THE IMPORTANCE OF A PROTOCOL IN THE RECOVERY AND HANDLING OF BURNED HUMAN REMAINS IN A FORENSIC CONTEXT

By

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Declaration

I, *Petra Michelle Schwab,* hereby declare that the work on which this dissertation/thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

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Abbreviations

CGS	-	Crow-Glassman Scale
CTFRS	-	Cape Town Fire and Rescue Services
FPO	-	Forensic Pathology Officer
FPS	-	Forensic Pathology Services
HREC	-	Human Research Ethics Counsel
PPE	-	Personal Protective Equipment
SAPS	-	South African Police Services
SRFPL	-	Salt River Forensic Pathology Services
WHO	-	World Health Organization

CHAPTER 1: RESEARCH PROTOCOL

1. Introduction

Fire-related deaths are a common occurrence globally, with approximately 90% of such deaths occurring in residential settings (DiMaio & DiMaio, 2001). The rate of injury related to household fires has been found to be highest in the elderly, minority and low-income populations (Istre *et al.*, 2001; Mock *et al.*, 2008). In South Africa, a review of national death notifications during 2011 revealed that 2243 deaths were associated with "exposure to smoke, fire and flames" within that year which, when calculated with the population at the time, translates to 4.3 deaths per 100 000 population (Statistics South Africa, 2014). The demographic information and circumstances surrounding those fire-related deaths were not documented. The City of Cape Town, South Africa, has previously reported the highest burn mortality rates within the country, at 7.9 deaths per 100 000 population (2001-2004 period) (Van Niekerk, Laubscher & Laflamme, 2009).

Salt River Forensic Pathology Laboratory (SRFPL) is one of two state mortuaries in the area, and it serves the West Metropole of the City of Cape Town, which has an average case load of 3 000 cases per annum (Forensic Pathology Services, 2014). The Tygerberg Forensic Pathology Laboratory (TFPL) serves the East Metropole of Cape Town. A brief review of the autopsy database (2011-2014) of SRFPL alone, reveals that the number of fire-related deaths assigned to the mortuary is noteworthy, at an average of 94 deaths per year.

Even though fire-related fatalities are not uncommon globally, complications are still faced at each phase in their investigation (DeHaan & Icove, 2007; Symes *et al.*, 2012). The use of a protocol for recovery, handling and transport of burned remains assists in managing these challenges, and promotes preservation of the state of the remains from scene to autopsy (Symes *et al.*, 2012). Currently, no protocol detailing methodologies for the recovery and handling of fire-related fatalities exists in Cape Town, South Africa. Furthermore, little is known regarding the settings in which fatal fire scenes occur in the area, the associated risk factors or the challenges faced on scene.

Currently SRFPL employ Forensic Pathology Officers (FPO's) who have a wide range of duties, including crime scene attendance and assessment, accompanying the body to the

mortuary, and assisting during autopsy procedures (South African Qualifications Authority, 2012). A forensic pathologist will attend scenes when required and specialised support, such as forensic anthropologists, are included on the scene and during analysis when deemed necessary. The extent of the involvement of specialised personnel at fatal fire scenes in Cape Town is undocumented. There are numerous ways in which a fire can begin, and although many are deliberate, deaths due to fire are often accidental (DiMaio & DiMaio, 2001; Mock *et al.*, 2008; Peck, 2011). There are a multitude of ways in which accidental fires can be started, including by those who smoke and by children who have been left unattended (DiMaio & DiMaio, 2001). On occasion fire is used as a method to commitsuicide, either by self-immolation or by burning the structure in which they are in (e.g. a house or car) (Laloë, 2004; Shkrum & Ramsay, 2007). Homicide by fire is due to the deliberate ignition of a fire which ultimately leads to the death of an individual (DiMaio & DiMaio, 2001; Peck, 2012). Fire is also commonly used in attempts to conceal or destroy evidence of a homicide (DiMaio & DiMaio, 2001; Symes *et al.*, 2012). It is, however, not believed to be possible to completely consume a body in a house or building fire, and that skeletal elements will remain which can successfully be recovered by trained osteologists and forensic anthropologists (Bass, 1984). Due to the fact that the manner of death in fire-related cases is not always immediately apparent, it is important that these cases are investigated thoroughly and that a full medico-legal autopsy always be performed.

The thorough and complete recovery of human remains is not only essential to ensure a comprehensive investigation, but also in order to fulfil the needs and expectations of the family and friends of the deceased (Waterhouse, 2013). The quantity and quality of the remains that are recovered is crucial, and currently burned remains pose an issue in this regard due to several factors, further discussed below (Waterhouse, 2013).

As a body is exposed to the heat of a fire, soft tissue is destroyed and the bones are burned. As bone is burned, it passes through a number of intermediary stages as it loses moisture and collagen, becoming calcined when all water or organic material have been removed (Fairgrieve, 2008; Waterhouse, 2013). This process causes the discoloration of bone; initially blackening bone as it chars before turning grey, and then white as the

remains become calcined (Correia, 1997; Waterhouse, 2013). Calcined bone is prone to fragmentation and it is difficult to locate and recover on a scene, due to its fragility and its white/grey colour being similar to that of the burned surroundings (Waterhouse, 2013).

When burned remains are located, depending on the circumstances, they may be charred or they could be partially/incompletely/completely cremated (Correia, 1997). Charred remains are not as difficult to analyse as those that have been exposed to more extensive forms of burning (Correia, 1997). When partial burning has occurred, ascertaining identification does not pose as many problems, however when the only remaining tissue comprises of a mass consisting of the torso, organs, and bony tissue, it becomes more difficult (Correia, 1997). Incomplete burning of remains presents the biggest taphonomic problem due to the effects of heat on soft tissue and bone (Correia, 1997; Symes *et al.*, 2012). The various heat-induced changes which occur complicate the analysis by creating artefacts and mimicking trauma. This makes it difficult to determine the number of individuals represented, the age and sex of individuals, living stature, race, perimortem condition, and if there is any trauma present (Correia, 1997). Incorrect recovery and transportation of the remains can further alter their state, which creates additional complications in analysis (Correia & Beattie, 2002; Symes *et al.*, 2012).

The Crow-Glassman Scale (CGS), is occasionally used to describe the extent of burn injury to human remains as a whole at a death scene (Glassman & Crow, 1996). The CGS ranges from Level 1 (least severe, minor burns) to 5 (highly fragmentary remains present) (Glassman & Crow, 1996). This scale also includes recommendations of which specialised personnel should be included on scene and assisting in the identification of the victim, such as forensic anthropologists (Glassman & Crow, 1996).

Forensic pathologists are responsible for the legal examination of the remains. The main questions they aim to answer are the following: Who was the deceased?; How did the deceased come to their death?; When did the deceased come to their death?; Where did the deceased come to their death?; By what means did the deceased come to their death? (Fairgrieve, 2008). Depending on the state of the remains, these questions can be answered if proper investigations have been done on scene, and often only with the

assistance of other disciplines. It is without a doubt that analysis at the scene, and the post-mortem examination, should be a team effort (Fairgrieve, 2008).

Forensic anthropologists can assist in cases involving burned remains to a large extent and should be included in the recovery and analysis of remains (Glassman & Crow, 1996; Fairgrieve, 2008; Symes *et al.*, 2012). Their knowledge of archaeological techniques, familiarity with fragmented as well as calcined bone, and ability to identify trauma and to detect deviations from normal burn patterns, allows them to have useful input on the recovery and documentation of human remains (Fairgrieve, 2008; Symes *et al.*, 2012). When the majority of soft tissue has been destroyed, a forensic anthropologist's analysis could form the bulk of an investigative report (Fairgrieve, 2008). This can include determining age at death, sex, population affinity, stature, presence of pathology, post-mortem interval and other aspects for positive identification (Fairgrieve, 2008).

When a pathologist and/or forensic anthropologist analyses remains, the heat-induced changes must be understood and considered if correct interpretations are to be made. Discussed further, are a number of important artefacts and heat-induced changes that need to be considered and preserved with proper recovery and transportation.

The pugilistic posture, caused by heat induced muscle contraction (generally the flexor muscles), results in a posture resembling someone in a "fight or flight" or defensive position (Bass, 1984; DiMaio & DiMaio, 2001; Shkrum & Ramsay, 2007). This posture needs to be documented and considered as it takes place in a predictable manner, and if deviations from the expected posture are noted, this could warrant further investigation (Symes *et al.*, 2012). Skin splitting occurs due to the heat, mimicking incised wounds and in extreme cases, evisceration of the organs takes place (Dix, 2000; Shkrum & Ramsay, 2007). Bilateral epidural haemorrhages that are observed in the cranium can be mistaken with ante-/peri-mortem trauma to the head, but this is in fact a common heat artefact which can be distinguished (DiMaio & DiMaio, 2001; Shkrum & Ramsay, 2007). Thermal fractures of the extremities may occur, particularly at the joints, and can be mistakenly interpreted as antemortem fractures, but fractures often also occur if improper recovery and transport techniques are used (Dix, 2000; Dana & DiMaio, 2006; Symes *et al.*, 2012).

Interpreting skeletal fractures without considering that they are resultant of fire modification, recovery or transport techniques, further complicates the analysis and requires an understanding of normal burning patterns if deviations from a patterns are to be noted (Symes *et al.*, 2012).

Perhaps the most influential heat-induced change is fragmentation of the remains, which heightens the need for proper recovery techniques (Waterhouse, 2013). Recognising fragmentary remains is a task best suited to forensic anthropologists as they are able to recognise osteological features, even on fragmentary remains, and determine which bone they originate from (Fairgrieve, 2008). If a juvenile is suspected to have been in a fire, recognition and recovery becomes an even more specialised task, as their bones are smaller and have unfused epiphyses (Waterhouse, 2013).

In an extensive study conducted by Symes *et al.* 2012, the recovery and interpretation of burned human remains was of interest. During this study, it was determined that the classic fire scene recovery protocols that existed, and were used in the United States of America at the time, were extremely prone to loses in information and evidence (Symes *et al.*, 2012). This was determined while processing both mock and actual fatal fire scenes, in which various protocols were tested and modified. The concept of approaching a scene using archaeological methods for the documentation and recovery of remains was found to be highly successful, and these methodologies are lacking in most fatal fire scene recovery protocols globally (Olson, 2009; Symes *et al.*, 2012). They also proved that identifying trauma (other than that due to fire) can be done successfully on burned skeletal remains, which supports the need for preservation of the state of the remains from scene to analysis (Symes *et al.*, 2012). Furthermore it was shown that heat alteration of the human body follows a clear and regular pattern, and that it can serve to identify potential criminal cases if deviations from these patterns are noted, and this is best done by a forensic anthropologist (Symes *et al.*, 2012). All of these findings further support the need for a modern protocol in the recovery and handling of burned remains in order to preserve elements that may have evidentiary value, and to standardise their analysis.

The lack of standard operating procedures and protocols at fatal fire scenes is a serious factor that can impede investigations. Issues surrounding the collection, analysis, and the reporting of results are all connected and if any one of these areas falters, evidence may be overlooked or misinterpreted (Fairgrieve, 2008). The need for standard recovery protocols cannot be underestimated, and these are non-existent in South Africa. Systematic collection, handling, and preservation techniques must be implemented and well documented in order for proper analysis of remains, reconstruction efforts and also for any subsequent evidence and hypotheses to withstand courtroom scrutiny (Symes *et al.*, 2008).

2. Study Aims

The aim of this study is to document current techniques used in the recovery, handling, and transport of burned human remains by the Salt River Forensic Pathology Laboratory (SRFPL) of Cape Town, South Africa, and how these affect the condition of remains from scene to autopsy. While doing so, the challenges, settings in which they occur and the associated risk factors of fatal fire scenes in Cape Town will be evaluated. With this knowledge, recommendations for improvement and a tailored protocol will be designed (which will be attached as Appendix A). The protocols shall intend to limit the alteration of remains from scene to autopsy, and ultimately aim to advance fatal fire investigations in Cape Town.

3. Methodology

3.1. Study Design

All burned remains that are assigned to SRFPL between April to December of 2015, will be included in this research. When cases occur, the researcher will attend the fatal fire scene with the assigned FPO and/or forensic pathologist.

The manner in which burned remains are recovered, handled and transported from scene to the SRFPL will be observed. The remains will be assigned a CGS Level. Various aspects will be documented (detailed in section 3.4) using a standardised form. Forms created for data collection can be seen in Appendix B, Appendix C and Appendix D. Most

importantly, the fragmentation and condition of the remains both on scene and at autopsy, will be documented descriptively and visually by means of a skeletal and tissue diagram and with extensive photography. Any change or further fragmentation of the remains from the scene to the mortuary can then be attributed to the recovery and/or transport techniques employed. The autopsy data will be collected using the proposed forms and the remains will be re-photographed. All data collected using the forms will be digitised.

The knowledge gained will be used to design a protocol for the recovery, handling and transport of burned remains by SRFPL. The protocols set out by Symes *et al.* are highly revered, particularly because they were set up by forensic anthropologists with the preservation of the condition of the remains being paramount (Symes *et al.*, 2012). These will be used as a guideline, but will have to be altered significantly to be applicable in a South African setting.

The research will serve to identify areas in need of improvement in fatal fire investigation and allow the designing a protocol with knowledge of the challenges and risk factors associated with fatal fires in Cape Town.

The decedents will be handled with respect by the researcher and in the presence of a pathologist or FPO. No identifying and personal data of decedents will be recorded or published.

3.2. Characteristics of Study Population

The research sample size will be dependent on the number of fire-related fatalities that occur during the period of data collection. The aim is a sample number of 60 decedents.

All individuals with thermal trauma, specifically caused by fire, assigned to SRFPL will be included in the study sample. In addition, cases in which fire is suspected to have been used to conceal a homicide will be included. All ages, sexes and races will be included. Those fire-related fatalities who do not exhibit burns (e.g. those who die from inhalation of smoke without being burned) will not be included in the study.

3.3. Recruitment

A member of Forensic Pathology Services will inform the researcher when they have been notified to collect remains which appear to have been burned, or involved in a fire. The researcher will meet a FPO at SRFPL and proceed to the fatal fire scene in their vehicle. If the decedent meets the inclusion/exclusion requirement, they will be included in the study.

3.4. Research Procedures and Data Collection

Two forms are proposed for usage in data collection. Appendix B illustrates the form that will be used to document the details of each fire scene attended. Some of the required scene details will be obtained from the Forensic Pathology Officers, such as the exact location (including GPS coordinates) of the scene, and the alleged account of events. Appendix C illustrates the form that will be used for each decedent found at a scene, and will document aspects of the remains on the scene and at the mortuary, as observed. On this form, the fragmentation and condition of skeletal elements of the descendant will be described in words. Part of the documentation process includes Appendix D, which consists of a skeletal and tissue diagram in order to note the extent of the remains which have fragmented or destroyed. This will be accomplished by filling in (blacking-out) the missing bones/fragments of bone and tissue and indicating fractures on the diagram

Extensive scene photographs will be taken and supported by scene sketches, where necessary. The manner in which burned remains are recovered and handled from the scene to SRFPL, will be observational and qualitative in nature. Some aspects that will be observed using the collection forms are the following: safety on scene, scene and contextual documentation techniques, tools used to recover remains, resources for transportation, and how the remains are loaded into the transportation vehicle. The time it takes to conduct the recovery will also be recorded. Most importantly, the condition of the remains as they are on scene, will be documented and their level of fragmentation will be recorded in words, Crow-Glassman Scale, and on the diagrams. Once the remains reach the mortuary, the handling and storage of remains prior post mortem will be documented.

The researcher will attend the autopsies for all cases, where the level of fragmentation and condition of the remains will be reassessed both in words and with the skeletal and tissue diagram. In this way, the condition of the remains at the scene can be compared to the condition they are in at the time of analysis. Any alteration or further fragmentation can then be attributed to recovery, handling and transport techniques employed. During autopsy, extensive notes will be taken, using the continuation of the burned remains information form (Appendix C). This form will, among other factors, document the manner in which the forensic pathologist handles the remains and what aspects they analyse and consider important when dealing with burned remains. The suspected cause of death and relevant autopsy findings will be noted.

3.5. Data Analysis

All data collected in both phases using the forms will be digitised into a Microsoft Office Excel® (2013) spreadsheet. Data will only be available to the researcher and supervisors of the study.

The data will include quantitative variables (i.e. date of death, time of death, age in years, total body surface area burned), but is largely qualitative and categorical in nature. Microsoft Office Excel® (2013) will be used to analyse the data. Quantitative variables will be analysed to determine a minimum and maximum, calculate averages and divide the variables into ranges (e.g. 0-10 years of age; 18h00-06h00). Categorical qualitative data will be analysed to count and calculate percentages within the various categories, and to create figures and tables to represent the data.

3.6. Work Plan

January - February 2015	-	Refinement of research plan
		Submission of Proposal
		Application for ethical approval

April to December 2015	-	Data collection
		Testing aspects of protocol
		Logging of all data into electronic format
December 2015	-	Interpretation and reporting of results
January 2016	-	Hand in Intention to Submit
February 2016	-	Submission of research

3.7. Budget

Transport to and from SRFPL	R 636.00
Printing of data collection forms	R 34.00
Personal Protective Equipment	R1500.00
TOTAL	R2170.00

3.8. Risks and Benefits

The risks of this study are minimal. Attendance of fire-scenes by the researcher carries some risk of injury. Many of the fires in Cape Town occur within the informal settlements and these areas are often considered unsafe, however the researcher will be in the presence of the South African Police Services, Forensic Pathology Services and on occasion the Cape Town Fire and Rescue Services. Part of the research will be conducted at the SRFPL, which puts the researcher as risk of any pathogens that may be present from infected decedents within the facility, however personal protective equipment will be worn at all times, and all human remains shall be handled correctly as per current protocols and procedures.

There is a risk that FPO's do not consent to be part of the study, and cases assigned to those who don't will not be included in the study. They will be given the opportunity, prior to attendance of scenes, to give their informed consent (explained further in 3.8 Ethical consent process). The risk that the staff alter the technique that they have been using for recovery of remains is possible, as they will knowingly be observed and know their work is being documented.

The benefits of this study are numerous. Aiding the law enforcement and fire departments in fire-scene analysis as a whole, is a hopeful outcome of the study. The protocol is also likely to equip FPO's with skills required for recovering fragile burned remains. The creation of a protocol for the documentation, recovery, handling, and transportation of burned remains could greatly benefit fire-related fatality investigation within South Africa as a whole and assist in the preservation of evidence.

Thorough and complete recovery of human remains will also help give the decedents families and friends some peace of mind.

3.9. Ethical Consent Process

All FPO's who the researcher attends the scenes with will be provided with an information sheet (Appendix E) outlining the importance of the research, its procedures and their involvement as research participants. Once all questions and issues have been addressed, a consent form will be given to each FPO (Appendix F). If they agree to participate in the research, the consent form will be signed in the presence of a witness. In this way informed consent will be obtained from each FPO.

Ethical clearance will be obtained prior to the commencement of the study from the Human Research Ethics Committee (HREC) of the University of Cape Town (Appendix G).

A pledge of confidentiality was signed by the researcher for Forensic Pathology Services, which can be found at Appendix H. The researcher is registered as a volunteer for Forensic Pathology Services, and has clearance to attend crime-scenes and assist, but

approval for attendance for research purposes will be obtained from the head of the Division of Forensic medicine, University of Cape Town (Appendix I).

All photography will be for documentation purposes only. If any photographs of the fire-scenes, recovery techniques and fragmentation of the remains are added into a thesis or any publication, no identifying features of decedents will be visible and their identity will remain anonymous.

3.10. Privacy and Confidentiality

A pledge of confidentiality was signed by the researcher for Forensic Pathology Services, which can be found at Appendix H.

The death registration number assigned (WC number) to decedents by SRFPL will be recorded for all forensic cases involving burned remains. All manually collected data at fire-scenes, will be entered in to an electronic spreadsheet available only to the researcher and supervisors. When reporting data, the WC number will not be reported and instead all individuals will be assigned a unique data number by the researcher.

4. References

Bass, W.M. 1984. Is it possible to consume a body completely in a fire? In *Human Identification: Case Studies in Forensic Anthropology*. T.A.R. Rathbun & J.E. Buikstra, Eds. Springfield, Illinois: Charles C Thomas Publisher. 159–167.

Correia, P.M. 1997. Fire Modification of Bone. In *Forensic Taphonomy: The Postmortem Fate of Human Remains*. W.D. Haglund & M.H. Sorg, Eds. Boca Raton, FL: CRC Press LLC.

Correia, P.M. & Beattie, O. 2002. A Critical Look at Methods for Recovering, Evaluating, and Interpreting Cremated Human Remains. In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*. W.D. Haglung & M.H. Sorg, Eds. Boca Raton, FL: CRC Press LLC. 435–450.

Dana, S.E. & DiMaio, V.J.M. 2006. Fire and Thermal Injuries. In *Handbook of Forensic Pathology*. Boca Raton, FL: CRC Press LLC. 185–198.

DeHaan, J.D. & Icove, D.J. 2007. *Kirk's Fire Investigation*. 7th ed. Boston: Pearson.

DiMaio, V.J. & DiMaio, D. 2001. Fire Deaths. In *Forensic Pathology*. 2nd ed. Boco Raton, FL: CRC Press LLC. 367–388.

Dix, J. 2000. *Color Atlas of Forensic Pathology*. Boca Raton, FL: CRC Press LLC.

Fairgrieve, S. 2008. *Forensic Cremation: Recovery and Analysis*. Boca Raton, FL: CRC Press LLC.

Forensic Pathology Services. 2014. *Our Facilities*. Available: http://www.westerncape.gov.za/general-publication/our-facilities [2014, October 30].

Glassman, D.M. & Crow, R.M. 1996. Standardization model for describing the extent of burn injury to human remains. *Journal of Forensic Sciences*. 41(1):152–154.

Istre, G.R., McCoy, M.A., Osborn, L., Barnard, J.J. & Bolton, A. 2001. Deaths and Injuries from House Fires. *New England Journal of Medicine*. 344(25):1911–1916.

Laloë, V. 2004. Patterns of deliberate self-burning in various parts of the world: A review. *Burns*. 30(3):207–215.

Mock, C., Peck, M., Peden, M. & Krug, E. 2008. *A WHO plan for burn prevention and care*. Geneva, Switzerland.

Van Niekerk, A., Laubscher, R. & Laflamme, L. 2009. Demographic and circumstantial accounts of burn mortality in Cape Town, South Africa, 2001-2004: an observational register based study. *BioMed Central Public Health*. 9:374.

Olson, G. 2009. *Recovery of Human Remains in a Fatal Fire Setting Using Archaeological Methods*. Ontario: Defence Research and Development Canada Centre for Security Science.

Peck, M.D. 2011. Epidemiology of burns throughout the world. Part I: Distribution and risk factors. *Burns*. 37(7):1087–1100.

Peck, M.D. 2012. Epidemiology of burns throughout the world. Part II: Intentional burns in adults. *Burns*. 38(5):630–637.

Shkrum, M.J. & Ramsay, D.A. 2007. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, NJ: Humana Press Inc.

South African Qualifications Authority. 2012. *National Diploma: Forensic Pathology Support*. Available: http://regqs.saqa.org.za/showQualification.php?id=58183 [2015, February 28].

Statistics South Africa. 2014. *Mortality and causes of death in South Africa , 2011 : Findings from death notification*. Pretoria.

Symes, S.A., Rainwater, C.W., Chapman, E.N., Gipson, R. & Piper, A.L. 2008. Patterned Thermal Destruction of Human Remains in a Forensic Setting. In *The Analysis of Burned Human Remains*. C.W. Schmidt & S.A. Symes, Eds. London: Elsevier Ltd. 15–54.

Symes, S.A., Ph, D., Dirkmaat, D.C., Ousley, S., Chapman, E. & Cabo, L. 2012. *Recovery and Interpretation of Burned Human Remains*. U.S. Department of Justice.

Waterhouse, K. 2013. The effect of victim age on burnt bone fragmentation : Implications for remains recovery. *Forensic Science International*. 231(1-3):409.e1–409.e7.

CHAPTER 2: LITERATURE REVIEW

1. Introduction

Fatal fire scenes have proved to be one of the most challenging death scene types to investigate (DeHaan & Icove, 2007; Price, 2010). Even though fire-related fatalities are not uncommon globally, complications are faced at each phase in their investigation: at the fire scenes (regarding challenges with both the scene environment and the human remains), during the transport of the remains, when performing the medico-legal post-mortem examination and in attempting to positively identify a decedent (DeHaan & Icove, 2007; Symes *et al.*, 2012). Taphonomy defines the circumstances, processes, and influences acting upon remains from the time of death until discovery/analysis (Fairgrieve, 2008; Symes *et al.*, 2012). In order for a reliable analysis of burned remains to take place, it is essential to both limit and understand the taphonomic forces involved, including the force of fire itself, as well as the recovery and handling methodologies employed (Fairgrieve, 2008; Symes *et al.*, 2012). Determining the of cause and manner of death is a considerably more challenging task in decedents subjected to fire, and an investigation often relies on thorough contextual documentation and inquiry at the scene (Symes *et al.*, 2012).

Study of current literature reveals that the analysis and interpretation of burned human remains recovered from fatal fire scenes is currently being affected by the lack of standard recovery protocols specific to this scene-type (Correia & Beattie, 2002; Symes *et al.*, 2012). It has been shown that creating protocols which incorporate standardised recovery and transport methodologies; and the training and hiring of professionals for detection, analysis and preservation of all evidence types; aids in conducting comprehensive fire scene investigation (Symes *et al.*, 2012).

The challenges faced with burned remains can be limited and managed with the creation of an appropriate protocol - written guidelines for the thorough investigation of fire-related deaths. A protocol should outline the agencies involved, the sequence of their involvement and the duties expected from personnel. A protocol also ensures inter-agency communication. Although there are protocols in place worldwide for certain scene types, and other aspects of death investigation, they cannot be directly transposed and

used in another environment, such as South Africa. South Africa's socio-economic situation displays features of both developed and developing countries, which has resulted in a lack of available resources and skill in some areas, and has led to preventing implementation of standardised protocols for death investigations (du Toit-Prinsloo *et al.*, 2013). The unique challenges present in the South African forensic field require tailored protocols to be drafted for death investigation, if they are to be successfully applied. The exact challenges faced on fatal fire scenes in South Africa have not been documented.

This research addresses some of these challenges by developing new fatal fire scene recovery guidelines and protocols. The protocol will be designed after observation and evaluation of current techniques and methodologies used in the documentation of fire scenes and in the recovery, transport and analysis of burned remains by Salt River Forensic Pathology Laboratory (SRFPL) of Cape Town, South Africa.

2. Investigation of Fatal Fires

Fire has the ability to damage, modify, or destroy evidence which could be crucial to any biological and behavioural reconstruction, and it poses many challenges during the medico-legal investigation of fire-related deaths (Symes *et al.*, 2008). It is essential that a full investigation be conducted for each case, most importantly including a post-mortem examination. In South Africa, the Inquest Act (Act 58 of 1959) stipulates that all unnatural deaths should undergo medico-legal investigation which includes a forensic autopsy ("Inquest Act (Act 58 of 1959)", 1959). In terms of this Act, all fire related deaths are considered unnatural and therefore should undergo a medico-legal post-mortem examination.

Worldwide, fire-related death investigation is considered a multidisciplinary investigation with numerous personnel and specialists involved (Glassman & Crow, 1996; Symes *et al.*, 2012; Tümer *et al.*, 2012). This includes those who are involved in the recovery of the body at the death scene to those responsible for the identification of the decedent (Glassman & Crow, 1996). This can consist of fire and rescue personnel, paramedics, crime scene investigators, forensic pathologists, forensic odontologists, and forensic anthropologists, depending on the case (Glassman & Crow, 1996). Due to the fact that

there are a number of parties involved in the investigation of fire fatalities, it is necessary to have a protocol to ensure each aspect of the investigation is appropriately handled by the correct agency, with interdisciplinary communication being crucial. Protocols include defining the roles and duties of each responding organisation. A recovery plan for effective implementation will assist in avoiding inter-agency conflict; enhance the principle of multidisciplinary involvement; and result in a prompt and appropriate response (Symes *et al.*, 2012).

Salt River Forensic Pathology Laboratory (SRFPL) is the mortuary which serves the West Metropole of the City of Cape Town, South Africa, which has an average case load of 3 000 cases per annum (Forensic Pathology Services, 2014). Currently SRFPL (and other mortuaries in the country) employ Forensic Pathology Officers (FPO's) who have a wide range of duties, from attending and assessing crime scenes, accompanying the body to the mortuary, and assisting during autopsy procedures (South African Qualifications Authority, 2012). According to the standard operating procedure of SRFPL for death scene attendance and investigation, the following are the assessments made on scene by FPO's: risk determination; appropriate personal protective equipment needed; tool/equipment requirements; appropriate procedures to be followed and activities required (Forensic Pathology Services, 2013). FPO's determine the presumed circumstances of death by obtaining preliminary investigative details from SAPS, who are at the scene (Forensic Pathology Services, 2013). These assessments will determine the necessity to engage with forensic medical practitioners and/or ancillary forensic experts (Forensic Pathology Services, 2013). FPO's are required to maintain record of the incident scene, which includes photography, sketching, documentation (including address and GPS location) and the gathering of information (including interviewing next of kin and obtaining medical records of the deceased, where relevant) (Forensic Pathology Services, 2013).

In Cape Town, forensic pathologists will only attend scenes when required (as determined by the existing standard operating procedures of SRFPL) and conduct the forensic autopsies in order to determine cause of death. They make use of forensic anthropologists and forensic odontologists when deemed necessary, as these specialities

are out-sourced. At SRFPL, no protocol currently exists for the recovery and handling of burned remains, interagency communication, the involvement of specialised personnel, and their respective duties.

3. Burn Prevalence and Risk Factors

Fire remains one of the foremost causes of morbidity and mortality worldwide (Mock *et al.*, 2008; Büyük & Koçak, 2009). The World Health Organization (WHO) estimates that globally 300 000 people die each year from flame or fire related burn injuries, with the global average for burn mortality at 5.0 per 100 000 population (Mock *et al.*, 2008). Approximately 90% of these fire-related deaths throughout the world occur in homes (Mock *et al.*, 2008). Although these deaths are considered highly preventable, burn mortality and prevention strategies are still a public health concern that is not being made a priority in low- and middle-income countries (Blom, Van Niekerk & Laflamme, 2011).

Studies illustrate that the vast majority (>90%) of fire-related fatalities occur in low- and middle-income countries, where there is a scarcity of fire prevention programs and the access and quality of acute care is varying (Mock *et al.*, 2008; Blom, Van Niekerk & Laflamme, 2011). In low- and middle-income countries, burn deaths and injuries are more common in those of lower socioeconomic status (Mock *et al.*, 2008). Fire-related deaths are especially common in the low- and middle-income regions of South-East Asia (11.6 deaths per 100 000 population per year), the Eastern Mediterranean (6.4 deaths per 100 000 population per year) and in Africa (6.1 deaths per 100 000 population per year) (Mock *et al.*, 2008). In high-income countries, the rates are much lower with an average of just 1.0 deaths per 100 000 population per year, which illustrates the highest discrepancy of all injury mechanisms (Mock *et al.*, 2008).

In South Africa, a review of national death notifications during 2011 revealed that 2243 deaths to were associated with “exposure to smoke, fire and flames” within that which, when calculated with the population at the time, translates to 4.3 deaths per 100 000 population year (Statistics South Africa, 2014: 48). No demographic and circumstantial information related to these fire related deaths are known (Statistics South Africa, 2014). The City of Cape Town, South Africa was previously found to have the highest burn

mortality rates within the country (7.9 deaths per 100 000 population in the 2001 – 2004 period), which is higher than the world average and higher than that of Africa (Van Niekerk, Laubscher & Laflamme, 2009). A brief look at the autopsy database of SRFPL in Cape Town, showed an average of 94 cases per year (2011-2014) with a prevalence of 4.7 deaths per 100 000 population.

The prevalence of fatal burns can vary within the areas of one country, as a persons living conditions and lifestyle have been shown to be strongly related to their occurrence (Blom, Van Niekerk & Laflamme, 2011). In low- and middle-income countries (e.g. Zimbabwe, India and South Africa), especially in rural areas and among the urban poor, risk factors for burn injury differ prominently from those found in the high-income countries (e.g. Australia, United Kingdom, United Sates of America) (Mock *et al.*, 2008; The World Bank, 2015). However, some common risk factors can be identified globally. The use of alcohol in adults and the concern of children being left unattended has been recognised as a risk (DiMaio & DiMaio, 2001; Mock *et al.*, 2008). Candles as a means for lighting, as well as various cooking and heating appliances are often a heat source which ignites destructive fires, if they are not monitored or used correctly (Truran, 2009). Over-heated electrical circuits and equipment, as well as improper or unsafe electrical connections commonly cause accidental fires (DiMaio & DiMaio, 2001; Mock *et al.*, 2008). Smoking and the use of open fires for heating purposes is a worldwide risk factor (Mock *et al.*, 2008). Many of these risk factors are largely preventable.

In many low- and middle-income countries, informal settlements with informal housing are prevalent. The Western Cape Province, in which Cape Town is situated, has a large portion (20%) of its citizens living in informal settlements, and often these settlements are densely populated (Blom, Van Niekerk & Laflamme, 2011; The Housing Development Agency, 2013). An informal settlement is defined as “an unplanned settlement on land which has not been surveyed or proclaimed as residential, consisting mainly of informal dwellings” and an informal dwelling is defined as “a makeshift structure not approved by a local authority and not intended as a permanent dwelling” (The Housing Development Agency, 2013).

Corresponding with the socio-economic characteristics and the landscapes in which they are situated, informal settlements are vulnerable to many environmental hazards, including fires (Harte, Childs & Hastings, 2009). Dwellings in informal settlements are often erected close to, or touching one another, which causes fires to spread swiftly resulting in severe destruction and an increased likelihood of multiple injuries or fatalities (Godwin, Hudson & Bloch, 1997; Harte, Childs & Hastings, 2009). Fire and safety education documents of the City of Cape Town recommend they be built at least 3 meters apart (City of Cape Town, 2015a). Many dwellings in these settlements are self-constructed, and made from a variety of materials which may include various new and scrap woods, plastic resources and corrugated iron sheets (Harte, Childs & Hastings, 2009). Some of these materials are highly flammable, and because of the variety of components used to build informal houses, and the dwellings uniqueness, one cannot predict how such a structure will burn or what fumes will be emitted. Often the materials in the informal house cause fires to spread rapidly and the victims may not have a chance to escape, resulting in them sustaining major burns and associated inhalational injuries (Godwin, Hudson & Bloch, 1997). It is a well-known fact that construction materials used in the roof, insulation, carpet materials, and paints all contribute to the various chemicals found in the fumes of a fire, which are often lethal themselves (Crewe *et al.*, 2014).

In many low-income and developing countries, such as South Africa, the high cost of electricity, or the lack of electricity supply in regions, leads to the use of others means of energy (Ouedraogo, 2006). Paraffin, also known as kerosene, is often used for cooking, lighting and heating purposes by means of open flame (Blom, Van Niekerk & Laflamme, 2011). Portability, availability, lack of access to energy alternatives, and affordability are some of the determining factors for its high usage (Truran, 2009). Paraffin itself can cause chemical burns if in contact with skin, but paraffin stoves which fall over or explode are a prominent cause of injury and fires in informal settlements (City of Cape Town, 2015b). Paraffin is occasionally purchased in containers contaminated with others chemicals such as petrol, or even intentionally mixed with volatile fuels such as methylated spirits which can cause it to flare dangerously or explode (City of Cape Town, 2015b). In South Africa, illegal and unsafe electricity connections creates a substantial risk in informal settlements (Mzezewa, 2008). In Cape Town, a census in 2011 revealed that for heating purposes,

14.9% of people made use of paraffin while 16.1% reported having no means of heating (Strategic Development Information & GIS Department: City of Cape Town, 2012). The census also showed that for lighting purposes, paraffin was the second most common means of energy (Strategic Development Information & GIS Department: City of Cape Town, 2012).

4. Demographics of Burn Victims

The demographic profile of burn victims vary significantly by country, and they tend to differ largely between developing and developed countries (Dissanaike & Rahimi, 2009). The demographics of the fire fatalities within Cape Town have been reported as a predominance of adult males (Lerer, 1994; Van Niekerk, Laubscher & Laflamme, 2009)

With regards to sex, the WHO reports that females are at a higher risk for burn injury than males, especially in younger age groups (Mock *et al.*, 2008). There are however, a large number of countries who do show a male dominance in fire related fatalities (Barillo & Goode, 1996; Holborn, Nolan & Golt, 2003; Büyük & Koçak, 2009; Afify *et al.*, 2012). Some studies point out that sex differences of fire deaths in high- and low-income countries are polar opposites (Peck, 2011).

A number of studies indicate both the young (<5 years) and elderly (>70 years) represent a disproportionate percentage of fire fatalities (Barillo & Goode, 1996; Dissanaike & Rahimi, 2009), but some show only the elderly to be at risk (Rogde & Olving, 1996; Holborn, Nolan & Golt, 2003). Interestingly burns in the elderly are uncommon in the developing world (such as south Asia and the Middle East) however they account for almost 20% of burns in economically developed countries (including the USA, Australia and New Zealand, and Scandinavian countries) (Dissanaike & Rahimi, 2009). Infants in Africa have been found to have an incidence of fire related burns that is three times the world average for this age group (Peck, 2011). Both in high- and low-income countries, children who reside in lower socioeconomic areas are at a higher risk of residential fire-related injuries (Peck, 2011).

5. Fire Mechanisms

To reliably interpret the damage done to human tissues by fire, it is important to have an awareness of the basic principles of fire and how it physically alters tissues (Fairgrieve, 2008). Fire is an oxidation reaction that generates heat and light, more commonly known as combustion (Fairgrieve, 2008). The four requirements for fire include fuel (combustible material), heat (sufficient to raise the fuel to its ignition temperature), oxidant (oxygen), and an uninhibited reaction environment (Fairgrieve, 2008).

Fire can proceed through both flaming and non-flaming phases (DeHaan, 2008; Gann & Frieman, 2014). The non-flaming phases include smouldering and pyrolysis (Gann & Frieman, 2014). Smouldering is defined as the "slow, low temperature combustion of solid material" and pyrolysis is defined as "the anaerobic decomposition of a gas, liquid or solid materials into other materials when heated" (Gann & Frieman, 2014: 94). Smouldering fires, which are often accidental, can be ignited by smoking materials (such as cigarettes) and hot embers and ashes (Gann & Frieman, 2014). Depending on the source of a fires ignition, it can begin as smouldering combustion and pyrolysis, and if the conditions are appropriate it could develop further into flaming combustion (Gann & Frieman, 2014). A fire can also begin directly as flaming in nature (Gann & Frieman, 2014). Some porous materials and furniture's (such as sofas/couches or mattresses), if ignited, can smoulder for a significant amount of time before progressing into flame combustion (Gann & Frieman, 2014). Fires which initially begin as smouldering, are the most likely to cause injury or death mainly due to the production of toxic fumes (including carbon monoxide and cyanide) (Knight & Saukko, 2004; Gann & Frieman, 2014).

6. Effects of Fire on the Human Body

Forensic Pathologists are responsible for the legal examination of the remains. At autopsy, the main question they are aiming to answer is whether the decedent was exposed to the fire (or its fumes) prior to or after death, which may have serious criminal implications (Knight & Saukko, 2004; Büyük & Koçak, 2009). They also need to answer the following important questions: "Who was the deceased?", "How did the deceased come to their death?", "When did the deceased come to their death?", "Where did the

deceased come to their death?", "By what means did the deceased come to their death?" (Fairgrieve, 2008). Depending on the state of the remains, these questions can be answered if proper investigations have been done, and often only with the assistance of other disciplines and departments. It is without a doubt that analysis at the scene and during the post-mortem examination is a team effort (Glassman & Crow, 1996; Fairgrieve, 2008). When a pathologist analyses remains, heat-induced changes must be understood and considered if correct interpretations are to be made, and a forensic anthropologist can assist with this (Fairgrieve, 2008).

The unique skills of a forensic anthropologist, and their successful involvement with scene recovery and interpretation of burned remains, has been well documented (Dirkmaat, 2002). They can be of great assistance in these circumstances as they are able to detect deviations from normal burn patterns, by using the "process signatures" caused by fire, and identify skeletal pathology and trauma (Fairgrieve, 2008; Symes *et al.*, 2008). Forensic anthropologists can also determine whether burned bones were fleshed or de-fleshed at the time of the fire (Symes *et al.*, 2008). These estimates may assist with the forensic pathologists final determination of post-mortem interval, if that is of concern in a fire-related fatality (Fairgrieve, 2008). When the majority of soft tissue has been destroyed, a forensic anthropologist's analysis could form the bulk of an investigative report (Fairgrieve, 2008).

The effects of fire on the soft and hard tissues of human remains are dependent on three variables: heat, environment, and duration (DeHaan, 2008). A human body is altered in a variable, but relatively systematic, predictable pattern with increasing exposure to fire temperature and duration (Glassman & Crow, 1996). The destructive nature of fire, which alters remains and physical evidence, leads to the creation of recognisable patterns defined as "process signatures" (Symes *et al.*, 2008). Rarely do the effects of the heat terminate with the time of death; therefore many findings seen at autopsy may be post-mortem (Bohnert, 2004). The laboratory analysis subsequent interpretation of burned human remains is currently hindered by a lack of knowledge of the general burn patterns of a human body; and the absence of standardisation (including terminology) and

guidelines for the analysis of burned human remains, particularly concerning the detection and analysis of perimortem trauma (Symes *et al.*, 2012).

A body that has been exposed to flames may exhibit with various degrees of burns. Burn wounds are usually classified according to their depth, using a scaling system (Knight & Saukko, 2004; Dana & DiMaio, 2006). There exists both a four-stage and a three-stage system of classifying burn wounds in the literature, however these systems are similar. First-degree burns are those limited only to the superficial epidermis, with associated erythema, oedema and even blistering (Knight & Saukko, 2004). Second-degree burns are partial thickness (but they may be superficial or deep) and they involve the entire epidermis and part of the dermis (Dana & DiMaio, 2006). Third-degree burns are full-thickness burns, with necrosis of all the layers of the skin (Dana & DiMaio, 2006). Fourth-degree burns involve charring and incineration of tissues with total loss of all the skin layers and subcutaneous tissues, and also accompanied charring of the bone (complete or partial) (Dana & DiMaio, 2006). If destruction and charring is significant enough, the internal organs can be reduced in size due to fluid loss and consumption by the fire (Bohnert, 2004). Often burn wounds examined by forensic pathologists were inflicted post-mortem, either because the decedent had already succumbed (owing to smoke inhalation or other causes) or because the severity of the post-mortem burning concealed the lesser degrees of burns present until death (Knight & Saukko, 2004). It is not always routine to document the degree of burns on deceased individuals and it is mainly reserved for live patients, however it can prove useful to do so on a deceased individual for reconstruction efforts and understanding the events of a fire and how it resulted in death.

It has been shown that a “pugilistic posture” may be assumed by a body after being exposed to temperatures between 670º and 810ºC for approximately 10 minutes (Fairgrieve, 2008). This posture resembles someone in a “fight or flight” or defensive boxing position, and it is caused by the heating and subsequent shrinkage of the muscles, which leads to their contraction and flexion of limbs (DiMaio & DiMaio, 2001; Shkrum & Ramsay, 2007; Symes *et al.*, 2008). Flexion occurs because of the bulk of flexor muscle groups being larger than the extensors, and this forces the limbs into flexion and the spine into opisthotonus (Knight & Saukko, 2004). This posture, also a process signature, needs

to be documented and considered as it takes place in a predictable manner, and if deviations from the expected posture are noted, this could warrant further investigation (Symes *et al.*, 2012). The pugilistic posture is however a mere post-mortem artefact, and it is no indication of vitality at the time of fire (Knight & Saukko, 2004).

When examining the skin, a pathologist may find leathery consolidation and tightening of the skin and the presence of skin splitting (Knight & Saukko, 2004). Skin splitting occurs due to the contraction of skin as it heats (Knight & Saukko, 2004). These wounds can seem to be ante-mortem trauma to the untrained eye mimicking incised wounds (Dix, 2000; Shkrum & Ramsay, 2007). These splits can occur anywhere on the body, but most often occur on the skin covering extensor muscles, at the joints, and the head (Knight & Saukko, 2004). Rupture of the abdominal wall with extruding intestinal loops, which subsequently may char, can also occur at extreme heat (Fairgrieve, 2008). Although these splits are artefactual, the prospect of an actual ante-/peri-mortem wound being present must always be considered (Knight & Saukko, 2004). A split caused solely by the heat of a fire will not exhibit any bleeding in the deeper tissues and the positioning on the body may also be suggestive (Knight & Saukko, 2004). Severe charring may confound the differentiation between a skin split and trauma (Knight & Saukko, 2004). For these reasons, skin splits should always be closely analysed and well documented.

Another common fire artefact is the 'burn haematoma' or “burn epidural” in the extradural space. When the cranium is exposed to severe heat, blood reminiscent of an actual extradural haematoma may form between the cranium and the dura, with the blood seeming “spongy” and chocolate-brown in colour (Knight & Saukko, 2004). The outer table of the cranium overlying the position of the haematoma is often found to be charred with the scalp burnt away (Knight & Saukko, 2004). This phenomenon can be confused with ante-/peri-mortem trauma to the head but in the absence of a fracture to the cranium (other than one purely due to heat), the haematoma should not be attributed to trauma (DiMaio & DiMaio, 2001; Knight & Saukko, 2004).

When bone is exposed to high temperatures the chemical composition of bone is modified and the structural integrity is compromised, as a result of the evaporation, organic

degradation, and alteration of the inorganic matrix which occurs (Symes *et al.*, 2008). The heat of a fire can cause warping, discoloration, shrinking, fracturing and subsequent fragmentation of skeletal material (Symes *et al.*, 2008). The colour change, which occurs during burning, is a diagnostic process signature which can be considered when analysing remains for deviations from typical burn patterns (Symes *et al.*, 2008). As heat intensifies, it will initially blacken bones as they char, before turning grey and eventually white as the bone becomes calcined (Correia, 1997; Waterhouse, 2013). At the most extreme stages, once bone becomes calcined, all water or organic material have been removed (Waterhouse, 2013). Calcined bone often fragments as a result of its fragile nature, which leads to a loss of skeletal structures (such as feet, hands or limbs), and it can prove difficult to locate and recover on a scene, due to its white/grey colour being similar to that of the burned surroundings (Waterhouse, 2013). Assuring preservation of calcined remains during recovery and transportation is a challenging task that requires strategy, planning and special training (Correia, 1997).

Thermal fracturing is another process signature of burning bone that one can use to identify deviations from normal burn patterns (Symes *et al.*, 2008). Thermal fractures of the extremities occur due to heat and muscle contraction, particularly of the long bones and near the joints, and can be mistakenly interpreted as antemortem fractures, but fractures often also occur if improper recovery and transport techniques are used (Dix, 2000; Dana & DiMaio, 2006; Demirci & Dogan, 2011; Symes *et al.*, 2012). Interpreting skeletal fractures without considering that they are resultant of fire modification, or recovery and transport techniques, creates additional challenges for analysis (Symes *et al.*, 2012). An understanding of normal burning patterns is required, if deviations from these patterns are to be noted (Symes *et al.*, 2012). A forensic anthropologist would be able to separate perimortem trauma from thermal fractures, and where possible, could assign temporal and sequential designations to trauma (Symes *et al.*, 2008). These important findings may contribute to the final determination of cause and manner of death and the post-mortem interval, made by a medical examiner (Symes *et al.*, 2008).

Fragmentation of the remains is possibly the most significant and influential heat-induced change, which heightens the need for proper recovery techniques (Waterhouse, 2013).

Severe fragmentation may complicate analysis further by making it difficult to determine the number of individuals represented, the age and sex of individuals, living stature, population affinity, perimortem condition, and if there is any trauma present (Correia, 1997). Meticulous documentation on scene with emphasis on any fracturing and fragmentation is essential, especially when a forensic pathologist or forensic anthropologist do not attend the scene.

Just as the scaling system is used for the degree of burns, a scaling system has been previously proposed, the Crow-Glassman Scale (CGS), which can be used to describe the extent of burn injury to human remains as a whole at the death scene (Glassman & Crow, 1996). It was intended to standardise and simplify on-scene descriptions for the various personnel involved, and also help determine what the recovery and transportation needs of the remains are, and which agencies should be involved in recovery and analysis (Glassman & Crow, 1996). A summary of the staging system; along with the respective burn injuries, recovery methods and identification methods; is depicted in Table 1. Importantly, a body or a single element on a body may exhibit characteristics pertaining to all the CGS levels due to differential burning which is common (Symes *et al.*, 2008). Although the system is simple and useful, is has not been widely adopted.

Table 1: The Crow-Glassman Scale for describing extent of burn injury, with associated recovery and identification procedures (Glassman & Crow, 1996; Fairgrieve, 2008).

Crow-Glassman Scale Levels	Description of criteria for staging, and recovery and identification methods
Level 1	**Burn Injuries:** Typical injuries associated with a smoke death. May display superficial skin blistering and singeing of hair **Recovery:** No special techniques required for recovery **Identification**: Recognisable for identification
Level 2	**Burn Injuries:** Often displays varying degrees of burning (including charring). May include the absence of focal elements of the extremities, such as the hands and/or feet, and possibly the genitalia and ears **Recovery:** Recovery of disarticulated elements requires further searching of the immediate surrounds **Identification:** Possibly recognisable. Identification frequently made by collaboration of the medical examiner and forensic odontologist
Level 3	**Burn Injuries:** Major destruction/disarticulation of extremities (e.g. limbs and head) **Recovery:** Recovery of disarticulated remains requires a thorough and extensive search, preferably conducted by a forensic anthropologist, allowing for a thorough and a successful scene recovery of remains **Identification:** Non-recognisable. Coordinated by a medical examiner, with the frequent assistance of a forensic odontologist. Depending on destruction, a forensic anthropologist may be called on to determine a biological profile (e.g. age, sex, race)
Level 4	**Burn Injuries:** Extensive destruction including fragmentation of the skull, or absence thereof. Portions of the extremities may still remain articulated to the charred body **Recovery:** In order to locate small body fragments and dental elements, a forensic anthropologist using archaeological methodologies should be included in the search and recovery procedures **Identification:** Coordinated by a medical examiner in collaboration with a forensic anthropologist and/or odontologist, as needed
Level 5	**Burn Injuries:** Destruction rendering little or no tissue remaining. The skeletal remnants are highly fragmentary, scattered and incomplete **Recovery:** For successful recovery efforts of the complete cremains, a forensic anthropologist should be an on-site consultant **Identification:** Coordinated by a medical examiner who designates a forensic anthropologist to interpret cremains and create a biological profile. A forensic odontologist may be called on if dental elements need to be recovered or analysed

The smoke emitted during a fire also affects an individual. At autopsy, the most significant internal finding suggesting vitality in a burned body is soot deposition in the respiratory tract and the oesophagus (Bohnert, Werner & Pollak, 2003). There can be thermal damage to the respiratory tract and lungs due to the inhalation of hot gases (Knight & Saukko, 2004). Oedema or bleeding of mucous membranes and/or detachment of the mucosa maybe be suggestive of the inhalation of hot gases (Bohnert, 2004). However, it is also possible for heat to affect the pharynx and the epiglottis post-mortem by means of the passive flow of hot gas through the open mouth (Knight & Saukko, 2004). Heating of the tissues post-mortem and the deposition of soot particles may also blacken surfaces and mimic or mask the true ante-mortem state (Knight & Saukko, 2004).

In many fire related fatalities, death is not caused directly by the flames of a fire but rather due to the inhalation of smoke and fume, including carbon monoxide, produced by combusting materials (Knight & Saukko, 2004). Carbon Monoxide poisoning is a significant aspect in most fire fatalities, especially when the origin of the fire is distant from the victim, as death can occur due to the fire long before the flames reach the body (Knight & Saukko, 2004). Another predominant toxic compound produced is cyanide, which can reach high levels in the blood of fire fatalities (Knight & Saukko, 2004). More complex substances such as nitric oxide, phosgene and others may also be emitted, especially when modern plastics and textiles are burned (Knight & Saukko, 2004). Furniture and structural components are progressively more often being made from polystyrene, polyurethane, polyvinyl and other plastic materials which are especially prone to generate these toxic gases when burned (Knight & Saukko, 2004). Toxicologically, post-mortem blood carboxyhaemoglobin levels should be ascertained in all fire-related cases, and raised levels would indicate signs of vitality during the fire (Dana & DiMaio, 2006; Büyük & Koçak, 2009). Blood cyanide levels can also be obtained and could assist in determining cause of death. Blood alcohol levels are commonly requested in fire related fatalities as alcohol usage has been previously identified as a risk factor in such deaths (Holborn, Nolan & Golt, 2003).

All the effects heat has on the human body, and the predictable patterns of burning, can in themselves be used to facilitate an investigation (Symes *et al.*, 2012). It is essential to

document and preserve artefacts caused by heat from the fire scene to a medico-legal laboratory and creation of protocols to ensure proper recovery and transportation of fragile burned remains can ensure this. At analysis, it is also important to have protocols in order to standardise the way in which autopsy reports are written and the terminology used. All burn artefacts should be noted in detail with attention to trauma, whether it be post-mortem, fire related or ante-mortem damage. In this way, when it comes to the task of deciding manner of death, the facts can be considered in their totality. Currently there are no protocols in place for the analysis and reporting of a medico-legal post-mortem in South Africa.

Although fire is destructive of both the soft and hard tissues of the body, it is however not believed possible to completely consume a body in a house or building fire (Bass, 1984; Symes *et al.*, 2008). Skeletal elements will remain which can be successfully recovered by trained osteologists and forensic anthropologists (Bass, 1984; Knight & Saukko, 2004). However, even though a body cannot be completely destroyed in normal fire conditions, there are several taphonomic challenges that are present when dealing with the remnants of burned remains (Symes *et al.*, 2008). The level of destruction of a body by fire, and the manner in which remains are handled are two such taphonomic issues that complicate retrieval and analysis (Symes *et al.*, 2008).

7. Identification of Burned Decedents

Ultimately, one of the central issues surrounding the analysis of burned human remains is establishing a positive identification, and in some cases this may be a challenge. As suggested by the Crow-Glassman scale in Table 1, the skilled personnel which may be beneficial to the identification of an individual, may vary at the different levels of burn injury. The successful identification of burned remains depends upon the quality and state of recovered remains, and the availability and quality of medical and dental records (Fairgrieve, 2008).

In some fire-related deaths, burn injuries to the body are not drastic or disfiguring and only require the forensic pathologist (DiMaio & DiMaio, 2001). In these cases, establishment of identity is readily performed by personal identification, photographs, or

fingerprinting (DiMaio & DiMaio, 2001). If a body is charred to such a degree that facial structures are mutilated and no fingerprints can be obtained, other methods of identification must be used (DiMaio & DiMaio, 2001). Positive identification often then relies upon dental examination and/or DNA analysis (DiMaio & DiMaio, 2001; Fairgrieve, 2008). Positive identification using dental examination generally includes the involvement of a forensic odontologist and relies on access to, and the existence of antemortem records (Fairgrieve, 2008). DNA analysis is most successful if blood or soft tissue still remains. The advantage of DNA identification is that it can be compared to known blood relatives, instead of relying on antemortem records (Fairgrieve, 2008). When only hard tissues remains, positive identification can become somewhat more challenging and often relies on a forensic anthropologist who can assist in providing age, sex, race and stature estimates (Fairgrieve, 2008). These estimates allow for a biological profile to be created for identification purposes (Fairgrieve, 2008). Surgical implants or unique skeletal features, such as orthopaedic implants, can also be used for identification if antemortem x-rays are available for an alleged decedent (Fairgrieve, 2008).

8. Manner of Death in Fire

A number of factors can contribute to the ignition of fires and although many are deliberately started, most often deaths due to fire globally are unintentional and can be attributed to the risk factors present (DiMaio & DiMaio, 2001; Mock *et al.*, 2008; Blom, Van Niekerk & Laflamme, 2011). A study on informal settlement fires in Cape Town revealed that the majority are accidental in nature (Godwin, Hudson & Bloch, 1997).

Homicide by fire can be due to the deliberate ignition of a fire which ultimately leads to the death of an individual (DiMaio & DiMaio, 2001; Peck, 2012). Fire is also commonly used in attempts to conceal or destroy evidence of a homicide (DiMaio & DiMaio, 2001; Symes *et al.*, 2012; Tümer *et al.*, 2012). It is a criminal's hope that ante-mortem trauma inflicted on a victim will be destroyed by a fire however, although the affects by fire do make analysis challenging, they may have evidentiary value themselves (Symes *et al.*, 2008; Tümer *et al.*, 2012).

In South Africa, a modality of homicidal burning known as “necklacing” has received extensive media coverage (Lerer, 1994). Necklacing involves placing a motor vehicle tyre around the neck of the victim, dowsing the tyre in petrol and setting the victim alight (Lerer, 1994). Necklacing is often used in a phenomenon known as “Community Assault” or “Mob Justice”, which involves the severe beating of victims (often using multiple methods) who are suspected of criminal activity, by members of the local community (Proctor, Carter & Barker, 2009). The tendency of communities to take the law into their own hands by violently punishing criminals is meant to serve as both punishment for the perpetrator, justice for the victims and as a warning to others (Proctor, Carter & Barker, 2009). Community assault is not unique to developing countries such as South Africa, but in the rural suburbs of Cape Town it has been found to be a regular occurrence over the years (Forgus *et al.*, 2014). The prevalence of community assault in Cape Town, and the use of burning as a means of inflicting harm has not yet been documented.

On occasion, fire is also used in suicides either by self-immolation or by burning the structure in which they are in (e.g. a house or car) (DiMaio & DiMaio, 2001; Shkrum & Ramsay, 2007). Use of this method to commit suicide is especially uncommon in Western countries (however, increasing); but in other regions such as India (which has the highest occurrence in the world) self-immolation is common, with a young female demographic (Laloë, 2004; Peck, 2011). In contrast, victims of intentional self-harm in Europe are majority males in their 40’s or 50’s (Peck, 2011). Due to the fact that it has been widely reported globally, with varying incidence, suicide should always be considered in any fire-related medico-legal investigation (Laloë, 2004). Most often a container of flammable accelerant is in close proximity (Knight & Saukko, 2004). The prevalence of suicidal burning in South Africa (and Cape Town) has not been investigated.

Although a medico-legal autopsy is crucial, there are no particular medical features to distinguish suicidal burnings from those which are accidental or homicidal, therefore a proper scene investigation and details of the circumstances surrounding the death are crucial (Knight & Saukko, 2004). It is vital that all agencies involved in the investigation are aware of the case facts and the possible manner of death (Symes *et al.*, 2012; Tümer

et al., 2012). Appropriate inter-agency communication will allow authorities to reliably determine the cause and manner of death.

9. Fatal Fire Scenes

Fatal fire scenes involving human remains are often multifaceted and they have many factors which may influence the processes of remains discovery and recovery (Waterhouse, 2013). Although this is well known, there is a paucity of research regarding fatal fire scene processing (DeHaan & Icove, 2007). Despite the knowledge of the importance and associated difficulty of the task, exact guidelines and procedures for the discovery, recovery and documentation of human remains at fatal fire scenes are greatly lacking in fire investigation and forensic anthropology literature (Symes *et al.*, 2012). The various agencies involved in the investigation of a fatal fire scene each have an important role to fulfil and these roles need to be well defined. In a study conducted, it was determined that the classic fire scene recovery protocols that existed and were previously used in America, were extremely prone to the loss of information and evidence (Symes *et al.*, 2012). This study was conducted while processing both mock and actual fatal fire scenes, in which various protocols were tested and modified.

One of the fundamentals of the search and recovery processes of the fatal fire scene, is the thorough documentation of contextual information and the association of burned human remains relative to the environmental setting, and any other potentially probative physical evidence (Symes *et al.*, 2012). Gathering contextual scene information using archaeological methods for the documentation and recovery of remains have been found to be highly successful, and these methodologies are lacking in most fatal fire scene recovery protocols globally (Symes *et al.*, 2012). Resultantly, contextual data which could be forensically significant, particularly pertaining to body location and positioning within the burned structure are often not noted in detail (Symes *et al.*, 2012). Documentation should be thorough and continue throughout, from the initial search for remains, right to the final stages once the remains have been recovered and transported. Documentation should ideally take place in three forms: written; photography/videography; and mapping (Symes *et al.*, 2012). Due to the similarly coloured surrounding matrix, mapping helps to

contextualise and visually represent information such as the orientation and position of the remains in relation to other evidence (Symes *et al.*, 2012). Organised search methodology, exhaustive photography, note-taking and systematic retrieval of remains is essential in conducting a well-rounded investigation.

The initial search for and identification of human remains usually takes place by Fire Department personal (Symes *et al.*, 2012). Ensuring scene safety and structural stability is of great importance prior to any recovery efforts at all fatal fire scenes (Symes *et al.*, 2012; Waterhouse, 2013). Often the large amount of debris created during structural fires is impeding, as it is necessary to search and document in a systematic manner that will limit cumulative damage to any human remains on the scene (Symes *et al.*, 2012; Waterhouse, 2013). On occasion, fire department personnel and fire investigators walk over and sometimes rake through the debris of a fatal fire scene in order to locate human remains swiftly (Symes *et al.*, 2008). This risks further fragmentation, displacement, destruction and further traumatic alteration of fragile human remains and other evidence (Symes *et al.*, 2008). At fatal fire scenes, it should be paramount to locate any visible remains without altering the scene and this can be accomplished through protocols with search methodology (Symes *et al.*, 2012). The failure to identify and retrieve bones on scene has been documented in cases in which specialised personnel, such as forensic anthropologists, were not involved (Brickley, 2007; Symes *et al.*, 2012).

One challenge met with searching for remains is the fact that a fire scenes surroundings often disguise the similarly coloured burned human remains, and may make it difficult to distinguish skeletal elements from the surrounding debris (Symes *et al.*, 2012). This may lead to unnoticed fragmented remains not being collected, and subsequently being accidentally destroyed.

The analysis and interpretation of the remains is best begun on-scene in the original context (Fairgrieve, 2008). The immediate surrounding contextual evidence aids in the understanding of trauma patterns, and also in identifying possible signs of criminal activity (Symes *et al.*, 2012).

If remains are located and they are beneath fine debris, methodical excavation by hand or by using excavation tools (such as trowels and dust-pans) should be conducted using proper archaeological techniques (excavating with the classic top-down vertical cuts) (Symes *et al.*, 2012). The use of forensic archaeological recovery methods and its documented benefits, is said to be the only method able to ensure the quantity and quality of the remains recovered (Dirkmaat *et al.*, 2008; Symes *et al.*, 2012). Forensic anthropologists often use skeletal inventories to document the body portion represented, and that which are absent on scene (Dirkmaat, 2002). Any debris removed should ideally be re-sorted and sifted in case any fragmentary remains or other physical evidence is still present. The *in situ* position and orientation of the body and any associated evidence should always be well documented throughout the recovery process, especially if anything is altered by the processes themselves (Symes *et al.*, 2012). Although this is a reliable manner in which to retrieve remains, the process tends to be time consuming and requires a level of skill or training, both which attribute to the lack of adaption to such methods in all countries and settings.

If the heat and duration of a fire has been sufficient, it causes fragmentation of the remains to occur (Waterhouse, 2013). This fragmentation of fragile burned remains is one of the biggest challenges faced in fire related cases and it heightens the need for recovery protocols. Individual fragments of remains should ideally be wrapped and bagged separately (Symes *et al.*, 2012). Recognising fragmentary and heat-modified remains is a skill possessed by forensic anthropologists, who can make the recovery process more rapid and thorough (Dirkmaat, 2002). This is due to their knowledge of archaeological techniques; their ability to recognise bone features, even on fragmentary and calcined remains (Fairgrieve, 2008; Symes *et al.*, 2012). If a juvenile is suspected to have been in a fire, recognition and recovery becomes an even more specialised task, as their bones are smaller and have unfused epiphyses (Waterhouse, 2013). If remains are highly fragmented or commingled, how many individuals the fragments may represent, should be queried. Forensic anthropologists are able to determine the minimum number of individuals involved on a scene through analysis of the fragments (Dirkmaat, 2002).

The proper, complete recovery of human remains is not only essential to ensure a comprehensive investigation, but also in order to fulfil the needs and expectations of the family and friends of the deceased (Waterhouse, 2013). The quantity and quality of the remains that are recovered are crucial and fragmentation poses an issue in this regard (Waterhouse, 2013).

Given that burned bone is frail and brittle in nature, it is highly susceptible to further fragmentation and post-mortem damage during transportation. For proper transportation of burned biological tissue (bones and soft tissue) and to limit further damage, it would be best to wrap delicate structures, and to place the remains on a solid underlying structure within body bags (Correia & Beattie, 2002; Symes *et al.*, 2012). In some areas of the world, placing preservative on fragile dental remains takes place as well so that odontology analysis can be ensured (Symes *et al.*, 2012). For the transport of the burned remains, it is essential to use an adequately sized vehicle, and when there are multiple decedents, remains should never be stacked upon one another (Symes *et al.*, 2012).

The protocols set out by Symes *et al.*, 2012, are highly revered, particularly because they were set up by forensic anthropologists with the preservation of the condition of the remains being paramount. There are currently no standard protocols for fire scene documentation, the searching for remains, retrieval methodologies and transportation techniques in South Africa. Methodologies employed on scene and the agencies generally involved are therefore not known and there is no standardisation.

10. Summary

Fire is a destructive force that provides challenges during any fire-related death investigation. Fatal fire scenes are multifaceted often with many factors influencing the processes of remains discovery, recovery, transportation and documentation, and research into these aspects has been limited. Systematic retrieval, handling, and preservation techniques must be designed and implemented in order for the proper analysis of remains, reconstruction efforts and for any subsequent evidence and hypotheses to withstand courtroom scrutiny (Symes *et al.*, 2008). Currently there are no

protocols in place for these procedures in South Africa, and it is unknown whether this may be hampering the medico-legal investigation of burned remains.

It is essential that a full post-mortem examination be conducted on all fire-related fatalities. Although a forensic post-mortem is mandatory in South Africa for these cases, there are no set protocols for the analysis and interpretation of pathology, when specialised professions should be involved (such as forensic anthropologists or odontologists), and what type of ancillary investigations should be conducted. Fire-related fatalities require a multidisciplinary approach to appreciate each case contextually and to interpret the artefacts and alterations present. Without such an approach, investigation may be limited.

It is important that the various disciplines and agencies involved endure communication to ensure comprehensive investigation. Protocols allow for ease of communication between agencies such as the Fire and Rescue teams, Investigative teams, and the Medical teams analysing the remains. With the lack of protocols for fire-related fatality investigation in South Africa, it is unknown if interdisciplinary communication is occurring and how this is affecting the comprehensiveness of the inquiry.

Although there are protocols in place worldwide for certain scene types, and other aspects of death investigation, they cannot be directly transposed and used in another environment, such as South Africa. Tailored protocols need to be put in place for the South African environment, due to the unique challenges faced in the regions forensic field. Although the exact challenges on fatal fire scenes in the country are not known, common challenges faced in include lack of staff, high case-loads, lack of equipment and resource demanding death scenes. The recovery and handling of remains from fatal fire scenes is known to be challenging, and this is one such aspect which could greatly benefit from the creation and implementation of protocols.

11. References

Afify, M.M., Mahmoud, N.F., Abd El Azzim, G.M. & El Desouky, N.A. 2012. Fatal burn injuries: A five year retrospective autopsy study in Cairo city, Egypt. *Egyptian Journal of Forensic Sciences*. 2(4):117–122.

Barillo, D.J. & Goode, R. 1996. Fire Fatality study: demographics of fire victims. *Burns*. 22(2):85–88.

Bass, W.M. 1984. Is it possible to consume a body completely in a fire? In *Human Identification: Case Studies in Forensic Anthropology*. T.A.R. Rathbun & J.E. Buikstra, Eds. Springfield, Illinois: Charles C Thomas Publisher. 159–167.

Blom, L., Van Niekerk, A. & Laflamme, L. 2011. Epidemiology of fatal burns in rural South Africa: A mortuary register-based study from Mpumalanga Province. *Burns*. 37(8):1394–1402.

Bohnert, M. 2004. Morphological Findings in Burned Bodies. In *Forensic Pathology Reviews*. M. Tsokos, Ed. New York: Springer Science and Business Media. 3–27.

Bohnert, M., Werner, C.R. & Pollak, S. 2003. Problems associated with the diagnosis of vitality in burned bodies. *Forensic Science International*. 135(3):197–205.

Brickley, M.B. 2007. A Case of Disposal of a Body Through Burning and Recent Advances in the Study of Burned Human Remains. In *Forensic Anthropology: Case Studies from Europe*. M.B. Brickley & R. Ferllini, Eds. Springfield: Charles C Thomas Publisher, Ltd. 69–83.

Büyük, Y. & Koçak, U. 2009. Fire-related fatalities in Istanbul, Turkey: Analysis of 320 forensic autopsy cases. *Journal of Forensic and Legal Medicine*. 16(8):449–454.

City of Cape Town. 2015a. *Preventing fires*. Available: https://www.capetown.gov.za/en/FireAndRescue/Pages/PreventingFires.aspx [2015, September 16].

City of Cape Town. 2015b. *Paraffin safety tips*. Available: https://www.capetown.gov.za/EN/ENVIRONMENTALRESOURCEMANAGEMENT/TIPS/Pages/ParaffinSafetyTips.aspx [2015, September 16].

Correia, P.M. 1997. Fire Modification of Bone. In *Forensic Taphonomy: The Postmortem Fate of Human Remains*. W.D. Haglund & M.H. Sorg, Eds. Boca Raton, FL: CRC Press LLC.

Correia, P.M. & Beattie, O. 2002. A Critical Look at Methods for Recovering, Evaluating, and Interpreting Cremated Human Remains. In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*. W.D. Haglung & M.H. Sorg, Eds. Boca Raton, FL: CRC Press LLC. 435–450.

Crewe, R.J., Stec, A.A., Walker, R.G., Shaw, J.E.A., Hull, T.R., Rhodes, J. & Garcia-Sorribes, T. 2014. Experimental Results of a Residential House Fire Test on Tenability: Temperature, Smoke, and Gas Analyses. *Journal of Forensic Sciences*. 59(1):139–154.

Dana, S.E. & DiMaio, V.J.M. 2006. Fire and Thermal Injuries. In *Handbook of Forensic Pathology*. Boca Raton, FL: CRC Press LLC. 185–198.

DeHaan, J.D. 2008. Fire and Bodies. In *The Analysis of Burned Human Remains*. C.W. Schmidt & S.A. Symes, Eds. London: Elsevier Ltd. 1–13.

DeHaan, J.D. & Icove, D.J. 2007. *Kirk's Fire Investigation*. 7th ed. Boston: Pearson.

Demirci, S. & Dogan, K.H. 2011. Death Scene Investigation from the Viewpoint of Forensic Medicine Expert. In *Forensic Medicine - From Old Problems to New Challenges*. D.N. Vieira, Ed. Rijeka: InTech. 13–52.

DiMaio, V.J. & DiMaio, D. 2001. Fire Deaths. In *Forensic Pathology*. 2nd ed. Boco Raton, FL: CRC Press LLC. 367–388.

Dirkmaat, D.C. 2002. Recovery and Interpretation of the Fatal Fire Victim: The Role of Forensic Anthropology. In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*. W.D. Haglund & M.H. Sorg, Eds. Boca Raton, FL: CRC Press LLC. 451–472.

Dirkmaat, D.C., Cabo, L.L., Ousley, S.D. & Symes, S.A. 2008. New perspectives in forensic anthropology. *Yearbook of Physical Anthropology*. 51:33–52.

Dissanaike, S. & Rahimi, M. 2009. Epidemiology of burn injuries: highlighting cultural and socio-demographic aspects. *International review of psychiatry*. 21(6):505–11.

Dix, J. 2000. *Color Atlas of Forensic Pathology*. Boca Raton, FL: CRC Press LLC.

Fairgrieve, S. 2008. *Forensic Cremation: Recovery and Analysis*. Boca Raton, FL: CRC Press LLC.

Forensic Pathology Services Western Cape Government. 2013. *Standard Operating Procedure: Death Scene Attendance and Investigation*. Cape Town, Unpublished Standard Operating Procedure.

Forensic Pathology Services. 2014. *Our Facilities*. Available: http://www.westerncape.gov.za/general-publication/our-facilities [2014, October 30].

Forgus, S., Delva, W., Hauptfleisch, C., Govender, S. & Blitz, J. 2014. Community v. non-community assault among adults in Khayelitsha: A case count and comparison of injury severity. *South African Medical Journal*. 104(4):299.

Gann, R.G. & Frieman, R. 2014. Combustion, Fire, and Flammability. In *Principles of Fire Behavior and Combustion*. Fourth ed. Burlington, MA: Jones & Bartlett Learning. 77–94.

Glassman, D.M. & Crow, R.M. 1996. Standardization model for describing the extent of burn injury to human remains. *Journal of Forensic Sciences*. 41(1):152–154.

Godwin, Y., Hudson, D.A. & Bloch, C.E. 1997. Shack fires: a consequence of urban migration. *Burns*. 23(2):151–3.

Harte, E.W., Childs, I.R.W. & Hastings, P.A. 2009. Imizamo Yethu: a Case Study of Community Resilience to Fire Hazard in an Informal Settlement Cape Town, South Africa. *Geographical Research*. 47(2):142–154.

Holborn, P.G., Nolan, P.F. & Golt, J. 2003. An analysis of fatal unintentional dwelling fires investigated by London Fire Brigade between 1996 and 2000. *Fire Safety Journal*. 38(1):1–42.

Inquest Act (Act 58 of 1959). 1959. Available: http://www.gov.za/sites/www.gov.za/files/Act 58 of 1959.pdf [2016, January 25].

Knight, B. & Saukko, P. 2004. *Knight's Forensic Pathology*. 3rd ed. Boca Raton, FL: CRC Press LLC.

Laloë, V. 2004. Patterns of deliberate self-burning in various parts of the world: A review. *Burns*. 30(3):207–215.

Lerer, L.. 1994. Homicide-Associated Burning in Cape Town, South Africa. *The American Journal of Forensic Medicine and Pathology*. 15(4):344–347.

Mock, C., Peck, M., Peden, M. & Krug, E. 2008. *A WHO plan for burn prevention and care*. Geneva, Switzerland.

Mzezewa, S.Z. 2008. Electrical burns. *Continuing Medical Education*. 26(9):436–438.

Van Niekerk, A., Laubscher, R. & Laflamme, L. 2009. Demographic and circumstantial accounts of burn mortality in Cape Town, South Africa, 2001-2004: an observational register based study. *BioMed Central public health*. 9:374.

Ouedraogo, B. 2006. Household energy preferences for cooking in urban Ouagadougou, Burkina Faso. *Energy Policy*. 34(18):3787–3795.

Peck, M.D. 2011. Epidemiology of burns throughout the world. Part I: Distribution and risk factors. *Burns*. 37(7):1087–1100.

Peck, M.D. 2012. Epidemiology of burns throughout the world. Part II: Intentional burns in adults. *Burns*. 38(5):630–637.

Price, J.D. 2010. *Death Investigation Protocol for Howard County Indiana*. Available: http://www.howardcountyin.gov/files_uploaded/DeathInvestigationProtocol.pdf [2016, February 01].

Proctor, M., Carter, N. & Barker, P. 2009. Community assault - The cost of rough justice. *South African Medical Journal*. 99(3):160–161.

Rogde, S. & Olving, J.H. 1996. Characteristics of fire victims in different sorts of fires. *Forensic Science International*. 77:93–99.

Shkrum, M.J. & Ramsay, D.A. 2007. *Forensic Pathology of Trauma: Common Problems for the Pathologist*. Totowa, NJ: Humana Press Inc.

South African Qualifications Authority. 2012. *National Diploma: Forensic Pathology Support*. Available: http://regqs.saqa.org.za/showQualification.php?id=58183 [2015, February 28].

Statistics South Africa. 2014. *Mortality and causes of death in South Africa , 2011 : Findings from death notification*. Pretoria.

Strategic Development Information & GIS Department: City of Cape Town. 2012. *City of Cape Town – 2011 Census – Cape Town*. Cape Town: City of Cape Town.

Symes, S.A., Rainwater, C.W., Chapman, E.N., Gipson, R. & Piper, A.L. 2008. Patterned Thermal Destruction of Human Remains in a Forensic Setting. In *The Analysis of Burned Human Remains*. C.W. Schmidt & S.A. Symes, Eds. London: Elsevier Ltd. 15–54.

Symes, S.A., Ph, D., Dirkmaat, D.C., Ousley, S., Chapman, E. & Cabo, L. 2012. *Recovery and Interpretation of Burned Human Remains*. U.S. Department of Justice.

The Housing Development Agency. 2013. *Western Cape : Informal settlements Status (2013)*. Johannesburg: The Housing Development Agency.

The World Bank. 2015. *Country and Lending Groups*. Available: http://data.worldbank.org/about/country-and-lending-groups#Upper_middle_income [2015, December 01].

du Toit-Prinsloo, L., Dempers, J., Verster, J., Hattingh, C., Nel, H., Brandt, V.D., Jordaan, J. & Saayman, G. 2013. Toward a standardized investigation protocol in sudden unexpected deaths in infancy in South Africa: A multicenter study of medico-legal investigation procedures and outcomes. *Forensic Science, Medicine, and Pathology*. 9:344–350.

Truran, G. 2009. Household energy poverty and paraffin consumption in South Africa. *Boiling Point*. 5(1955):2–6.

Tümer, A.R., Akçan, R., Karacaoğlu, E., Balseven-Odabaşi, A., Keten, A., Kanburoğlu, Ç., Ünal, M. & Dinç, A.H. 2012. Postmortem burning of the corpses following homicide. *Journal of Forensic and Legal Medicine*. 19(4):223–228.

Waterhouse, K. 2013. The effect of victim age on burnt bone fragmentation : Implications for remains recovery. *Forensic Science International*. 231(1-3):409.e1–409.e7.

CHAPTER 3: MANUSCRIPT

The Importance of a Protocol in the Retrieval and Handling of Burned Human Remains in a Forensic Context

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Abstract

Fire-related fatalities pose many investigative challenges, in part due to their fragility. This can be managed with the creation of protocols, specific to the environment in which they are implemented. Currently, no protocol for the recovery and handling of fire-related fatalities exists in Cape Town, South Africa. Additionally, the challenges, risk factors, and resources present at forensic scenes in the area have not been documented.

From April to December of 2015, fire-related death scenes were attended with Salt River Forensic Pathology Laboratory, which serves the West Metropole of Cape Town. Details of the fatal fire scenes were noted, including the challenges faced, and the settings in which the fires occurred. Emphasis was placed on methodologies used to recover, handle, and transport remains, and the availability and utilisation of resources. The affect these methodologies had on the condition of the remains between scene and autopsy was assessed.

In total 32 fire-related death scenes were attended, with 48 decedents recovered. Males predominated (64.6%), and the majority were young adults (75%). Accidental deaths were most prevalent (79.2%), however a fire-related suicide and homicides highlighted

the importance of thorough investigation. Informal housing constituted 68.8% of the fatal fire scenes and presented unique scene constraints, including no direct road access at 50% of these scenes. Investigative limitations included: inadequate interagency communication, resulting in a lack of collateral information available at autopsy; deficient scene and contextual documentation; non-standardised recovery methodologies; insufficient availability and utilisation of resources (including safety equipment); and no specialised personnel (e.g. forensic pathologists/ anthropologists) conducting scene recovery. The majority of cases (60.4%) were further fragmented or fractured by time of autopsy, illustrating the necessity for improvement of current methodologies and the importance of the involvement of forensic anthropologists in recovery of fragmentary remains

The critical analysis of fire-related death scene processing and investigation in Cape Town, revealed a necessity for improvement and the importance of standardisation, which can be accomplished by the implementation of a tailored protocol. A protocol "prototype" was designed, intended for the enhancement fire-related death investigation, specific to the Cape Town setting. It promotes training of those retrieving burned remains, resource procurement and utilisation, improvement of scene safety, encourages interagency communication and involvement of specialised personnel at scene, and facilitates contextual documentation. Standardised methodologies for recovery, handling and transportation of burned remains according to the extent of burn injury, ensure complete and safe recovery of burned remains while minimising their alteration from scene to autopsy.

Keywords: Protocol, Burned Remains, Fatal Fire, Forensic Anthropology, Forensic Pathology

1. Introduction

Fire remains one of the foremost causes of morbidity and mortality worldwide, with the vast majority (95%) of fire-related fatalities occurring in low- and middle-income countries [1]. The world average for burn mortality is 5.0 per 100 000 population, however it has been found to be higher in low- and middle-income regions (e.g. South-East Asia: 11.6 deaths per 100 000 population per year; Africa - 6.1 deaths per 100 000 population per year) [1]. Although fire-related deaths are predominantly accidental, the use of fire also occurs in suicides, homicides and during crime concealment [1–3].

South Africa is a middle-income country [4]. A review of the national death notifications during 2011 revealed that 2243 deaths were associated with "exposure to smoke, fire and flames" [5] within that year which, when calculated with the population at the time (51.8 million), translates to 4.3 deaths per 100 000 population [6]. The City of Cape Town, South Africa, however, has previously reported the highest burn mortality rates within the country, at 7.9 deaths per 100 000 population (2001-2004 period) [7].

Salt River Forensic Pathology Laboratory (SRFPL), administered by the Forensic Pathology Services (FPS) of South Africa, is the mortuary which serves the West Metropole of the City of Cape Town [8]. SRFPL has an average overall case load of 3 000 cases per annum [8]. Forensic Pathology Officers (FPO's) are employed by FPS and their duties include scene attendance, assessment of crime scenes, transporting decedents to the mortuary and assisting during autopsy procedures [9]. SRFPL is notified when an unnatural death occurs requiring medico-legal investigation, as stipulated by the Inquest Act (Act 58 of 1959) [10]. All fire-related deaths are considered unnatural according to this act.

Although fire-related fatalities are not uncommon globally, challenges are still met at each phase in their investigation, particularly with regards to scene characteristics and the burned remains themselves [11–13]. The use of a protocol for recovery, handling and transport of fire-related fatalities has been shown to assist in limiting and managing these challenges and promotes the preservation of the state of the remains from scene to autopsy [14]. A protocol is most successful when tailored to the specific environment in

which implementation is intended, created with knowledge of the challenges, risk factors, and resources available in the area [14,15]. Currently, no protocol detailing methodologies for the recovery and handling of fire-related fatalities exists in Cape Town, and little is known regarding the settings in which they occur, and the associated risk factors of fatal fire scenes in the area.

One of the fundamentals of the search and recovery processes of the fatal fire scene is the thorough documentation of contextual information, and the association of burned human remains relative to the environmental setting, and any other potentially probative physical evidence [14,16]. Often contextual data which could be forensically significant, particularly pertaining to body location and positioning within the burned structure, are often not noted in detail [14]. Documentation should ideally take place in three forms: written; photography/videography; and mapping [14].

Burned human remains are challenging to detect, recover and handle amoung the burned debris, and analysis and interpretation of the remains is best begun on-scene in their original context [14,17]. Given that burned bone is frail and brittle in nature, particularly when calcined, it is highly susceptible to further fragmentation and post-mortem damage during recovery, handling and transportation [13,14,18]. Recognising these remaining fragments requires osteological knowledge, such as that held by forensic anthropologists who can make the process quicker and more thorough [19,20]. Scene approaches using archaeological methods and tools for the documentation and recovery of remains have been shown to be highly successful, and these methodologies are lacking in most fatal fire scene recovery protocols globally [4]. This includes the use of scene gridding, the sifting of debris and ashes for fragmentary remains, and excavation tools and techniques [14,21,22]. Methodologies to preserve the state of remains should be utilised, such as the wrapping and individual bagging of skeletal fragments, and the use of a solid surface to transport remains upon (in substitute of flexible body-bags) [14,17,21]. For the transport of the burned remains, it is essential to use an adequately sized vehicle to account for pugilistic posture, and when there are multiple decedents, remains should never be stacked upon each another [14].

The Crow-Glassman Scale (CGS), is used to describe the extent of burn injury to human remains as a whole at a death scene [23]. The CGS ranges from Level 1 (least severe, minor burns) to 5 (highly fragmentary remains present), as seen in Table 2. A body, or a single element on a body, may exhibit characteristics pertaining to more than one CGS level due to differential burning [24]. The CGS scale also recommends for the various levels, which skilled personnel could be beneficial in recovery and analysis.

Table 2: The burn-injury criteria used to stage burned human remains into the Crow-Glassman Scale (CGS), compiled from Glassman and Crow (1996), and reproduced by Fairgrieve (2008) [17, 23].

CGS Levels	Description of criteria for staging
Level 1	Typical injuries associated with a smoke death. May display superficial skin blistering and singeing of hair
Level 2	Often displays varying degrees of burning (including charring). May include the absence of focal elements of the extremities, such as the hands and/or feet, and possibly the genitalia and ears
Level 3	Major destruction/disarticulation of extremities (e.g. limbs and head).
Level 4	Extensive destruction including fragmentation of the skull, or absence thereof. Portions of the extremities may still remain articulated to the charred body
Level 5	Destruction rendering little or no tissue remaining. The skeletal remnants are highly fragmentary, scattered and incomplete

During analysis of the remains, the most important aspect investigated by a forensic pathologist is whether the decedent was exposed to the fire (or its fumes) prior to or after death, which may have serious criminal implications [20,25]. Identifying ante-mortem trauma, the presence of soot and thermal damage to the respiratory tract, and raised

carboxyhaemoglobin levels, are some of the most prominent aspects to consider when determining vitality at the time of fire [20,26,27].

Bone trauma analysis is a challenging task in burned remains, in which perimortem trauma must be distinguished from post-mortem alteration and burn artefacts, and a forensic anthropologist can be indispensable in this regard [14,24]. Common fire artefacts seen at the autopsy of burned remains include pugilistic posture, thermal skeletal fractures, burn lacerations, and burn hematomas [2,3,20]. These fire artefacts need to be examined and distinguished from ante-mortem trauma.

1.1. Aims and Objectives

The aim of this study was to critically assess the current methodologies used by the SRFPL of Cape Town, in the recovery, handling and transport of burned human remains, and how these processes affect the preservation of remains. With this knowledge, a tailored protocol for these procedures could be designed, intended for usage by the SRFPL. This was done by:

- Attending the death scenes and autopsies of fire-related fatalities assigned to SRFPL and gathering data using tailored standardised forms, taking photographs, and making sketches.
- Creating the protocol prototype while taking into account the unique challenges faced at fatal fire scenes in the area, and resources currently available to SRFPL.

2. Methods and Materials

Prior to the commencement of the study, ethical clearance was obtained from the Human Research Ethics Committee (HREC) of the University of Cape Town (Appendix G). As per their requirements, informed consent was obtained from FPO's with whom scenes were attended and were observed for research purposes. A participant information sheet and informed consent form is attached at Appendix E and F respectively. This study was observational and, although it included certain quantitative variables, it was largely qualitative and categorical in nature.

2.1. Fatal Fire Scenes

Fire-related death scenes were attended from April to December of 2015. When cases were reported to SRFPL involving fire-related deaths, the researcher was informed and met with FPO's at SRFPL prior to being dispatched to scene. The minimum standards generally acceptable for scene processing were determined from a broad review of current literature, in order to define the aspects of fatal fire scenes to critically observe during the study. The forms designed for observational data collection are attached at Appendix B and C. Certain scene and decedent details which were non-observational, were collected from the FPO's. All data gathered on scene was digitised into a database which was anonymised, using Microsoft Office Excel® (2013) for analysis.

Photographic records were taken of the scene, the surroundings, and the decedents, which remained confidential on the researcher's access-controlled work computer. Written records were kept for each scene and the following were the main aspects observed and documented on scene:

2.1.1. Fatal Fire Scene Details

- Details of the fire scene itself were noted, which included the following aspects: Date of recovery. This included the day, month and year of recovery. Season could be inferred from this.
    - Summer: December, January, February
    - Autumn: March, April, May
    - Winter: June, July, August
    - Spring: September, October, November
- Time of arrival on scene and time of the fire. This was noted in 24-hour clock format. Day was considered 06h00 - 18h00 and night was considered 18h00 - 6h00.
- Personnel on scene. Including Cape Town Fire and Rescue Services (CTFRS), Forensic Pathology Officers (FPO's), South African Police Services (SAPS) and Forensic Pathologists.
- Location of recovery. Including physical address (if possible) and GPS coordinates (using the Garmin technology). This was obtained from the FPO's.

- Scene type. This was divided into -
    - Formal housing: a dwelling constructed in a permanent manner (with bricks/concrete)
    - Informal housing: a temporary dwelling made of rudimentary materials, including corrugated iron and wooden boards [28]
    - Open land: outdoors
    - Car: in a road traffic accident
- Number of structures damaged by fire.
- Fire suppression methods.
- Site description. The description included:
    - Access to scene via a road
    - Extent of damage to a structure, divided as: structure in tact but damaged; partial destruction; levelled/completely destroyed structure; no structure
    - Contextual information
    - Safety concerns
- Alleged account of events including cause of fire, which was obtained from the FPO's.
- Weather conditions at the time of retrieval.

2.1.2. Decedent Details at Scene

Details of all decedents on scene were noted, which included the following aspects:

- Official death register number assigned to an individual by SRFPL/FPS.
- Data number. The unique data number given to each decedent by the researcher.
- Date of death.
- Number of decedents discovered on one scene.
- Positioning on scene. This was noted as prone, supine, left side, right side, or other.
- Extent of burning. Noted as incomplete or complete burning, and divided as charred tissue, charred tissue and bone, or charred tissue and calcined bone.
- Crow-Glassman Scale Level (CGS). Remains classified into the levels of the CGS with Level 1 being least severe with minor burns; to Level 5 being highly fragmentary

remains. Details for each level can be found in Table 2. Classification was only done by the researcher (see 4.9. Study Limitations).

- Debris on the remains: Presence or absence of debris and the nature thereof.
- Pugilistic posture: Presence or absence and deviations from the expected posture.
- Osteological inventory. Each skeletal element in the body was described when damage/destruction was noted or if it was no longer present.
- Skeletal and tissue diagrams were used to illustrate the condition of the remains (Appendix D).

2.1.3. Resources and Methodology

Resources and methodologies used by FPO's during the recovery, handling and transport of burned remains was noted, as observed, as follows:

- Documentation techniques. Whether the following documentation was performed on scene: photography, videography, sketches, positioning noted, and contextual information.
- Personal protective equipment. Any PPE worn was noted which included, but not limited to: goggles, disposable gloves, protective gloves, protective footwear, respirators/masks, and helmets.
- Tools. All tools available and used for recovery.
- Recovery techniques. This included: whether debris was removed before retrieving the body, if excavation was done, if gridding was used, if sifting was done, how remains were handled and picked up, and if a systematic retrieval plan was in place.
- Transportation methods. What was used to carry remains to the vehicle and how they were used. This included use of a body bag, a gurney or a body scoop.
- Vehicle. What vehicle was used for transportation and the methods loaded into, and removed from the vehicle.

2.2. Autopsy

All respective autopsies from the fatal fire scenes were attended. The characteristic autopsy pathologies observed in burned remains were considered when designing the

data collection form used at autopsy, a continuation of Appendix B. All data gathered at autopsy was digitised into a database using Microsoft Office Excel® (2013) for analysis, which remained anonymised and confidential.

Photographic records of all burn artefacts, burn pathology, and traumatic pathology were taken. At autopsy the following aspects were analysed:

2.2.1. Decedent Details at Autopsy

- Date of death and Date of autopsy. Time elapsed between recovery and performance of autopsy was calculated.
- The details of which Forensic Pathologist, Forensic Pathology Officer or any other specialised personnel were assigned to the case.
- Identity features. Age and sex were noted from the alleged identity documented by FPO's, as provided by SAPS. If no alleged identity was provided, sex was confirmed anatomically and age was noted as 'unknown'.
    - Age was noted in years. Adults were considered as those 18 years and older, juveniles were considered as those bellow 18 years.
    - Age was further divided as (using World Health Organization guidelines [29]):
        - Infancy and Childhood – 0-9 years
        - Adolescence – 10-19 years
        - Young Adult – 20-59 years
        - Older Adult – 60 years and above
- Osteological inventory. An inventory was re-done at autopsy and each skeletal element was re-described if damage/destruction was noted or if it was not present.
- Skeletal and tissue diagrams were used to illustrate the condition of the remains (Appendix D).
- Aspects examined by Forensic Pathologist. Main autopsy findings were noted. This was in particular reference to burn artefacts (e.g. burn lacerations, burn fractures, pugilistic posture, burn hematoma), burn pathology (e.g. degree of burn wounds, soot in the respiratory tract) and trauma pathology (e.g. fractures, intracranial hematoma, lacerations).

3. Results

From April to December of 2015, 32 fire-related death scenes were attended in which 48 decedents were retrieved.

3.1. Fatal Fire Scenes Details

The monthly distribution of cases varied, as depicted in Figure 1, with the greatest number of cases attended being in winter (n=15, 46.9%) and in June (n=7, 21.9%). The recovery of decedents occurred equally during the day as the night, and predominantly on weekends (Saturday and Sunday) (n=23, 71.9%).

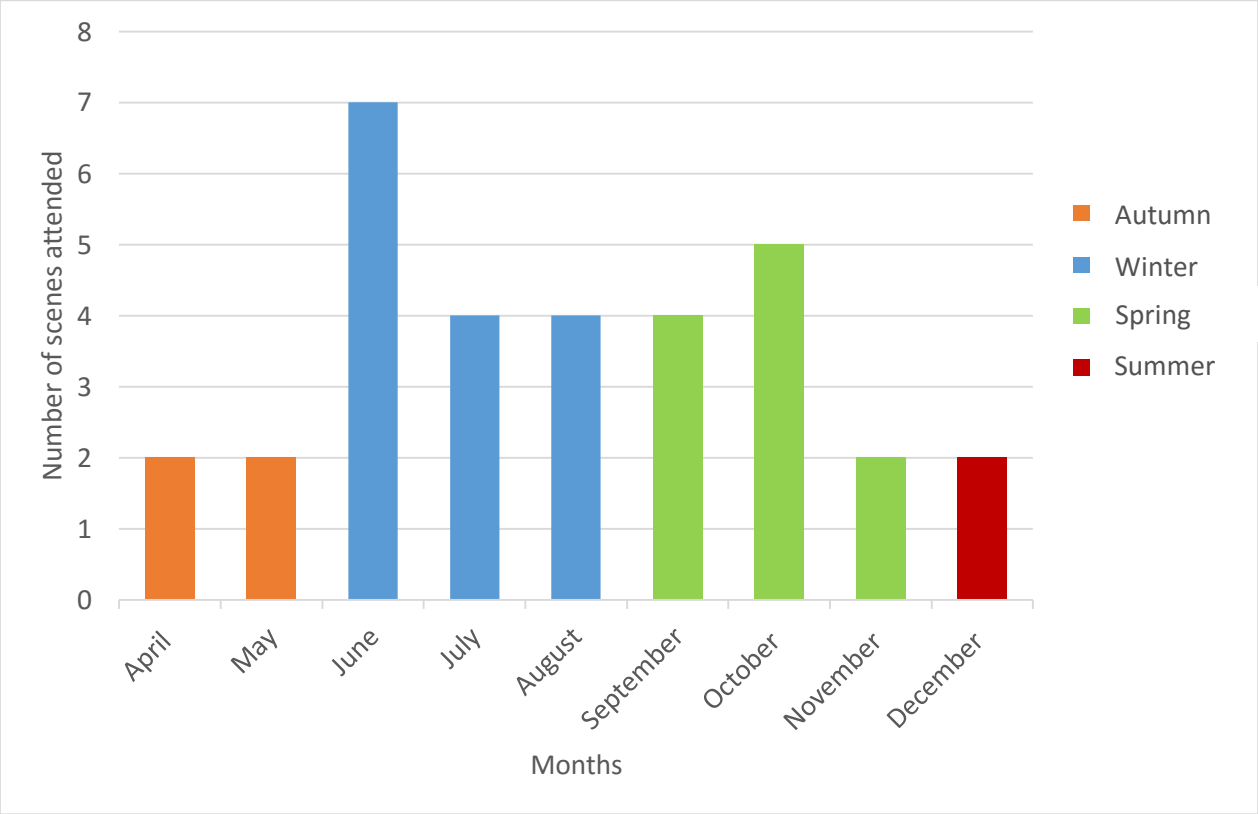


Figure 1: Monthly and seasonal distribution of fatal fire scene attendance.

3.1.1. Scene-type and Geographic Location

Figure 2 shows the scene-types in which fatal fires occurred. The majority of fire scenes occurred in residential dwellings, with informal housing (n=22, 68.8%) predominating, followed by formal housing (n= 8, 25%). Two scenes differed in that they were in the setting of a road traffic accident (car) and a community assault on open land.

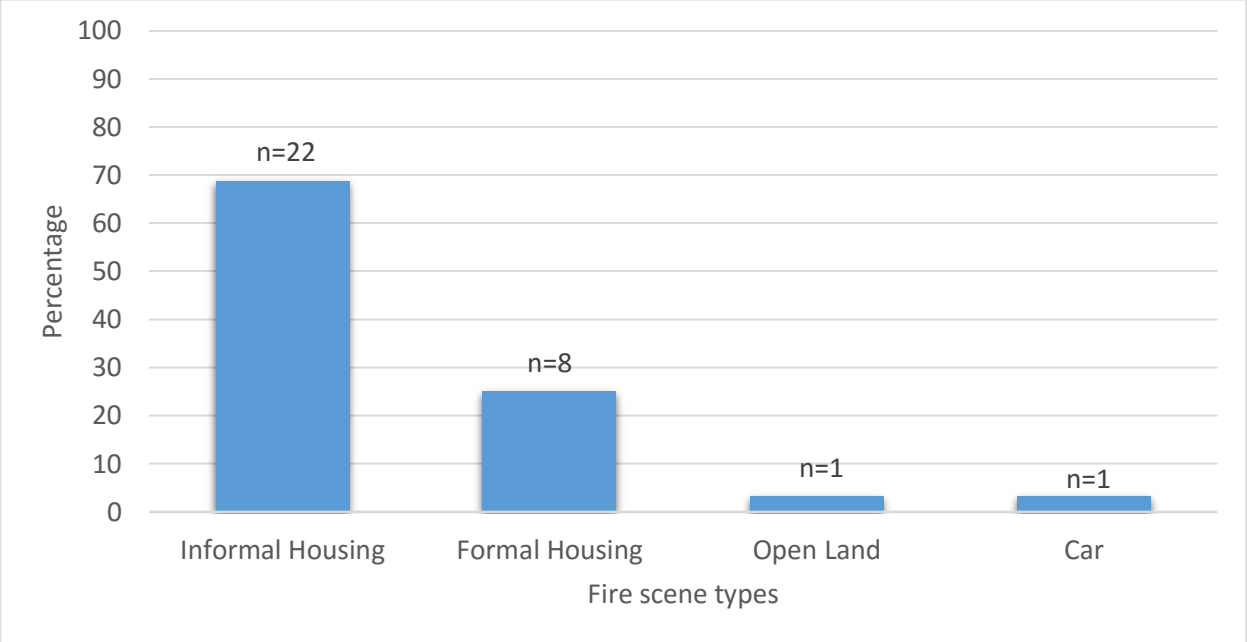


Figure 2: Scene-type of fatal fires

Of the 22 scenes which were in the setting of informal housing, 11 (50%) of them had no direct road access for the FPS vehicle.

The most common suburbs of Cape Town in which fatal fire scenes were attended were Philippi (n=10, 31.3%), followed by Nyanga (n=5, 15.6%). In Philippi, 9 of the 10 (90%) fatal fire scenes were in informal housing. In Nyanga, 4 of the 5 (80%) fatal fires were in informal housing.

3.1.2. Site Description

The extent of destruction to structures in which remains had to be retrieved from varied, as depicted in Table 3. Structures (residential dwellings and a car) were involved and damaged by fire on 31 (96.9%) scenes as one scene had no structure, occurring on open

land. The majority of structures were levelled/destroyed entirely (n=15, 46.9%), and all of these were informal houses. On 16 (50%) scenes, an intact or partially damaged structure had to be entered.

Table 3: The extent of destruction to structures, as divided by scene-type

Extent of Destruction	**Scene-type and Number of Scenes**		**Total Number of Scenes**	**Percentage of Scenes**
Intact but Damaged Structure	Informal House	2	6	18.8%
	Formal House	3		
	Car	1		
Partially Damaged Structure	Informal House	5	10	31.3%
	Formal House	5		
	Car	0		
Levelled/Destroyed Structure	Informal House	15	15	46.9%
	Formal House	0		
	Car	0		
No Structure Present		1	1	3.1%
Total:			32	100%

At the majority (n=20, 62.5%) of fire scenes, one structure was confirmed to be involved. On 6 (18.8%) scenes, between 2 to 5 structures were confirmed to be have been damaged. On 5 (15.6%) scenes a large, yet undetermined, number of structures were involved, with the most devastating fire involving an estimated 800 informal houses. Large

scale destruction in these 5 cases caused challenges for those searching for remains and in one instance, the remains of 1 individual were found under debris a week after the fire event.

3.1.3. Safety Concerns and Challenges

Safety concerns and challenges confronted with on scene included:

- No heat/sharp resistant protective gloves were used to handle debris or remains.
- A helmet was worn on 1 (3.1%) occasion by one FPO.
- Debris had not been removed off of remains by CTRFS on 14 (43.8%) scenes. The materials used to build informal housing tend to remain heated and were too hot for FPO's to remove off the body on 9 (28.1%) scenes. The materials were also often sharp (e.g. corrugated iron and steel nails).
- On 1 (3.1%) scene, a fire reignited while FPO's were in the structure retrieving remains.
- The remains themselves were still smouldering on 8 (25%) scenes, at the time FPS were expected to remove the body.
- Lack of lighting on scene (only one portable light available per FPS vehicle).

3.1.4. Personnel and Agencies on Scene and Alleged Account of Events

No forensic pathologist or forensic anthropologists were involved with scene recovery. At 30 (93.8%) scenes, recovery was conducted by FPO's. On 1 (3.1%) scene, Cape Town Fire and Rescue Services (CTFRS) were requested to retrieve remains from an unsafe structure, and at 1 (3.1%) scene the family of the deceased retrieved and carried the remains.

The South African Police Services (SAPS) always remained on scene until FPS retrieved decedents. CTFRS were still present on our arrival at 3 (9.4%) scenes. At these 3 scenes, FPO's could collect collateral information regarding the fire, and the fire suppression method could be confirmed (all suppressed using water). At the remaining 29 (90.6%)

scenes, information from CTFRS could not be obtained regarding these aspects. On 3 (9.4%) occasions, CTFRS had to be contacted to return due to safety concerns regarding the structure in which the remains had to be retrieved from. Fire Investigation teams from SAPS were not present on scene at the time FPS collected remains in any cases.

The cause of the fires, as provided by SAPS and CTFRS on scene, were largely speculative and unsubstantiated, based on limited information available at scene. Common causes suggested on scene included the use of a candle as lighting, the use of paraffin heaters and stoves, and faulty electrical wiring. Fire investigation reports were not sent to forensic pathologists for any cases.

3.2. Decedents Details at Scene

There were 32 scenes attended by the researcher, in which 48 decedents were retrieved. The majority of scenes (n=20, 62.5%) had one decedent, and at 12 (37.5%) scenes multiple decedents were recovered, as depicted in Figure 3.

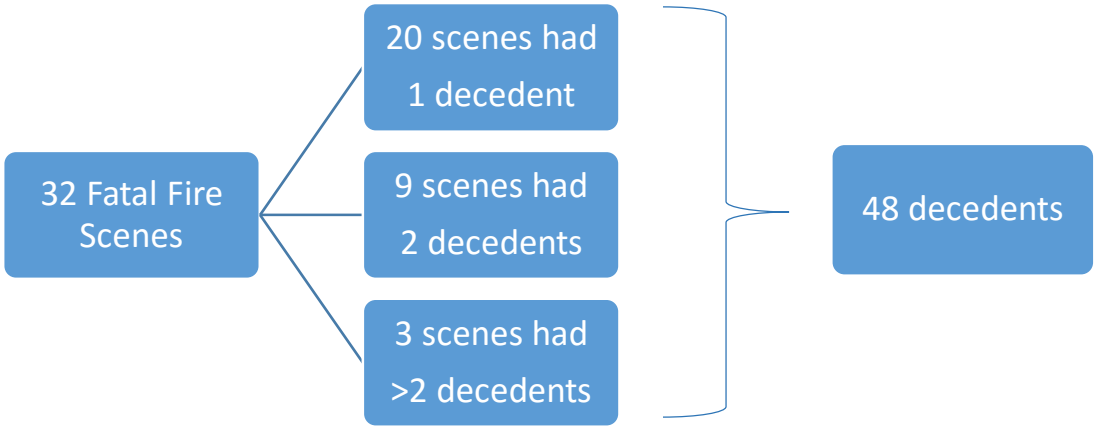


Figure 3: The number of fatal fire scenes attended and the respective number of decedents retrieved

With regards to extent of burning, the majority (n=18, 37.5%) of decedents exhibited charred tissue and bone, accompanied by regions of calcined bone. In 4 (8.3%) decedents, lower degrees of burning were exhibited with no charring present.

In the 48 decedents, all levels of the Crow-Glassman Scale (CGS) were exhibited, with the majority (n=18, 37.8%) falling into Level 2. The number of individuals categorised into each level of the CGS system can be seen in Table 4.

Table 4: The number of individuals in the sample categorised into each CGS level

CGS Level	Number Individuals Categorised into Level	Percentage Individuals Categorised into Level
Level 1	5	10.4%
Level 2	18	37.5%
Level 3	11	22.9%
Level 4	11	22.9%
Level 5	3	6.3%
TOTAL:	**48**	**100%**

3.3. Resources and Methodology at Scene

Documentation techniques:

The documentation techniques used to note the details of the scene and the decedents were limited**.**

- At all scenes, photographic documentation was performed by FPO's.
- No other documentation techniques were performed (such as videography or sketching)
- Contextual information regarding the decedents in relation to the scene, or one another, was rarely noted.
- No skeletal inventory or diagrams were used at any scene to document the condition of the remains.

Personal protective equipment (PPE):

The utilisation and availability of PPE on scene was lacking and not standardised.

- Disposable gloves were used at all scenes during recovery.
- Heat/sharp resistant gloves and footwear were not used for protection at any scene.
- No respirators or masks were worn at any scenes.
- No goggles were worn at any scenes
- At 10 (50%) scenes a structure had to be entered which was either intact or partially damaged, as depicted in Table 3, and a helmet was only worn at 1 (3.1%) of these scenes by one FPO.

Tools:

There was a lack of tools available for use during recovery.

- At 1 (3.1%) scene, tools (a spade and trowel) were found on-scene and used to excavate the remains.
- At 8 (25.0%) scenes, hands and pieces of debris (e.g. roof tiles) were used to uncover partially buried remains.

Recovery techniques:

The recovery methodologies used were limited and highly variable.

- Excavation using archaeological methods, such as the gridding of a site or sifting of debris and ashes, did not occur on any scene.
- No systematic plans for recovery of remains were used.
- At 2 (6.3%) scenes, it was confirmed that not all skeletal remains were initially retrieved. Residual remains had to be recollected.
- Due to the fragility of the remains (particularly the extremities) and the techniques used to lift them, fragmentation and fractures were caused.

Transportation materials:

Resources available for the transportation of remains were restrictive and non-standardised.

- For transport, one body scoop and two gurneys (with wheels) were available per vehicle to place remains on.
- Flexible plastic body bags were used for all 48 decedents.
- A body scoop or gurney was used with 22 (45.8%) decedents to move the remains to the vehicle.
- In 26 (54.2%) decedents, the unsupported body bag itself was used to carry and transport the remains to the vehicle. In these instances, the bag was carried on either end by FPO's on scene until placed on the gurney and put into the vehicle. Once at the mortuary, the body bag was picked up and placed on a mortuary gurney until the time of autopsy
- With 3 (6.3%) decedents, smaller fragments were placed in a separate body bag from the bulk of the remains. In all other cases (n=45, 93.8%) the remains were placed in one body bag. This included 22 decedents (45.8%), all of CGS Level 3 and above, which had disarticulated fragments on scene.
- On two occasions 2 bodies (4 decedents in total) were placed within the same body bag for transportation.
- One vehicle, a "Toyota Quantum", suitable for transporting burned remains (accounting for pugilistic posture) is available to SRFPL, and it is designed for a capacity of 2 decedents and 3 FPO's.
- With 7 (14.6%) decedents, an alternative and unsuitable vehicle was used. At 3 (9.4%) scenes at which there were multiple casualties, the remains were stacked upon one another in the vehicle.

3.4. Decedents Details at Autopsy

All respective decedents underwent full autopsies, performed by a forensic pathologist. Autopsies occurred, on average, 3 days after the date of death. In 1 (2.1%) case, an official forensic anthropological analysis was requested.

A demographic summary of the 48 decedents is represented by Table 5. Males predominated (n=31, 64.6%), with 17 (35.4%) decedents being female. Age ranged from 1 to 79 years, with an overall average age of 31.2 years. Adults (those 18 years and above) had an average age of 35.8 years and children (those below 18 years) had an average age of 5.9 years. The vast majority (n=36, 75.0%) were young adults (20-59 years).

Two adults did not have alleged identities at the time of autopsy, therefore no exact ages were known. Two decedents, CGS Level 5, could not have their sex or age confirmed at the time of autopsy however their alleged identities (as provided by SAPS) were used.

Table 5: Sex and age ranges of decedents

Age range	Sex		TOTAL	TOTAL PERCENTAGE
	Male	Female		
Infancy & Childhood (0-9 years)	2	3	5	10.4%
Adolescence (10-19 years)	3	0	3	6.3%
Young Adult (20-59 years)	23	13	36	75%
Older Adult (60+ years)	2	0	2	4.2%
Unknown Age	1	1	2	4.2%
TOTAL:	31	17	**48**	**100%**

3.4.1. Alteration to Remains

After comparing osteological inventories made at scene and at autopsy, alteration (further fragmentation or fracturing) to the remains had occurred in 29 (60.4%) of decedents.

In cases classified as CGS Level 1 (n=5, 10.4%), no alteration occurred (0%). In all (100%) of the CGS Level 5 cases (n=3, 6.3%) further alteration between scene and autopsy occurred. Figure 4 illustrates occurrence and non-occurrence of alteration in relation to CGS Level of remains. The occurrence of alteration to remains exponentially increased as CGS Level increased, and the two graphs intersected after CGS Level 2.

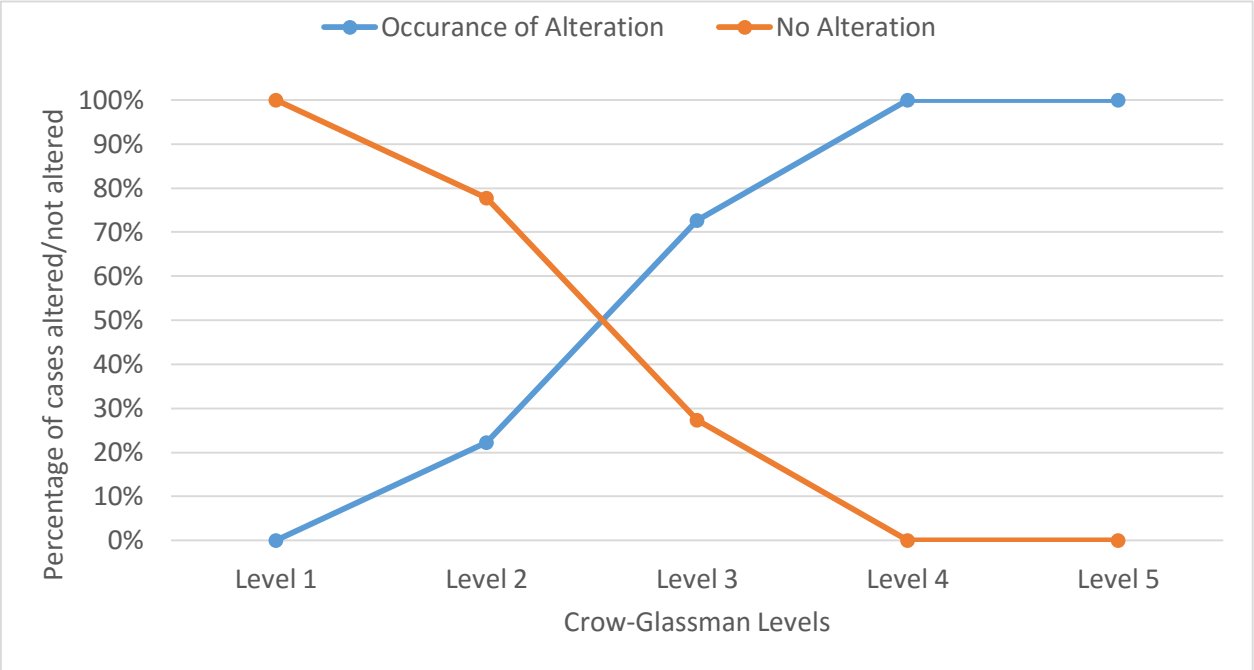


Figure 4: Occurrence vs. non-occurrence of alteration/fragmentation at Figure 6: Cause of death in the nine homicides.

3.4.2. Manner and Cause of Death

The distribution of manner of death is illustrated in Figure 5. The majority of deaths were deemed accidental (n=38, 79.2%), followed by homicide (n=9, 18.8%) and a singular suicide (2.1%).

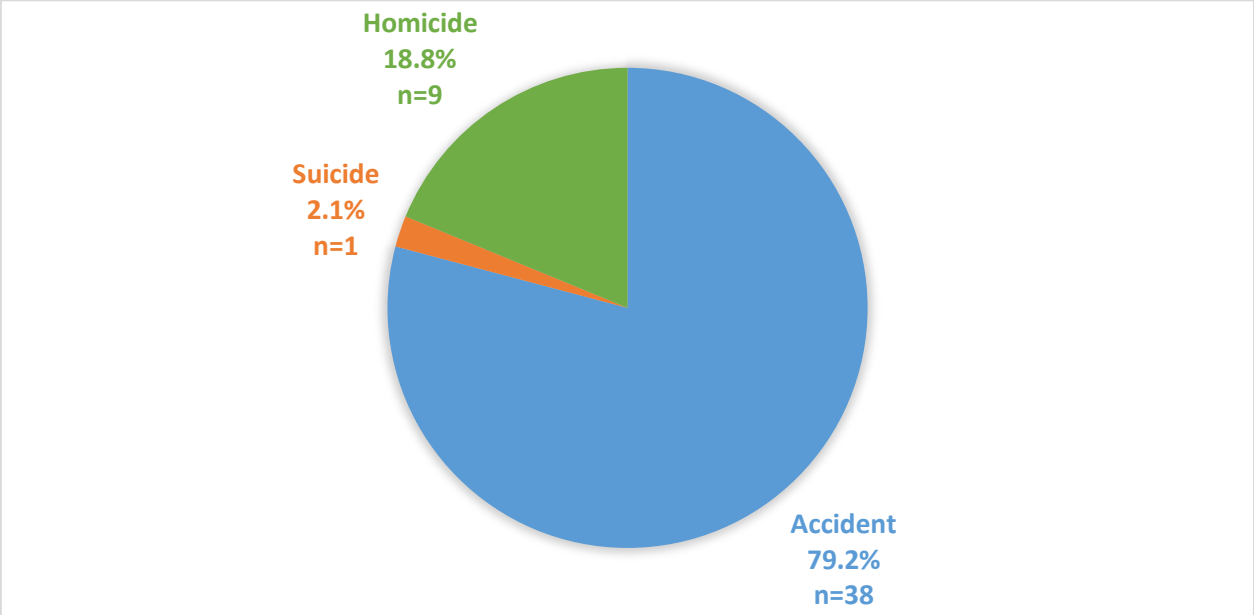


Figure 5: Manner of death of decedents

The cause of death in all accidents and suicide were attributed to burns and smoke inhalation, and the consequences thereof. The homicides however, displayed varied causes of death, as illustrated in Figure 6, with the most common cause being attributed to blunt force trauma.

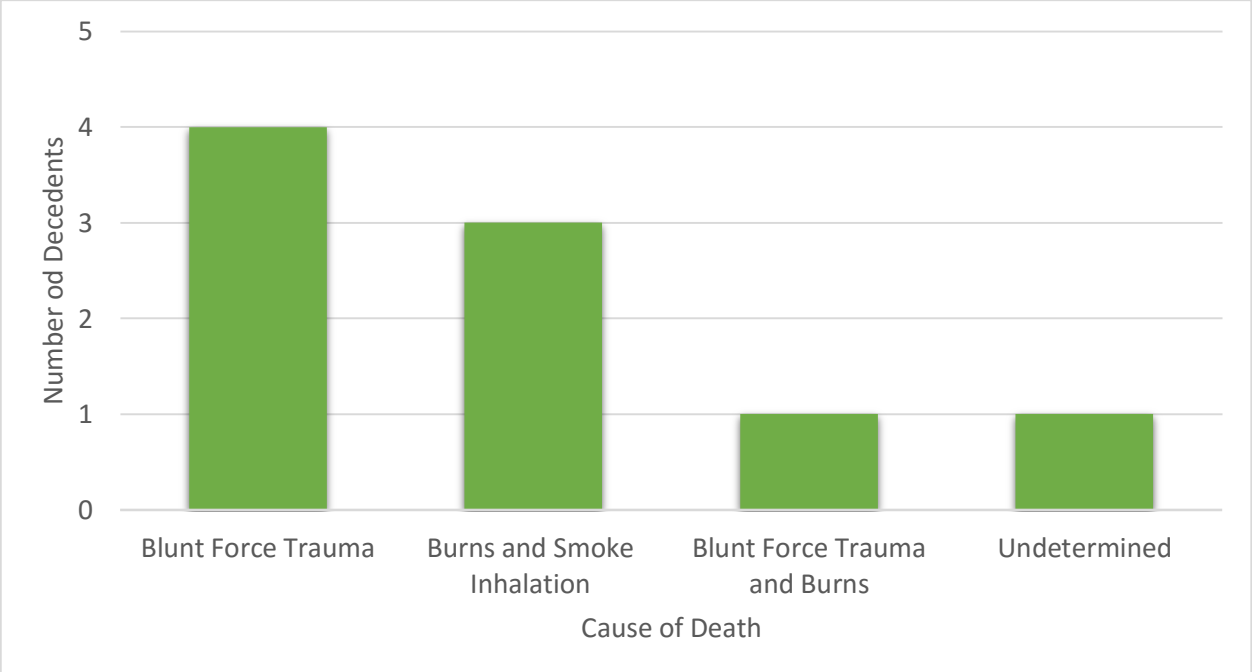


Figure 6: Cause of death in the nine homicides.

3.4.3. Autopsy Findings

Table 6 depicts the autopsy findings of fire-related injury and trauma. In 3 (6.3%) decedents, there were no organs remaining for examination, therefore aspects such as soot in the respiratory tract, burn hematomas or ante-mortem trauma could not be determined.

In 6 decedents, all suspected homicides, pathology due to trauma was noted which consisted of lacerations, ante-mortem skeletal fractures and intracranial haemorrhages (including subdural, subarachnoid and cerebral haemorrhages).

Pugilistic posture presented in 36 (75%) decedents, and in 1 (2.1%) a deviation from expected pugilistic posture was noted. In 7 (14.6%) decedents no pugilistic posture was assumed and in 5 (10.4%) the presence of pugilistic posture could not be ascertained due to the extent of destruction.

Table 6: Autopsy findings

Autopsy Findings	Number decedents exhibiting finding	Percentage decedents exhibiting finding
No Organs for Examination	3	6.3%
Soot in the Respiratory Tract	39	81.3%
Pugilistic Posture	36	75%
Thermal Fractures	33	68.8%
Burn Epidural Hematoma	21	43.8%
Intracranial Brain Haemorrhage	4	8.3%
Lacerations	4	8.3%
Trauma Fractures	5	12.5%

4. Discussion

This study, a first of its kind in Cape Town, South Africa, revealed a number of noteworthy findings. These findings revealed a need for standardisation of the various processes involved in fatal fire investigation. These concerns could feasibly be managed by the implementation of a tailored protocol. Attached as Appendix A, is a protocol "prototype" intended for use by FPO's at the SRFPL/FPS.

4.1. The Victims of Fatal Fire

The demographics of the decedents in this study indicated a male predominance, which is in contrast to a number of other low- to middle-income regions of the world, such as India, Iran, Pakistan, Zimbabwe and Ethiopia [30, 31]. The World Health Organization (WHO) also reported that globally, females have been found to be at a higher risk for burn injury than males [1]. Previous burn-related fatality studies in South Africa however, have indicated a male majority in correlation with this study [7,32]. This is also in keeping with the majority of all deaths in South Africa being Male [5]. Interestingly, males do not predominate (48.9%) in the population of the City of Cape Town [33].

It has been suggested that globally, sex differences in burn mortality may vary by age category [30]. In this study, from adolescence onwards, males predominated. The majority (75%) of this sample consisted of young adults (20-59 years).This is also in keeping with the fact that the majority of all deaths in South Africa are Male [5]. In India, young adults have also been shown to be at a higher risk than other age groups [34]. However, this is in contrast to most global studies which indicated that either the young or elderly (or both) were represented disproportionately in burn mortality [30,31,35–37]. In Africa, infants have been found to have a high incidence of fire related burns, which was not supported by this study [30].

The reasoning behind the excess risk for young adult males in South Africa is unclear, however previous South African studies have related this phenomenon to a variety of living and working habits and conditions [7,32]. The prominent use of alcohol (identified as a common risk factor for burn injury globally) particularly in men in Cape Town, has

been proposed as a contributory factor to this phenomenon, with Cape Town having a high level of intoxication as compared to other South African cities [7,38,39]. Further studies into the prevalent risk factors for fire of this demographic in Cape Town need to be conducted, in order to understand why this is in contrast to most regions of the world.

One hypothesis for the high number of young adult male fire fatalities and the low levels of infant mortality may be related to urban migration. There has been an increase single migrant workers, local and foreign, moving to large South African cities such as Cape Town, and finding residence in informal housing while seeking employment in the city [40,41]. Not only does this result in many living in single male households, but often children are left behind in the rural areas to be cared for by family [42]. This may have resulted in a large number of migrant residents living without small children in urban informal housing, accounting for the low incidence of infant fire fatalities. Young single males are also prone to risky drinking, a known fire risk factor, particularly over the weekends which may account for the higher number of male fire fatalities [7].

Although the majority of cases were deemed accidents, the occurrence of homicides and a suicide in this sample illustrate the need for detailed investigation in fire fatalities and the importance of collateral information. There are no particular medical features to distinguish suicidal burnings from those which are accidental or homicidal, therefore proper scene investigation and details of the circumstances surrounding the death are crucial [20]. The high proportion of accidental fire-related deaths is not unexpected, as this is the common global pattern and has also been reported as such in Cape Town [1,30,40]. Suicidal burning is not a common occurrence in the western world, however it has been widely reported in the Middle East, and should therefore always be a consideration during investigation [43]. All accidents and the singular suicide in this study shared a common cause of death, that being due to burns and smoke inhalation, and the consequences thereof. The majority of homicide victims (66.7%) had a cause of death not related to burns or smoke inhalation, predominantly being due to blunt force trauma. It is unsure whether the use of fire in these cases was an attempt to do further harm to the victim, or to conceal evidence of a homicide, as this is a common means of body disposal [44].

Of the 9 homicides, 2 were in the setting of a “community assault” (both on one scene) and both decedents had been “necklaced”. The phenomenon of community assault is also known as “Mob Justice”, which involves members of the local community beating those suspected of criminal activity (often using multiple methods) [45]. In South Africa, a modality of homicidal burning involves placing a car tire around the neck of the victim, dowsing the tire in petrol and setting the victim alight [38]. Community assault, not exclusive to developing countries (such as South Africa), has been regularly reported to occur in the rural suburbs of Cape Town [46]. In India, a similar phenomenon exists, namely dowry deaths or bride burnings, where a young woman is drenched in paraffin and set alight by her conjugal family [34]. The prevalence of community assault in Cape Town, and the use of burning and necklacing as a means of inflicting harm, has not been documented. In this study, community assault scenes were often reported as hostile and violent, presenting safety risks. A number of scenes were not attended by the researcher for this reason and FPO’s either had to be escorted to retrieve remains, or the SAPS retrieved the body.

4.2. Investigative Limitations

It was discovered that in notifications received by SRFPL of an unnatural death requiring medico-legal investigation, the incident details were not verified nor standardised, and information regarding the nature of a scene was limited prior to being dispatched. This resulted in the researcher only attending 32 of the 66 fire-related death scenes assigned to SRFPL during the data collection period, as the involvement of fire, or presence of burn injuries, had not been reported. For all types of forensic investigation, it is essential to have the relevant case details prior to dispatchment of personnel, in order to ensure the necessary resources and vehicles are prepared, and that protocols (if in place) are followed [13]. Cases involving fire, or the presence of burn injuries, are often more demanding in resources and require additional time on scene, therefore it is especially important to have this information prior to being dispatched [12,14].

American fatal fire scene recovery protocols designed by Symes *et al.* (2012), emphasise the importance of interagency communication and the establishment of an incident

command structure [14]. This command structure aims to keep the following agencies in communication with one another: Fire Fighters (as first responders); the Medical personnel (forensic pathologist/medical examiner); Law Enforcement; the Fire Investigator; a Forensic Anthropologist (if required) [14]. The agencies involved in fatal fire investigation in Cape Town included SAPS, FPS, and CTFRS. The integration of these local agencies and how their duties overlap has not been defined, and there is no regulation of the manner in which information is transferred between agencies. This lack of standardised interagency communication limits fatal fire investigation as a whole, as it is a multidisciplinary task [14,23]. CTFRS were only present on our arrival at 3 (9.4%) scenes and only in these instances was it possible for FPO's to gather reliable information regarding cause of fire, for consideration at time of autopsy. If CTFRS were to remain on scene, or convey relevant information through SAPS, who are required to stay on site, collateral information could be ensured. The most effective interagency communication would include ensuring that fire investigation reports were forwarded to FPS, as they currently are not.

The recognition of burned fragmentary remains is most successful if one has osteological knowledge, such as that possessed by forensic anthropologists [14,17]. No forensic pathologists or forensic anthropologists were involved with scene recovery, even in highly fragmented cases, which may be viewed as a limitation on investigative quality. At 2 scenes, it was confirmed that fragmented remains were not fully recovered. This further emphasised the need for standardised inclusion of specialised personnel during fragmentary remains recovery and the need for improved methodologies.

4.3. Safety at Fire Scenes

Occupational health and safety is a concern at fire-related death scenes in Cape Town. This concern is linked to limitations on resource availability and use, the agencies involved in investigation and the hazards present at these scenes. Fire scenes are a particularly hazardous death scene, and common safety concerns include structural instability, energised electrical circuits, leaking fuel gases and fire gases (including carbon monoxide, cyanide, and biohazards) [47]. Scene safety and security should be ensured

prior to entering a fire scene or structure, to prevent injury or further loss of life, and this may require contacting the appropriate agencies for assistance [47,48]. In this study, on a few occasions (n=3, 9.4%), the stability and safety on scene was questioned, and CTFRS had to be recalled. On two of those occasions, recall was in order to stabilise the structure requiring entrance (such as that depicted in Figure 7*)*, and on one occasion a structural fire reignited while the remains were being retrieved. Based on these experiences, and that at 16 (50%) scenes damaged structures had to be entered, it is suggested that CTFRS personnel remain on scene to ensure structural stability and safety.

Figure 7: A burned, unstable and unsafe informal house in which remains were retrieved

It has been suggested by American protocols that PPE worn during the recovery of burned remains include: goggles, respirators/masks, disposable gloves, and heat-resistant work gloves (e.g. leather) [14]. Limitations on the use and availability of PPE resources were noted on scene, which presents an occupational health hazard. Masks or respirators to prevent inhalation of soot and ash were not used, as well as heat resistant

gloves and footwear to protect against heated and hazardous debris. The use of helmets when entering a damaged structure should also be enforced

4.4. Informal Housing Fires: The Risks and Challenges

Informal housing was found to be the most common setting of fatal fires. The Western Cape Province, in which Cape Town is situated, has a large portion (20%) of its citizens living in densely populated informal settlements [28]. Due to the socio-economic characteristics and the landscapes in which they are situated, informal settlements have associated risk factors and also provide unique challenges in the forensic setting [49]. Informal settlements are not unique to South Africa and been documented in other low- and middle-income countries worldwide, including India, Brazil, Ghana and Tanzania [50-55]. The risk factors noted by this study in Cape Town, are of concern in other informal settlements too.

The concern of inadequate road access in informal settlements is global, and has been documented in other countries as limiting emergency services and health care access [50,52,53, 55]. In this study, the lack of direct road access to 12 scenes was a noteworthy challenge, present in the setting of some informal settlements. For FPS, it is of concern as the officers need to walk a distance with all the required equipment, often along pathways between informal housing which are unstable and not easy to navigate, particularly at night. This phenomenon is illustrated by Figure 8. Once a body has been recovered, it must be carried back the distance to the vehicle. If appropriate resources are not available for such a task, not only does it pose a health and safety risk to the officers, but it may lead to further fragmentation or fracturing of the remains. For this task, a body scoop instead of a wheeled gurney is preferable. This challenge is additionally a concern for the CTFRS and paramedics who require prompt access to fire scenes. This was identified as a risk factor for fatal fires in Cape Town and is a public health and safety concern.

Informal dwellings in South Africa have been documented as frequently being erected close to one another, with a multitude of materials (often flammable) being used to build them, allowing fast spreading fires and extensive destruction [40,49]. The high density

and close proximity of informal houses to one another has also been noted as a risk factor in other countries, including Brazil and India [53,55]. High density housing and flammable building materials create a risk for fast-spreading fires and large-scale destruction. In this study. In this study, the 5 (15.6%) scenes in which a large, yet undetermined amount of destruction occurred, all were in the setting of an informal settlement. Large scale destruction creates a logistical challenge for CTFRS, and in turn forensics, as the debris has to be rapidly searched for decedents. This was highlighted by the fact that at one scene, remains were only discovered underneath debris one week after the fire event.

Figure 8: Limited direct road access in informal settlements. Yellow pin - where FPS vehicle was parked; Yellow line - pathway taken through informal settlement; Blue dot - fatal fire scene.

The high cost of electricity, or the lack of electricity supply, in South Africa has led to the use of others means of energy and illegal and unsafe electricity connections, especially in informal housing [56-58]. This is of concern in India too, where the high-demand for electricity supply in informal settlements has led to illegally over-loaded electrical boxes, posing a substantial fire-risk [55]. Paraffin, is often used for cooking, lighting and heating purposes by means of open flame [32]. Paraffin stoves or heaters were a common suggested cause of fire, and on a number of scenes, their remnants were noted. Candles used as lighting, as well as faulty electrical systems were often attributed as the cause of fire in informal settlements. Although these causes were suggested at the time on scene, they were speculative and their contribution to the fire was not confirmed by CTFRS or Fire Investigation (part of SAPS) teams.

In Philippi, the predominant location for fatal fires in this study, 9 of the 10 (90%) fatal fire scenes were in informal housing. In Nyanga, 4 of the 5 (80%) fatal fires were in informal housing. This is suggestive that these two areas are at a high-risk for fatal fires with informal housing.

4.5. The Recovery, Handling and Transport of Burned Remains

Scene processing methodologies, and information documentation affect the quality of any investigation [14,48]. Thorough documentation of contextual information and the association of burned human remains relative to the environmental setting, is essential [14]. Ideally documentation should be continuous and should take place in three forms: written; photography/videography; and mapping [14]. In this study, on scene documentation was limited, as no mapping or sketching occurred, and contextual information was rarely noted. Collateral information available on scene for documentation was restricted by the lack of communication with other involved agencies, however contextual information could still have been noted. Photographs of the decedents were always taken. Documentation methods used by SRFPL could be enhanced by utilising a standardised form to gather information, specific to fire-related deaths.

Appropriate resources available on scene, and their proper use, affect the quality of the remains recovered and ultimately the quality of the investigation [14]. Archaeological tools

and methodologies have been suggested for use in recovering burned remains, with particular reference to those which are fragmentary [14,59]. This includes gridding of a site or sifting of debris and ashes [14]. These practices ensure collection of all fragmentary remains and promote systematic recovery techniques [14,60]. Tools suggested include trowels, dustpans, brushes and shovels [14]. These methodologies are however time consuming and require training. None of these methodologies were performed and the appropriate tools were not available on scene. At 8 (25.0%) scenes, partially buried remains were uncovered either by hand or by using pieces of debris (e.g. roof tiles; piping) as tools. This is an occupational safety risk for FPO's and also decreases the quality of excavation attempts. It is suggested that, due to the staff and time constraints of SRFPL, that forensic anthropologists conduct the recovery of fragmentary burned remains, as recommended by the CGS.

The preservation of remains and associated evidence is paramount in any forensic investigation [48,61]. Fragmentation of burned remains creates a challenge in this regard. Ideally standardised procedures should stipulate that delicate structures should be wrapped, fragments should be placed in separate bags, and that remains are placed on a solid underlying structure [14,21]. In this study, efforts to minimise the alteration of remains was limited and no wrapping of delicate structures occurred. However, only in 3 of the 25 cases (12%) with disarticulated fragments, the fragments were placed in a separate body bag. For the majority of decedents (n=26, 54.2%), the body bag itself was used to carry and transport remains to the vehicle. These bags are flexible and are known to cause further alteration to remains as they are carried [14,21]. A solid structure was provided by a body scoop or gurney in 22 (45.8%) cases. The appropriate vehicle is limited to one body scoop and two gurneys (wheeled), which is of concern. On two occasions 2 bodies (4 decedents in total) were placed within the same body bag for transportation. This practice allows alteration of remains to occur and the commingling of fragments is a possibility during transportation.

The transportation of burned remains requires the use of an adequately sized vehicle, in order to account for the pugilistic posture of burned decedents [14]. One adequately sized vehicle suitable for transporting burned remains is available to SRFPL, namely a "Toyota

Quantum", and it is designed for a capacity of 2 decedents and 3 FPO's. This vehicle was used to transport the majority of cases while in 7 (14.6%) cases, an alternative and unsuitable vehicle was used. It should be standard practice to use the "Toyota Quantum" for all burned remains assigned to SRFPL.

4.6. Multiple Decedents on Scene

In this study, at 12 (37.5%) scenes multiple decedents were recovered. Multiple decedents add complexity to scene recovery and the transport of decedents, and are a resource demanding task [62]. Constraints on time, personnel and resources further augment the challenges faced on scenes in which this phenomenon occurs.

If fragmented remains are in close proximity to one another, the possibility of commingled remains becomes an issue [17,21,59]. This occurred at 4 (12.5%) scenes. When commingling occurs, skeletal fragments should be assigned to a specific individual, where possible, and this can only be accomplished if proper scene photography, contextual documentation, and careful recovery methods are employed [17]. Those with a knowledge of osteology, such as forensic anthropologists, in these instances are highly beneficial to the investigation and analysis of remains [14,17]. This further indicated the necessity for SRFPL to routinely include specialised personnel during fragmentary burned remains recovery.

Multiple decedents on one scene presented a challenging transportation need. The stacking of decedents in the vehicle occurred on 3 scenes where there were more than 2 individuals, which enhanced alteration and fragmentation. Additional appropriate vehicles need to be acquired, or multiple trips using the current vehicle need to take place when more than two decedents are on scene.

4.7. The Effect of Current Methodologies on the Condition of Burned Remains

In this study, alteration (further fragmentation or fracturing) to the remains had occurred in 29 (60.4%) cases between scene and autopsy. This can be attributed to the recovery, handling and transport techniques currently employed. This fragmentation is possibly the most noteworthy and influential heat-induced change, conveying the necessity for

standardised recovery processes and resource acquirement and utilisation [63]. Severe fragmentation and the loss of evidence from scene to autopsy may complicate analysis, and therefore should be limited.

The majority of decedents (n=18, 37.5%) presented with charred tissue and bone, accompanied by regions of calcined bone. Calcined bone is particularly fragile and can lead to the loss of skeletal structures [63]. It also proves difficult when locating and recovering remains due to its white/grey colour being similar to that of the burned surroundings [63]. Assuring preservation of calcined remains during recovery and transportation is a challenging task that requires strategy, planning and special training [18]. Improved methodologies to ensure calcined regions of bone are preserved are need.

As previously stated, as the CGS Levels progress, so does the extent of fragmentation and fragility. Using the Crow-Glassman Scale (CGS), the majority of decedents were classified at Level 3 or above (n=25, 52.1%). This demonstrates that the majority of decedents showed fragmentation and would have benefited from the inclusion of a forensic anthropologist in recovery, according to the scale.

Figure 4 illustrates an exponential relationship between CGS Level and fragmentation, and an inverse relationship between the occurrence and non-occurrence of alteration as CGS level increases. While alteration occurs at CGS Level 2, the intersection of the graphs following this level and the dramatic increase in alteration, prove the necessity of more refined recovery and handling processes and the inclusion of a forensic anthropologist on scene from CGS Level 3 onwards.

4.8. Importance of Contextual Information During Autopsy

Although all decedents were subject to full autopsies, there were no organs or tissue present for examination in 3 (6.3%) cases. This is of concern as conclusive determination of an individual's vitality at the time of fire could not occur. In only one of these cases was a forensic anthropologist's analysis requested. Enhanced scene documentation, interagency communication and the inclusion of specialised personnel are all highlighted by cases such as these.

The presence of soot in the respiratory tract of the majority of decedents (n=39, 81.3%) was utilised to conclude vitality at the time of fire. The finding of no soot in the respiratory tracts of 6 (12.5%) homicide victims assisted in determining cause of death being unrelated to the fire itself. The fact that in 3 (6.3%) of the homicides, soot was present in the respiratory tract illustrates that the manner of death cannot always be conclusively determined from autopsy and pathology findings alone. This further illustrates the importance of thorough fire investigation and consideration of contextual information.

Expected pugilistic posturing presented in 35 (72.9%) cases, however in 1 (2.1%) case deviation from normal pugilistic posture was noted on scene. This was ultimately attributed to debris which had been removed off the remains before the arrival of FPS, however it illustrated the importance of considering pugilistic posture during scene processing and documenting it for consideration during autopsy.

Thermal fracturing is a process signature of burning bone that one can use to identify deviations from normal burn patterns [24]. Although there was a high incidence (n=33, 68.8%) of burn fractures, the occurrence of ante-mortem trauma fractures in 5 (10.4%) decedents demonstrate the importance of forensic pathologists (or forensic anthropologists) distinguishing between the two. If thermal fractures are noted in detail on scene, any further fragmentation or fracturing featured during autopsy can be attributed to the recovery, handling and transport of the remains. Identifying a trauma fracture could greatly influence the determination of manner and cause of death and guide the investigation further [14,44,64]. This aspect further indicates the importance of detailed documentation on scene, and the need to preserve the state of remains from scene to autopsy.

5. Study limitations

Various limitations on the study were noted as follows:

- Not all fire-related death scenes assigned to SRFPL during the study time period were attended. This was partly due to insufficient scene details prior to being dispatched, detailing the involvement of burn injuries on a decedent. Scene safety also limited

scene attendance as cases of suspected community assault were often reported as hostile.

- Scene safety also limited data collection in that at a number of scenes violence in the surrounding area required hasty retrieval of remains.
- Due to the high case load of SRFPL, and limited staff, the time spent on each scene was restricted. With more time on scene, both the FPO's and the researcher could have potentially collected more data and had more detailed documentation of the scene, the remains and the alleged cause of fire.
- Inter-observer classifications were not able to be conducted as only the researcher was able to go to scene, for logistical reasons. This practice could particularly have confirmed the reliability of classifying remains according to the CGS.
- The manner of death reported in this study was the suspected manner of death at the time of autopsy, and may have not been the final conclusion of the investigation. The determination of manner of death is not decided by forensic pathologists in South Africa, only cause of death.
- This study had a small sample size and a limited time period of data collection. This may have affected the demographic profile of fire victims in Cape Town, reported by this study.
- Knowing that they were being observed, the FPO's may have altered their usual routines and techniques used during scene recovery.

6. Recommendations

The follow recommendations are made based on the study's findings and the necessity of further initiatives in Cape Town and South Africa:

- Protocols should be implemented which ensure the adequate reporting of death scene details to FPS.
- Implementation of a protocol for burned remains recovery in Cape Town.
- Enhanced training for FPO's and CTRFS personnel for fatal fire scene processing and recovery of remains.

- Epidemiological studies need to be conducted further exploring the demographics and distribution of fatal fires in Cape town, and to identify areas in need of public health and safety education programs for fire prevention.
- Initiatives to ensure that access roads are maintained throughout informal settlements should be prioritised.
- Collaborative studies between the various agencies involved on fatal fire scenes should be conducted.
- An incident command structure detailing the exact roles of each agency involved in fatal fire investigation, needs to be made clear to each agency by implementing over-lapping, integrative protocols.
- Research needs to be conducted into the feasibility of standardisation of reported information to SRFPL/FPS prior to dispatchment.

7. Conclusions

The critical analysis of fire-related death scene processing and investigation in Cape Town, South Africa, identified challenges and limitations, and revealed the necessity for improvement and the importance of standardisation. The frequency of fragmentation of burned remains between scene and autopsy illustrated that current procedures used by SRFPL for recovery, handling and transport are contributing to the alteration of the remains, and the regrettable loss of evidence.

The implementation of a tailored protocol for SRFPL is the most effective manner in which standardisation of the recovery, handling and transport of remains can be accomplished. By standardising methodologies and the resources used therewith, occupational safety can additionally be prioritised on hazardous fatal fire scenes.

A protocol “prototype” was designed (attached as Appendix A), intended for the enhancement of fire-related death investigation, specific to the Cape Town setting. It promotes training of FPO’s retrieving burned remains, resource procurement and utilisation, improvement of scene safety, encourages interagency communication, emphasises the involvement of specialised personnel on scene, and facilitates the collection of contextual information. Standardised methodologies for recovery, handling

and transportation of burned remains according to the extent of burn injury, are crucial in order to ensure the complete and safe recovery of burned remains while minimising their alteration from scene to autopsy.

8. Conflict of Interest

There are no conflicts of interest.

9. References

[1] Mock C, Peck M, Peden M, Krug E. A WHO plan for burn prevention and care. Geneva, Switzerland: 2008.

[2] DiMaio VJ, DiMaio D. Fire Deaths. Forensic Pathol. 2nd ed., Boco Raton, FL: CRC Press LLC; 2001, p. 367–88.

[3] Shkrum MJ, Ramsay DA. Forensic Pathology of Trauma: Common Problems for the Pathologist. Totowa, NJ: Humana Press Inc.; 2007.

[4] The World Bank. Country and Lending Groups. Data Ctry Lend Groups 2015. http://data.worldbank.org/about/country-and-lending-groups#Upper_middle_income (accessed December 1, 2015).

[5] Statistics South Africa. Mortality and causes of death in South Africa , 2011 : Findings from death notification. Pretoria: 2014, p. 48.

[6] Statistics South Africa. Census 2011 Statistical release. Pretoria: 2012.

[7] Van Niekerk A, Laubscher R, Laflamme L. Demographic and circumstantial accounts of burn mortality in Cape Town, South Africa, 2001-2004: an observational register based study. BMC Public Health 2009;9.

[8] Forensic Pathology Services. Our Facilities. Forensic Pathol Serv 2014. http://www.westerncape.gov.za/general-publication/our-facilities (accessed October 30, 2014).

[9] South African Qualifications Authority. National Diploma: Forensic Pathology Support 2012. http://regqs.saqa.org.za/showQualification.php?id=58183 (accessed February 28, 2015).

[10] Inquest Act (Act 58 of 1959). Union Gaz Extraordinary 1959:36–44. http://www.gov.za/sites/www.gov.za/files/Act 58 of 1959.pdf (accessed January 25, 2016).

[11] Price JD. Death Investigation Protocol for Howard County Indiana. Coroner's Off 2010. http://www.howardcountyin.gov/files_uploaded/DeathInvestigationProtocol.pdf (accessed February 1, 2016).

[12] DeHaan JD, Icove DJ. Kirk's Fire Investigation. 7th Editio. Boston: Pearson; 2007.

[13] Demirci S, Dogan KH. Death Scene Investigation from the Viewpoint of Forensic Medicine Expert. In: Vieira DN, editor. Forensic Med. - From Old Probl. to New Challenges, Rijeka: InTech; 2011, p. 13–52.

[14] Symes SA, Ph D, Dirkmaat DC, Ousley S, Chapman E, Cabo L. Recovery and Interpretation of Burned Human Remains. U.S. Department of Justice; 2012.

[15] Hattemer-Apostel R. Standard operating procedures - A novel perspective. Qual Assur J 2001;5:207–19.

[16] DeHaan JD. Fire and Bodies. In: Schmidt CW, Symes SA, editors. Anal. Burn. Hum. Remain., London: Elsevier Ltd.; 2008, p. 1–13.

[17] Fairgrieve S. Forensic Cremation: Recovery and Analysis. Boca Raton, FL: CRC Press LLC; 2008.

[18] Correia PM. Fire Modification of Bone. In: Haglund WD, Sorg MH, editors. Forensic Taphon. Postmortem Fate Hum. Remain., Boca Raton, FL: CRC Press LLC; 1997.

[19] Bass WM. Is it possible to consume a body completely in a fire? In: Rathbun TAR, Buikstra JE, editors. Hum. Identif. Case Stud. Forensic Anthropol., Springfield, Illinois: Charles C Thomas Publisher; 1984, p. 159–67.

[20] Knight B, Saukko P. Knight's Forensic Pathology. 3rd ed. Boca Raton, FL: CRC Press LLC; 2004.

[21] Correia PM, Beattie O. A Critical Look at Methods for Recovering, Evaluating, and Interpreting Cremated Human Remains. In: Haglung WD, Sorg MH, editors. Adv. Forensic Taphon. Method, Theory, Archaeol. Perspect., Boca Raton, FL: CRC Press LLC; 2002, p. 435–50.

[22] Olson G. Recovery of Human Remains in a Fatal Fire Setting Using Archaeological Methods. Ontario: Defence Research and Development Canada Centre for Security Science; 2009.

[23] Glassman DM, Crow RM. Standardization model for describing the extent of burn injury to human remains. J Forensic Sci 1996;41:152–4.

[24] Symes SA, Rainwater CW, Chapman EN, Gipson R, Piper AL. Patterned Thermal Destruction of Human Remains in a Forensic Setting. In: Schmidt CW, Symes SA, editors. Anal. Burn. Hum. Remain., London: Elsevier Ltd.; 2008, p. 15–54.

[25] Büyük Y, Koçak U. Fire-related fatalities in Istanbul, Turkey: Analysis of 320 forensic autopsy cases. J Forensic Leg Med 2009;16:449–54.

[26] Dana SE, DiMaio VJM. Fire and Thermal Injuries. Handb. Forensic Pathol., Boca Raton, FL: CRC Press LLC; 2006, p. 185–98.

[27] Bohnert M, Werner CR, Pollak S. Problems associated with the diagnosis of vitality in burned bodies. Forensic Sci Int 2003;135:197–205.

[28] The Housing Development Agency. Western Cape : Informal settlements Status (2013). Johannesburg: The Housing Development Agency; 2013.

[29] World Health Organization. Fact sheet: Womans Health 2013. http://www.who.int/mediacentre/factsheets/fs334/en/ (accessed February 10, 2016).

[30] Peck MD. Epidemiology of burns throughout the world. Part I: Distribution and risk factors. Burns 2011;37:1087–100.

[31] Dissanaike S, Rahimi M. Epidemiology of burn injuries: highlighting cultural and socio-demographic aspects. Int Rev Psychiatry 2009;21:505–11.

[32] Blom L, Van Niekerk A, Laflamme L. Epidemiology of fatal burns in rural South Africa: A mortuary register-based study from Mpumalanga Province. Burns 2011;37:1394–402.

[33] Strategic Development Information & GIS Department: City of Cape Town. City of Cape Town – 2011 Census – Cape Town. Cape Town: City of Cape Town; 2012.

[34] Sanghavi P, Bhalla K, Das V. Fire-related deaths in India in 2001 : a retrospective analysis. Lancet 2009;373:1282–8.

[35] Barillo DJ, Goode R. Fire Fatality study: demographics of fire victims. Burns 1996;22:85–8.

[36] Rogde S, Olving JH. Characteristics of fire victims in different sorts of fires. Forensic Sci Int 1996;77:93–9.

[37] Holborn PG, Nolan PF, Golt J. An analysis of fatal unintentional dwelling fires investigated by London Fire Brigade between 1996 and 2000. Fire Saf J 2003;38:1–42.

[38] Lerer L. Homicide-Associated Burning in Cape Town, South Africa. Am J Forensic Med Pathol 1994;15:344–7.

[39] Steenkamp WC, Botha NJ, Van Der Merwe AE. The prevalence of alcohol dependence in burned adult patients. Burns 1994;20:522–5.

[40] Godwin Y, Hudson DA, Bloch CE. Shack fires: a consequence of urban migration. Burns 1997;23:151–3.

[41] Cox KR, Hemson D, Todes A. Urbanization in South Africa and the changing character of migrant labour. South African Geogr J 2004;86:7–16.

[42] Poswa AN, Levy R. Migration study in Monwabisi Park (Endlovini), Khayelitsha 2006.

[43] Laloë V. Patterns of deliberate self-burning in various parts of the world: A review. Burns 2004;30:207–15.

[44] Tümer AR, Akçan R, Karacaoğlu E, Balseven-Odabaşi A, Keten A, Kanburoğlu Ç, et al. Postmortem burning of the corpses following homicide. J Forensic Leg Med 2012;19:223–8.

[45] Proctor M, Carter N, Barker P. Community assault - The cost of rough justice. South African Med J 2009;99:160–1.

[46] Forgus S, Delva W, Hauptfleisch C, Govender S, Blitz J. Community v. non-community assault among adults in Khayelitsha: A case count and comparison of injury severity. South African Med J 2014;104:299.

[47] Lentini J. Scientific Protocols for Fire Investigation. Boca Raton, FL: CRC Press LLC; 2006.

[48] U.S Department of Justice. Death Investigation: A Guide for the Scene Investigators (Technical Update). Washington: 2011.

[49] Harte EW, Childs IRW, Hastings PA. Imizamo Yethu: a Case Study of Community Resilience to Fire Hazard in an Informal Settlement Cape Town, South Africa. Geogr Res 2009;47:142–54.

[50] Young G. Socioeconomic Analysis of Informal Settlement Growth in Dar es Salaam: The concept for an agent based model. International Institue for Geo-information Science and Earth Observation, 2010.

[51] Malaviya P, Bhagat NK. Urban poverty and health risk factors : A case study of slum dwellers of Jammu India. Int J Dev Sustain 2013;2:1645–70.

[52] Osumanu IK. Environmental concerns of poor households in low-income cities:

the case of the Tamale Metropolis, Ghana. GeoJournal 2007;68:343–55.

[53] Snyder RE, Jaimes G, Riley LW, Faerstein E, Corburn J. A Comparison of Social and Spatial Determinants of Health Between Formal and Informal Settlements in a Large Metropolitan Setting in Brazil. J Urban Heal Bull New York Acad Med 2013;91:432–45.

[54] Claret AM, Baranoski EL, Felicetti M. An evolutionary approach for fire risk assessment in Brazilian slums. J Fire Prot Eng 2011;22:11–21.

[55] Subbaraman R, Nolan L, Shitole T, Sawant K, Shitole S, Sood K, et al. The psychological toll of slum living in Mumbai, India: A mixed methods study. Soc Sci Med 2014;119:155–69.

[56] Ouedraogo B. Household energy preferences for cooking in urban Ouagadougou, Burkina Faso. Energy Policy 2006;34:3787–95.

[57] Mzezewa SZ. Electrical burns. Contin Med Educ 2008;26:436–8.

[58] City of Cape Town. Paraffin safety tips 2015. https://www.capetown.gov.za/EN/ENVIRONMENTALRESOURCEMANAGEMENT/TIPS/Pages/ParaffinSafetyTips.aspx (accessed September 16, 2015).

[59] Dirkmaat DC, Cabo LL, Ousley SD, Symes SA. New perspectives in forensic anthropology. Am J Phys Anthropol 2008;51:33–52.

[60] Dirkmaat DC. Recovery and Interpretation of the Fatal Fire Victim: The Role of Forensic Anthropology. In: Haglund WD, Sorg MH, editors. Adv. Forensic Taphon. Method, Theory, Archaeol. Perspect., Boca Raton, FL: CRC Press LLC; 2002, p. 451–72.

[61] Bertino AJ. Forensic Science - Fundamentals and Investigations. 1st ed. Mason, OH: South-Western Cengage Learning; 2009.

[62] Ranson D. The Role of the Coroner. In: Oxenham M, editor. Forensic Approaches

to Death, Disaster Abus., Sydney: Australian Academic Press; 2008, p. 191–224.

[63] Waterhouse K. The effect of victim age on burnt bone fragmentation : Implications for remains recovery. Forensic Sci Int 2013;231:409.e1–409.e7.

[64] Fanton L, Jdeed K, Tilhet-Coartet S, Malicier D. Criminal burning. Forensic Sci Int 2006;158:87–93.

[65] Forensic Pathology Services. Standard Operating Procedure: Death Scene Attendance and Investigation. Cape Town: 2013.

Appendix A: Protocol for the recovery and handling of burned remains

PROTOCOL FOR RETRIEVAL OF BURNED REMAINS

For use by the Forensic Pathology Services, South Africa

Written by Petra Schwab
2015

Purpose

This protocol is intended for usage on all fatal fire scenes in which a body exhibits burn injury. The protocol aims to enhance the recovery and handling of burned human remains, especially those which are fragmentary, by standardising the methodologies and resources utilised. It also aims to ensure the safety of those recovering the remains.

Background

The proper, complete recovery of human remains is not only essential to ensure a comprehensive investigation, but also in order to fulfil the needs and expectations of the family and friends of the deceased. The quantity and quality of the remains that are recovered are crucial, and currently burned remains pose an issue in this regard. This is due to several factors including concerns such as fragmentation of the fragile remains, and limited resources for utilisation during their recovery and transport.

A number of factors can start fires, however most often deaths due to fire are **accidental**. On occasion, fire is also used in **suicides** either by self-immolation or by burning the structure in which they are in (e.g. a house or car). **Homicide** by fire can be due to the deliberate ignition of a fire which ultimately leads to the death of an individual. This includes “necklacing”, in which tires are placed over an individual and set alight, often used during community assaults. Fire is also commonly used in attempts to **conceal or destroy evidence of a homicide**. All these possibilities regarding manner of death need to explored when investigating fire related fatalities.

Protection of individuals collecting burned remains (Forensic Pathology Officers (FPO’s)) is important on scene. Fire scenes are often hazardous due to energised electrical wires, gases produced during the fire, and the debris and rubble formed when a structure burn. Informal housings are a common location for fire fatalities, and often materials used to form these houses can be sharp and dangerous, such as large nails and sharp metals.

Debris, and the body itself, can still be heated when on scene and precautions should be taken in order to protect officers.

Using the correct methodologies and equipment when retrieving burned remains is vital in order to preserve their condition from scene to the mortuary. It also provides protection for those retrieving the remains by preventing injury. The correct processes shall be outlined, which includes the use of a body scoop/gurney with a body bag on top, in which the body should be placed in directly. Minimising the movement of burn remains, and having them on a stable platform, prevents fragmentation and preserves their condition.

Proper scene documentation is essential, including the noting of contextual information. Amoung other aspects, the position of a victim on scene (E.g. supine, prone, or on their side), and their location on scene (e.g. on a bed or on the floor) is crucial in aiding an investigator to ascertain manner of death, and whether or not foul play should be suspected. These aspects could help explain the pugilistic posture of a body. This is the predictable posture burned remains assume due to heat, resembling someone in a boxing stance. If multiple casualties are present, their position in relation to one another is important. Other law enforcement officers, fire and rescue personnel, and even witnesses should be questioned to gain an alleged account of the events leading to the fire, and whether any cause of the fire is suspected.

Communication between all agencies on scene and throughout the duration of the investigation is essential as fatal fire inquiries are no doubt a team effort, requiring multidisciplinary involvement.

Burned remains can be classified using the Crow-Glassman Scale, which describes 5 levels of burn injury. The CGS ranges from Level 1 (least severe, minor burns) to 5 (highly fragmentary remains present). The scale should be consulted on scene and a processing plan can be devised accordingly. A modified version of the CGS scale is attached as Attachment 1. It describes the burn injury at each level along with what personnel should conduct the recovery of the remains, and the important methodologies and tools that should be utilised.

Standardised methodologies for recovery, handling and transportation of burned remains according to the extent of burn injury, ensure complete and safe recovery of burned remains while minimising their alteration from scene to autopsy.

Responsibilities

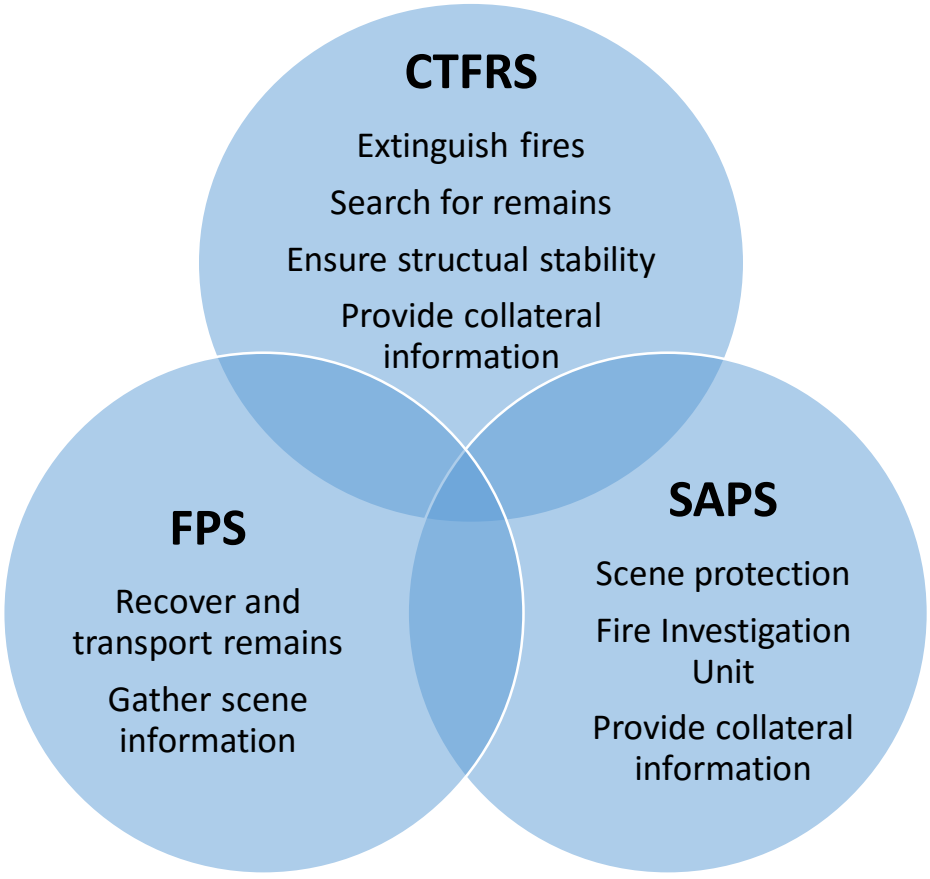
There are three main agencies involved in investigation of a fatal fire scene in Cape Town. Each agency has specific duties, although some do overlap. Communication is key for a thorough, informed investigation to take place. FPO's should request from the other agencies an alleged account of events, and whether a possible cause of fire has been determined. Amoung other duties, the following are important duties of each agency at a fatal scene:

1. **The City of Cape Town's Fire and Rescue Service (CTFRS)**
    - Extinguish Fires
    - Recover survivors
    - Search for remains/decedents
    - Remove large debris
    - Ensure scene safety, including stabilising any structures which require entrance
    - Provide collateral information about possible cause of fire to FPS

2. **South African Police Service (SAPS)**
    - Secure and protect fire scene/death scene
    - Fire Investigation unit
    - Remain on scene until FPS collect decedent
    - Handle the public
    - Provide collateral information about alleged account of events and possible cause of fire
    - Provide an alleged identity, if one has been determined

3. **Forensic Pathology Services (FPS)**
    - Recover remains
    - Gather information (using forms at Attachment 2) regarding:
        - The fire scene
        - The decedent
        - The alleged account of events
        - The alleged cause of fire
        - Possible manner of death (i.e. accident suicide, homicide, natural, or unknown)
    - Transport remains to the mortuary for medico-legal investigation
    - Provide collected information to Forensic Pathologists for consideration during autopsy

Communication is key!



Personal Protective Equipment




- Use of **heat and penetration resistant gloves** provides protection when removing sharp or hot debris off remains.

- **Protective shoe-wear** should be worn, which prevents penetration of sharp debris through the sole (such as nails) and protects against heated debris.

- Use of a **protective helmet** when one has to enter any burned and unstable structures to retrieve a body. It provides protection in the event any debris or structural parts fall.

- A **heat resistant jacket** should be used when burned structures are entered to retrieve a body as the scene could still be significantly heated.

- **Masks** or respirators should be worn in instances where the scene, or the body, are still hot and smoking or when ash and soot have to be handled. Burned materials can also emit hazardous gases.

Facilities and Equipment

- Always use the largest vehicle one can, such as the **"Toyota Quantum" van** belonging to FPS, when possible, to retrieve burned remains. This van should only transport two decedents at a time. The "Pugilistic Posture" of burned victims, which occurs due to the heat of a fire, makes it problematic for bodies to always fit into the regular vehicles. Manipulation of the body in attempts to fit them into any other vehicle could alter the condition of the remains and affect subsequent investigations.

- Use of a **light source** on scene is important. It provides protection for officers by allowing them to see where they are walking and what they are handling. A light source ensured identification of fragmentary remains and additional evidence on scene.

- A small **shovel** can be used to remove large amounts of debris and ash off remains.

- Use of a **trowel** when scraping rubble off and around remains prevents injury to the person retrieving remains and prevents alteration of remains. The edge of the trowel should be used to make top-down vertical cuts in debris.

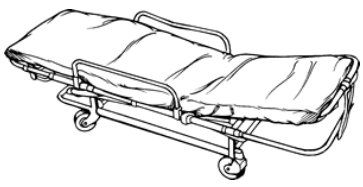
- Use of a **dust pan and brush** allows fine debris to be removed off remains and also assists in identifying disarticulated bodily fragments.

- Use of a **sieve** to sift ash and debris surrounding remains in order to identify small disarticulated bodily fragments.

- **Evidence bags** need to be used if any additional elements are found, whether it be fragmented body remains or additional evidence which needs to be packaged.

- A **body scoop or gurney**, already equipped in all FPS vans, should be used with all burned remains. The board should be **brought as close as possible to the remains** with the body bag placed on it. Remains should be **placed directly into the body bag on the board**.

    - Once a body is in the bag on the gurney, it should be **strapped in**.



Documentation on Scene

Documentation on scene should be conducted in a systematic manner using the proposed standardised form, attached as Attachment 2. The following aspects are included on the form:

- Detailed **photography** on scene is essential. Using the **"Photography Check-list"** on the proposed documentation forms, one can ensure all the necessary photographs have been taken of the scene and the body.

- **Alleged account of events and cause of fire**: asking the SAPS on the scene, or CTFRS if present, what the alleged account of events are, in order to provide the Forensic Pathologist with necessary details, aiding in their considerations regarding manner of death.

- **Number of bodies on scene**: if more than one decedents are present on one scene, note this and their corresponding death register (WC) numbers. Not all victims found on one scene are allocated to the same doctor and this information is useful for any subsequent investigations and for record keeping.

    - **If more than one body, this body's location in relation to the others**: when multiple casualties are present, take note of their location in relation to one another. This could be useful in subsequent investigations.

- **Type of scene location:** the type of location should always be noted. This refers to the scene type e.g. a formal house, informal house or open land.

- **Position of body on scene:** the position of a body on scene (e.g. supine, prone, on their side etc.) assists in the determination of manner of death. It also helps determine if the pugilistic posture is normal in relation to position. This information aids in determining manner of death and alleged account of events.

- **Crow-Glassman Scale of Burn Injury:** Full scale attached as Attachment 1. The CGS ranges from Level 1 (least severe, minor burns) to 5 (highly fragmentary remains present). The CGS also makes recommendations for specialised personnel who should be involved on scene (forensic anthropologists) and the key methodologies and tools to be utilised. If, according to the scale (Level 3 upwards), specialised personnel should be involved in recovery, they should be contacted before remains are disturbed.

- **Location of body on scene:** this refers to where the body is on scene (e.g. on a bed or on the floor). This can help determine the alleged account of events.

- **Debris on top of body:** note any debris on the body, even though most often it has been removed by CTFRS. If there is any debris on the body, it may help explain the pattern of pugilistic posture or explain any fractures.

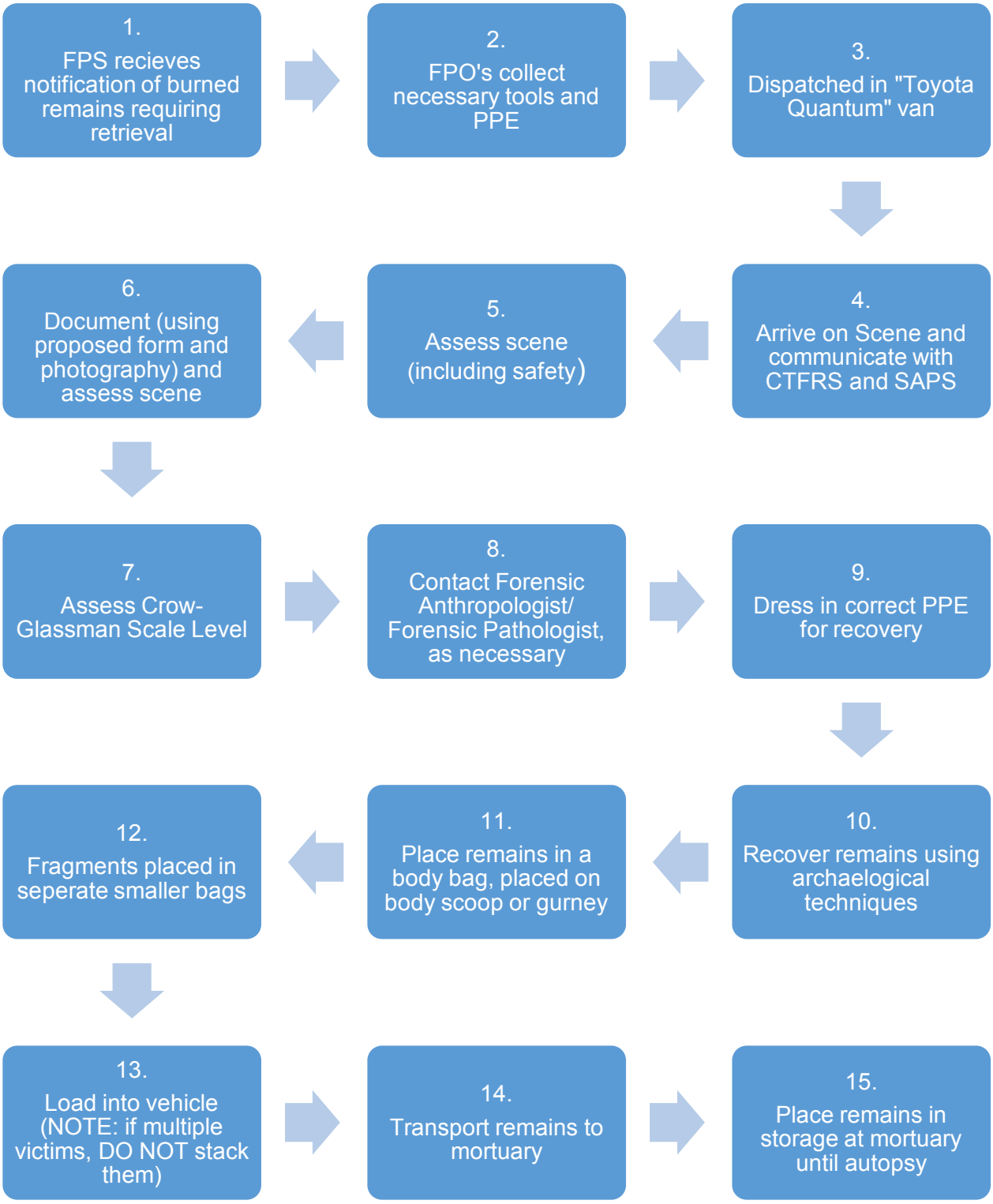
- **Remaining clothing on body:** note any remaining clothing, and if any clothing is found beneath the bodies it should be retrieved too. This could help in identification of a victim and also help ascertain the alleged account of events (e.g. if a decedent is not badly burned (CGS 1) but is naked, this could warrant further investigation).

- **Additional evidence:** any additional evidence found on the body or around it (e.g. loose electrical wires, wire around hands; pieces of burned tire, cartridge casings etc.) should be retrieved, if it has not already been by the SAPS. This information could aid in determining the manner of death and the alleged account of events.

- **Missing elements:** if any body pieces are obviously missing (such as a foot or hand), this should be noted on scene using the diagram provided on the documentation form. This allows the forensic pathologist to know that it was burned off and that it did not just fragment during transport from scene to mortuary. If found they should be placed in separate bags, and this should be noted.

- **Broken elements:** if any bones are obviously broken or fractured, note these and indicate this on the diagram included on the documentation forms.

Process of Burned Remain Retrieval



DO's and DON'Ts of Activities on Scene

SAFTEY:

- DO'S: **The scene must be assessed for all safety concerns**, prior to entering any fire scene to retrieve human remains. **Recommended PPE should be worn. Recommended tools should be utilised.**

- DON'T'S: **Do not dismiss the use of of proper PPE** on scene in favour of comfort or time. Fire scenes are more hazardous than other scenes and the proper precautions need to be taken.

DEBRIS:

- DO'S: Following initial photography and documentation, **all debris should be removed** piece by piece to uncover remains entirely, **before remains are moved.**

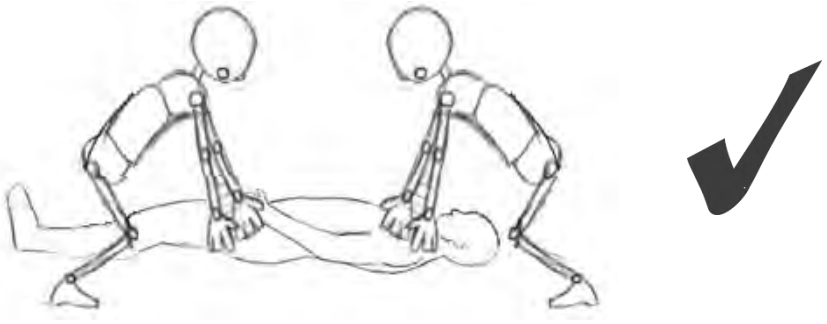
    - **By hand**, large debris can be removed.
    - Using a **trowel**, surrounding rubble can be gently pushed away before removing remains.
    - Using a **brush and dustpan**, ash and debris can be dusted off of remains without harm

- DON'TS: **Never remove a body before debris has been moved.** This could cause the remains to fragment.

LIFTING REMAINS

- DO'S: At least two people/FPO's should lift the remains. They should only **take hold onto stable aspects of the remains** which are less affected by burning and not fragmentary, often the shoulders and hips.

- DON'TS: **Never take hold of the arms or lower legs,** they have been shown to be more fragile in burned remains and are at risk of fragmenting.



REMOVAL OF REMAINS

- DO'S: The **body should be placed directly on a body scoop or gurney** which already has a **body bag on it,** directly adjacent to the remains.

- DON'TS: **Never pick the body bag itself up** to transport remains. **Never drag a body bag** (with remains in) over debris on the scene to get to a body board or gurney. **Never place more than one body in one bag.**

MISSING ELEMENTS

- DO'S**: Note any missing elements** from the body. The **area should be searched as much, and as logically, as possible to locate any missing elements** in order to ensure they are not being left on scene. If they are found, note this and see next point for details.

- DON'TS: **Never assume body parts have been burned away completely** if not still connected to the remains and are missing. First conduct a thorough search before making this assumption.

FRAGMENTED OR BROKEN BONES:

- DO'S: Any **fragmented or broken bones should be noted, collected** and **kept in separate bags.**

- DON'TS: **Never place fragmented pieces in the same body bag** with the body. They could further fragment if done so.

VAN'S

- DO'S: Always try **use a larger vehicle** for retrieval of burned remains, such as the **"Toyota Quantum"**.

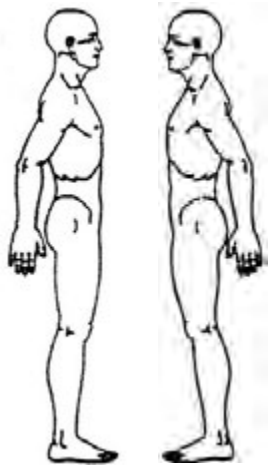
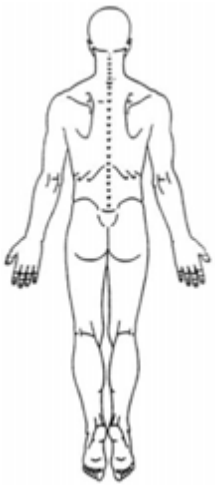
- DON'T'S: **Never force a body into a vehicle** if it does not fit, request that a larger vehicle be brought to scene. **Never place remains on top of each another** in the van, this could cause further fragmentation of the remains.

Attachment 1: Crow-Glassman Scale – Levels of Burn Injury on Scene

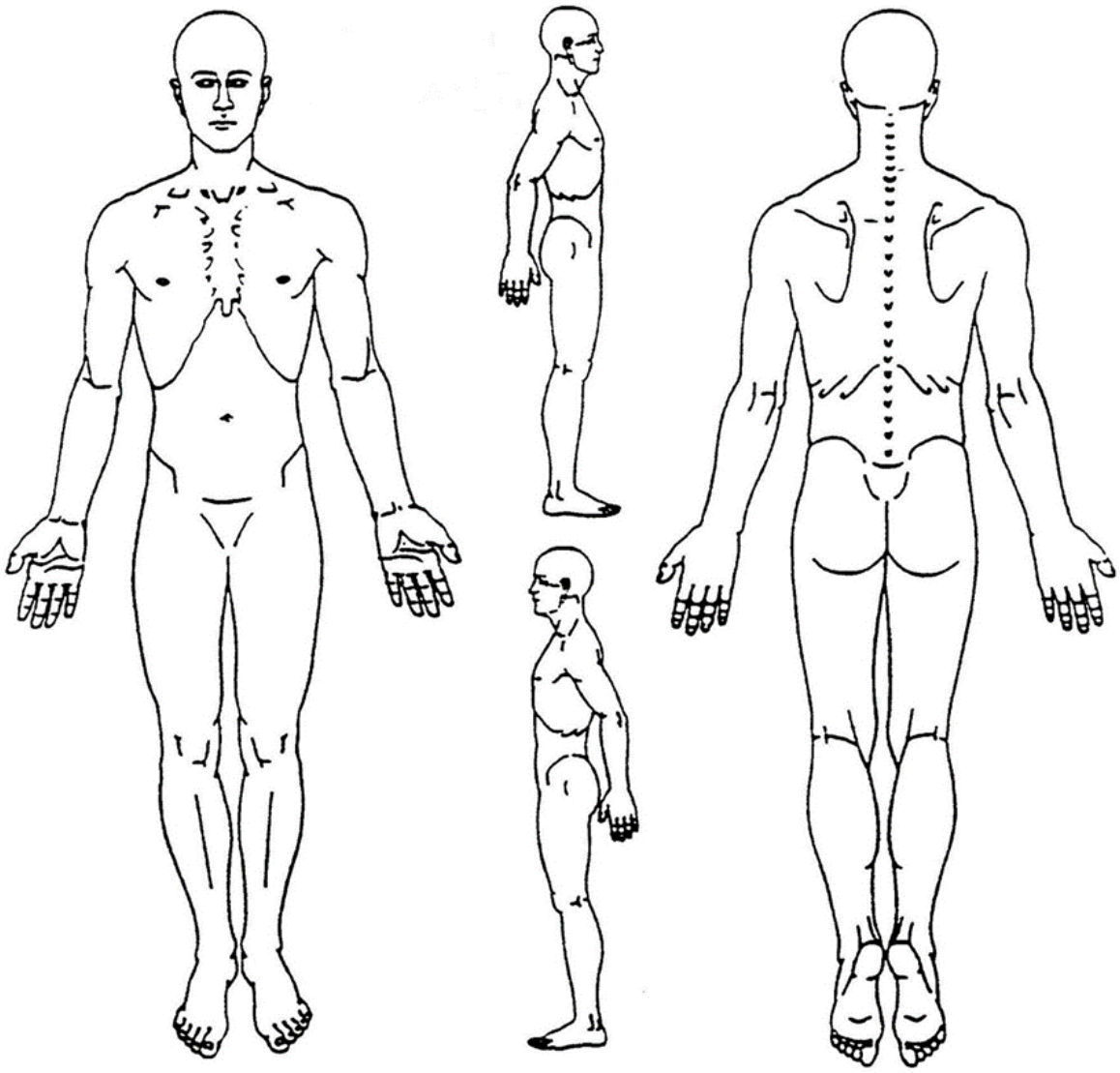
Crow-Glassman Scale Levels	Description of criteria for staging, and recovery and identification methods
Level 1	**Burn Injuries:** Typical injuries associated with a smoke death. May display superficial skin blistering and singeing of hair **Recovery:** No special techniques required for recovery **Identification**: Recognisable for identification
Level 2	**Burn Injuries:** Often displays varying degrees of burning (including charring). May include the absence of focal elements of the extremities, such as the hands and/or feet, and possibly the genitalia and ears **Recovery:** Recovery of disarticulated elements requires further searching of the immediate surrounds **Identification:** Possibly recognisable. Identification frequently made by collaboration of the medical examiner and forensic odontologist
Level 3	**Burn Injuries:** Major destruction/disarticulation of extremities (e.g. limbs and head) **Recovery:** Recovery of disarticulated remains requires a thorough and extensive search, preferably conducted by a forensic anthropologist, allowing for a thorough and a successful scene recovery of remains **Identification:** Non-recognisable. Coordinated by a medical examiner, with the frequent assistance of a forensic odontologist. Depending on destruction, a forensic anthropologist may be called on to determine a biological profile (e.g. age, sex, race)
Level 4	**Burn Injuries:** Extensive destruction including fragmentation of the skull, or absence thereof. Portions of the extremities may still remain articulated to the charred body **Recovery:** In order to locate small body fragments and dental elements, a forensic anthropologist using archaeological methodologies should be included in the search and recovery procedures **Identification:** Coordinated by a medical examiner in collaboration with a forensic anthropologist and/or odontologist, as needed
Level 5	**Burn Injuries:** Destruction rendering little or no tissue remaining. The skeletal remnants are highly fragmentary, scattered and incomplete **Recovery:** For successful recovery efforts of the complete cremains, a forensic anthropologist should be an on-site consultant **Identification:** Coordinated by a medical examiner who designates a forensic anthropologist to interpret cremains and create a biological profile. A forensic odontologist may be called on if dental elements need to be recovered or analysed

Attachment 2: **WC 11 / / .**

SCENE INFORMATION						
Alleged account of events & cause of fire:						
Number of bodies on scene:	1	2	3	4	More:	
If more than one body, this body's location in relation to the others: (E.g. in the same room; one on bed and one on floor)	Same room/area		Different room/area			
	Details:					
Type of scene location: (E.g. informal house, open land etc.)	Shack	House	Open Land	Vehicle	Other:	

BODY INFORMATION					
Position of body on scene:	Supine (Face-up)	On side (Left / Right)		Prone (Face-down)	
					
Crow-Glassman Scale of Burn Injury	1	2	3	4	5
Location of body on scene: (E.g. Inside; on bed etc.)	Inside		Outside		
	Bed	Floor	Bushes	Other:	
Debris on top of body: (E.g. roof tiles, wood etc.)	Yes		No		
Remaining clothing on body:					
Additional evidence: (E.g. wire around hands; burned tire etc.)					

Please indicate on the diagram all MISSING, LOOSE or BROKEN ELEMENTS on the body



<u>Photograph Check-list</u>

Overall Scene	☐
Bodies in relation to one another (if multiple casualties)	☐
Full body BEFORE debris removed	☐
Full body AFTER debris removed	☐
Face	☐
Broken elements (if present)	☐
Missing elements	☐
Additional evidence	☐

Literature used

Correia, P.M. & Beattie, O. 2002. A Critical Look at Methods for Recovering, Evaluating, and Interpreting Cremated Human Remains. In *Advances in Forensic Taphonomy: Method, Theory, and Archaeological Perspectives*. W.D. Haglung & M.H. Sorg, Eds. Boca Raton, FL: CRC Press LLC. 435–450.

Dana, S.E. & DiMaio, V.J.M. 2006. Fire and Thermal Injuries. In *Handbook of Forensic Pathology*. Boca Raton, FL: CRC Press LLC. 185–198.

Fairgrieve, S. 2008. *Forensic Cremation: Recovery and Analysis*. Boca Raton, FL: CRC Press LLC.

Glassman, D.M. & Crow, R.M. 1996. Standardization model for describing the extent of burn injury to human remains. *Journal of forensic sciences*. 41(1):152–154.

Godwin, Y., Hudson, D. A & Bloch, C.E. 1997. Shack fires: a consequence of urban migration. *Burns*. 23(2):151–3. Available: http://www.ncbi.nlm.nih.gov/pubmed/9177883.

Mock, C., Peck, M., Peden, M. & Krug, E. 2008. *A WHO plan for burn prevention and care*. Geneva, World Health Organization, Switzerland.

Peck, M.D. 2011. Epidemiology of burns throughout the world. Part I: Distribution and risk factors. *Burns*. 37(7):1087–1100.

Proctor, M., Carter, N. & Barker, P. 2009. Community assault - The cost of rough justice. *South African Medical Journal*. 99(3):160–161.

Symes, S.A., Rainwater, C.W., Chapman, E.N., Gipson, R. & Piper, A.L. 2008. Patterned Thermal Destruction of Human Remains in a Forensic Setting. In *The Analysis of Burned Human Remains*. C.W. Schmidt & S.A. Symes, Eds. London: Elsevier Ltd. 15–54.

Symes, S.A., Ph, D., Dirkmaat, D.C., Ousley, S., Chapman, E. & Cabo, L. 2012. *Recovery and Interpretation of Burned Human Remains*. U.S. Department of Justice.

Appendix B: Fire Scene Information Documentation

Date of fire: _____

Time of fire: _____ Time of arrival: _____

Case number & Station: _____ Fire Department: _____

Forensic Pathology Officer: _____ Investigating Officer: _____

Forensic Pathologist on scene: Yes/No

Location of fire-scene: _____

_____

GPS coordinates: _____

Scene:

□ Formal House □ Informal dwelling □ Open Land

□ Car □ Other _____

Number of decedents on scene. _____

Number of structures/dwellings/houses damaged: _____

Fire suppression methods used: _____

Site Description (access to scene included):

. _____

_____

_____

_____

Alleged account of events:

. _____

. _____

. _____

. _____

Weather Conditions:

□ Cloudy/overcast □ Raining □ Clear Skies

□ Windy □ Partly cloudy

Appendix C: Burned Remains Documentation

On scene

1. Decedent WC number: _____ Assigned data number: _____
2. Date of Fire: _____
3. Number of deceased persons discovered: _____
4. Positioning:

   □Prone □ Supine □Left side

   □ Right side □Other:_____

5. Extent of burning:

   □ Incomplete □ Complete □ Charred tissue

   □ Charred tissue + burned bone □ Charred tissue + calcined bone

6. Crow-Glassman Scale Level: _____
7. Debris on remains: Yes/No
8. Pugilistic positioning: _____

   _____

9. **Osteological Inventory and condition:**

Teeth:	Maxilla	R	M	M	M	PM	PM	C	I	I	I	I	C	PM	PM	M	M	M	L
	Mandible	R	M	M	M	PM	PM	C	I	I	I	I	C	PM	PM	M	M	M	L

Cranium:_____.

Mandible:_____.

Hyoid:_____.

Vertebra:_____.

Scapula: _____.

Ribs(24):_____.

Sternum:_____.

Clavicle(R/L):_____.

Humerus (R/L):_____.

Radius(R/L):_____.

Ulna(R/L):_____.

Hands (Carpals, Metacarpals, Phalanges): _____.

_____

Pelvis:_____.

Femur (R/L):_____.

Tibia (R/L):_____.

Fibula (R/L):_____.

Feet(Tarsals, Metatarsals, Phalanges) (R/L):_____.

_____

Documentation:

□ Photography □ Videography □ Sketches

□ Notes □ Positioning noted □ Context

□Forms of measurement

_____

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_____

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_____

_____

Recovery:

Personal Protective Equipment: _____

_____

Tools used:_____

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_____

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_____

How remains were recovered: _____

_____

Transportation materials/device: _____

_____

_____

How remains were placed into/onto transportation material/device: _____

_____

_____

How remains were placed into vehicle: _____

.

_____

_____

Time taken for recovery: _____

Mortuary

How remains are removed from vehicle: _____

_____

. _____

Placing and storage of remains: _____

_____

_____

Autopsy

Date of fire: _____ Date of Autopsy: _____

Pathologist assigned: _____

Forensic Pathology Officer assisting: _____

Alleged Identity features: Sex: M/F Age: _____

Osteological Inventory and condition:

Teeth - Maxilla	R	M	M	M	PM	PM	C	I	I	I	I	C	PM	PM	M	M	M	L
Mandible	R	M	M	M	PM	PM	C	I	I	I	I	C	PM	PM	M	M	M	L

Cranium: _____.

Mandible: _____.

Hyoid: _____.

Vertebra: _____.

Scapula: _____.

Ribs(24): _____.

Sternum: _____.

Clavicle(R/L): _____.

Humerus (R/L): _____.

Radius(R/L): _____.

Ulna(R/L): _____.

Hands (Carpals, Metacarpals, Phalanges): _____.

_____

Pelvis: _____.

Femur (R/L):_____.

Tibia (R/L):_____.

Fibula (R/L):_____.

Feet(Tarsals, Metatarsals, Phalanges) (R/L):_____.

_____

Aspects examined by pathologist:

_____

_____

_____

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_____

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_____

_____

Possible fire-artefacts noted:

_____

_____

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_____

Main autopsy findings and possible cause of death:

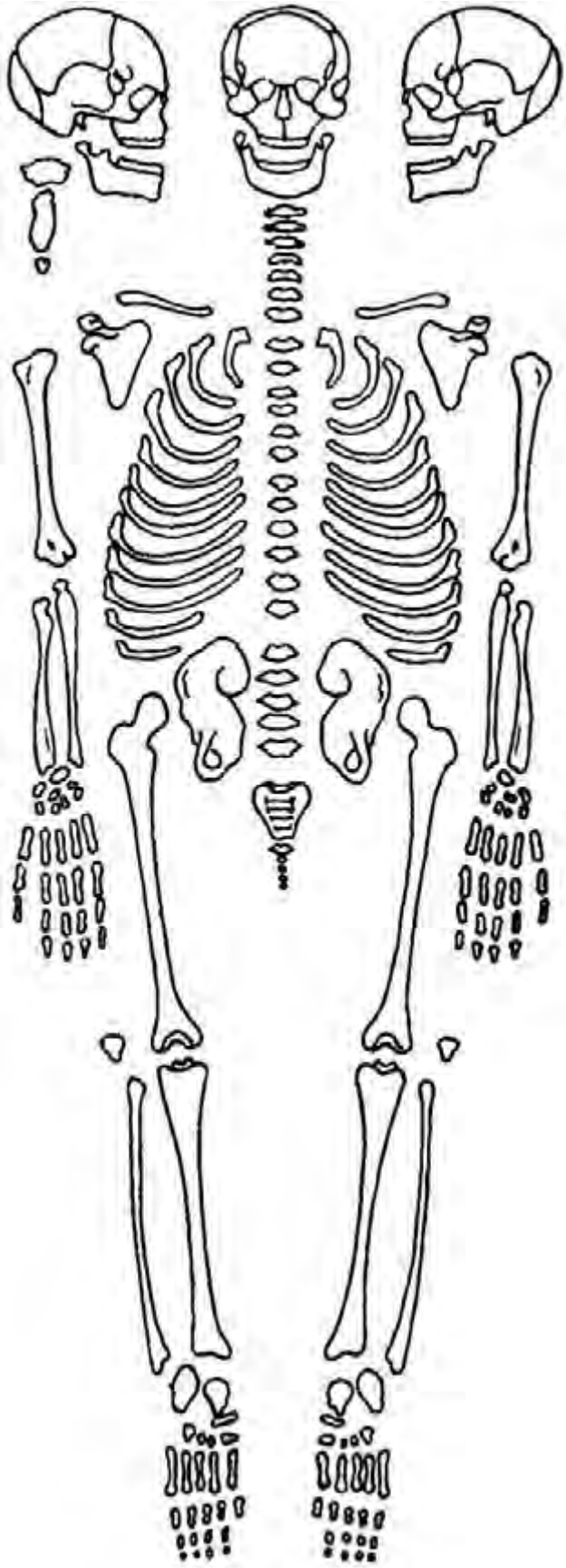
_____

_____

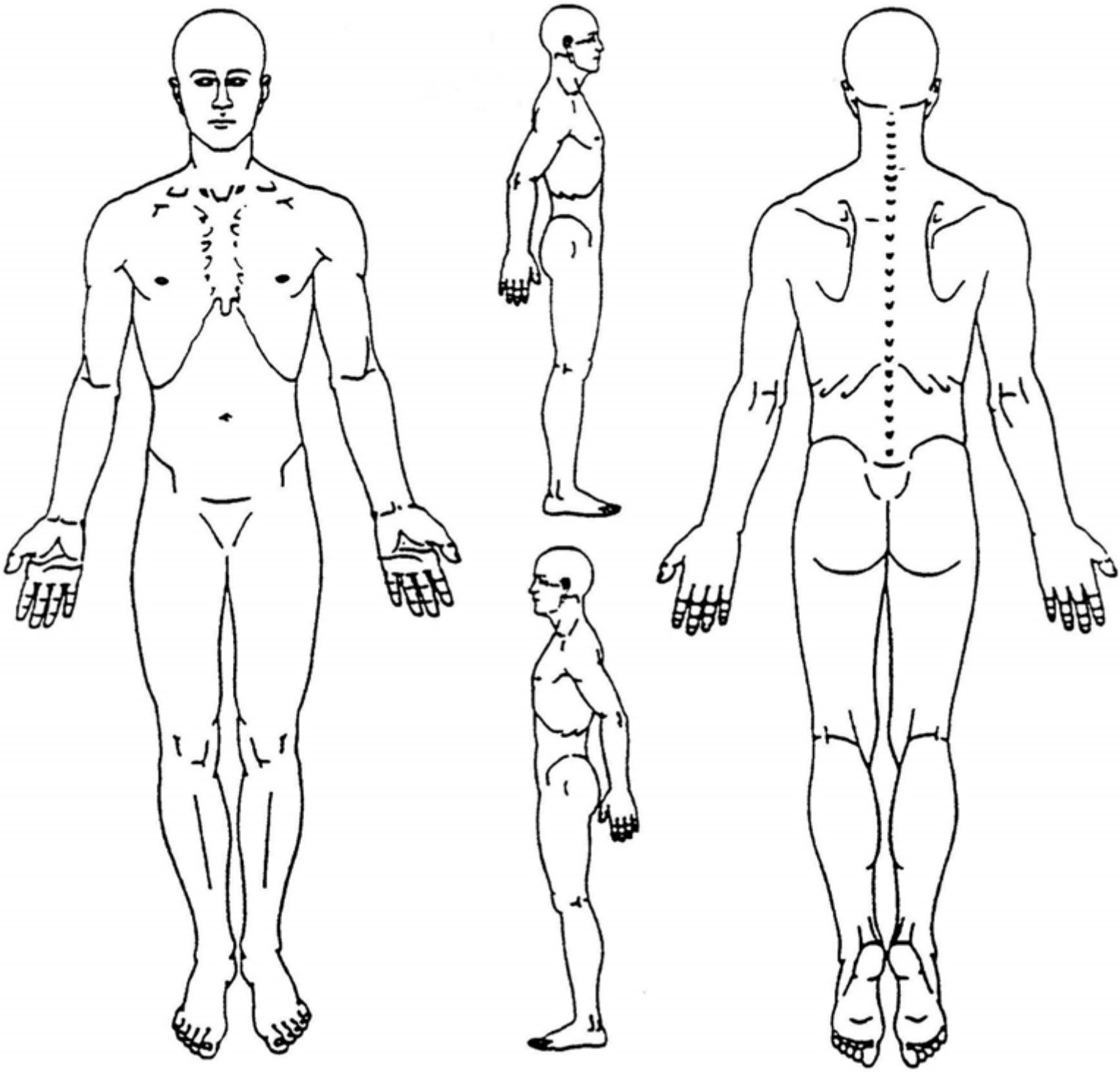
_____

Appendix D: Diagrams

Skeletal Diagram



Tissue Diagram



Appendix E: Participant information sheet

Division of Forensic Medicine
University of Cape Town
Faculty of Health Sciences
Falmouth Building, level 1, Entrance 3
Anzio Road
Observatory

Tel: 021 406 6412 / 6110

PARTICIPANT INFORMATION SHEET: **The Recovery and Handling of Burned Remains**

My name is Petra Schwab and I am currently completing my M.Phil. in Biomedical Forensic Sciences at the University of Cape Town.

Below you will find information about the research I hope to conduct, and it will explain your involvement. Please read all the information carefully before giving your consent and feel free to ask any questions you may have.

Purpose of the Study and Background

Salt River Forensic Pathology Laboratory (SRFPL) serves the West Metropole of the City of Cape Town, which has an average case load of 3 000 cases per year. An average of 90 cases involving burned remains are assigned SRFPL each year. At SRFPL, Forensic Pathology Officers (FPO) are the individuals who attend the crime scenes in order to retrieve human remains.

Many fires that occur are accidental, but on occasion fire is also used in suicides, homicides, or as a way to conceal or destroy evidence of a homicide. It is essential that all scenes involving burned remains are thoroughly documented so that the appropriate investigations can be done.

The complete recovery of human remains is not only essential for a comprehensive investigation, but also it also helps fulfil the needs and expectations of the family of the deceased. The complete retrieval of remains and the preservation of their condition is crucial, and currently burned remains pose a challenge or FPO's in this respect.

As a body is burned, it passes through a number of stages. Once the soft tissue is destroyed and the bones start to burn, they lose moisture and become very fragile. This causes burned remains

to break into pieces (fragment) which makes it quite difficult to locate and recover all the remains. On scene, small fragments of the burned remains may be missed because the surroundings are the same colour and texture. With burned remains being so fragile, they can often fragment more during transportation.

Fire effects a body in a particular way and the effects are usually predictable in accidental fires. One example is the “Pugilistic Posture” which burned bodies are often found in, which involves the arms and legs being bent in a specific way. These effects need to be preserved from the scene to the mortuary for the Forensic Pathologist to accurately analyse remains.

SRFPL is currently interested in setting up protocols (guidelines) for various aspects of their service. One aspect, which does not have any protocol implemented, is the recovery and transport of burned human remains. As explained, burned remains can pose various problems during recovery and transport, therefore a protocol may assist in making this task easier and safer and improve the quality of remains recovered, enhancing fatal fire investigation.

Procedure

For all cases assigned to SRFPL that involve burned remains, a staff member will contact me so that I can accompany FPO’s to scene.

Details of the fatal fire scenes will be noted, including the challenges faced, and settings in which the fires occurred. The condition of the remains will be analysed and documented in writing and by means of photographs. FPO’s will be observed in order to document aspects such as the current methodologies used to recover, handle, and transport remains, and the availability and usage of resources. Once at autopsy, the condition of the remains will be reassessed. By comparing the condition of the burned remains on scene to their condition at autopsy, any changes that have occurred can be attributed to recovery, transport and/or handling of the remains.

Once this knowledge has been gained, a protocol will be designed for usage by SRPFL during the recovery, handling and transport of all burned remains.

Both myself and all FPO’s have signed a confidentiality agreement with Forensic Pathology Services, preventing disclosure of any personal information and any information regarding crime scenes and procedures.

This research will not occur until the study has been reviewed and approved by the University of Cape Town, Faulty of Health Science, Human Research Ethics Committee. This committee is responsible for protecting the rights and welfare of individuals who participate in research studies. If you have any questions concerning the rights and welfare of a research participant in a study, please contact the Chairperson of the University of Cape Town, Faulty of Health Science, Human Research Ethics Committee, Professor Marc Blockman on (021) 406 6338.

Duration

This research will run from April to December 2015.

Risks

There are no known risks to any consenting research participants.

Benefits

This research will benefit SRFPL by setting up guidelines to use in cases involving burned remains. When the protocol is implemented, it will equip FPO's with the skills necessary to collect fragile remains, such as burned bodies, and improve occupational health and safety of officers on scene. The protocol aims to make the recovery of burned remains easier and more efficient for the FPO's.

Costs

There is no cost to any research participants.

Compensation

There will be no form of payment for taking part in the research.

Alternative

You may chose not to partake in this research and not to sign the consent forms. Your choice is personal, therefore it will not be questioned and it will not affect you negatively in any way. You may withdraw consent of participation at any point of the research however, I must be informed if you wish to do so.

Please read each sentence below in order to make your choice. After reading each sentence, please circle YES or NO. Your choice will not be questioned.

I, _____a Forensic Pathology Officer of Salt River Pathology Laboratory:

1. Have been informed about the study's purpose, procedures, possible benefits and risks.

   YES NO

2. Have been informed that my actions will be observed during the retrieval and transport or burned remains, for research purposes.

   YES NO

3. Have been given the opportunity to ask questions about the study and any misunderstanding I might have, has been addressed.

   YES NO

Thank you for your time. Please find attached the consent form if you wish to proceed.

Appendix F: Consent form

CONSENT FORM: MAKING YOUR CHOICE

I,_____a Forensic Pathology Officer of Salt River Pathology Laboratory:

1. Accept to be a participant of this specific research study.
   YES NO
2. Have been informed that consenting Forensic Pathology Officers will be observed during the recovery, transport and handling of burned remains, for research purposes.
   YES NO
3. Accept that all data collected during observation of FPO's will be used to improve the recovery and transport of burned remains.
   YES NO
4. Accept that all data collected during observation of FPO's can be used for further research into the setting up of protocols.
   YES NO

If you require any further information about this study, please contact Dr Sairita Maistry on (021) 406 6412 or by email at sairita.maistry@uct.ac.za. AND/OR contact Petra Schwab on (082) 850 0718 or by email at schpet036@myuct.ac.za.

Thank you for your time and participation. Please sign the consent form below if you so wish.

Signature of Participant Authorising Consent Date

_____

Printed Name of Participant Authorising Consent

_____ _____

Signature of Witness Date

_____

Printed Name of Witness

As a representative of this study, I have explained to the Forensic Pathology Officer, the purpose, procedures, possible benefits and possible risks of this research study, and the purpose of the data collection.

_____ _____

Signature of person obtaining consent Date

_____

Printed name of person obtaining consent

Appendix G: Human Research Ethics Committee approval letter

UNIVERSITY OF CAPE TOWN
Faculty of Health Sciences
Human Research Ethics Committee

Room E52-24 Old Main Building
Groote Schuur Hospital
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
Email: shuretta.thomas@uct.ac.za
Website: www.health.uct.ac.za/fhs/research/humanethics/forms

10 April 2015

HREC REF: 171/2015

Dr J Friedling
Human Biology
Anatomy Building

Dear Dr Friedling

PROJECT TITLE: THE IMPORTANCE OF A PROTOCOL IN THE RECOVERY AND HANDLING OF BURNED HUMAN REMAINS IN A FORENSIC CONTEXT (M-Phil-candidate-P Schwab)

Thank you for your response to the Faculty of Health Sciences Human Research Ethics Committee dated 9 April 2015.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30th April 2016.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

We acknowledge that the student, Petra Schwab will also be involved in this study.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Yours sincerely

Signed

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP), South African Good Clinical Practice Guidelines (DoH

2006), based on the Association of the British Pharmaceutical Industry Guidelines (ABPI),and Declaration of Helsinki guidelines.
The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

Appendix H: Pledge of Confidentiality

Western Cape Government

FORENSIC PATHOLOGY SERVICE

PLEDGE OF CONFIDENTIALITY

HANDLING OF CASE FILE RECORDS AND INFORMATION IN THE FORENSIC PATHOLOGY SERVICE

I, the undersigned, hereby declare that I understand that I will due to the nature of my work handle and have access to and insight in the confidential information of Forensic Pathology Case files and records. I further declare that I understand that everybody has the right to privacy in terms of the Constitution of the Republic of South Africa and further that the information for impart of a medico-legal investigation of death process .

I hereby pledge to-

- honour individuals' right to privacy as contemplated in the Constitution;
- hold in trust and confidence any information and/or documents of individual case files disclosed to me or discovered by me or prepared by me in the course of the handling of such documentation;
- not disclose (in any form/means) any information and documents to any unauthorised party/any other person;
- not to retain copies of any written information of any individual for any other purposes than the official records of this Department;

I understand and declare that I am fully aware of the serious consequences that may follow any breach/contravention of this Pledge of Confidentiality.

NAME	SIGNATURE	DATE

INDEMNITY

I, _____, hereby agree that during my clinical attachment period in the Division of Forensic Medicine & Toxicology, University of Cape Town, I am responsible for my own safety and that I will take all due precautions.

I understand that, should I be injured during my clinical attachment, I have no recourse against WCG property, WCG personnel or the University of Cape Town.

Signed: .....

Date: .....

Appendix I: Permission from the head of the Division of Forensic Medicine

Division of Forensic Medicine

Professor Lorna J Martin

P O Box 13914, Mowbray, 7705
Faculty of Health Sciences, Falmouth Building, Entrance 3, Level 1
Tel: +27 (0) 21 406 6412/6110 Fax: +27 (0) 21 448 1249
E-mail: lorna.martin@uct.ac.za
Internet: www.forensicmedicine.uct.ac.za

2 March 2015

I, Lorna Jean Martin, hereby grant permission for Miss Petra Schwab to attend death scenes and autopsies at Salt River Forensic Pathology Laboratory (Mortuary) for her research project. This will take place under the supervision of a forensic pathologist and in accordance with the UCT ethics approval.

I also grant permission for Miss Schwab to have access to our Office Autopsy Database and related records for this project.

The research must be anonymised by removing all identifiable patient information, and in accordance with the UCT HREC approvals.

Lorná J Martin
Professor, & Head of Clinical Department

Appendix J: Guide for Authors
Journal: "Burns" published by Elsevier

Introduction

Burns aims to foster the exchange of information among all engaged in preventing and treating the effects of burns. The journal focuses on clinical, scientific and social aspects of these injuries and covers the prevention of the injury, the epidemiology of such injuries and all aspects of treatment including development of new techniques and technologies and verification of existing ones. Regular features include clinical and scientific papers, state of the art reviews and descriptions of burn-care in practice.

Submission of papers

Authors are requested to submit their original manuscript and figures online viahttp://ees.elsevier.com/jbur which is the Elsevier web-based submission and peer-review system. Please follow these guidelines to prepare and upload your article. Once the uploading is done, our system automatically generates an electronic pdf proof, which is then used for reviewing. All correspondence, including notification of the Editor's decision and requests for revisions, will be managed via this system. If any illustrations, diagram or part of the text have been published elsewhere the source must be given in full, permission having been granted by the author and by the publisher.

Submitted manuscripts will be reviewed by selected referees and the author will be informed of editorial decisions based on the referee comments as soon as possible. For information about the status of your paper, please log on tohttp://ees.elsevier.com/jbur On receipt of the first decision letter authors should submit their revised manuscript within three months in order to ensure that the scientific content of their manuscript is timely and up to date.

Types of paper

- Original Paper
- Case Report
- Burn-care in practice
- Letter to the Editor
- Review Paper
- Editorial
- Personal Report
- Addendum
- Book Review

Online only publications

Due to the large volume of submissions to the journal, Case Reports will be published online-only and will be listed on the contents page of a print issue. Authors will be informed if their submission is selected to appear online only.

Contact details for submission

If you have any problems submitting your paper through this system, please contact the Editorial Office on e-mail: burns@elsevier.com; tel: +44 (0)20 7424 4267; or fax: +44 (0)20 7424 4911

Before You Begin

Ethics in publishing

For information on Ethics in publishing and Ethical guidelines for journal publication see https://www.elsevier.com/publishingethics andhttps://www.elsevier.com/journal-authors/ethics.

Human and animal rights

If the work involves the use of human subjects, the author should ensure that the work described has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for experiments involving humans, http://www.wma.net/en/30publications/10policies/b3/index.html; Uniform Requirements for manuscripts submitted to Biomedical journals,http://www.icmje.org. Authors should include a statement in the manuscript that informed consent was obtained for experimentation with human subjects. The privacy rights of human subjects must always be observed.

All animal experiments should be carried out in accordance with the U.K. Animals (Scientific Procedures) Act, 1986 and associated guidelines, EU Directive 2010/63/EU for animal experiments, or the National Institutes of Health guide for the care and use of Laboratory animals (NIH Publications No. 8023, revised 1978) and the authors should clearly indicate in the manuscript that such guidelines have been followed. **All animal studies need to ensure they comply with the ARRIVE guidelines.** More information can be found athttp://www.nc3rs.org.uk/page.asp?id=1357.

Conflict of interest

All authors must disclose any financial and personal relationships with other people or organizations that could inappropriately influence (bias) their work. Examples of potential conflicts of interest include employment, consultancies, stock ownership, honoraria, paid expert testimony, patent applications/registrations, and grants or other funding. If there are no conflicts of interest then please state this: 'Conflicts of interest:

none'. See alsohttps://www.elsevier.com/conflictsofinterest. Further information and an example of a Conflict of Interest form can be found at:http://service.elsevier.com/app/answers/detail/a_id/286/supporthub/publishing.

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Contributors

Each author is required to declare his or her individual contribution to the article: all authors must have materially participated in the research and/or article preparation, so roles for all authors should be described. The statement that all authors have approved the final article should be true and included in the disclosure.

Authorship

All authors should have made substantial contributions to all of the following: (1) the conception and design of the study, or acquisition of data, or analysis and interpretation of data, (2) drafting the article or revising it critically for important intellectual content, (3) final approval of the version to be submitted.

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Introduction
State the objectives of the work and provide an adequate background, avoiding a detailed literature survey or a summary of the results.

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Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference: only relevant modifications should be described.

Theory/calculation
A Theory section should extend, not repeat, the background to the article already dealt with in the Introduction and lay the foundation for further work. In contrast, a Calculation section represents a practical development from a theoretical basis.

Results
Results should be clear and concise.

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This should explore the significance of the results of the work, not repeat them. A combined Results and Discussion section is often appropriate. Avoid extensive citations and discussion of published literature.

Conclusions
The main conclusions of the study may be presented in a short Conclusions section, which may stand alone or form a subsection of a Discussion or Results and Discussion section.

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If there is more than one appendix, they should be identified as A, B, etc. Formulae and equations in appendices should be given separate numbering: Eq. (A.1), Eq. (A.2), etc.;

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Abstract

A concise and factual abstract is required. The abstract should state briefly the purpose of the research, the principal results and major conclusions. An abstract is often presented separately from the article, so it must be able to stand alone. For this reason, References should be avoided, but if essential, then cite the author(s) and year(s). Also, non-standard or uncommon abbreviations should be avoided, but if essential they must be defined at their first mention in the abstract itself.

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Highlights are mandatory for this journal. They consist of a short collection of bullet points that convey the core findings of the article and should be submitted in a separate editable file in the online submission system. Please use 'Highlights' in the file name and include 3 to 5 bullet points (maximum 85 characters, including spaces, per bullet point). See https://www.elsevier.com/highlights for examples.

Keywords

Immediately after the abstract, provide a maximum of 6 keywords, using American spelling and avoiding general and plural terms and multiple concepts (avoid, for example, 'and', 'of'). Be sparing with abbreviations: only abbreviations firmly established in the field may be eligible. These keywords will be used for indexing purposes.

Abbreviations

Define abbreviations that are not standard in this field in a footnote to be placed on the first page of the article. Such abbreviations that are unavoidable in the abstract must be defined at their first mention there, as well as in the footnote. Ensure consistency of abbreviations throughout the article.

Acknowledgements

Collate acknowledgements in a separate section at the end of the article before the references and do not, therefore, include them on the title page, as a footnote to the title or otherwise. List here those individuals who provided help during the research (e.g., providing language help, writing assistance or proof reading the article, etc.).

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Follow internationally accepted rules and conventions: use the international system of units (SI). If other quantities are mentioned, give their equivalent in SI. You are urged to consult IUB: Biochemical Nomenclature and Related Documents:http://www.chem.qmw.ac.uk/iubmb/ for further information.

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Please submit math equations as editable text and not as images. Present simple formulae in line with normal text where possible and use the solidus (/) instead of a horizontal line for small fractional terms, e.g., X/Y. In principle, variables are to be presented in italics. Powers of e are often more conveniently denoted by exp. Number consecutively any equations that have to be displayed separately from the text (if referred to explicitly in the text).

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• Submit graphics that are disproportionately large for the content.

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