, centres in which experienced, qualified radiographers, radiologic technologists or radiography technicians undertook examinations or had a direct input into the planning, coordination and training programmes of the service, were characterised by better standards, safer working environments, increased utilisation and appropriate application of new technologies.

The study found that education and training for radiographers at undergraduate level was generally restricted to non-accidental injury. None of the countries surveyed had any guidelines or protocols for radiographers and there was little information, post-graduate training or CPD opportunities available for radiographers.

The situation in these countries thus reflected Brogdon's observations and reflected the situation in the UK in the mid-1990s, as described by Baker and Hughes (1997) who discovered many radiographers were asked to undertake forensic imaging with no prior training, knowledge of procedures or the reasons for examinations that they had been asked to undertake, and no guidelines or protocols to refer to.

The emphasis of *The Role of Radiology in Mass Fatality Incidents* (IX a and b) was to detail scientific principles underpinning development of protocols and SOPs. It set out a systematic method of applying these and presents for the first time a process flowchart for the primary, secondary and tertiary radiography survey model first described in Publication IIa (Section 3.1.2, p32) providing case studies and sample recording forms drawn from publications VI-VIII (Section 3.3.1, p43)

The second edition incorporates results from further action research undertaken during an investigation (2009) of First World War mass graves in which the Principal Researcher applied similar principles to those used in forensic investigation (Section 3.3.1, p43) to an historical archaeological investigation. Observation and feedback from targeted interviews with service users identified specific challenges within archaeological studies requiring re-evaluation and modification of the imaging procedures. A total of five targeted interviews were conducted. Interviewees comprised the senior forensic archaeologist, a forensic anthropologist, the programme manager, a radiation physicist and a radiographer.

Each interview was conducted face-to-face by the Principal Researcher one day towards the end of the project. Interviews were conducted in accordance with the ethical principles discussed in Appendix 2 (Section A2.6, p104). They were designed to be semi-structured, with a number of pre-determined open questions formulated to test the practicality and applicability of the protocols and SOPs to archaeological investigation and to elicit suggestions for improvements that could be made. Other questions sought to address knowledge gaps identified in the literature review and concept analysis and gain further understanding of the scope of practice of forensic radiography in the archaeological investigation of mass graves and the knowledge and competencies required by forensic radiographers. The average interview time was 40 minutes.

Written notes taken at the time by the Principal Researcher were transcribed and shared with the interviewee for verification and amendment in order to ensure accuracy and test understanding.

Since publication in 1998, Brogdon's Forensic Radiology had been the comprehensive standard text for those using radiology within forensic investigation. As a result of international recognition of his work, the Principal Researcher was asked by Brogdon to co-edit a new edition as part of an international team comprising two radiologists and a radiographer. This completely revised edition was published as *Brogdon's Forensic Radiology – 2nd Edition* (X).

In addition to co-editing the volume, the Principal Researcher authored a chapter on mass fatality incidents, setting out a proposed SOP, building on that described in publication IX above, together with a new chapter on the organisation and management of forensic radiology. This drew significantly upon, and referenced, publication I (Section 3.1.1, p31), providing a template for procedures and SOPs. The Principal Researcher was also lead editor for the revised section on forensic radiography intended as a primer for non-radiographers undertaking forensic imaging.

Contribution of New Knowledge

Both textbooks are recognised as key texts in forensic medical sciences and are used as course material in universities throughout the world. Through these publications, intended for multidisciplinary audiences, the Principal Researcher advanced greater understanding of the scope and potential of forensic radiography and the role of the radiographer in forensic investigation. Through these publications, the Principal Researcher has contributed new knowledge by:

- Advancing the understanding of the scope of forensic radiography and role of the radiographer in forensic imaging amongst the wider forensic community
- Developing policy and guidance for forensic radiography for a wide range of forensic investigations
- Developing protocols and SOPs for forensic radiography of mass fatality incidents
- Identifying underpinning knowledge and competencies required by forensic radiographers

3.4 Action Research Cycle 6 (Figure 1, p16-17) - Publications XI-XIII (2011-16)

The Principal Researcher is a founding board member of both the IAFR and ISFRI, and has been a member of the DVI working group of ISFRI since its inception in 2014. The latter has published a series of position statements on the use of radiology in DVI. The Principal Researcher is lead

author of one of these statements and joint author of another two which represent the first internationally agreed protocols and procedures for the use of radiology in mass fatality incidents [XI-XIII].

3.4.1 Publications XI (2014), XII (2015), XIII (2016)

These publications together with a subsequent publication in 2018 (Rutty et al. 2018), incorporate the results of research undertaken in cycles 2-5 (Figure 1, p16-17; Publications II, III, IX and X) and represent the official adoption of significant aspects of the previously defined protocols and SOPs by both ISFRI and IAFR.

The Principal Researcher worked with a multidisciplinary team to devise international recommendations for the management of mass fatality incidents. The outcomes of previous research cycles were evaluated through inter- and intra-professional group discussions, concept analysis of correspondence and observations and reflections from the Principal Researcher's practice (Viner, 1998, Viner et al. 2006, Viner, 2010, Viner and Robson 2017, Viner et al. 2018).

These were combined with observations and data from the targeted interviews and group discussions following testing, review, fine-tuning and evaluation of procedures and SOPs during simulation training exercises for radiographers led by the Principal Researcher during cycle 5 for the Inforce Foundation in 2004, together with observation and reflection from a series of similar simulation training exercises held during 2006-10 (Hutchings et al. 2008). Outcomes of previous research were evaluated by the Principal Researcher through group discussions and concept analysis of correspondence across a number of possible scenarios within different jurisdictions. Findings from the different data sources were triangulated to enhance validity and reliability (Sagar 2000), and guidance was refined in order to make it applicable to an international audience.

Contribution of New Knowledge

Through these publications, the Principal Researcher has contributed new knowledge by:

- Defining the scope of practice of forensic radiography for DVI internationally
- Advancing understanding of the role of the radiographer in forensic imaging for DVI
- Developing international policy and guidance for forensic radiography for DVI
- Developing protocols and SOPs for forensic radiography in DVI incidents in a range of jurisdictions.

3.5 Summary of Contribution of New Knowledge

The Principal Researcher's contribution to new knowledge and the impact of the publications are summarised in Table 2 (p58-64).

4. Discussion and Impact

4.1 Advancing the Understanding of the Role of the Radiographer in Forensic Imaging and Defining the Scope of Practice

Review of literature published by the late 1990s (Appendix 1, p68), showed that the radiography profession had a limited understanding of the scope and role of forensic imaging. Most radiographers had received no specific training and were largely ignorant of the technical, organisational and procedural issues.

The Principal Researcher's work and subsequent publication in 1999 of *The Guidance for Provision of Forensic Radiography Services* (I) by the College of Radiographers filled an information vacuum. It advanced understanding of the role of the radiographer in forensic imaging and defined scope of practice, clarifying that forensic imaging did not simply apply to examination of the deceased but in every scenario where it could be used to answer questions of law. It clarified the legal framework, giving advice on how to apply rules of evidence, and in doing so gave radiographers and managers a framework to develop practice within their own setting.

A study undertaken in the year following publication evaluated implementation of the guidelines across 47 hospitals within the London region. It concluded that, whilst dissemination of the guidance had been somewhat passive, it had affected practice in those hospitals which had evaluated its implications, with over 70% of those having developed departmental protocols for forensic radiography (Christmas, 2001). However, some 65% of all departments surveyed still lacked any formal forensic radiography guidance. This perhaps reflects levels of awareness within the profession at that time of the importance of protocols and guidance for radiography across all areas, and a poor understanding amongst radiographers of their degree of professional responsibility. The researcher commented that *"Radiographers seemed not to understand that they are, and will remain, personally responsible for their practices".*

In the same year the UK Government Health Act (1999) introduced regular formal assessment of clinical performance of NHS hospitals in England, subjecting imaging departments to regular inspections of quality and audit. This resulted in greater understanding amongst radiographers of the importance of professional standards and accountability.

In recent years there has been increasing interest in, and understanding of, the forensic sciences amongst the public, and a number of high profile cases where forensic science played a key role in securing a conviction and cases that exposed failures of procedure which resulted in wrongful convictions. Both the Forensic Science Regulator (2018) and House of Lords Science and Technology Select Committee (2019) highlighted failures in procedure and placed great emphasis on the importance of standards and SOPs.

One area that came under particular scrutiny was the investigation of cases of NAI/SPA in children. The deaths of Victoria Climbie in 2000, and Baby P in 2007 exposed failures in child protection procedures within healthcare and social services and resultant public inquiries brought changes to legislation e.g. Children Act (2004). Professional bodies responded by introducing guidelines for practitioners.

The College of Radiographers published *The Child and the Law: The Roles and Responsibilities of the Radiographer* (COR, 2005) and *Skeletal Survey for Suspected NAI, SIDS and SUDI/C Guidance for Radiographers* (2009). Both documents address radiography examinations for NAI/SPA referring the reader to *Guidance for Provision of Forensic Radiography Services* (1999 and 2008), making clear that these examinations are forensic in nature and recommending that the guidance concerning conduct of examinations and application of rules of evidence established by the Principal Researcher's work be applied.

A survey of practice in the imaging of NAI/SPA in 2014 found a widespread understanding amongst radiographers of the forensic nature of these examinations and high level of awareness of the guidelines (Imtiaz, 2014). This contrasts with Brown and Henwood's findings (1997, Appendix 1, Section A1.4, p80), demonstrating an increased level of awareness and understanding since publication of the Principal Researcher's work (I).

The Principal Researcher's work in developing protocols and SOPs for use of radiography in the investigation of mass graves (VI, VII, VIII) has led to greater understanding of the scope of practice and the role of the radiographer in this unique type of investigation. Examination of human remains from mass graves and clandestine burials has traditionally been undertaken by archaeologists and anthropologists, particularly in cases where remains are skeletonised. As discussed in the literature (Appendix 1, p68), access to, and use of, radiography has been limited and as a result the scope of radiography in such cases had not been recognised.

The Principal Researcher's work demonstrated the value of radiography at a much earlier stage for radiographic triage. In the examination of a First World War mass grave in 2009, radiography was used for initial triage examination on-site immediately following excavation, referencing the

Principal Researcher's work (Loe et al., 2014), and a forensic radiographer was employed for the duration of the project. This is discussed further in 4.3.2 below (p54).

Within DVI, radiography had proved valuable in mass fatality incident investigation since 1949. However, the literature (Appendix 1, p68) showed limited understanding of its potential role, misconceptions surrounding its logistical requirements, and little advance planning for its use in such incidents.

Research undertaken by the Principal Researcher to develop a new paradigm and apply knowledge from large scale criminal investigations to disaster victim identification (publications IIa, IIb, III, IXa, IXb), has led to greater understanding of the scope of practice of and the role of the radiographer in the investigation of mass fatality incidents. As a result of the London Mass Fatality Plan (III), use of radiology and trained, experienced forensic radiographers has been considered central to UK mass fatality plans since the creation of the UK DVI team in 2005. Planning and resourcing recommendations made by the Principal Researcher (IIa and IIb) have been adopted at government level, and use of CT scanning is now a key planning requirement (College of Policing, 2019). Radiology is now also recognised as a key component of the DVI process by INTERPOL which has adopted the recommendations of the ISFRI/IAFR DVI working group based upon the Principal Researcher's work (INTERPOL, 2018).

4.2 Identifying the Underpinning Knowledge and Competencies Required by Forensic Radiographers

Section 11 of *Guidance for Provision of Forensic Radiography Services* (1999, Publication I) identified the knowledge and competencies required by forensic radiographers, recommending that they should be appropriately trained, having knowledge of techniques, health and safety, cultural, religious and ethical issues, and the medico-legal context in which they work. It argued that radiographers should be adequately supported in this work which often involves distressing experiences.

The knowledge and competencies identified by the Principal Researcher were not previously identified at postgraduate or undergraduate level training for radiographers in the UK and adoption of the guidelines by imaging departments created a need for education and training programmes and CPD events for radiographers. The first formal postgraduate course in forensic radiography for radiographers was developed at the University of Central England in 1999. The course development team established learning outcomes based upon the competencies identified by the Principal Researcher (Publication I). Subsequent courses were developed at other UK

universities and regular CPD events are organised by the IAFR and other professional organisations to assist radiographers to maintain these competencies.

One such course at Teesside University has been developed into a Master's degree course attracting international applicants annually. The Principal Researcher has also assisted and advised University College Dublin and Central University of Technology, Bloemfontein, South Africa to develop post-graduate forensic radiography programmes designed to develop competencies identified by the Principal Researcher's work.

In contrast to the situation identified by Brogdon in 1998 (Brogdon, 1998a), radiographers in the UK and other countries now have a range of resources to assist them to acquire and maintain the knowledge and skills identified by the Principal Researcher.

Brogdon's Forensic Radiology (X) is currently recognised as the essential text in forensic radiology and is used as standard course material for these courses and at a number of universities internationally. It has sold over 2,500 copies, and according to *Scopus* has 775 downloads. It is widely cited, having 108 citations since publication in 2011 with a worldwide geographic spread. One of the Principal Researcher's chapters, "Radiology in Mass Casualty Situations", has a *Scopus* field weighted citation score of 1.5 placing it in the 81st percentile of cited publications in this field.

The Council for the Registration of Forensic Practitioners (CRFP) was established by the UK Government in 1999 to build and maintain a register of competent forensic practitioners. In 2007 radiographers became eligible for registration with the CRFP and in determining the level of knowledge and experience required by a forensic radiography practitioner, the CRFP referred to the CoR guidelines (I) to develop assessment criteria based upon the competencies identified by the Principal Researcher's work. The Principal Researcher was appointed lead assessor by the CRFP and potential registrants were assessed by scrutinising evidence of practice against these established professional standards. The CFRP was superseded by the Chartered Society of Forensic Sciences (CSFS) and is currently establishing criteria for registration which are based upon the Principal Researcher's work in the current revision of the CoR/IAFR guidelines (I, 2014).

As shown by the literature review (Appendix 1, p68), radiographers were unprepared, untrained, and ill equipped to respond to mass fatality incidents (Gillespie, 1992). Material developed by the Principal Researcher for courses to equip radiographers with the necessary knowledge and competencies (Section 3.1.3, p38) was used to develop training for the IAFR UK Forensic Radiography Response Team. Trained, experienced radiographers are now considered an essential component of the UK DVI team (Section 4.1, p49) and training courses for UK DVI

radiographers are government-funded and delivered jointly by IAFR and senior police officers. Learning outcomes are based on the underlying competencies identified by the Principal Researcher.

Human Identification (Thompson and Black, 2006) including the Principal Researcher's chapter on the use of Radiology (IV) was adopted as a standard text for training of police officers on the UK DVI course at the University of Dundee. This chapter has been cited by 16 authors in Europe, North America and Asia and the principles detailed have been applied to the application of CT scanning within forensic anthropology (Brough et al., 2012; Streetman and Fenton, 2017; Uldin, 2017).

4.3 Development of Policy, Guidance and SOPs for Forensic Radiography

4.3.1 National

As shown by the literature (Appendix 1, p68), prior to the late 1990s, there was little forensic radiography guidance available. Radiographers, managers, forensic professionals, emergency planners and others wishing to utilise radiography in forensic investigation were obliged to develop their own methods and schemes of work, often in ignorance of key requirements.

Recommendations resulting from the Principal Researcher's work in *Guidance for Provision of Forensic Radiography Services* (I) are now widely understood and referred to by radiographers. The majority of clinical departments undertaking forensic imaging have developed policies and SOPs based upon the recommendations (Christmas, 2001; Imtiaz, 2014) although, as both these researchers highlight, there is some room for improvement at organisational level.

Issues surrounding the health and welfare of radiographers undertaking forensic radiography and awareness of PTSD are now much better understood, with forensic protocols including risk assessments and support mechanisms for forensic radiographers. However, as Glaysher et al. (2016) point out, there is no literature that provides advice on coping strategies and other treatments in the specific context of radiography.

Forensic imaging has increased considerably as a result of guidance issued by HM Chief Coroner in 2013 (Chief Coroner for England and Wales ,2013) and the latest revision of the COR/IAFR guidelines includes a definition of minimally invasive autopsy, recognising the increasing role of CT and MRI scanning in forensic medicine. Accordingly, in 2015, the College of Radiographers and IAFR jointly published *Standards of Practice for Post-Mortem Cross Sectional Imaging* (CoR, 2015) which is designed to accompany the *Guidance for the Provision of Forensic Radiography Services*

(I), making clear that the forensic standards developed by the Principal Researcher should also be applied for these examinations.

As previously discussed (3.1.2, p32), *Provision of Radiology Services within Temporary Mortuaries in the event of a Mass Disaster* (IIa) was aimed at, and circulated to, emergency planning officers and government representatives who had little guidance to assist with planning for use of forensic radiography. Its recommendations were immediately adopted by some emergency planners within their mass fatality plans.

The Principal Researcher's research in evaluating the application of these recommendations resulted in publication of *The London Mass Fatality Plan* (III) in June 2005. This was put into operation seven days later in response to 7th July London Suicide Bombings in which the radiography response team of TIG(FR) (now IAFR), played a key role (Viner et al., 2006c). The incident attracted national and international interest and many more local and regional authorities subsequently adopted the principles for the provision of radiology within their own emergency plans. The UK DVI Team, established in 2006 includes radiographers as a key component and government plans for radiography in DVI incidents adopted the principles defined by the Principal Researcher in *The London Mass Fatality Plan* (III).

The Principal Researcher subsequently advised the UK Home Office upon radiography equipment requirements to support the planning assumptions, writing the specification for X-ray equipment procured by the government. Radiological Imaging is now a fundamental part of UK DVI procedures, with trailer-mounted Computed Tomography scanners being the modality of choice (College of Policing, 2013).

4.3.2 International

Brogdon (1998b) noted little guidance available regarding forensic radiography in the USA or elsewhere. *Guidance for the Provision of Forensic Radiography Services* (publication I) has generated interest in other countries since its publication in 1999.

In 2003, the Irish Institute of Radiography and Radiation Therapy published *Forensic Imaging – Guidelines on Best Practice,* now in its second edition (2010), for which the Principal Researcher's work (I), was used as a reference source. The South African Society of Radiographers also published guidelines for forensic radiography (SORSA, 2003), citing the same document (I), and in 2008 a team from the American Society of Radiologic Technologists (ASRT) examined the position in the UK during a visit co-ordinated at their request by the Principal Researcher. Their report cites the guidelines (I) concluding that the ASRT should seek to increase awareness of forensic issues, and establish best practice guidelines and training programmes (Kudlas et al., 2010).

Similar initiatives to develop best practice guidelines are underway in Australia and New Zealand (E Doyle, 2019, 10th August, Personal Correspondence). The COR guidelines (I) are recognised and promoted by the International Society of Radiographers and Radiologic Technologists (ISRRT) as an example of best practice (ISRRT, 2015) and the Principal Researcher has recently worked with the IAFR and ISFRI to publish best practice guidelines for forensic age estimation in association with the ISRRT (Doyle et al., 2019).

The Scientific Investigation of Mass Graves: Towards Protocols and Standard Operating Procedures (VI-VIII) is recognised as the first, and to date only, comprehensive scientific text regarding the examination of mass graves. *Mendeley* indicates that it has been cited 20 times and has 125 downloads. The Principal Researcher defined for the first time, protocols and SOPs for the use of radiography in the investigation of mass graves and this informed and developed policy, guidance, protocols and SOPs for the use of forensic radiography in the investigation of this type of incident.

The forensic investigation of mass graves is a rare event, making evaluation of the impact of this work difficult. Firstly, whilst many historical mass graves are exhumed and evaluated, this is usually performed by archaeologists within the context of a historical rather than forensic investigation. Contemporary events warranting forensic investigation most often occur in conflict or immediate post-conflict zones, requiring a stable security situation and an international mandate. Whilst the Principal Researcher refined and tested procedures and SOPs in the context of training Iraqi investigators (Section 3.3, p43), there have been very few forensic investigations of mass graves in Iraq due to the security situation. Secondly, such investigations are complex and take many years, if not decades, for legal proceedings to be concluded. In such circumstances, publication is severely restricted due to information being sub judice.

Nevertheless, protocols and procedures developed by the Principal Researcher have been adopted by international investigating teams. These include the International Criminal Tribunal which invited the Principal Researcher to advise upon radiography equipment requirements and author protocols and SOPs. The team has deployed radiography during investigations in the Ivory Coast and Mali (E Baccard, 2011, 12th July, personal correspondence; E. Baccard, 2015, 26th June, personal correspondence).

Radiography was also used in the forensic identification of soldiers from a 1916 WWI mass grave, employing the protocols and SOPs developed by the Principal Researcher (Loe et al. 2014). This application is discussed in “The Role of Radiology in Mass Fatality Incidents” (IXb), the impact of which is discussed further below. Recently, an International Red Cross Team used the

radiography SOPs for systematic investigation and identification of Argentine war dead exhumed from graves on the Falkland Islands (L Fondebrieder, 2018, 22 February, personal correspondence; Infobae, 2019)

The London Suicide Bombings generated international interest and the Principal Researcher presented the findings of research that underpinned the *London Mass Fatality Plan* (III) at the American Academy of Forensic Sciences Meeting in Seattle, USA (Viner et al., 2006c) and the ISRRT World Congress in Durban, South Africa (Viner et al., 2008) and addressed the 19th Annual Meeting of the INTERPOL Standing Committee on DVI in Lyon, France in 2007.

Publication IX(a and b) has been cited 17 times by other researchers (Franklin et al., 2016; D'Arcy et al., 2019) and has 76 downloads/reads across both editions according to *Mendeley and Scopus.* It has a *Scopus* field weighted citation score of 3.01 placing it in the 92nd percentile of cited publications in this field. In particular, one researcher has developed the concept of primary and secondary radiology surveys further by applying this principle to collection and evaluation of post-mortem identification data obtained through other techniques and proposed a "next generation conceptual DVI process" decision support tool for mass fatality victim identification (de Cosmo, 2012).

Position statements on the use of radiology in DVI published by the DVI working group of ISFRI have been developed using principles established by the Principal Researcher and are the first internationally agreed protocols and procedures for the use of radiology in mass fatality incidents (XI-XIII). They have been cited by over 50 international researchers since 2015 with 290 downloads recorded by *Mendeley*. In particular, the position statements on the use of post-mortem computed tomography and radiography and fluoroscopy in DVI have *Scopus* field weighted citation scores of 2.47 and 1.13 respectively, placing them in the 90th and 74th percentiles of cited articles in this field. Their principles have been applied in DVI incidents including the Grenfell Tower disaster and the investigation of the MH17 plane crash (Rutty et al., 2019).

These recommendations have been recognised and adopted by the INTERPOL Standing Committee for DVI. Elements of the recording form developed by the Principal Researcher for the use of fluoroscopy and radiography (publications VI-VIII) were adapted and adopted by INTERPOL for inclusion in the standard INTERPOL DVI recording sheets, as discussed in Section 3.3.1 (p43), (Rutty et al., 2018).

4.4 Summary of Impact

The Principal Researcher's contribution to new knowledge and the impact of the publications are summarised in Table 2 (page 58-64).

In evaluating the credibility of the contribution of new knowledge and its impact in the development of practice in forensic radiography, the Principal Researcher's work can be compared against McNiff's "three steps" (McNiff, 2013, Appendix 2, p94).

Firstly, through the sequence of iterative cycles of data gathering the Principal Researcher reflected upon and critically analysed his own practice, developing strategies to improve practice and implementing and testing these in subsequent steps. This is demonstrated in publications III, VI–VIII, where the Principal Researcher applied existing knowledge to new situations, adapting and improving practice to meet the requirements of the specific situation and ultimately producing guidelines for practice (Section 3.1, p28; Section 3.3, p43).

Secondly, the Principal Researcher actively engaged in interdisciplinary discussion and debate regarding developing the practice of forensic radiography and debated and refined this in conjunction with practitioners in the same field, collaborating on joint initiatives and co-producing a number of key texts. This is seen in publications I, XI-XIII where findings were debated and validated externally with other practitioners in the process of formulating national and international guidelines (Section 3.1, p28; Section 3.4, p47).

Thirdly, this new knowledge and the resultant developments in professional practice have been adopted by others within the profession, forming the basis for ongoing training, learning and development. This is demonstrated in publications II, III where the Principal Researcher applied the knowledge gained from large scale criminal investigations and the radiological management of trauma to the organisation of forensic radiography services for mass fatality incidents, (Section 3.1.2, p32) and in publications IV, IX, X and IX-XIII through which new methods of service delivery and organisation of forensic radiography has been adopted as national and international policy for the management of, and training for, DVI incidents (Section 3.2.1, p40; Section 3.3.2, p45).

The impact of the Principal Researcher's work in the contribution of new knowledge and development of practice in the field of forensic radiography has been recognised by the Society and College of Radiographers with the award of the Fellowship of the College of Radiographers in 2005 and the prestigious Gold Medal of the Society of Radiographers in 2015.

Table 2 Contribution of New Knowledge and Impact of Publications

Objective	New Knowledge	Initial Impact	Subsequent Impact

Advancing understanding of the role of the radiographer in forensic imaging and defining the scope of practice	**<u>Publication I</u>**
	• Advanced understanding of the role of the radiographer in FR
	• Defined scope of practice of forensic radiography
	• Clarified the legal framework and application of rules of evidence
	• Provided a framework for development of practice.
	
	<u>Publications V, X</u>
	• Advanced understanding of the role of the radiographer in FR amongst the wider forensic community
	• Clarified the legal framework across a range of legal and organisational contexts internationally.
		• Recommendations widely implemented at local level - hospital departments developing protocols for Forensic Radiography *(Christmas 2001)*
		
		• Resulted in widespread understanding amongst radiographers of the forensic nature of NAI/SPA examinations and high level awareness of guidelines (Imtiaz, 2014)
		
		• Publication X recognised as the essential text in forensic radiology across the forensic professions. Total sales in excess of 2,500, downloads/reads of 775 and 108 citations
		
		• One of the Principal Researcher's chapters, "Radiology in Mass Casualty Situations", has a *Scopus* field weighted citation score of 1.5 placing it in the 81st percentile of cited publications in this field.
			• Revised and updated in 2008, 2010 and 2014 to take account of changes in legislation and practice. Additional sections covering NAI/SPA, DVI, Assistant practitioners and students, reporting, etc.
			• Referenced by and referred to in subsequent specific guidance for NAI/SPA:
			  • *The Child and the Law* (COR, 2005)
			  • *Skeletal Survey for Suspected NAI, SIDS and SUDI/C Guidance for Radiographers* (COR, 2009)
			  • *Standards of Radiographic Practice for Post-Mortem Cross-Sectional Imaging* (PMC-SI), (COR, 2015**).**

Table 2 (ctd)			
Objective	**New Knowledge**	**Initial Impact**	**Subsequent Impact**
Advancing understanding of the role of the radiographer in forensic imaging and defining the scope of practice	**<u>Publications II(a&b), III, IV, IX(a&b), XI,XII,XIII</u>** • Defined the scope of practice of forensic radiography in mass fatality incidents • Advanced understanding of the role of the radiographer in these incidents • Developed a new paradigm for application of radiography in DVI.	• Principal Researchers' new paradigm adopted by Resilience team in London Mass Fatality plan and applied in response to London Suicide Bombings 2005 • UK Government (Home Office) adopted planning and resourcing recommendations for deployment of radiographers in UK DVI team • Publication IV was adopted as standard text for training of police officers in disaster victim identification at University of Dundee for the UK DVI team.	• Use of radiography, fluoroscopy & CT scanning now considered a central component of UK planning for DVI (College of Policing, 2019) • Radiography now recognised as a key component of the DVI process by INTERPOL (INTERPOL, 2018) • The Principal Researcher's work in publication IV has been cited 16 times by authors in Europe, North America and Asia and the principles detailed have been applied to the application of CT scanning within Forensic Anthropology (Brough et al., 2012; Streetman and Fenton, 2017; Uldin, 2017).
	<u>Publications VI,VII,VIII</u> • Advanced understanding of the role of the radiographer and the scope of practice in the forensic investigation of mass graves.	• Greater understanding of the potential role of radiography within forensic and archaeological investigation • Publication cited 20 times and has 125 downloads/reads • Inclusion of radiography as a key element of forensic investigation of mass graves for examination of human remains and artefacts.	• Adoption of radiography triage at an early stage within archaeological excavation of mass graves • Forensic radiographers integrated within the team of large scale investigation of mass graves (Loe et al., 2014).

Table 2 (ctd)			
Objective	**New Knowledge**	**Initial Impact**	**Subsequent Impact**
Identifying the underpinning knowledge & competencies required by forensic radiographers	**<u>Publication I</u>** • Identified knowledge and competencies required by forensic radiographers, recommending appropriate training, having knowledge of techniques, health & safety, cultural and religious and ethical issues, and the medico-legal context in which they work. **<u>Publications V, X</u>** • Further developed the knowledge and competencies required by radiographers across differing models of service provision in an international context.	• First postgraduate course in forensic radiography established at UCE in 1999 using learning outcomes based upon competencies identified by the Principal Researcher • Competencies for DVI identified by the Principal Researcher in publications I & II (a&b) used to train radiographers for the UK forensic response team. Courses for UK DVI radiographers, now government funded and delivered by IAFR and senior police officers • Publication X recognised as the essential text in forensic radiology. Used as standard course material for these courses and at a number of universities worldwide. Total sales in excess of 2,500, downloads/reads of 775 and 108 citations • CRFP registration for forensic radiographers established in 2007 with assessment criteria based upon the competencies identified in the Principal Researcher's work.	• Subsequent courses including first MSc in forensic radiography developed at other UK universities using learning outcomes based upon the competencies identified by the Principal Researcher • Post-graduate forensic radiography programmes developed at universities in the Republic of Ireland and South Africa developed using competencies identified by the Principal Researchers work • CFRP now superseded by CSFS and work ongoing to develop assessment competencies based upon the latest revision of publication I.
	<u>Publications VI,VII, VIII</u> Identified the knowledge and competencies required by forensic radiographers working in multidisciplinary forensic teams investigating mass graves.	• Inforce Foundation developed UK government FCO funded training for Iraqi radiologists and radiographers using learning outcomes developed by the Principal Researcher.	• Publication cited 20 times and has 125 downloads/reads.

Table 2 (ctd)			
Objective	**New Knowledge**	**Initial Impact**	**Subsequent Impact**
Development of policy, guidance and SOPs for forensic radiography	**<u>Publication I</u>** • Set out CoR policy and provided guidance for radiographers, managers, forensic professionals and emergency planners charged with developing local protocols and SOPs.	• Recommendations widely understood and referred to by radiographers. Majority of clinical departments undertaking forensic imaging have developed policies and SOPs based upon the Principal Researcher's recommendations (*Christmas 2001,*Imtiaz, 2014) • Radiography organisations in other countries have developed guidelines for best practice in forensic radiography, referencing the Principal Researcher's work, including the IIRRT (2003) and the SORSA (2003), ASRRT (2009). Initiatives to develop guidelines are underway in Australia (E Doyle, 2019, Personal Correspondence).	• Latest revision of guidelines (version X) includes a minimally invasive autopsy recognising the increasing role of CT and MRI scanning • IAFR/SCoR jointly published Standards of Practice for Post-Mortem Cross-Sectional Imaging which makes clear that forensic standards developed by the Principal Researcher in publication I should also be applied • The guidelines developed by the Principal Researcher are recognised and promoted by the ISRRT as an example of best practice (ISRRT, 2015) and supplemental guidelines for forensic age estimation have been developed (Doyle et al., 2019).

Table 2 (ctd)			
Objective	**New Knowledge**	**Initial Impact**	**Subsequent Impact**
Development of policy, guidance and SOPs for forensic radiography	**<u>Publications II,(a,b)</u>** • Set out planning guidance for the use of radiography in DVI incidents. • Detailed a framework for the development of SOPs for these incidents **<u>Publication III</u>** • Set out policy and guidance for use of radiography in the management of DVI incidents in London.	• Principal Researcher's recommendations in publication IIa immediately adopted by some UK local authority emergency planners and guidance used to develop local SOPs • Recommendations of the Principal Researcher in publication IIb adopted by HM Coroner for West London and subsequently formed the basis for the development of policy and guidance set out in publication III • Recommendations and guidance of the Principal Researcher set out Publication III adopted within official London Resilience Mass Fatality Plan. • London Resilience Mass Fatality Plan put into operation for London Suicide Bombings, 7th July 2005 and subsequently adopted by several other UK regional resilience teams.	• The UK DVI team, established by the UK government in 2006, includes radiographers as a key component and government plans for DVI incidents have adopted the principles defined by the Principal Researcher • UK DVI procured radiography equipment to support planning guidance developed by the Principal Researcher. Radiological imaging now a fundamental part of UK DVI procedures using trailer mounted CT scanners • Findings of the research underpinning development of the London Mass Fatality Plan (III) presented at AAFS, Seattle, USA, 2006, (Viner et al., 2006c), 19th Annual Meeting of INTERPOL Standing Committee on DVI, Lyon, France 2007 and ISRRT World Congress, Durban, South Africa, 2008 (Viner et al., 2008).

Table 2 (ctd)			
Objective	**New Knowledge**	**Initial Impact**	**Subsequent Impact**
Development of policy, guidance and SOPs for forensic radiography	**<u>Publication VI,VII,VIII</u>** • Development of policy and guidance for the organisation and use of forensic radiography in temporary mortuaries • Defined for the first time, protocols and SOPs for the use of radiography in the investigation of mass graves.	• Policy and SOPs developed by the Principal Researcher adopted by international forensic teams including; International Criminal Court (E Baccard, 2011, 12 July; 2015, 26th June, personal communications); International Red Cross (L Fondebrieder, 2018, 22 February, personal communication) • Publication cited 20 times and has 125 downloads/reads.	• Planning guidance and SOPs developed by the Principal Researcher used in an archaeological investigation of mass graves by the Commonwealth War Graves Commission for the UK and Australian Governments (Loe et al., 2014).
	<u>Publication IX (a&b)</u> • Details scientific principles underpinning the development of protocols and SOPs. Sets out a systematic method of applying these in a flowchart process for the primary, secondary and tertiary radiography survey model within a multi-disciplinary investigation first described in IIa.	• Publications cited 17 times by other researchers (e.g. Franklin et al., 2016; D'Arcy et al., 2019) with 76 downloads/reads. Has a *Scopus* field weighted citation score of 3.01 placing it in the 92nd percentile of cited publications in this field • De Cosmo has applied the principle of primary and tertiary surveys to collection and evaluation of post-mortem data obtained through other techniques and proposed a "next generation conceptual DVI process" (de Cosmo, 2012).	• The Principal Researcher's protocols and SOPs for the systematic application of radiography surveys subsequently incorporated in international guidance position statements (XI-XIII).

Table 2 (ctd)			
Objective	**New Knowledge**	**Initial Impact**	**Subsequent Impact**
	<u>Publications XI,XII,XIII</u> • Internationally agreed policy and guidance, protocols and SOPs for the use of radiology in mass fatality incidents.	• Publications cited by over 50 international researchers since 2015 and have 290 downloads/reads. In particular, the position statements on the use of post-mortem computed tomography and radiography and fluoroscopy in DVI have Scopus field weighted citation scores of 2.47 and 1.13 respectively, placing them in the 90th and 74th percentiles of cited articles in this field • The principles applied in DVI incidents including the Grenfell Tower disaster and the MH17 plane crash. (Rutty et al., 2019).	• The policy recommendations have been adopted by the DVI Standing Committee of INTERPOL for inclusion in the International DVI process. (Rutty et al., 2018).

5. Conclusion

Review of the literature published prior to the start of the Principal Researcher's work showed that there was widespread ignorance amongst radiographers regarding the scope of practice of forensic radiography with most believing that it only referred to examination of the deceased. They had little awareness of their responsibilities as part of an investigating team nor of the standards of evidence and documentation procedures to be followed. This lack of understanding extended to users of their services who were largely unaware of the potential benefits offered by modern radiological techniques, and although radiography had been successfully employed for mass fatality incidents over many years, there was little advance planning for its use and no national co-ordinated resource.

The Principal Researcher's work and publications have advanced understanding of the role of the radiographer in forensic imaging and defined the scope of practice, making clear that every instance where radiography is used to answer questions of law should be considered to be forensic. This has clarified the legal position, providing the profession with advice on how to apply rules of evidence. The challenges faced by radiographers and the possible emotional and psychological effects of undertaking forensic imaging, are now much better understood.

The publication of national professional guidance for forensic radiography has created a framework in which practice can be developed, and has led to the widespread adoption of forensic radiography protocols and SOPs for in imaging departments across the UK by which radiographers can be appropriately trained, prepared and supported in this challenging work. Radiography organisations in other countries have subsequently published forensic radiography guidance referencing the Principal Researcher's work.

The underpinning knowledge and competencies required by forensic radiographers identified by the Principal Researcher and adopted by the professional body have been used to set professional standards for registration of forensic practitioners in the UK. They are now widely understood and are used as the basis for numerous postgraduate courses and CPD training events in the UK and overseas, and the Principal Researcher's publications are extensively used as course reference material for forensic radiology and DVI.

Furthermore, the Principal Researcher's work has developed a greater understanding of the potential applications of forensic radiology amongst service users and this has led to more effective use of radiography in forensic investigation.

The Principal Researcher has developed protocols and SOPs and a systematic means of applying radiological methods within a mass fatality incident which have been adopted to form the basis of

UK national and regional emergency disaster plans and trained, experienced forensic radiographers are now considered essential to the UK DVI team.

INTERPOL and other international organisations have also incorporated the policy and guidance developed by Principal Researcher for the use of radiography in DVI and guidance and SOPs developed by the Principal Researcher for use of forensic radiography in the investigation of mass graves have been adopted by international organisations and investigating teams.

The objectives (Section 2.1.2, p13) of the research have thus been met. The scope of practice of forensic radiography and the radiographer's role in forensic imaging is now widely understood within the profession and amongst forensic service users nationally and internationally, with resultant increase in utilisation and publication of research articles in forensic radiology since 2000 (Baglivo et al. 2013). Effective professional policy and detailed guidance is now available to radiographers and managers, allowing them to develop local procedures and SOPs to practise safely and effectively. Practitioners and educators have a much greater understanding of the knowledge and underpinning competencies required by forensic radiographers and have developed educational training programmes accordingly.

Whilst some authors (Imtiaz, 2014; Christmas, 2001) have highlighted that there is still work to do in encouraging some practitioners and managers to adopt the recommendations made, the situation is greatly improved from that which existed in the late 1990s. Aalders et al. (2017) noted that forensic radiology has seen a huge increase in interest and utilisation in recent years and this looks set to continue with increasing use of cross-sectional imaging in place of autopsy in a number of jurisdictions. Forensic imaging has yet to be formally recognised as a specialty within radiology but the creation of international forensic radiology and radiography organisations and an international forensic imaging journal can only hasten this inevitability.

During the course of this research, a number of themes have been identified which could form the basis for further work. In addition to the ongoing development of generic international standards which can be applied within a range of jurisdictions and with differing levels of resources, there is scope for addressing the education and training needs of some of those currently undertaking forensic imaging who have little understanding of the underlying principles of radiography. Whilst the Principal Researcher's work has defined the scope of practice and advanced understanding of the role of the radiographer in forensic imaging amongst service users, there may be economic limitations that inhibit the employment of dedicated radiographers to perform this work. There is scope in these circumstances for advancing the role of radiographers as advisors, mentors and trainers to oversee the provision of the service.

As discussed above, there has been a dramatic increase in research articles on the subject of forensic radiology since 2000 and many of these involve the application of “new” technologies such as Multi-detector CT Scanning (MDCT) within post-mortem forensic investigation (Baglivo et al. 2013). In most cases, the equipment used is specifically designed for the imaging of live subjects in a hospital or clinic environment, and imaging procedures, scanning protocols, sequences and algorithms do not take account of post-mortem changes such as decomposition and dehydration. There is considerable scope for further research in this area to develop specific guidelines, techniques and equipment adaptations.

The Principal Researcher’s work has highlighted the need to provide appropriate emotional support and monitoring mechanisms for forensic radiographers. As Glaysher et al. (2016) point out, there has been increasing awareness and research of PTSD amongst healthcare and forensic professionals in recent years but, as yet, no literature which provides advice on coping strategies and other treatments within the specific context of radiography, and this is an area which could be further researched.

Following a century of relative stagnation, as described by Brogdon (1998a), forensic radiology is now a rapidly developing field. As a result of the Principal Researcher’s work, the profession of radiography is now better prepared to adapt to the challenges and opportunities that this presents.

Appendix 1

Literature Review

Appendix 1 Literature Review

A1.1 Background

The literature was reviewed over many stages. An initial literature review was conducted at the start of the first research cycle, with further targeted reviews during subsequent cycles (Figure 1, p16-17). A more comprehensive review was subsequently conducted for this thesis to present this work within an overarching action research model.

The initial review showed that prior to mid-1990s very little, if any, information concerning forensic radiology was available for radiographers or radiologists. In reviewing this literature it is noticeable that the majority of studies which discuss applications of radiology in forensic science are written by pathologists, dentists, anthropologists, crash investigators, law enforcement officers or specialist medical personnel and *not* by radiologists or radiographers (Brogdon, 1998a; Christmas, 2001).

There was little information concerning the technical, organisational and legal aspects of forensic imaging that would be necessary to inform and underpin good practice. One exception to this was the investigation of non-accidental injuries in children, where texts written by paediatric radiologists addressed issues of standardisation of projections and methods of improving image quality whilst reducing radiation dose (Kleinman, 1990; Hall, 1994; Nimkin and Kleinman, 1997).

The situation at that time was summarised by Brogdon in the preface to *Forensic Radiology* (Brogdon, 1998b), which describes how he encountered many radiological images presented at meetings that had been taken and/or interpreted with variable results by non-radiographers and radiologists with little knowledge of the principles involved, or of existing and prior research within the field of radiology. Brogdon also recognised that there were many applications of radiology within forensic science of which he and other imaging professionals were ignorant. Central to both issues, he asserted, was that there was no common fund of knowledge of forensic radiology available to the different disciplines that may need to use radiology in their investigations (Brogdon, 1988b, ii-iii).

Forensic Radiology (1998) was Brogdon's attempt to create such a resource by bringing together, in one place, a comprehensive reference for all involved in forensic imaging – from radiologists and radiographers to pathologists, dentists, physical anthropologists and other scientists. Stoffey, writing in 2012, was in no doubt about its significance, referring to it as a milestone in forensic literature, unique in its role as the premier source for the entire scope of radiology applications in forensic science (Stoffey, 2012).

Brogdon made clear that it was never intended to be a "how-to-do-it" book. He was however aware that forensic radiographs in the USA were often performed by morgue staff with little training or experience, a situation which was, and is, not uncommon in other parts of the world (Brogdon 1998b, ii-iii; Brogdon, 1998b, p155-6; Viner, 2006a; Viner, 2006b). He included three chapters designed to act as a primer in radiography for those non-radiographers who were required to undertake forensic imaging. However Brogdon asserted that employment of a radiographer or radiologic technologist for forensic work was desirable, as the skills involved in taking the radiographs "*is absolutely critical to the whole endeavour"* (Brogdon, 1998b, pp155-6). Thus, whilst his book created a comprehensive manual for radiologists involved in forensic radiology, he recognised the need for radiographers to be educated, trained and practised in forensic radiography.

A1.2 Forensic Radiography within the UK

In the UK at that time the situation was somewhat different to that of the USA. Historically, forensic pathology services had developed in university departments of forensic medicine often associated with teaching hospitals where radiographers were requested to undertake forensic imaging either in the mortuary or hospital imaging department.

Baker and Hughes (1997), in the first comprehensive study of UK forensic radiographic services, surveyed 25% of hospitals with both accident and emergency and acute services and found that 81% of these undertook forensic examinations. Hospitals included in the study were selected to give a representative sample across all geographical regions of the UK. The survey comprised a written questionnaire with follow up reminder letters achieving a response rate of 71%. This represents a good response, being above the mean response rate of 68% for mail surveys of non-physicians published in medical journals at that time (Asch et al., 1997).

Although vague in terminology, the study identified types of examinations performed and specific information on the extent of examinations of deceased subjects was presented. The study found that the typical radiographer carrying out such examinations was relatively inexperienced (less than five years' experience), unfamiliar with the 1985 CoR guidelines on forensic examinations, had not received specific training and felt compelled to carry out such examinations as part of their job. They recommended that forensic examinations be carried out by volunteer radiographers who had received training, especially pertaining to legal aspects of forensic examinations. Furthermore they recommended that professional guidelines and departmental protocols for forensic examinations be developed.

By 2003 the situation had changed and in some respects had deteriorated further. As reported to the Home Office in 2003, following the closure of many university departments of forensic medicine in England and Wales during the previous decade, forensic services were fragmented and access to support services and special investigations such as radiology had become logistically difficult. In response, the report suggested the development of a "hub-and-spoke" service centred upon regional forensic pathology centres (Home Office, 2003).

A1.3 Scope of Practice

The few papers published in radiology or radiography journals were generally restricted to review articles summarising applications of radiography within forensic medicine and addressed few of the technical, organisational or procedural issues pertinent to radiographers (Gee, 1975; Pilling, 1976; Simpson, 1980; Sinclair, 1980; Knight, 1984; Hughes and Baker, 1997).

Papers published within the forensic scientific press were often also review articles or case studies detailing the contribution of imaging to a specific investigation (Glaister and Brash, 1937; Sassouni, 1959; Schmidt and Kallieris, 1982; Buchner, 1985; Rhine and Sperry, 1991; Resnick et al., 1992; Donchin et al., 1994; Maclean et al., 1994; Reipert et al., 1995a).

Radiography can support forensic investigation in a number of different circumstances. These can be divided into four broad categories (CoR, 1999)

- Investigation of cause of death
- Investigation of non-fatal injury
- Human Identification
- Location and examination of forensic evidence

A1.3.1 Investigation of Cause of Death

The use of radiography to assist in establishing cause of death is discussed as the main forensic application of radiography by a number of authors. Indeed, Hughes and Baker (1997) confined their review of the use of radiography in forensic medicine almost entirely to its use as an adjunct to autopsy in the determination or confirmation of cause of death.

They, with others, identified the main applications of radiography as: identification of fractures , determination of shape and size of weapons, dating of injuries, location of foreign bodies detection of air embolism, investigation of dramatic subarachnoid haemorrhage, (Gee, 1975;

Pilling, 1976; Sinclair, 1980; Simpson, 1980; Evans and Knight, 1981; Knight, 1984; Knight, 1991; Knight, 1996; Kahana and Hiss, 1999) as well as determination of cause of brainstem and upper spinal cord injury (Kondo et al., 1995), and use of angiography to assess the mechanism of interruption of blood supply (Vanezis,1979; Knight, 1996).

Many of these authors discussed its usefulness in identifying old and multiple fractures in cases of suspected NAI/SPA in children. Radiography is pivotal in not only detecting fractures but also in their classification and determination of mechanisms of injury (Chapman, 1990; Kleinman, 1990; Merten and Carpenter, 1990; Carty, 1997). Brown (1995) stated that more than 80% of all identified child abuse related injuries in the USA were detected through medical imaging and Hughes and Baker pointed out that in the UK, with an estimated 200 deaths per year and long-term physical injuries in 2000 children, NAI/SPA is one area where radiographers are frequently involved. It is not therefore surprising that some authors addressed the significance of this point and developed detailed protocols for imaging examinations (Hall, 1994; Nimkin and Kleinman, 1997; Cook et al., 1998).

A1.3.2 Investigation of Non-Fatal Injuries

In the context of NAI/SPA, many injuries inflicted are not fatal, and in the texts cited above, authors discussed the role of Radiography to evaluate both fatal and non-fatal injuries. Protocols developed for examination of such cases were designed for both examination of the living and the deceased, but whilst they are detailed in radiological and technical radiographic aspects, most did not address medico-legal issues of consent and continuity of evidence. This failure to emphasise the forensic nature of both the examination of the deceased ***and*** the living was perhaps responsible for perpetuating the view amongst radiographers that forensic radiography was confined to examinations of the deceased, as Baker and Hughes discovered (1997). This aspect is further evaluated in Section A1.3.4 (p78).

Other widespread applications of forensic radiology include investigation of NAI/SPA in adults (McDowell and Brogdon, 1998), and injuries sustained due to torture and human rights abuses (Fitzpatrick, 1984; Brogdon and Lawson, 1998). They may also include non-fatal injuries following assault, motor vehicle incidents, medical negligence, criminal injury compensation, industrial injury etc. (Evans and Knight, 1981), many of which involve insurance claims heard in the criminal or civil courts (Mason, 2001; Cowan and Hunt, 2008).

Most of these authors confined themselves to a brief discussion of the application of radiology in the investigation of such cases. The phenomenon of NAI/SPA in adults was only beginning to be recognised at this time and many other applications traditionally falling under the umbrella of

other branches of medicine were not widely recognised as forensic. Radiographers would undertake examinations on victims of such incidents in the course of their normal clinical work and no specific guidance regarding the possible forensic nature of these examinations was available.

A1.3.3 Human Identification

a) Identification of unidentified human remains

The distinguished forensic pathologist Bernard Knight (1984; 1991), described radiological techniques for identifying the deceased that can broadly be divided into: a) general classification of species, age, biological sex, race and stature and b) positive identification by comparison of ante-mortem and post-mortem images. His 1984 paper, published in *Radiography,* and the article by Kahana and Hiss (1999) are reviews of methods by which radiography can support forensic medicine and are useful in providing radiographers with a basic understanding from the view of "service user" rather than "service provider".

There is no discussion of the technical issues associated with the radiography of the deceased, for example; difficulties in positioning cadavers or fragmented remains, changes to exposure associated with different states of decomposition, medico-legal aspects of documentation and the need to ensure continuity of evidence, or discussion of procedures or protocols to be applied. Likewise, *Simpson's Forensic Medicine (1991)* which Knight edited was primarily directed at the trainee forensic pathologist, scientist or investigator, guiding them in how radiology may be used in investigations by seeking the assistance of radiographers and radiologists. The implication was that the profession of radiography is best placed to apply its own technical expertise to these endeavours.

Reipert et al. (1995a) conducted a study that reviewed 30 cases occurring over a six year period between 1987 and 1993 in which unknown bodies had been identified by comparison of ante-mortem and post-mortem radiographs. The study was restricted to one institute of forensic medicine in West Germany, located within a relatively affluent area with good access to primary and secondary healthcare. Radiographs were widely available and included images which were up to 25 years old. This sample is perhaps not representative of the situation in less affluent areas or developing countries, however their results demonstrated significant potential of radiology to assist with post-mortem identification. They concluded that radiography provides a useful, inexpensive and rapid means of assisting identification and demonstrated that radiographs of the skull were most helpful, contributing to over 36% of cases. Whilst this study is a useful measure of

efficacy, it did not address the technical or procedural methods and processes by which radiography makes this significant contribution.

A number of authors described the methods by which radiography may be used in forensic identification. Simpson (1980), Murphy et al. (1980), Salgado et al. (1988) and others described comparison of ante-mortem and post-mortem radiographs. Schuller (1921), Mayler (1935) and Rhine and Sperry (1991) discussed the significance of unique features within the skull to identify the deceased through comparison. Sinclair (1980), Frayer and Bridgens (1985), Owsley et al. (1993), Ludolph and Herring (1995), discussed identifying features such as degenerative changes and surgical interventions within the spine. Others discussed other bony elements including the clavicle (Sanders et al,, 1972), extremities (Owsley and Mann, 1989; Reipert et al., 1995b) and sternum (Tsunenari et al., 1982).

The majority of these authors are not radiographers or radiologists and discussion was limited to methods of comparison of images rather than the process of undertaking the radiographic examination within a legal context. Some, such as Ludes et al. (1994) and Owsley et al. (1995), highlighted the benefits of multidisciplinary approach, particularly in identification of human remains following a mass fatality event, but these issues appear never to have been addressed by the radiographic or radiological communities.

Identification by superimposition of post-mortem radiographs on to ante-mortem photographs was first used in the Ruxton case described by Glaister and Brash (1937). This was evaluated by Yoshino et al. (1995) who concluded that the ideal method should employ ante-mortem photographs and post-mortem radiographs of the skull and facial bones taken in frontal, oblique and lateral projections. Minaguchi et al. (1994) reported a case in which cranio-facial superimposition was combined with CT scanning. Whilst forensic techniques of comparison were discussed, there was little discussion of procedural or technical methods by which the radiography examination was conducted.

Buitrag-Tellez et al. (1992) discussed advantages of digitisation as a method of enhancing detail bone detail on poorly preserved or technically deficient films. Although a single case-study application of the technique, this was forward looking in its use of digital comparison and enhancement at a time when such methods were in their infancy, but did not address the most pertinent issue for radiographers: what circumstances led to ante-mortem films being poorly preserved or post-mortem films being technically deficient.

Dental radiography is a well-established method of identification frequently used for both age estimation and positive identification by comparison of post-mortem and ante-mortem

radiographs. MacLean et al. (1994) assessed the validity of comparison of ante-mortem with post-mortem radiographs for forensic identification by a study in which three observers were asked to assess 280 pairs of bitewing radiographs (140 positive match and 140 negative match) and indicate a binary forced choice of match or non-match. The study used radiographs from dental patients with no dental restorations and observers with varying degrees of experience. Observers were provided with the date of the radiographs as additional information. Results were assessed for accuracy, sensitivity and specificity. The sample can be considered representative of casework, as it used the most common radiograph taken in dentistry at that time – the bitewing. The use of anonymised patients' radiographs ensured a sufficient level of independent verification, and inclusion of non-matching pairs within the sample represents a balanced design. It could be argued that the sample size was very high, leading to possible fatigue or boredom of the participants and this may account for the low number of observers when compared with similar studies. The study determined an accuracy rate of 93% and greater levels of specificity with observer experience. Others have shown similar rates of accuracy and dependency upon the skill of the observer and time interval between radiographs (Kogon, 1996, [93%]; Sholl and Moody, 2001, [93.3%]). The latter made use of both bitewing and periapical radiographs and was perhaps more representative of situations that forensic odontologists may be presented with. However, this study did not include non-matching pairs and can be considered of unbalanced design for this reason.

In the majority of these cases radiography was performed by the forensic odontologist and there was some discussion of radiography projections and suggested basic protocols. General dental practitioners are experienced in practical aspects of radiography and some authors (Ligthelm, 1994; Benthaus, 1997) discussed the technical aspects of image acquisition and specific problems faced when undertaking post-mortem intraoral dental radiographs. However, these papers were published in forensic science or odontological journals and not immediately accessible to medical imaging professions.

Many papers described post-mortem radiography following surgical resection and cleaning of the maxilla and mandible, a technique that was in widespread use at the time prior to Lord Justice Clarke's "Marchioness Enquiry" report (Clarke, 2001). In such circumstances the post-mortem radiography was often undertaken on these specimens in the dental radiology department, or using a cabinet X-ray system within a laboratory. In his report upon identification procedures used following the Marchioness disaster, Clarke criticised a similar practice of removal of hands for fingerprinting and recommended that methods of identification which rely on invasive procedures causing disfigurement to the deceased should only be used when all other non-

invasive methods have been exhausted. This recommendation has significant implications for Radiology, not only within the context of identification as there are many forensic examinations of the deceased where radiology may provide an answer through non-invasive means.

b) Mass Fatality Incidents

A number of authors discussed the use of radiography in mass fatality incidents which was systematically used for the first time in 1949 following the "Noronic" steamship fire in Toronto harbour, as described by Singleton (1951). During this incident, survey radiographs were performed on 79 of the 119 fatalities and ante-mortem radiographs were obtained for 35 of these. Many additional radiographs were obtained for comparison, and 24 cases were positively identified by radiology alone. In many other cases X-rays were helpful in supporting or excluding identifications suggested by other techniques.

Radiography has been employed in a similar manner throughout the following five decades in incidents involving air crashes and terrorist attacks (Tarlton, 1973; Hill, 1986; Harbinson, 1987; Alexander and Foote, 1988; Mulligan et al., 1988; Joyce and Stover, 1991; Ludes et al.,1994). These included the largest systematic application of radiology in a mass fatality incident involving the 1977 crash of two 747 jumbo jets in the Canary Islands resulting in 576 fatalities. The bodies of 326 American victims were repatriated to the USA Armed Forces Institute of Pathology (AFIP) which examined the deceased, radiographing all remains during initial processing and subsequently as required by the identification process (Lichtenstein et al., 1980, Lichtenstein and Madewell, 1982).

Radiology played a key role in investigation of the 1979 crash at O'Hare airport in Chicago in which a number of cadavers were severely fragmented. Following initial examination, 50 victims remained unidentified, and in one of the first applications of computing power in mass fatality investigation, radiologist John Fitzpatrick used a computer database to facilitate the tedious sorting and processing of massive amounts of ante-mortem and post-mortem radiology data (Lichtenstein et al., 1988).

In almost all of these cases – with the exception of the Oklahoma City bombing, (Nye et al., 1996) – there was no advanced planning for the use of radiology in such incidents, and practitioners found themselves "reinventing the wheel" with no established guidelines or procedures to draw on (Gillespie, 1992). The Oklahoma bombing in 1995 was notable for extensive use of radiology, employing a team of almost 60 radiographers and 10 radiologists as part of a pre-planned mass-fatality response. The significant role played by radiology in investigation of the deceased is testament to the advance planning and preparedness of the imaging team (Nye et al., 1996).

This incident also highlighted the resource-intensive nature of a large-scale radiological response to a mass fatality incident but there was no real evaluation of the significance of the radiological information gained versus the resources utilised. By the mid-1990s the science of DNA was beginning to become well established for human identification and although expensive, was thought destined to become the gold standard for identification in the mass fatality context.

Despite the frequency of these disasters, the number of papers cited above outlining the authors' experiences, and some examples of good practice offered by the response to the Oklahoma incident, there appeared to have been no systematic attempt by the radiography or radiology professions to evaluate the current and post DNA contribution of radiology in mass fatality incidents nor to devise guidelines, protocols, procedures, recording methods or training programmes in order to prepare the profession for future events.

Whilst most radiographers working in a trauma environment may have been aware of, and well-rehearsed in, major incident response, it was clear that in most cases this did not extend to any understanding or awareness across the profession of the requirement for forensic radiography in the investigation and Identification of subjects following a mass fatality incident (Alexander and Foote, 1988; Lichtenstein et al., 1988; Gillespie, 1992; Lichtenstein, 1998). In many incidents involving mass fatalities there are an even greater number of surviving victims who will be treated in local emergency departments. As both Meserve (1992) and Green (1993) pointed out, these casualties form part of the "crime scene" of the incident, and the standards of evidence that must be applied in a particular jurisdiction, whilst well-known to law enforcement officers, were not routinely taught to medical or paramedical professionals. Radiographers were thus undertaking examinations on victims of crime during their normal clinical work and no specific guidance regarding the forensic nature of these examinations was available to them.

c) Identification of Living Subjects

There are many cases in which it is necessary to verify the identity of living subjects for legal reasons. In particular, estimation of age is important in many medico-legal situations such as sentencing for criminal convictions; where the "tariff" may be less for those who have not reached the age of majority, and for those seeking asylum – where different rules may be applied to minors (Mincer et al., 1993; Brogdon, 1998b p70; Kahana and Hiss, 1999). Whilst techniques associated with radiography to determine biological age or "bone age" for clinical reasons were well documented, nearly all authors who deal with this subject do so in the context of forensic anthropology or odontology and there is little in the literature prior to the late 1990s and nothing in the radiography literature suggesting that these be treated by radiographers as forensic

examinations. Nevertheless, these cases will be heard in civil or criminal courts where rules of evidence and the importance of documentation of consent will apply. Radiographers undertaking such cases should be familiar with and apply these rules but there was nothing in the literature or guidance at the time to alert them to this requirement.

A1.3.4 Location and Examination of Forensic Evidence

Despite use of a wide range of applications of radiology within forensic investigation - almost all of which, as Brogdon (1998a) notes, had either been tried or suggested before the end of the first decade after Rontgen's discovery of X-rays in 1895 - by the mid-1990s the terms *"forensic radiology"* and *"forensic radiography"* were almost exclusively used by radiographers to describe examinations of the deceased to establish cause of death or injury or for post-mortem identification.

The College of Radiographers guidance on forensic radiography (CoR, 1985) was devoted entirely to the examination of cadavers and recommends that examinations be undertaken in the mortuary. There was no discussion or definition of the term "forensic" with the implication that forensic radiography is solely related to examination of the deceased.

In their review article "The Use of Radiography in Forensic Medicine" (1997) Hughes and Baker limited their paper primarily to address the use of radiography in the forensic contest where death is involved. However, one short paragraph is devoted to *"other legal usage"* of forensic imaging, noting that *"forensic radiography is not exclusively limited to examination of the deceased or pathological specimens, medico-legal investigations also fall within the scope"* citing narcotics trafficking as one example.

The use of radiology to detect and apprehend "body packers" - those who smuggled contraband drugs across borders in specially devised packages, either swallowed or secreted in the rectum or vagina - was employed in the 1970s when this phenomenon was first recognised (Freed et al., 1976; Dunne, 1983). A number of authors discussed radiologic appearances of packages detailing and classifying packaging techniques that were developed by smugglers attempting to make detection by radiography more difficult (McCarron and Wood, 1983; Caruana et al., 1984; Pamilo et al., 1986; Karhunen et al., 1987; Horrocks, 1992). In most of these cases, radiography of suspects was undertaken within the clinical setting by medical radiographers and interpretation performed by medical radiologists. There was little discussion of the medico-legal implications including informed consent and continuity of evidence or any examination of the role of the radiographer in what was a crime scene investigation. Only Horrocks (1992) addressed these points stating that *"no radiographer or radiologist involved could be compelled to undertake such*

an examination, particularly if he/she was in any way dissatisfied with either the grounds for suspicion or the quality of consent obtainable" (p324), and pointed out that the duty of radiographers and radiologists is to remain neutral within the judicial process and protect the public and the suspect from unnecessary radiation exposure.

Radiological techniques have been used to detect and examine all manner of other artefacts including bullets and other ballistic material embedded in live and deceased victims. Many have discussed the use of radiological techniques to enable location and rapid retrieval of ballistic material (Di Maio, 1985; Hughes and Baker, 1997; Brogdon, 1998b, p209-224) determine the number and nature of projectiles (Messmer and Fierro, 1986), and their correlation with entry and exit wounds and angle and direction of fire (Brogdon, 1998, p209-224). Whilst the importance of radiology in the investigation of gunshot wounds appears to have been well understood by pathologists, the majority of texts dealing with the subject were published in non-radiological journals with little discussion of the technical aspects of undertaking examinations particularly on deceased and decomposed remains. Simple adaptations to radiographic technique such as the importance of both AP and lateral radiographs in all circumstances and of increasing the size of the X-ray field to include the skin surface to identify projectiles which may be lodged under the skin surface are not discussed, and there is little discussion of the role of the radiographer.

Others discussed the use of radiology to detect and analyse precious stones and jewellery (Bruwer, 1984; Brogdon, 1990), non-destructive testing to establish authenticity e.g.: detection of forged vehicle identification numbers (Springer and Bergman, 1994), verification of art objects and antiques (Falke et al., 1987; James, 1987; Brogdon, 1998b, pp265-277), analysis of paintings (Bridgeman and Keck, 1961; James et al., 1982; James et al., 1983; James and Gibbs, 1987), fingerprinting using radiopaque powder (Graham, 1973). In the majority of these cases techniques were discussed simply from the perspective of their value to the investigator and there was little technical or contextual information to guide the radiographer called upon to undertake examinations outside the scope of their day-to-day role. Nevertheless, these examinations will often form part of evidence presented in criminal cases of alleged forgery and the articles examined can be considered as part of the "crime scene". The radiological examination must therefore be of the highest standard and follow established rules of evidence.

A1.4 Medico-legal Implications

Two areas of forensic radiology that had been covered most extensively in the literature up until the end of the 1990s, namely detection of NAI/SPA in children, and the use of Radiology in mass fatality investigations, identified the need for standardised examinations and recording of relevant medico-legal information to guide practice so that radiological evidence is not open to challenges in the courts (Brown and Henwood, 1997; Carty, 1997; Nimkin and Kleinman, 1997; Alexander and Foote, 1998).

The Coroners Rules applicable at that time, specified that documentary evidence used in the courts should be correctly identified certified and witnessed. The process of producing such evidence and any expert report based upon it should also be clearly documented "to ensure continuity; the chain of evidence from the patient, to irrefutable legally admissible evidence pertaining to that patient" (The Coroners Rules – Rule 37 HMSO 1984). Any person responsible for the production of evidence may be called upon to testify in court to authenticate the evidence if doubts exist as to its authenticity.

In spite of these important requirements, few studies considered the medico-legal issues that apply for radiographers undertaking forensic examinations. Brown and Henwood (1997) conducted a study of 30 radiographers who undertook examinations for NAI/SPA of children. The radiographers were selected to provide representation of a range of grades and levels of experience and were asked to review a series of six anonymised images performed for NAI/SPA and score these for image quality. Quality criteria were established by targeted interviews with a senior paediatrician, barrister at law and a senior academic radiographer. In-depth interviews were conducted with six radiographers to improve quality of data, three of these selected from a lower scoring bracket and three from a higher scoring bracket and thematic data analysis was undertaken.

As a small-scale study, the selected sample cannot be assumed to be representative of the level of understanding amongst radiographers at that time. However, results showed a worrying lack of knowledge amongst the radiographers participating in the study of the importance of obtaining high quality images and the possibility that inaccurate or inadequate radiographs could be ruled inadmissible in court. Only 10% of those surveyed achieved a score of over 90% with almost half of the radiographers failing to identify 50% of the quality issues evident. However, the study made no attempt to distinguish between technical, radiographic issues and procedural issues. These were explored within the interviews with the majority of radiographers reporting that they were unaware of the legal implications of NAI/SPA imaging, a finding which was supported by Baker and Hughes (1997). Brown and Henwood set out guidance for good practice in such

examinations and highlighted the need for training in forensic techniques, concluding with the point made by Cameron and Rae (1975) that *"failure to follow the necessary protocols may cause the film to be inadmissible in court…. The child's life may depend on it".*

Horrocks (1992) discussed issues of consent and identified the role of radiology personnel in protecting both the public and the suspect (in cases of drug smuggling) from unnecessary radiation, and Baker and Hughes (1997) addressed the issue in their report. Generally however, consideration of medico-legal aspects of forensic radiography is poorly covered in the available texts.

The radiographers' professional code of conduct applicable at that time (COR, 1996) made clear that the radiographer is ultimately responsible for all aspects of their practice and that "no overarching responsibility is held by another person". Hughes and Baker (1997) argued that a consequence of poor medico-legal practice is the denigration of radiographers' professional integrity.

Thus, in those cases which the radiographers understood to be forensic in nature, the importance of documentation to ensure the integrity of evidence was appreciated. However, there was no general understanding amongst radiographers as to exactly what that entailed and no guidance to refer to.

A1.5 Policy, Guidelines, Protocols and SOPs

Despite the key role played by radiographers in forensic imaging, the only information available from their professional body until 1998 was a very short guidance document (CoR, 1985) which comprised of two sheets of A4 paper. This focussed entirely on post-mortem examination of the deceased and provided basic procedural information regarding validity of requests, location and timing of examinations, transportation of cadavers to the imaging department, the voluntary nature of forensic radiography and the necessity for separate remuneration. In addition, there were some basic guidelines regarding identification of the subject and radiographs and the need for the examination to be witnessed by the Police or Coroners Officer. However this did not extend to any explanation regarding the rules of evidence or documentation of the examination. Some basic guidelines on infection control *"use of disposable plastic envelopes to contain cassettes"* and use of *"masks, gloves and plastic aprons"* were given, together with some scant recommendations on radiographic technique. These were essentially limited to *"use of the most appropriate film/screen combination"* and *"it is essential that accurate, standard views are*

undertaken" although no advice was offered as to how this could be achieved with the subject kept within the recommended *"sealed polythene bag"*.

In 1998, Queen Mary's Hospital for Children, Carshalton, Surrey published *"A manual for all X-ray Departments: Guidelines on Best Practice in the X-ray Imaging of Children".* This comprehensive manual set out recommendations for the radiographic examination of children in a range of circumstances. It included a specific section detailing recommendations for the skeletal survey examination of children for NAI/SPA. Whilst these recommendations covered technical aspects and stressed the importance of correctly identifying the radiographs, they failed to discuss forensic aspects, such as the concepts of continuity of evidence, informed consent, documentation and witnessing (Cook et al., 1998).

The document made no mention of the wider role of the radiographer as part of the chain of healthcare professionals who may come into contact with vulnerable victims of abuse and there was no discussion of the requirement to record and report concerns or observations.

Brogdon's Forensic Radiology (1998b) included a section intended as a primer for non-radiographers who were required to undertake post-mortem radiography. These three chapters, written by radiographers, provided basic information on radiography and radiographic technique for mortuary staff familiar to all trained radiographers. However, they did provide useful advice on adaptation of exposure factors to account for specific changes in density within the deceased subject due to decomposition, as well as the detailed identification of images forming part of the evidential record. It is one of the only texts to deal with specific technical and procedural aspects of this nature (Newell and Jalkh, 1998).

The few guidelines and protocols that did exist by the late 1990s were based on a poor understanding of the scope of forensic radiography and the nature of forensic investigation and were, by their nature, limited in application. There was little if any technical and procedural information to assist the radiographer in the conduct of examinations or assist those responsible for managing forensic investigations and emergency response in the planning of facilities.

A1.6 Training, Education, Continuing Professional Development and Welfare of Staff

As Baker and Hughes (1997) discovered, many radiographers were asked to undertake forensic imaging with no prior knowledge of equipment available or the underlying reasons for examinations that they had been asked to undertake and those practitioners who became skilled and experienced in forensic imaging did so through "ad-hoc" and "on-the-job" training. In some

cases cadavers or body parts were transported to the imaging department and examined in sealed opaque bags for fear of distressing staff and patients, making positioning and technical evaluation of the subject very difficult. With increasing fragmentation of forensic pathology services, as highlighted in the report discussed above, opportunities for radiographers to teach and learn from others who were more experienced in this field became increasingly limited.

The issues of staff welfare and training, together with infection control and the concepts of preparing staff for, and protecting them from, the physical and emotional effects of dealing with deceased and/or living victims of violent crime do not appear to have been addressed by any authors. The only document that dealt in any way with this issue was the College of Radiographers guidance notes (1985) which recommended that all forensic radiography should be carried out by volunteer radiographers and that undue pressure should not be placed upon radiographers to do this work.

It has been recognised for many years that some people experience long term psychological effects of experiencing a traumatic event which inhibits their ability to function. The term "shell shock" was used to refer to soldiers exhibiting psychological issues during and after the First World War. These symptoms would now be referred to as Post Traumatic Stress Disorder (PTSD) , a term first used in relation to the American Veterans of the Vietnam War, but now used to describe psychological issues resulting from any traumatic event (March, 2014).

It was not until 1980 that PTSD was first recognised as a syndrome by the American Psychiatric Association and, probably unsurprisingly, much of the early research focussed upon the effects of trauma experienced by personnel in the armed services. In recent years however, there has been an increasing focus on diagnosis of PTSD in emergency responders and healthcare workers. Czaja et al. (2012), in their study of 173 nurses working in acute care at a tertiary care children's hospital reported that 21% demonstrated strong symptoms of PTSD. In another study of 248 emergency nurses across 15 hospitals in Belgium, Adriaenssens et al. (2012), found that 8.5% of nurses met clinical levels of PTSD and reported that death or serious injury to a child or adolescent was perceived as the most traumatising event in an acute trauma unit. Radiographers often examine the victims of trauma and thus are exposed to the same types of critical incidents as those described within these studies.

Recognising the importance of the issue, particularly amongst healthcare workers, emergency services first responders and those involved in mass disasters, the National Institute for Health and Care Excellence introduced PTSD guidelines in 2005, which were updated in 2018 (NICE, 2018).

Brondolo et al. (2008), described two key factors in establishing a diagnosis of PTSD; firstly that an individual must have experienced, witnessed, or been confronted with an event that involved actual (or threatened) death or serious injury and secondly that they responded to the event with intense fear, helplessness or horror. Symptoms of PTSD often develop immediately after the traumatic event but for some the onset of symptoms may be delayed and sufferers may not present for treatment for months or even years after the initial onset of symptoms (PTSD UK, 2020).

Undertaking forensic examinations on live or deceased victims of trauma can, as Glaysher et al. (2016) suggest, be distressing for radiographers, particularly so when undertaking imaging of children who are the victims of suspected abuse. The study by Brondolo et al. (ibid) specifically addressed the problem of PTSD in forensic workers responding to mass fatality incidents and found that 13% of a sample of recovery workers at the 9/11 attack on the World Trade Center in New York reported symptoms of PTSD. In this context, radiographers undertaking forensic examinations following mass fatality incidents, often in unfamiliar and unpredictable circumstances and surroundings and away from their normal environments and support mechanisms, may be particularly vulnerable.

Increasing awareness of the issue in recent years has led to more effective strategies for prevention and treatment of PTSD with specific guidance now provided by both the Home Office (2004) and the National Institute for Health and Care Excellence (NICE, 2018).

As Glaysher et al. (2016), pointed out that forensic imaging protocols should take the issue into account and ensure that safeguards and welfare strategies for staff are in place.

Appendix 2

Research Methodology

Appendix 2 Research Methodology

A2.1 The Researcher's Worldview and Research Stance

As many writers have suggested, a consideration of the philosophical stance or worldview of the researcher is important when conducting research of any kind (Guba and Lincoln, 1990; Creswell, 2009; Koshy at al.,2011) with Creswell describing worldview as a general orientation about the world and the nature of research that the researcher holds. The worldview or philosophical position of the researcher will influence the choice of methodology (Holden and Lynch, 2004) and in the field of scientific research, several philosophical approaches or paradigms are possible.

The positivist paradigm is based on belief in objective reality gained from observable data. This view is often referred to as scientific method, and knowledge gained is based upon observation and measurement of the objective reality that exists (Creswell, 1990).

The interpretivist paradigm is a worldview developed within the social sciences using qualitative methods of research based upon the belief that knowledge is socially constructed, subjective, and influenced by culture and social interactions. In this worldview the researcher gathers data while still retaining their objectivity.

Action research assumes the social world to be constantly changing with both researcher and the research being one part of the change (Collis and Hussey, 2003). Within this context, as Koshy at al. (2011) discussed, action research can be positivist, interpretivist, critical or participatory.

Critical theory, based on the work of Habermas (1984) was described by Waterman et al. (2001) as the most influential of the philosophical perspectives underpinning action research in health care. They argued that this approach arose from a desire to democratise research and encourage participation, linking this to Aristotle's notion of praxis – acting on the condition of one's own situation in order to change it. As Kemis and McTaggart (2000) asserted, to study practice means to change it, but also, practice is changed in order to study it. Within this approach value is attached to both qualitative and quantitative research methods which are seen as complementary.

Others suggested that action research is located in the participatory worldview and is unique because it is bound by context and involves action designed to change situations. The researcher is involved in the research process which informs practice and knowledge is generated from practice. Punch (2009) describes this as the central idea conveyed by the term action research.

The scientific research paradigm helps to define scientific research philosophy. Literature on scientific research claims that the researcher must have a clear vision of paradigms or worldview which provides the researcher with philosophical, theoretical, instrumental, and methodological foundations (Zukauskas et al., 2018).

Easterby-Smith et al. (2008) discussed three main components of the scientific research paradigm:

- Epistemology – the nature of knowledge
- Ontology – the nature of reality
- Methodology –the tools and techniques used in the conduct of research.

The worldview and research stance of the Principal Researcher, as categorised against these components, is set out in Table 3 (below).

Table 3: Principal Researcher's Worldview and Research Stance

Epistemology	*Interpretivist:* Knowledge is socially constructed, subjective, formed of human experiences and influenced by culture and social interactions. The researcher is part of the research.
Ontology	*Subjective:* Multiple realities exist. The researcher and reality are inseparable.
Methodology	
Focus of research	Understanding and interpretation, based on relativist constructivist thinking.
Role of the researcher	*Participatory*: The researcher experiences, and is part of the phenomenon being studied. The researcher allows feeling and reason to govern actions. The researcher partially creates what is studied. Use of experience and prior knowledge and understanding is important. The researcher accepts influence from both science and personal experience.
Methods used	*Action research:* Predominantly qualitative methods. Holistic and contextual analysis. Use of multiple methods to establish different views. Observation and reflection, interviews, focus groups, analysis of correspondence, case studies. Small samples investigated in depth or over time.

The worldview of the Principal Researcher is essentially interpretivist, believing that knowledge is subjective and is influenced by social context and culture in which practitioners operate. It is recognised that this worldview has influenced the way in which the research has been undertaken and the ontological perspective adopted dictates that this research is the Principal Researcher's version of the truth and perception of reality. It is acknowledged that there are other points of view and other interpretations of the data gathered.

The research is based on the Principal Researcher's own perceptions, both in the way that the data has been collected and the way in which it was interpreted. The Principal Researcher recognises that the researcher is part of the research, that researcher and the results are thus inseparable, and that personal perspectives have formed part of the findings and interpretation of the data. Throughout the work this has been acknowledged and extensive efforts have been made to triangulate the findings and interpretation by obtaining the perspective of peers and other professionals, and through co-production of publications.

The Principal Researcher has attempted to create meanings based on personal interpretation of the data. It is recognised that all data and interpretations are grounded in specific circumstances and that whilst some emergent principles may be applicable in other similar situations, generalisations cannot be made.

The Principal Researcher's worldview and research stance have influenced the choice of methodology and methods detailed in Table 3 (p87). The central aims of this participatory action research involved action by the Principal Researcher designed to change situations and inform practice, thus generating new knowledge from practice.

A2.2 Research Methodologies

The concept of the practitioner as researcher was developed by Kurt Lewin in the 1940s as a research approach in which individuals promote change and improve procedures through their own enquiry. Lewin (1946) used the term "action research" to describe this process and described action research as "*a comparative research on the conditions and effects of various forms of social action and research leading to social action*" that uses "*a spiral of steps, each of which is composed of a circle of planning, action and fact-finding about the result of the action*".

Shultz (1972), Gadamer (1975) and Habermas (1979) argued that research has no real value unless it can be demonstrated to solve problems. Action research attempts to address practical problems which have evolved out of previous theories, research or actions by shifting the

emphasis and perspective on to the practitioner and enquiry rather than concentrating upon the methodology. It is thus concerned with both "action" in the sense that it aims to solve problems, and "research" in the sense that it contributes to knowledge (Castle, 1994). In this sense it is unlike traditional positivist science which aims at creating knowledge only (Coughlan and Coughlan, 2002, Greenwood, 2018).

This thesis details the use of action research which was undertaken over a period of time in the field of forensic radiography, highlighting new contributions to the body of knowledge in this discipline from the respective studies.

This work in the field of developing standards, protocols and SOPs in forensic radiography has followed a participatory action research approach (PAR) (Whitehead et al. 2003; Lingard et al. 2008) using a range of data collection tools. Koshy et al. (2011), identify this as an approach commonly used for improving practice in healthcare environments, which in turn can enhance their working environment and the working environments of those who are part of it, often across a wide range of differing disciplines.

The aim of this approach was both to develop and improve standards within Forensic Radiography while simultaneously building up a body of scientific knowledge to underpin and develop protocols and SOPs within this specialist field. As demonstrated from the publications which are discussed in the thesis, this approach involved a sequence of iterative action research cycles, applying a scientific method of fact-finding and experimentation to practical problems requiring action solutions. Key to this approach was the role of the Principal Researcher in securing, leading, and directing the collaboration and cooperation of a number of key stakeholders within the spheres of forensic medicine, forensic dentistry, forensic anthropology, crime investigation and emergency planning both within the UK, and internationally.

A2.3 Action Research

Action Research (AR) is a generic term which covers many forms of action-based research, with diversity in theory and practice amongst action researchers. This provides a wide choice for potential researchers to develop an appropriate methodology to address their research question (Reason and Bradbury, 2001). In their review of the literature, Coughlan and Coughlan (2002) identified several broad characteristics which define action research;

- Research *in* action, rather than research *about* action – the principle being that AR uses a scientific approach to study the resolution of important social or organisational issues together with those who experience those issues directly
- Participative - in that members of the system which is being studied participate actively in the cyclical process of planning, taking action, evaluating the action leading to further planning and so on
- Concurrent with action – the goal being to make the action more effective whilst simultaneously building up a body of scientific knowledge
- A sequence of events and an approach to problem solving - a sequence of iterative cycles of gathering data, feeding back to those concerned, analysing the data, planning action, taking action and evaluating etc., and an application of the scientific method of fact finding and experimentation to practical problems requiring action solutions and involving the collaboration and co-operation of the action researchers and members of the organisational system.

The research framework discussed below (Section A2.4, p99; Figure 1 p16-17) has been retrospectively applied within this thesis to demonstrate how a sequence of iterative cycles, using a range of data collection tools designed by the Principal Researcher to address specific organisational issues, and involving the active participation of practitioners and service users as members of the organisational system, led to collaborative findings, and the development of new knowledge in the field of forensic radiography and its practice.

This approach contrasts with that of positivist science which aims to create universal knowledge or covering law, whilst action research focuses on knowledge in action (Susman and Evered 1978). The knowledge created in positivist science is universal, whilst that created through action research is particular, situational and arising from practice. In action research data is contextually embedded and interpreted. In positivist science findings are validated by logic, measurement and the consistency achieved by consistency of prediction and control whilst in action research the basis for validation is the conscious and deliberate enactment of the action research cycle. The positivist scientist's relationship to the setting is one of neutrality and detachment whilst the action researcher is immersed in the setting as both an actor and an agent of change (Coughlan and Coughlan, 2016).

The action research approach is well suited to the particular circumstances for this research as the Principal Researcher set out to study the resolution of important organisational issues within forensic investigation. How forensic radiography could and should be utilised, when and where within the investigative process should examinations be performed, how the appropriate

examination is determined and by whom, who should undertake the examinations and what skills they should have.

The Principal Researcher studied these issues as a radiographer and researcher together with those who experienced the issues directly. The research approach adopted was participative in that the Principal Researcher involved key stakeholders within the system being studied to participate actively in the cyclical process of planning, taking action and evaluating the actions. These issues crossed a number of professional boundaries, between pathologists, anatomical pathology technicians, dentists, anthropologists, as can be seen in publications V and X and further discussed in Section 3.2 (p40) and Section 3.3 (p43).

In this action research model the Principal Researcher worked as part of multidisciplinary, multinational forensic teams undertaking forensic investigations for the United Nations. These teams included forensic pathologists, forensic dentists, forensic anthropologists, archaeologists and investigators. By means of participatory action research through the use of a range of methods including observation and reflection, concept analysis, focus groups and multi-disciplinary group discussions, the Principal Researcher, working as both active participant and researcher, developed protocols and standard operating procedures for forensic radiography and identified emerging themes for further research. The new knowledge gained through in these settings, developed from the need to systematically apply forensic radiography as part of large scale criminal investigations in a number of different circumstances, was adjusted and refined through several feedback cycles and group discussions and is demonstrated in publications VI-VIII (Section 3.3, p43).

Action research may be an appropriate approach in a number of situations but particularly when the research question relates to describing an unfolding series of actions over time in a given group, community or organisation (Coughlan, 2001, Coghlan and Brannick, 2014; Molineux, 2018). It has thus found favour amongst researchers in a variety of settings including the management of change in organisations (Molineux, 2018), operations management (Coughlan and Coughlan, 2002; Greenwood 2018), education (Stringer, 2008), healthcare (Koshy et al., 2011) clinical practice (Castle, 1994) radiography (Hammick, 1995), emergency preparedness (Raman et al., 2006).

The Principal Researcher applied such an action research methodology to examine the practice of forensic radiography through the study of a number of different situations over a period of time, each of which presented specific organisational issues requiring resolution. These situations and issues, whilst individually different, required the development of new strategies and professional

practice. These were developed and evaluated through observation and reflection and the use of focus groups and multidisciplinary group discussions. This new knowledge was then applied and further examined and refined in subsequent situations, forming a coherent sequence of iterative cycles of data gathering. Publications II,III,VI-X and XI-XIII show how the new knowledge gained from development and co-production of protocols and procedures for the investigation of human remains from mass graves was then applied and refined through use of further focus groups, peer group discussion and co-production of documents within the context of applying forensic radiography to other mass disaster fatality events (Section 3.1, p28; Section 3.3, p43, Section 3.4, p47).

As Stringer (2013) pointed out, such situations may be complex organisations in which a number of different individuals or teams with different expertise and competing priorities work together in order to deliver a service or create a product. In such organisations, action research may be used as a reflective process of progressive problem solving led by individuals working with others in teams or as part of a "community of practice" to improve the way they address issues and solve problems, or to solve a particular problem and to produce guidelines for effective practices (Denscombe, 2010).

In the context of healthcare, Castle (1994) asserted that the action research process is *"particularly appropriate in clinical settings where small-scale problem-solving and evaluation enquiry can be effective in enhancing practice and developing professional autonomy."*

Radiography is employed as part of an overarching forensic process. Its practitioners are required to work as part of an integrated team with the aim of employing a number of scientific disciplines to the examination of human remains and artefacts in order to collect and present evidence in a court of law. Each case and investigation presents unique challenges for the individual practitioners and the team, not least because each team of experts will be unique with individuals drawn from different disciplines depending on the complexity of the case.

The Principal Researcher adopted such a reflective process of progressive problem solving , working with others within each team to solve particular problems and with this new knowledge ultimately to co-produce guidelines for effective practice. The new knowledge arising from the development of protocols and procedures for the application of forensic radiography within the large-scale forensic investigations described above was developed through use of further focus groups, peer group discussion and co-production of documents into a series of underlying principles that could be applied to a range of more “routine” circumstances faced by the

radiography practitioner, as demonstrated through publications I, IV and X (Section 3.1, p28; Section 3.3, p43).

A2.3.1 Rigour and Criticality

Action research is not without its limitations. It has often been challenged on the basis that it is subjective and therefore that the results are unreliable and often invalid because they cannot be universally tested. Parkin (2009) listed a number of possible limitations of action research:

- A lack of precision over its nature and definition
- Potential limitations on generalising findings beyond the local situation
- It attracts attendant problems of change management including resistance and conflict
- It can be time consuming for little gain
- It can encounter cultural, professional and managerial constraints on change initiatives
- Its methods can conflict with the notions of autonomy and individualisation particularly where these are highly valued
- The ethical issues require careful explanation and management.

However, Lomax (1986) made the point that action researchers do not claim to find the final answer to a specific practical problem and that the validity of the results obtained are based on the degree to which the research is useful and relevant in promoting and facilitating debate about improving practice within a profession. Reil (2010) went a step further by describing action research as a reflective process of progressive problem-solving led by individuals working with others in teams as part of a "community of practice to improve the way they address issues and solve problems".

This thesis demonstrates how the solutions to practical problems developed to overcome specific organisational issues in different circumstances (the number of large scale criminal investigations for the United Nations discussed in Section 3.1 (p28), were subsequently applied and refined by the Principal Researcher in different situations including mass disasters and routine forensic radiography cases, as discussed in Section 3.1.1 (p31). It discusses how this new knowledge has been promoted and debate facilitated amongst radiography and other forensic practitioners about improving the professional practice and contribution of radiography within the forensic process.

As Castle (1994) indicated, the feature of action research which distinguishes it as research is that practitioners develop the theories and rationale from their own personal knowledge and experience. Personal knowledge is the cornerstone of professional autonomy and requires

practitioners to reflect on how they conduct their affairs. Kemmiss (2009) believed that personal knowledge is crucial to the action research process and it is this knowledge that provides the basis for developing a research framework.

Forensic science is the application of scientific techniques to answer questions of law. It is thus intrinsic that the forensic practitioner will draw on his or her considerable experience in their own scientific field and apply this to a specific situation and investigation. The forensic practitioner is thus best placed to reflect on their own practice and how they overcame challenges of each specific situation and to contextualise their contribution to the team investigation by a process of debate and discussion with those of other disciplines. The thesis demonstrates how the Principal Researcher applied existing personal knowledge and experience of radiography to the resolution of organisational issues, developing new knowledge in the field of forensic radiography and how this new knowledge was further refined and developed to improve practice within the profession as shown in publications I, X and XI-XIII, discussed in Section 3.1 (p28), Section 3.3 (p43) and Section 3.4 (p47).

Action research has been criticised as being of poor quality and neither solving problems nor contributing to knowledge (Adelman, 1989). However, as Robson (1993) pointed out, whilst action research takes a relaxed view of scientific research methods, it has value in appropriate contexts for anyone who wants to make sense of complex issues and problems which are not subject to conventional laboratory experiments. Kemmis (2009) described it as a "meta-practice" i.e.: a practice that changes other practices.

McNiff (2013) suggested that there are three steps to establishing the validity of action research:

- *Self validation* - where individual action researchers interpret their own practice and make decisions about improving it. Their actions are deliberate and based on the desire to improve professional practice through critical self-reflection
- *Peer validation* - by making findings public and engaging in debate, claims can be validated externally by other practitioners in the same field
- *Learner validation* - Learners who can show that they have moved forward during the process of action research and give examples of instances where their thinking has developed and the reasons for it, provide a powerful confirmation of its value.

Coughlan and Coughlan (2002; 2016) suggested that the main threat to validity for action research is the lack of impartiality on the part of the researcher and that, in order to maintain validity, action researchers must consciously and deliberately enact the action research cycles, testing their own assumptions and subjecting their assumptions to public testing. Accordingly,

action researchers need to combine advocacy with enquiry and present their inferences, attributions, opinions and viewpoints as open to testing and critique by illustrating their inferences with observable data and making reasoning both explicit and publicly testable in the service of learning.

This thesis demonstrates how each of McNiff's three steps have been applied within the action research process:

- Firstly through the sequence of iterative cycles of data gathering, the Principal Researcher reflected upon and critically analysed his own practice, developing strategies to improve practice and implementing and testing these in subsequent steps
- Secondly the Principal Researcher actively engaged in interdisciplinary discussion and debate regarding developing the practice of forensic radiography and debated and refined this in conjunction with practitioners in the same field, collaborating on joint initiatives and co-producing a number of key texts
- Finally it demonstrates how this new knowledge and the developments in professional practice have been adopted by others within the profession, forming the basis for ongoing training, learning and development.

A2.3.2 The Action Research Process

As discussed previously, action research is a particularly appropriate approach in circumstances when the research question relates to describing an unfolding series of actions over time. As such, it necessitates a sequence of iterative cycles of data gathering, designed to address specific organisational issues.

Whilst each situation described, and the action researched in the field of forensic radiography was individual and presented different challenges, the strategies, solutions and changes to professional practice developed in order to address each issue have been brought together within this thesis as cohesive pattern of research. New knowledge developed to address each issue was applied and further examined and refined in subsequent situations which have been retrospectively linked to form a coherent sequence of iterative cycles of data gathering.

Various authors (Kemmis and McTaggart, 2000; O'Leary, 2004; Elliot 1991) proposed models of action research that describe different approaches to the use of the iterative cycles of; planning, taking action, evaluating the action leading to further planning, etc., described by Coughlan and Coughlan above (Section A2.3, p89).

Sagar (2000) described a seven-step cycle within the process of:

1. Selecting a focus - serious reflection directed towards identifying a topic.

2. Clarifying theories - identifying the values, beliefs and theoretical perspectives the researchers hold relating to their focus.

3. Identifying research questions - generating a set of personally meaningful research questions to guide the inquiry.

4. Collecting data - making sure that the data used to justify actions are valid and reliable and that the lessons drawn from the data align with any unique characteristics of the system being studied. Sagar asserts that, in order to ensure reasonable validity and reliability, action researchers should avoid relying on any single source of data and advocates using triangulation to enhance the validity and reliability of their finding by comparing and contrasting what is being seen through a variety of lenses.

5. Analysing data - methodically sort, sift, rank and examine data to answer two generic questions: What is the story told by the data? Why did the story play itself out this way? By answering these two questions the researcher can acquire a better understanding of the phenomenon under investigation and can produce grounded theory regarding what might be done to improve the situation.

6. Reporting results – often through informal settings such as faculty meetings, conferences and discussions to share and test the results of action research with peers. The act of reporting on action research proves powerful for both the researchers and their colleagues.

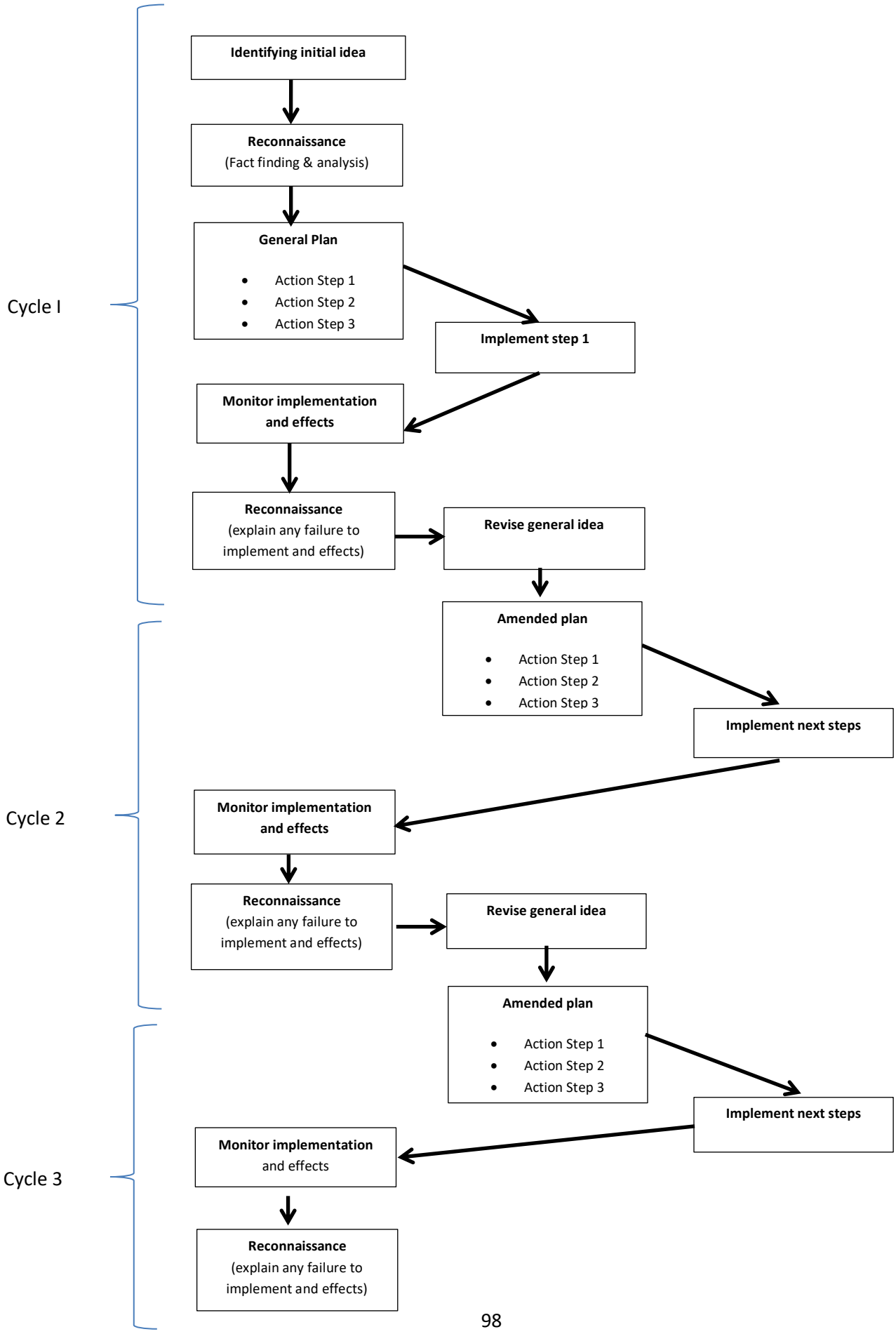
7. Taking informed action - action planning is the last step in the action research process. With each refinement of practice, action researchers gain valid and reliable data on their developing knowledge and the research process liberates them from continuously repeating their past mistakes.

Another model is that employed by Elliott (1991), based on Lewin's work of the 1940s. It includes identifying a general idea or focus, reconnaissance or fact-finding, planning, action, evaluation,

amending the plan and taking the second action step and so on. This is graphically represented in Figure 2 (Page 98).

Whilst such models are useful in clarifying an approach, Coughlan and Coughlan (2016) stated that excessive reliance on a particular model or following the stages or cycles of a model too rigidly could adversely affect the unique opportunity offered by the emerging nature and flexibility which are the hallmarks of action research.

Figure 2 **Elliot's Action Research Model**



A2.4 Theoretical Framework

The theoretical framework used in this thesis is summarised diagrammatically in Figure 1 (p16-17), which maps the cycles of research activity against the respective publication outputs.

This theoretical framework, based on Elliot's Model, has been applied retrospectively within this thesis to demonstrate how research designed and undertaken by the Principal Researcher to address specific organisational issues in a number of different situations over time have been brought together as a cohesive pattern of research.

The six cycles detailed within the framework (Figure 1, p16-17) each follow the steps outlined by Elliot and Sagar:

- **Focus:** at the start of the first cycle the initial focus was identified with the research question "What is the scope of practice and what guidance is required for radiographers undertaking forensic radiography?"

- **Reconnaissance – fact finding:** an initial literature search, together with a series of interviews with representatives of key service users (pathologist, forensic anthropologist, crime investigator, project manager) and radiographer peers, clarified and contrasted both the theoretical position and the understanding, beliefs and perspectives of practitioners.

  The two first steps in cycle 1 led to the development of the initial plan. Evaluation of actions undertaken within each cycle in a subsequent reconnaissance phase led to amendments of the plan and further refinement of the focus and research questions, as detailed at the start of each subsequent cycle.

- **Planning:** within each cycle, a plan was developed with a series of steps comprising actions to be implemented, and data gathering methods.

  The actions to be undertaken and studied within the cycle were identified. For example, in cycle 1 these comprised the drafting and implementation of basic guidelines for radiographers undertaking forensic examinations of the deceased exhumed from mass graves as part of a large scale criminal investigation. Actions for each cycle are detailed in Figure 1 (p16-17), and further discussed in Section 3 (p28).

The methods of data gathering to be used to monitor and evaluate the actions were defined. These were selected to take account of specific operational issues being evaluated and the actions implemented, and to ensure a number of different data sources to allow triangulation, as recommended by Sagar (2000).

Across the six cycles a range of methods were used, as detailed in Figure 1 (p16-17) and Table 1 (p18-27). These included observation and reflection, questionnaires and targeted semi-structured interviews, concept analysis of correspondence, focus groups and multi-disciplinary group discussions and table top exercises. These are further discussed for each cycle in Section 3 (p28).

- **Action - implementation and monitoring:** within each cycle actions were implemented and data collected according to the plan.

  A number of research designs were employed:

  Longitudinal: for example in cycles 1-3 where several iterations involving similar organisational challenges were implemented in which understanding tested and refined , changes implemented and tested

  Cross sectional: employed in all cycles across a range of professions and roles and jurisdictions to develop concepts, test assumptions, clarify the impact and consequences of actions

  Case studies: for example in cycle 2, 3, 5 and 6 through observation and reflection on practice in a range of circumstances.

  The use of different designs in this way enabled testing the application of the actions in different practical situations, thus extending experience and adding strength to the previous research. Furthermore, it ensured triangulation through range of perspectives from practitioners who were both users and providers of the forensic radiography service, and as those investigators tasked with overseeing the process.

- **Reconnaissance - fact-finding and evaluation:** The data gathered using the methods employed in the action phase for each cycle was methodically sorted and categorised and examined to answer the two generic questions posed by Sagar (2000): What story was told by the data? Why did the story play itself out this way?

  Notes were taken at the time by the Principal Researcher and were transcribed and shared with the interviewee for verification and amendment, to ensure accuracy and test understanding. Qualitative findings were evaluated using a mixed content analysis using a three coding framework (Charmaz, 2006). Emerging ideas were listed, relationships expressed diagrammatically and frequently used keywords coded. The focussed coding stage further refined coding by combining, subdividing and eliminating codes to identify recurring ideas and wider issues and themes. Analysis was undertaken both at collective and individual level to both draw out the group consensus but also identify views of different professions within the process.
  Findings from the different data sources were triangulated to develop a comprehensive understanding of the findings.

  The evaluation aimed to establish the degree to which the concepts and actions had been operationalised, to explain any failure in implementation and its effects, and to categorise emerging themes for further exploration. Further literature review was undertaken as necessary during these reconnaissance stages to explore identified issues and themes.

  Through this process of evaluation and reconnaissance the Principal Researcher identified issues and produced further grounded theory and proposals for improving the situation (Figure 1, p16-17). These are further discussed in Section 3 (p 28).

- **Revise idea/reporting:** Following evaluation, findings from each cycle were reported, shared and discussed with a wider audience of peers and groups of practitioners from other disciplines. This was achieved through sharing of reports and co-produced documents and a combination of informal group discussions, project steering groups, conference presentations, working groups. These facilitated further triangulation, enhancing the validity and reliability of the findings.

- **Amended Plan:** As a result of reporting and discussion the initial focus of the research (cycle 1) was further refined and amended. Further research questions were developed and plans formulated for further action to be implemented in subsequent cycles (Figure 1 p16-17).

  This process marked the start of a new cycle and resulted in the implementation of further steps in the action research process (Elliot, 1991: Sagar, 2000).

A2.5 Limitations of the Study

As discussed in Section A2.3.1 (p 93), action research has a number of limitations. In considering the limitations which apply to this research, those identified by Parkin (2009) and Coughlan and Coughlan (2002; 2016) are considered to be particularly relevant.

It is acknowledged that, due to the extended time frame and the retrospective application of the research framework, there may be a perceived lack of precision over the nature and definition of the research. However, as Coughlan and Coughlan (2002) point out, action research applies the scientific method of fact finding and experimentation to practical problems requiring action solutions.

In this study, as with much of action research, the problems and the actions taken to address them were driven by a series of operational circumstances which required implementation of actions prior to testing. The evaluation of those actions led in turn to the development of further research questions, actions and evaluation. The nature and definition of the research was thus action driven. As Robson (1993) asserts this has value in appropriate contexts for anyone who wants to make sense of complex issues and problems which are not subject to conventional laboratory experiments.

The research within this study was conducted over an extended time period of 20 years. It is acknowledged that there is possibility for lack of currency of the findings. Against this limitation is weighed the fact that the research was conducted across several cycles in a developing operational environment which allowed further refinement in a variety of circumstances. During the reconnaissance stage within each cycle, Section A2.4, (p99) further review of the literature was undertaken as necessary to explore identified issues and themes. Several of the Principal Researcher's publications included in this thesis are in their 2nd and 3rd revisions, reflecting re-examination of findings and revision of guidance as knowledge has developed.

Because each operational circumstance researched was influenced by a unique set of circumstances, it is acknowledged that there are limitations in generalising upon the application of findings in other circumstances.

Due to the nature of forensic investigation, swift action was often required to address problems and issues that arose. In some cases this inhibited the ability of the Principal Researcher to implement change and actions suggested by the research. Conversely, in some situations the autocratic nature of police investigation facilitated the implementation of agreed changes by minimising possible resistance and conflict.

This research was conducted within existing cultural and professional constraints which limited changes that could be made. Furthermore, in the context of some of the international operational circumstances, participants from different cultural backgrounds, legal systems and with differing standards of professional education, practice and degrees of autonomy made the implementation and evaluation of changes more difficult.

The postal questionnaire used to collect data in cycle 3 (Figure 1, p16-17 and Section 3.1.2 p32) received a poor response rate of 43% overall, well below the average 67% response rate for this type of questionnaire (Asch et al., 1997). It is acknowledged that this limits the conclusions that can be drawn from this data.

In some of the methods used in this study, such as observation and interviewing, the presence of the observer- interviewer can affect the social interaction and influence the outcome. The Principal Researcher has attempted to minimise any influence by ensuring that reports and documents were shared and co-produced with interviewees and those observed by giving the opportunity for reflection and correction. It is however acknowledged that such influence cannot be entirely eliminated.

As advocated by Kemmiss (2009), the Principal Researcher applied existing personal knowledge and experience of radiography to the resolution of organisational issues, developing new knowledge in the field of forensic radiography. However, Coughlan and Coughlan (2002, 2016) suggest that the main threat to validity for action research is the lack of impartiality and subjectivity on the part of the researcher. As detailed in Section A2.4 (p99), the Principal Researcher reported, shared and discussed the findings from each cycle with a wider audience of peers and multi-disciplinary groups of practitioners presenting the inferences, attributions, opinions and viewpoints of the Principal Researcher as open to testing and critique.

This was achieved through active engagement in interdisciplinary discussion regarding developing the practice of forensic radiography and debate and further refinement in conjunction with practitioners in the same field, collaborating on joint initiatives and texts. Findings were presented and discussed at national and international conferences, leading to the creation of collaborative international guidance.

A2.6 Ethics and Ethical Issues

Ethical principles should be applied to all aspects of research including the design of the research and the manner in which it is conducted. The Academy of Social Sciences set out five generic ethics principles for research (ACSS, 2015):

- Social science is fundamental to a democratic society and should be inclusive of different interests, values, funders, methods and perspectives
- All social science should respect the privacy, autonomy, diversity, values, and dignity of individuals, groups and communities
- All social science should be conducted with integrity throughout, employing the most appropriate methods for the research purpose
- All social scientists should act with regard to their social responsibilities in conducting and disseminating their research
- All social science should aim to maximise benefit and minimise harm.

As the research within this study was conducted to examine operating processes of forensic investigation and did not include research on the outcomes of any specific investigation involving victims of crime, it did not require prior ethical approval. However in all cases involving observation and research related to processes during an ongoing investigation prior written permission was sought and obtained from the Coroner, Medical Examiner other appropriate authority. Assurance was given that no details pertaining to the investigation would be disclosed.

A2.6.1 Confidentiality

During observation and research of ongoing forensic investigations, no case numbers or identifiers were used during the study and any documents relating to specific cases e.g. continuity of evidence forms were examined in situ and not removed from the laboratory. No details that could identify the case or victims were recorded.

Names of staff were not used during the study and when necessary staff members were referred to by their professional title and numbered e.g. Pathologist 1, Radiographer 1 etc. These numerical identifiers were only known to the Principal Researcher and so remain anonymous.

A2.6.2 Informed Consent

Questionnaires: The postal questionnaire employed in cycle 2 (Section 3.1.2, page 32) was accompanied by a covering letter detailing the purposes of the research. It explained that all data would be anonymised and that no individuals would be identifiable from responses. Respondents were asked to tick a box on the questionnaire confirming their consent.

Observation visits: Forensic facilities are by necessity highly secure environments and it is therefore not easy to gain access research purposes. In the course of research undertaken during cycle 4 (Section 3.2.1, p 40), the Principal Researcher was fortunate to obtain permission through personal professional contacts and introductions to visit a number of forensic facilities in South Africa, Australia, Argentina and the United States.

In many cases the invitation to visit and observe these facilities had been extended by the senior pathologist or investigator and in such cases the possibility of the risk of coercion exists. The Principal Researcher therefore ensured that any participants made an informed decision about being observed, were assured of the anonymity of any comments that they made, and were given an opportunity to read any notes taken at the end of the observation session.

However, forensic facilities can be very busy environments with a number of personnel entering and leaving during the course of an investigation and it was not always possible to gain consent from everyone present. Steps were taken to ensure that all members of staff were informed that observation was being undertaken and that they would not be identified in any findings.

Interviews: At the start of the semi-structured interviews employed in a number of cycles participants were given an explanation of the purpose of the research and an assurance that all data would be anonymised and that no individuals would be identifiable from the research. They were asked to give consent and were provided with a copy of notes taken during the interview.

A2.6.3 Potential Ethical Issues

Before commencing observation visits, the issue of possible observation of poor practice was considered. However, as the purpose of the visits was to examine different levels and standards of practice within jurisdictions outwith the experience of the Principal Researcher it was decided that whilst it would be possible to determine what constituted poor practice within the Principal

Researcher's own jurisdiction, it would not be possible to draw conclusions in other jurisdictions. It was therefore decided that, unless the practice was considered to have the potential to cause harm to individuals, the Principal Researcher would not intervene. The practice would be observed and documented with any issues that arose discussed within the context of testing understanding.

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Additional publications

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Additional publications

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Viner M.D., 2016 “Forensic Dental Radiography” *Proceedings of the ISFRI & IAFR Joint Congress, Amsterdam, Netherlands 2016 .*

Conlogue G., Viner M.D., “Making the best use of your expensive x-ray equipment.” Workshop, *Proceedings of the American Academy of Forensic Sciences 65th Meeting, Las Vegas 2016.*

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Web-Based Publications

Viner M.D. (Ed) (2017): Day, A., Loughlin A., Image Interpretation – *Dental & Maxillo-Facial Radiography: Session 4 HEE e-learning for Healthcare*.

Viner M.D (Ed) (2015): Woodhouse A, Boland N. Image Interpretation - *Dental and Maxillo-facial Radiography: Sessions 1, 2 & 3 HEE e-learning for Healthcare*.

Other Publications

Bourne S., Viner M.D., Intra-oral radiography techniques, (2017) *Dental Practice Magazine*, October 2017.

Loughlin A., Viner, M.D., Bourne, S., (2017) Practical aspects of radiation protection in dental radiography, *Dental Practice Magazine*, September 2017.

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Curriculum Vitae

CURRICULUM VITAE

Mark D. Viner

FCR, MSc, HDCR, DipHSM, DipFMS, DipFHID, MCSFS, CertRP, SRR

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Mark Viner FCR, MSc, HDCR, DipHSM, DipFMS, DipFHID, MFSSoc, CertRP, SRR

Present Positions

2014- **Barts & The London School of Medicine & Dentistry, Queen Mary College, University of London**
Senior Tutor - Radiography, Institute of Dentistry

2010- **Director, Reveal Imaging Limited**

2006- **Cranfield University, Defence Academy of The United Kingdom**
Fellow, Cranfield Forensic Institute & Module Leader, Radiographic Investigations in Forensic Science, Forensic MSc Programme

2005- **Lymington Hospital Hampshire**, Senior Radiographer (Bank)

Previous Experience

37 years experience as a radiographer, radiology manager and senior hospital manager in the United Kingdom:

2006-2015 **Barts and The London NHS Trust**
Deputy Head of Clinical Design & Commissioning, New Hospitals Project.

2001-2006 **Barts and The London NHS Trust, London**
Senior Project Manager (Clinical), New Hospitals Project

1998-2001 **Barts and The London NHS Trust, London**
Radiology Services Manager

1992-1998 **The Royal London Hospital**
Lead Superintendent Radiographer & Deputy Operations Manager

1990-1992 **The Westminster Hospital, London**
Superintendent Radiographer (Accident & Emergency)

1988-1990 **The Brook Hospital, Greenwich, London**
Senior Radiographer

1982-1988 **The London Hospital, Whitechapel, London**
Radiographer, Senior Radiographer & Acting Superintendent Radiographer (Dental)

Education & Training

2008 Diploma of Forensic Human Identification
2002 Diploma of Forensic Medical Sciences
1996 Master of Science, Health Service Management by Research
1994 Diploma of Institute of Health Service Managers
1993 Higher Diploma of College of Radiographers
1989 Certificate of Radiological Protection
1982 Diploma of College of Radiographers

Mark Viner FCR, MSc, HDCR, DipHSM, DipFMS, DipFHID, MFSSoc, CertRP, SRR

Awards

2010 Gold Medal, Society & College of Radiographers
2005 Fellowship of The College of Radiographers
2005 Winston Churchill Travelling Fellowship

Professional Memberships

- Health Professions Council UK State Registration, Registration No: RA 24673 (Continuous since 1982)
- British Association for Forensic Odontology 2017-
- The International Society of Forensic Radiology & Imaging 2012-
- Registered Forensic Practitioner (CRFP) 2009
- The American Academy of Forensic Sciences 2008-
- The International Association of Forensic Radiographers 2005-
- Member, Centre for International Forensic Assistance (CIFA) 2001-
- British Association for Human Identification 2001 -
- The Chartered Society of Forensic Science (MCSFS) 1997-
- The Trauma Imaging Group 1996-05
- International Society of Radiographers and Radiologic Technologists 1994-
- The Society of Radiographers 1982-

Other University Appointments

Teaching & course development of undergraduate and postgraduate radiography education:

2015-present External Examiner, MSc in Forensic Radiography
Teesside University

2013-present Visiting Lecturer University of Greenwich
Member of module development team, Disaster Victim Identification Module, BSc Forensic Science programme

2007–2009 Visiting Lecturer at Christ Church College Canterbury (Forensic Science BSc, Radiography MSc)

2002-2014 Visiting Lecturer at Bournemouth University, (Forensic Archaeology & Anthropology MSc) & Disaster Management Centre

1998 - 2006 Visiting lecturer at University of Central England in Birmingham
Facilitated development of the first post-graduate certificate course for Forensic Radiography in UK

1997 - 2001 Visiting Lecturer at University College of North Wales (Postgraduate Diploma - Trauma and Forensic Radiology)

1987 – 2008 Visiting lecturer at City University, London (Radiography, Forensic Imaging and Management)

- Development committee for forensic radiography module 2003-04
- Research Steering Group member 1996-00
- Development committee for management module 1993-4

Mark Viner FCR, MSc, HDCR, DipHSM, DipFMS, DipFHID, MFSSoc, CertRP, SRR

Academic Activities

2012-Present Editorial Board Member, Journal of Forensic Radiology & Imaging

2001 – 2007 Chair of College of Radiographers Forensic Conference Committee

2001 – 2004 Editor, Forensic Radiography Pages, British Association for Human Identification

1997 – 02 JVC Validator (Diagnostic Clinical) for courses eligible for State Registration by the Radiographers Board of the CPSM

1997-Present College of Radiographers Assessor for post-graduate courses

1999-00 Chair of College of Radiographers/SPSM working party, "Issues facing the New Curriculum"

1997-00 College of Radiographers representative to the CoR CPSM Joint Validation Committee and Link Validator for: University of Central England & University of Wales (Bangor)

1997-00 College of Radiographers representative to the faculty boards of; *University of Liverpool, Glasgow Caledonian University*

1997-99 External Advisor for course development team for the BA Hons & MA in collaborative care; *Oxford Brookes University*

1997-2003 Editorial Board Member for the Journal of Radiography and Diagnostic Imaging

1995-Present Review panel member for papers submitted to *Radiography*

Dissertations & Research Projects

2006 The Role and Development of Radiography in Forensic Medicine In the USA, South Africa & Argentina,
Travelling Fellowship – Winston Churchill Memorial Trust

2002 Mass Disaster Planning – A Comparative Study:
A comparison of Emergency planning arrangements for the use of Radiology for identification in incidents involving multiple fatalities
A research project sponsored by the Trauma Imaging Group

1996 An analysis of present, interim and future functional content, space and staffing requirements (1995 – 2005) and proposals for the provision of imaging services during the rationalisation programme across the hospital sites of The Royal London. St Bartholomew's, The London Chest and Queen Elizabeth Children's Hospitals *MSc Dissertation*

1993 Recycling Schemes within Imaging Departments
Higher Diploma Dissertation, College of Radiographers

1986 Changing Patterns in Radiography
A research project for the College of Radiographers

Mark Viner FCR, MSc, HDCR, DipHSM, DipFMS, DipFHID, MFSSoc, CertRP, SRR

Publications

For publications not included or referenced in the submitted thesis, please see page 123

Eponymous Lectures

William Stripp Memorial Lecture, UK Radiological Congress 2007, Invited Review: The Bone Detectives. *College of Radiographers– Eponymous Lecture*

Other invited presentations

"El futuro de la identificación forense", *10th Reunion Cinetifica, Associacion Espanola de Anthropologia y Odontologia Forense*, Palma, Majorca, November 2018

"An overview of technological advances in dental and maxillo facial imaging" Th*e SA 2017 RSSA & SORSA Imaging Conference* Durban, South Africa 2017

"Ethics in Forensic Radiography" *The SA 2017 RSSA & SORSA Imaging Conference* Durban, South Africa 2017

What to do if you find yourself being called to give evidence. European Congress of Radiology, Vienna, March 2014

"The Use of Portable Radiography in Forensic Archaeology" *4th Annual European Meeting of Forensic Archaeology*, Shrivenham, UK August 2014

"Forensic & Archaeological Radiography", *1st Conference of RadForensics*, Tunica, MS, USA, Apr 2013

"Forensic Radiology – A Review", *Manchester Medical Society*, February 2012

"Forensic Radiology*", Cambridgeshire Constabulary Scientific Officers Training*, Huntingdon, January 2012

"Forensic Radiography – Advances in Digital Radiography" *"Virtopsy" Course, University of Zurich*, November 2013 & November 2011

The Bone Detectives. *Congress of the Canadian Association of Radiologic Technologists, Saskatoon, Canada June 2011*

"Forensic Radiology", *Metropolitan Police Scientific Officers Training Day*, Scotland Yard, London May 2011

"Putting the pieces together: Realising the benefits of an integrated multi-disciplinary approach to the forensic investigation of mass graves" Hanson I., Viner M.D., Special Session on Forensic Radiology, *European Congress of Radiology, Vienna*, March 2010

Picking up the Pieces, The Role of Radiography following Mass Disasters *Radiological Society of North America*, Chicago November 2010

The Bone Detectives. *European Congress of Radiology, 2009*

Forensic Radiography, Response to the London Bombings on 7th July 2005 - *ISRRT World Congress* Durban , South Africa, 2008

"The Role of Radiography in the Forensic Investigation of Mass Incidents*", First International Symposium on Forensic Radiography*, University College Dublin, 2008

Other invited presentations (ctd)

"Forensic Radiography, The London Bombings" *19th Annual meeting of the Interpol Standing Committee For Disaster Victim Identification,* Lyon, France, May 2007

Forensic Applications of Direct Digital Radiography Technology*, X-Ograph Healthcare Seminar,* Warrington, May 2007

"Forensic Radiography – Protocols, Training and Regulation" *Invited Speaker, Irish Institute of Radiography,* Cork, Apr 2007

"Forensic Radiography – An international Perspective"*, Annual Conference, Irish Institute of Radiography,* Dublin, Nov 2006

"Post Mortem Examinations in a Grain Store – Emergency Incident Mortuaries" *Invited Speaker - Institute of Cemetery and Cremation Managers Conference*, Harrogate, Oct 2006

Forensic Radiography, An International Perspective. *The 24th International Congress of Radiology*, Cape Town, South Africa, September2006,

"Radiography in the Post Mortem Room" *Invited Speaker, Association of Anatomical; Pathology Technologists Annual Conference*, Manchester, Sept 2006

Viner, M.D., Forensic Radiography: A Framework for the Future?, I*SRRT 12th World Congress, Amsterdam, Netherlands*, ISRRT 2002

"Human Identification – The Role of Forensic Radiology" *Invited Speaker, Inaugural Conference, British Association for Human Identification* Glasgow, 2002

Viner, M.D., Forensic Investigation: The Role of Radiography, *European Congress of Radiology,* March 2001

Other Professional Activities (Current)

- Fitness To Practice Panel Partner, Health Care Professions Tribunal Service
- Founder Board Member & first Vice-Chair, International Society of Forensic Radiology & Imaging
- International Liaison Officer & Founder Member, International Association of Forensic Radiographers
- Forensic Radiography Advisor & member of Forensic Imaging Guidelines Committee, College of Radiographers/IAFR.

Other Professional Activities (Previous)

2003-2012	Forensic Radiography advisor to the Government Office for London and member of the London Mass Fatality Planning Group.
2005-2009	College of Radiographers radiography advisor to the UK Government Home Office Mass Fatalities Working Group & UK DVI Stakeholder Forum
1998–2007	Founder Member of the Trauma Imaging Group Forensic Committee and first chair of its successor; The Association of Forensic Radiographers

Other Professional Activities (Previous, ctd)

2000-2002 Chair of College of Radiographers Advisory Committee to NHS Estates Committee for the revision of "Health Building Note 6: Radiology Departments"

2000-2002 Chair, College of Radiographers Forensic Imaging Conference,

1999 Planning consultant to the Omnicare Clinic Project, Harare, Zimbabwe

1996-1997 Planning consultant to Westminster Healthcare
Harley Street Imaging Project

1997-2002 College of Radiographers Expert Panel Member,
National Radiology Review, Clinical Management Unit, Keele University

1997-2000 National Council Member, Society & College of Radiographers

- *Executive Member, College of Radiographers Board of Trustees*
- *Member of Professional & Educational Advisory Committee*
- *COR representative to the Association of Radiology Managers*
- *Member of College of Radiographers / British Institute of Radiology Joint Venture Board*
- *Chair of review committee for the publication of guidance on forensic imaging*

1985 – 1997 Committee Member, London & Home Counties Branch, Society & College of Radiographers (Offices held; Chair, Vice-chair, Hon Secretary, Educational Programme Secretary)

UK Forensic Consultancy & Casework

Forensic and archaeological radiography casework at the request of HM Coroners, hospital & Home Office pathologists, regional police forces, archaeological companies and universities

- Forensic Radiography Consultant to LGC Forensics
- Consultant Radiographer for Metropolitan Police, Scotland Yard
- Consultant Radiographer to Oxford Archaeology
- Forensic Radiography Team Co-ordinator for the London Resilience Team Response to the Tsunami and 7/7 London Bomb attacks
- Lead Assessor for radiography applications to the Council for the Registration of Forensic Practitioners (CRFP) – now disbanded
- Radiography advisor to Atlantic Productions / Chanel 5 Documentary *"Mystery of the Tibetan Mummy"*

International Forensic Consultancy & Casework

Current Roles:

- Forensic Radiography Advisor to the United Nations International Criminal Court, advising on equipment, protocols, workflow, radiation safety and radiography team deployment.
- Forensic Radiographer team member for Kenyon International Emergency Services
- Member of the Centre for International Forensic Assistance (CIFA)
- Advisor to the Bioarchaeological Imaging Institute, Quinnipiac University, Connecticut, USA

International Forensic Consultancy & Casework (ctd)

Extensive previous experience as Forensic Radiography Advisor & Consultant:

- Chief Executive of the International Forensic Centre of Excellence (INFORCE), at Cranfield University. Co-ordinating programmes for training in International Mass Fatality response.
- Consultant Forensic Radiography Advisor to Oxford Archaeology for the Fromelles Project to Recover & Identify WWI service personnel (2009)
- Radiography advisor to the Office of the Chief Medical Examiner, City of New York, (2005-06)
- Advisory Board Member of the Inforce Foundation and co-ordinator of Inforce radiography training for the Iraq Special Tribunal (2004-05)
- Consultant radiographer to United Nations Office of Missing Persons in Kosovo for mortuary design and training of forensic radiographers (2002-3)
- Member of the CIFA forensic team to Kosovo (2002)
- Consultant radiographer to the United Nations Mission in Sierra Leone for the recovery and identification of missing peacekeeping personnel (2000)
- Forensic radiography advisor and team leader for the United Nations International Criminal Tribunal for the Former Yugoslavia, (ICTY). Advised on mortuary design, set up, imaging protocols, workflow, equipment selection & maintenance, radiation safety and co-ordinated staffing for the period 1996 – 2001. Worked extensively in Croatia, Bosnia and Kosovo.
- Consultant radiographer to the Dublin Coroner and State Pathologist, Republic of Ireland for identification of IRA disappeared. (1999-2000)
- Extensive experience of Major Incidents at London Hospitals (1984-99)