DISASTER VICTIM IDENTIFICATION AFTER MASS FATALITY EVENTS:
LESSONS LEARNED AND RECOMMENDATIONS FOR THE BRITISH COLUMBIA
CORONERS SERVICE

By

MEGAN BASSENDALE
MSc, Dip FM

A thesis submitted in partial fulfilment of
the requirements for the degree of

MASTER OF ARTS

In

DISASTER AND EMERGENCY MANAGEMENT

We accept this thesis as conforming
to the required standard

Joe Scanlon, BJ, DPA, MA
Academic Supervisor

Jean Slick, MEd
Program Head, MA Disaster and Emergency Management

Gregory Cran, PhD
Director, School of Peace and Conflict Management

ROYAL ROADS UNIVERSITY

April 2009

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ABSTRACT

Identification of disaster victims from catastrophic mass fatality events should be an essential aspect of disaster response plans. This research analysed three case studies to identify issues that past identification efforts have encountered after mass-fatality events and key areas to incorporate into the British Columbia Coroners Service updated disaster response plan.
ACKNOWLEDGMENTS

I would like to express my sincere gratitude to my supervisor, Joe Scanlon, for his inspiration, patience, and positive feedback throughout the duration of this project. I would also like to extend a thank you to the British Columbia Coroners Office and, in particular, Karen Collins for providing me with an opportunity to conduct this research as well as for her continual support and optimism with regard to this project.

My gratitude also goes to my family, friends, and colleagues for their continued patience, support, and understanding while I carried out this project and degree program.
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TERMINOLOGY

In this thesis I use a number of specialised terms. Their definitions within the context of this research are as follows:

1. BCCS: The official acronym for the British Columbia Coroners Service.
2. Ante Mortem (AM) data: Information about a person when he or she was alive (e.g., dental x-rays).
3. Post mortem (PM) data: Data gathered from the human remains after death; for example, fingerprints.
4. Disaster victim identification (DVI): The task of establishing the identity of victims of a disaster (Prinz et al., 2007, p. 4).
5. Disaster response plan: The organisation, preventive measures, and response protocols developed based on the study of hazards and vulnerability in a specific location (Pan American Health Organization, World Health Organization, International Committee of the Red Cross, & International Federation of Red Cross and Red Crescent Societies [PAHO], 2006, p. 188).
6. Mass fatality: Any event in which there are more deceased individuals than can be handled using the existing local resources; or, within the Canadian context, an incident in which 20 or more people die in Canada at one time from one cause, or in which 20 or more Canadians die outside the country at one time from one cause (Scanlon et al., n.d.).
7. Closed disasters: Those in which the identities of all of the victims are known; the AM data collection can begin immediately after an incident (Sledzick & Kauffman, 2008). Generally, airline crashes or transportation incidents are considered closed.
incidents, and although it is important to consider that a manifest list may be incomplete or incorrect, the majority of the victims will be identified in this type of event (NIJ, 2006, p. 24).

8. Open disasters: Those in which there is no definitive list of the numbers or identities of the victims, such as floods, earthquakes, and tsunamis (Sledzick & Kauffman, 2008). It is important to note that it is possible for a closed incident to become open. For example, if a plane crashes into a neighbourhood, the victims on the ground will change an event that would normally be considered closed to open because who was on the ground would not be known (NIJ, 2006, p. 24).

9. Kinship analysis: A method of identification through analysis of the genetic structure of the family. The DNA profile of the human remains must fit into the family genetic structure for an identification to be made (Shaler, 2005b).

10. Nuclear genome (DNA): The autosomes and sex chromosomes that reside in the nucleus; excludes mtDNA (Jobling et al., 2004, p. 506). DNA is inherited from both parents—half from the mother and half from the father (NIJ, 2006).

11. Mitochondrial DNA (mtDNA): The circular genome carried by the mitochondrion (Jobling, Hurles, & Tyler-Smith, 2004). It is maternally inherited, and although it can be used to trace the maternal lineage, it is not necessarily unique (Shaler, 2005b).

12. Y-chromosome: One of the sex chromosomes, present only in men (Jobling et al., 2004, p. 510). Inherited only through the paternal line, the Y-chromosome of father and son and of full brothers is identical.
CHAPTER ONE – INTRODUCTION

Research has indicated that the frequency of mass disasters is increasing around the world (Perera & Briggs, 2008, p. 1), many of which are accompanied by mass fatalities. British Columbia is an area that is susceptible to natural disasters such as earthquakes and tsunamis; or with the upcoming Olympics in 2010, it could potentially be the target of terrorism, which could result in mass deaths. Such incidents would create pressure for the fatalities to be identified which would be the responsibility of the British Columbia Coroners Service (BCCS). Therefore, the procedure to manage mass deaths must be an essential and established element of the BCCS disaster response plan.

Although disaster plans usually account for the recovery of a small number of dead people in the immediate aftermath of a disaster, identification in the wake of a large-scale disaster can be much more complex and long term. Often disaster response plans do not comprehensively address this aspect despite warnings from experts about the lack of preparedness and useable guidelines to address this issue (Tidball-Binz, 2007).

Protocols need to be established prior to an event to overcome the challenges and facilitate an organised response to disaster victim identification (DVI) in the aftermath of a mass fatality. These protocols should incorporate lessons learned from earlier events, which thereby necessitates critical comparisons of the response to past mass-fatality events to identify areas for improvement (Perrier, Bollmann, Girod, & Mangin, 2006, p. S32).

Purpose of Disaster Victim Identification

The overall purpose of DVI is to identify victims and return them to their families as quickly and efficiently as possible. Past experience has demonstrated that families will pressure the relevant authorities to identify their relatives and return them to have closure and carry out
the death rituals according to their traditions, as well as to complete the procedures associated with death (life insurance claims, reading of wills, etc.) (International Committee of the Red Cross ([ICRC]), 2003). Authorities therefore need to have the capacity and capabilities to identify the individuals who have died in a given incident. If fatalities are mismanaged, the trauma that the bereaved families and affected communities suffer as a result can last much longer than the more physical effects of disasters (Sledzik & Kauffman, 2008; Tidball-Binz, 2007, p. 422).

Often the DVI efforts after a mass death event will be multidisciplinary and include various areas of expertise such as forensic odontology, pathology, genetics, forensic anthropology, and general forensic sciences. Open incidents that include unknown numbers and identities of the dead can make the identification efforts particularly difficult and possibly a long-term process.

In the past, a failure to document and learn following mass-fatality disasters has resulted in similar mistakes occurring time and time again, including a lack of appropriate planning for mass fatalities, a lack of operational protocols to address the needs of a mass-fatality situation, and nonconformity internationally with the protocols and guidelines for mass-fatality situations (De Winne, 2006, p. S9; Morgan et al., 2006, p. 6).

**DVI Guidelines**

Although an increasing number of manuals and guides have been dedicated to DVI to provide recommendations on what authorities should consider in creating mass-fatality plans, there is no consensus on which system should be followed; thus local jurisdictions decide on the techniques and protocols that they will use (National Institute of Justice [NIJ], 2006). The International Police Criminal Organization ([Interpol] 2008) has developed a DVI manual that it has distributed to member countries that includes forms for the collection of data and guidance
on techniques to use to identify human remains after mass-fatality incidents. However, use of the Interpol guidelines is not universal, and although many countries, including Canada, Australia, and the United Kingdom, have chosen to adopt this approach, it is not officially the international protocol, but a set of recommendations.

In addition, some aspects of the Interpol guide are impractical for widespread fatalities because they do not take into account the realistic situation after an incident (Scanlon, 2006a, 2008; Tyrrell et al., 2006). Assumptions such as that the bodies will be in one contained area are often not the case after a mass-fatality event (Hershiser, 1974; Hershiser & Quarantelli, 1979; Scanlon, 2006a, 2008; Scanlon, McMahon, & van Haastert, 2007). Typically in these incidents, bodies are spread across a wide area, and untrained civilians rather than the authorities that the guidelines recommend carry out the initial recovery (Hershiser & Quarantelli, 1979; Scanlon, 2008). Consequently, although the Interpol suggestions are valuable as a structure for DVI efforts, they have limited practical use. Local jurisdictions need to decide on the exact needs and protocols for their particular plan.

DVI Response

Typically, after an incident, the jurisdiction in which the event occurred will conduct and control the identification efforts (Scanlon, 2006b). However, as in the Bali bombing and the tsunami disaster, outside assistance, including international cooperation, may be involved if the event exceeds the capacity of the local authorities, if assistance is requested, or if assistance is offered to the jurisdiction in which the disaster occurred and is accepted (Griffiths, Hilton, & Lain, 2003; Lain, Griffiths, & Hilton, 2003; Scanlon, 2006b, 2008).
DVI in Canada varies from province to province depending on the incident and the death management system within a given area. In British Columbia, disasters fall under the jurisdiction of the coroner, and the DVI process is addressed within the BCCS’s disaster response plan.

BCCS DVI Plan

In the event of a mass fatality, the BCCS will respond in the same manner that it would with individual deaths in terms of identifying the decedents and determining where, when, and how the individual(s) died (BCCS, 2008). The province has developed and adopted the British Columbia Emergency Management System (BCERMS), which is a comprehensive arrangement that supports coordinated and organised response and recovery for disasters, and Interpol (2008) has proposed the plans that follow the guidelines.

In 2006 the BCCS established the Identification and Disaster Response Unit (IDRU), which is responsible for the coordination of disaster and mass-fatality response for the BCCS. Although this unit is still in the early stages of its development, under the direction of the chief coroner and in accordance with the BC Coroners Act, the IDRU has established a DVI task force composed of professionals in the DVI field which is based on recognized DVI and Incident Command System principles and practices (BCCS, 2008). Currently, the mission of the task force is, in accordance with the BC Coroners Act and following Interpol (2008) guidelines, to enhance the current BCCS Disaster Response Manual with established DVI and Incident Command System principles and practices (BCCS, 2008).

The task force is in the initial stages of establishing the operational structure of the DVI aspect of the disaster response plan. Thus the protocols and procedures that will be used in future mass-fatality situations are in the development stage. To ensure that the BCCS is properly prepared to handle a large-scale mass-fatality event, the IDRU intends to incorporate the lessons
Disaster Victim Identification

learned from past events into the DVI plan. This includes understanding and recognising the issues that have been identified in previous DVI efforts and planning ahead to avoid similar issues, where possible, in the BCCS response.

Identification Methodologies

In regular death situations, visual identification and personal effects can generally be relied upon to secure identification if the number of deceased is limited and there is minimal distortion to the physical features of the human remains. However, in situations of mass death, the standard protocols and procedures used for identification after single deaths are often not appropriate because the situation can be much more complex as a result of the distortion of physical features and/or fragmentation of bodies. Factors that will influence the complexity of the identification process in mass-fatality situations include the number of fatalities and the scope of the population involved in the incident, the condition of the human remains, the rate of recovery, the presence of a manifest and the availability of antemortem (AM) data (Brondolo, 2005; Interpol, 2008; Sledzick & Kauffman, 2008, p. 99; Tun et al., 2005, p. 455).

According to the Interpol (2008) guidelines, primary techniques (DNA, fingerprint, and odontological analysis) that involve comparing AM information to postmortem (PM) information to ascertain the identity of the dead should be used as the main identification techniques after a mass fatality and secondary techniques (visual identification, personal effects, and medical implants) only as corroborative data (Interpol, 2008; for a brief summary of the techniques, see Appendix A).

Purpose of Thesis

The purpose of this thesis is to examine three specific mass-fatality incidents that are similar to disasters that could occur within the BCCS jurisdiction, isolate the challenges
associated with the DVI aspects of these incidents, determine whether similar issues emerged in these events, and identify the lessons that can be learned from these experiences. Based on this information, I will suggest the key guidelines that need to be included in the newest version of the BCCS disaster response plan to assist the BCCS in developing relevant and comprehensive protocols and procedures to successfully handle DVI after a mass-fatality event. I will (a) review the literature on this subject; (b) discuss the major issues that emerged in the DVI aspect of three recent large-scale, open disasters; (c) compare the common factors in the mass-fatality events; and (d) assess the elements that should be incorporated into the BCCS DVI plan to better prepare the province for a mass-death event.

Assumptions and Limitations

The following research focused on the identification of the deceased in mass-death situations. I recognise that the identification methodologies used in single-death incidents or multiple fatalities (less than 20 people) are different from those employed in mass-fatality situations. Typically with single or multiple deaths, it is possible to identify bodies based on visual confirmation or personal effects (e.g., wallets, identification papers). In mass-fatality situations, these methods are often not appropriate if there is no presumptive identification and/or the remains are not in good condition because of the force of the incident and/or the recovery time.

The case studies that I used for this research are large-scale, open disasters with mass fatalities. Given that in this research I investigated DVI in cases of mass death, I assumed that the numbers of dead exceeded the capacities and protocols that the BCCS uses to investigate single deaths or the local capacities that it uses to investigate mass deaths. This research focuses on mass disaster death excluding pandemic deaths.
The problems that I discuss herein are limited to those that have been presented in the literature rather than any that I have directly observed. It is possible that I have not included additional issues in this research because published documents have not reported them.

Considering that the BCCS agreed to the research and intends to utilise it to enhance the disaster response plan, I assume that the reader has some knowledge of DVI and the 2008 version of the Interpol protocols and procedures.
CHAPTER TWO – LITERATURE REVIEW

Mass Death Literature

The body of literature on mass-fatality incidents and DVI spans numerous disciplines such as forensic sciences, dentistry, police investigation, emergency management, and government relations. In the past, emergency management literature has largely ignored the issue of mass death and particularly the issue of DVI within the confines of disaster and emergency management.

Much of the early research on the handling of mass death and the manner in which societies respond to mass-death incidents has been published through the Disaster Research Center at the University of Delaware (Blanshan, 1977; Hershiser, 1974; Hershiser & Quarantelli, 1976, 1979). In addition, Pine (1974, 1979) has written a number of articles on the role of the funeral director and other death specialists after mass-death situations. More recent disaster and emergency management literature has addressed the types of morbidity and mortality that are expected to occur from a disaster (Bourque, Siegel, Kano, & Wood, 2007); however, many researchers of emergency management and preparedness (e.g., Auf der Heide, 1989; Godschalk et al., 1999; Quarantelli, 1998) have tended to overlook this aspect of emergency management.

An increasing number of articles have addressed the issues and limitations of the current research literature on mass death and reviewed the changing patterns of dealing with the dead from mass-fatality events (Scanlon et al., n.d.; Scanlon et al., 2007). Scanlon et al. (2007) looked at the differences and similarities among the responses to pandemic as well as disaster deaths and suggested that the separation in planning for disaster deaths and pandemic deaths is needless and that an all-hazards approach to death planning is appropriate. Scanlon et al. also examined the
differences between the two types of death and the ways in which mass death has been handled in the past.

Scanlon (1998, 2006a, 2006b, 2008) also extensively explored the historic and current response to mass death incidents. In the 2008 article in particular, he analysed the response to the tsunami in Thailand and Sri Lanka and the emergence of multinational organizations in the aftermath of the event. In earlier articles, Scanlon (2006a, 2006b) discussed international cooperation after mass-fatality events, specifically the DVI process that was used in the tsunami incident and the problems that were encountered in the identification process. Scanlon (2006a) suggested that experts from various countries can learn from each other, but questioned whether the lessons that have been learned in the tsunami experience will be transferred into plans and guidelines in the future. Tsokos, Lessig, Grundmann, Benthaus, and Peschel (2006) also described the aftermath of the tsunami and the local and international response to the DVI efforts.

Tyrrell et al. (2006) explored the multinational response to mass fatalities and focused particularly on the tsunami response. In their poster presentation, which they delivered at the 2006 American Academy of Forensic Science meetings, they addressed the applicability of the Interpol (1997) guidelines for use in DVI and critically reviewed the tsunami response. This current study ultimately questions the practicality of using Interpol guidelines after a mass-fatality event.

No recent studies have examined numerous large-scale incidents and the common issues that arise with identification efforts. However, De Winne (2006) suggested that a lack of preplanning and nonexistent procedures and guidelines are not necessarily the reasons that major incidents are often not handled properly. Alternatively, he proposed that response to such events
would work better if mission statements encouraged everybody to work towards the same
desired ends, because people who are preparing for major incidents typically come from different
official bodies and disciplines and need a clear and common vision to give their people a sense
of direction and inspiration (p. S10).

Disaster Victim Identification Literature

In the recent past various organisations have produced guidelines to assist with planning
for mass death and identification efforts (Interpol, 2008; NIJ, 2006). In response to the World
Trade Center disaster in 2001, government agencies published several DVI handbooks. Some of
the more comprehensive publications include *The President’s DNA Initiative: Lessons Learned
from 9/11: DNA Identification in Mass Fatality Incidents* (NIJ, 2006) and *Mass Fatality
Incidents: A Guide for Human Forensic Identification* (NIJ, 2005). These documents are
designed as guides to the entire process of mass-fatality management and DNA identification.
The 2005 publication in particular is designed to help investigators to understand the death
investigation process and to assist them in developing operational tactics to identify human
remains from routine as well as mass-fatality incidents. As a result, the amount of information on
any one aspect of the process is limited. Round-table discussions and conference sessions have
also been generated as a result of these recent disasters (International Committee of the Red
Cross [ICRC], 2002, 2004, 2005; Prinz et al., 2007; Sribanditmongkol et al., 2005; Tun et al.,
2005; Tyrrell et al., 2006).

Currently, the Interpol (2008) guidelines are widely used to facilitate international
identification of disaster victims. This document outlines options for DVI and guides the overall
process. The most recent draft (Interpol, 2008) is more in depth than the previous version
(Interpol, 1997) and includes specific details on several aspects of the DVI process that were
missing from the earlier document such as the various identification techniques and the AM information that is required for each. However, because this guide is fairly general in nature, it does not address the potential drawbacks and problems associated with the various identification techniques, including the necessary conditions for a given identification method to work.

Although this guide is a useful tool to understand the processes involved in the management of the dead, it is of limited practical use for nonspecialists in the immediate aftermath of a disaster because it assumes that the responders will have a certain level of expertise that nonspecialists who respond to the disaster might not have (Tidball-Binz, 2007, p. 423). In many cases forensic specialists will not be able to reach a disaster site for days and potentially weeks after an incident, and during this time it is often local residents and volunteers who will handle the dead (Hershiser & Quarantelli, 1979; Tidball-Binz, 2007, p. 423). These individuals need practical and easy-to-follow guidelines to ensure proper and dignified management of the dead and to take the necessary steps to assist the future identification efforts of forensic specialists (Tidball-Binz, 2007).

To assist nonspecialist first responders in handling the dead, PAHO, in co-operation with the World Health Organization (WHO), the ICRC, and the International Federation of Red Cross and Red Crescent Societies (IFRC), has published a handbook on managing the deceased in the aftermath of a disaster entitled *Management of Dead Bodies After Disasters: A Field Manual for First Responders* (PAHO, 2006). This manual provides practical advice to non–forensic experts and first responders but does not go into extensive detail on any aspect of the identification process. It provides brief instructions on how to handle dead bodies after a disaster and includes AM and PM forms to collect basic information. These are complementary to those that Interpol
uses to collect the same information. In addition, this guide offers suggestions on how to create a reference number system to catalogue the human remains.

Within the academic literature, Scanlon (1998) has published an extensive article on the handling of the dead after the 1917 Halifax explosions that presents an in-depth look at the way in which the bodies were dealt with and identified. Scanlon also discussed several other events and contrasted how the bodies were dealt with in the different incidents and the changing procedures associated with death identification.

Tun et al. (2005) summarized the presentations and discussions at the Health Aspects of the Tsunami Disaster in Asia conference and analysed the identification aspects of the tsunami response, the management of fatalities with respect to public health, and the use of DNA in identification efforts. The authors examine several mass-fatality incidents and identified the resource requirements to manage such incidents. They suggested that assessment tools to determine the allocation of available resources, advance planning, and learning from past events will help future projects to deal with mass-fatality events.

A significant number of articles have been published on the technical aspects of the World Trade Center response; in particular, multiple articles on the DNA aspect of the World Trade Center response. Holland, Cave, Holland, and Bille (2003) discussed the advanced DNA extraction procedures that were developed to analyse the World Trade Center samples, and Brenner and Weir (2003) used the data from the World Trade Center and focused on the technical and theoretical genetic issues of the DNA efforts after this incident. Specifically, they explored the issue of the remains of possibly related people recovered from the incident and distinguishing between true and false relatives based on genetic information. They found that the
number of false relatives in a given disaster is proportional to the size of both the reference list and the victim list.

In addition, Leclaire et al. (2007) discussed the specialized software used to identify the remains from the World Trade Center. Because this incident resulted in massive fragmentation of bodies, and there were such a large number of victims, family reference samples and personal effects, it was necessary to re-write and rebuild the sophisticated software that had first been used after the Swissair disaster to match DNA samples and identify victims. This software became known as the Mass Disaster Kinship Analysis Program (MDKAP) program; it was designed to match large numbers of complete or incomplete DNA profiles to deduce the identity of or biological relationship between tested samples. The adaptation of the MDKAP program facilitated identification based on limited genetic profiles, which had previously been a problem in this incident.

Alonso et al. (2005) also discussed the challenges that affect DNA identification, including the number of victims, the mechanism of body destruction, and the extent of fragmentation, and examined the different steps involved in DNA identification from DNA sampling to analysis, database searching, and kinship analysis. They also looked at some of the lessons that had been learned from past events in terms of DNA identifications, including the importance of scientific collaboration and coordination and the use of internationally standardized DNA technology.

Budowle, Bieber, and Eisenberg (2005) also assessed strategic considerations that can be planned in advance of an incident with regard to the DNA strategy. These authors suggested 12 different areas related to DNA analysis that can be developed in advance in an action plan to make the DNA process smoother. Their recommendations include elements such as preparing
chain-of-custody paperwork prior to an event to having a quality control mechanism in place and software available for tracking and managing data.

Several studies have also suggested considerations that should be incorporated into future disaster planning. In examining the response to mass fatalities, Stehr and Simpson (2002) and Simpson and Stehr (2003) used the World Trade Center as a case study and suggested a number of new elements that should be included in disaster preparedness and response plans: planning for unthinkable events such as the tsunami, creating logistical mechanisms to deal with large numbers of casualties and fatalities, and having emergency drills to prepare for events.

In addition, Robert Shaler of the New York City Office of the Chief Medical Examiner (OCME) recently published a book in which he detailed the experience of identifying the human remains from the World Trade Center (Shaler, 2005b). He took an honest and direct approach to the World Trade Center identification efforts and described the process from the moment that the incident occurred to the end of the efforts. In addition, he presented another version of this information was at a conference (Shaler, 2005a). He provided detailed descriptions of the identification efforts after this event and the issues and challenges encountered during this work, including problems related to the collection of AM information and the lack of appropriate software at the beginning of the identification efforts to process the degraded DNA sample. For example, the people collecting the AM data were not experienced and therefore did not gather the correct details initially.

Similarly, numerous articles have been published on various aspects of the tsunami disaster. Morgan et al. (2006) studied the management of fatalities after mass disasters with a particular emphasis on natural disasters. Referring to the tsunami disaster and the response to it in three different countries, the authors advocated for the development of appropriate guidelines
to handle fatalities after a natural disaster. They suggested that there is a need to learn from the post disaster management of the dead from past disasters and stressed that the survivors of an incident have a right to see deceased victims treated with dignity.

Sirisup and Kanluen (2005) discussed the role of forensic techniques in the tsunami response and offered seven recommendations from the lessons learned in this incident, including adequate preplanning for an event in terms of protocols and logistics. They also stressed the necessity of proper training prior to an event and good teamwork during the response. Kvaal (2006) presented further recommendations for quality control and best practices in terms of forensic odontologists who work in situations that require DVI. The author proposed the use of documentation techniques such as x-rays and photographs and suggested that, although the Interpol forms are useful tools, they need to be improved as the science of dentistry progresses.

Valck (2006) assessed the DVI response to the tsunami with a particular emphasis on the use of forensic odontontology and the collection of AM dental records. Valck looked at the DVI process in this incident and some of the problems that were encountered, including overestimates of the dead, over reliance on one identification technique, and incomplete AM information for many of the victims. Kieser, Laing, and Herbison (2006) also presented information on the quality of the dental data that were submitted for entry into the Plass Data DVI System International software that was used for AM and PM data matching in the tsunami experience. They addressed the problems with the data entry at the temporary mortuary facilities as well as the problems with the incoming AM data and suggested that many of the records that were received at the mortuaries were of unacceptable quality for the DVI process. They recommended that a forensically trained dentist collect the AM dental information in the country of origin.
Further researchers on the development of matching software include Clement et al. (2006), who studied the development of newer software that had been created to match AM and PM data. The software is designed predominantly for the input of odontological information, and Clement et al. discussed the pros and cons of other software packages that were designed to facilitate this type of matching and the benefits of new software created by the authors, known as the DAVID Web. The authors gave a detailed account of the database design and the data entry process, the matching procedure, and the system requirements. They suggested that this software is easier to use than the DVI International program and corresponding Interpol forms because the DAVID Web does not require the user to memorize many pages of code as the DVI International program does. Furthermore, Clement et al. pointed out that the DAVID Web allows information to be entered directly into the program and thereby eliminates the need to handwrite forms. They suggested that this program is easy to use, is useful in DVI and missing persons investigations, and minimizes data entry but produces accurate results, limited only by the quality of the available data.

Schuller-Götzburg and Suchanek (2007) also discussed the use of dental techniques in identifying human remains after the tsunami experience and some of the problems with the identification efforts such as obtaining dental information for some nationalities. Petju, Suteerayongprasert, Thongpud, and Hassiri (2007) also reviewed the use of dental records in the tsunami response and the usefulness of this method overall as an identification technique. They concluded that it is a useful method because it is more efficient and easier than DNA analysis and can be used in cases of complete skeletonization where fingerprints cannot be used.

Schuller-Götzburg (2007) looked at the overall identification process after the tsunami, including the use of each forensic technique, and discussed the problems encountered in the response and
the changing need for flexibility in the use of the forensic techniques to establish identifications as time progresses. Schuller-Götzburg reported that some methods are potentially not viable because of the condition of the remains.

Sweet (2006) presented further information on the forensic odontological aspect of the tsunami response and gave examples of how the Canadian Bureau of Legal Dentistry laboratory at the University of British Columbia used the Internet to solve problems with the transmission of dental information in the aftermath of the tsunami incident by developing innovative solutions that allowed AM dental records to be quickly transmitted across a secure Internet site to the identification teams in Thailand.

Numerous articles have also been published on the genetics aspect of the DVI efforts. Lessig, Thiele, and Edelmann (2006) reported on DNA sampling and casework undertaken in the tsunami experience, and Prinz et al. (2007) published the results of a round table discussion that took place during the 21st congress of the International Society for Forensic Genetics. They recommended that the scientific community become better prepared to answer local authorities’ questions by formulating generally acceptable scientific standards for the most efficient use of DNA-based victim identification methods. Their 12 separate recommendations on the use of DNA in identification efforts focused on the role of the forensic geneticist in DVI efforts, and Prinz et al. stressed the need for a preparedness plan and an appropriate method of tracking samples, the importance of AM data collection, and the need for laboratories with appropriate qualifications to do the genetic analysis. These authors concluded with a statement on the importance of taking a multidisciplinary approach to identification efforts.

Research on the deaths associated with Hurricane Katrina is currently fairly limited. Although there are many popular magazine and newspaper articles on the deaths associated with
this event, there are few academic references. Donkervoort (2007) researched the manner in which accurate biological relationships in mass-fatality kinship identification can be established. The author suggested that forms used to record biological relationships are often critical and that inaccurately documented information can hamper the kinship analysis and DNA identification process. Donkervoort examined the Family and/or Donor Reference Collection (FDRC) forms that were used to document the familial relationships between the DNA donors and the purported missing individuals in the Katrina experience and suggested that the forms be improved to include categories that allow for the detailed collection of information in a clear and efficient manner. The author also suggested that frequent DNA collectors are more successful in recording accurate information and that training is necessary to enhance the information that is collected on the FDRC forms.

Donkervoort, Dolan, Beckwick, Northrup, and Sozer (2008) further discussed the role of kinship analysis in DVI efforts and, similarly to Donkervoort (2007), discussed the problems with the forms with regard to documenting the relationships between the DNA donors and the purported missing individuals. They analysed the effectiveness of the updated forms that were utilized in the Hurricane Katrina experience, which were developed after taking into consideration the lessons learned from the tsunami and World Trade Center identification efforts. Donkervoort et al. offered guidance on how to enhance the accuracy of data collection and suggested that improving the sample collection form by streamlining the DNA kinship identification process would decrease the burden on valuable resources during the identification efforts.

The Louisiana Department of Health (2006) published further information on the Hurricane Katrina DVI efforts in the report *Reuniting the Families of Katrina and Rita*, which
summarizes the work of the Louisiana Family Assistance Center, the national collection point for information on separated families as a result of Hurricanes Katrina and Rita. This report discusses the problems associated with the identification efforts in this incident as well as the overall number of dead and the manner in which they were identified.

Finally, forensic handbooks or textbooks include some discussion of fatality identification methods (Dix & Graham, 2000); however, often these books limit the information to ways to identify single bodies and/or bodies that have not suffered a great deal of damage. Often there is only cursory or no mention of how to identify victims of large-scale disasters with many dead, and normal death identification procedures do not apply because of the fragmentation or destruction of bodies from the incident. The exception to this is Adams and Byrd’s (2008) highly technical textbook that focuses on commingled remains at the World Trade Center from an anthropological and archaeological point of view, the identification of victims, and methods of processing this type of site using techniques such as bone-growth fusion and osteometric methods.

Chapter Summary

The literature covering disaster victim identification is spread across a multitude of disciplines. Many earlier articles focus on smaller scale identification efforts, and it is in recent years, with the occurrence of high profile disasters with large numbers of dead, that mass fatality identification has come to the forefront of research. Many of the case studies as presented above provide important details regarding aspects of the identification efforts that were successful as well as those aspects that were difficult and problematic, however, there is a lack of literature that compares the identification efforts of various events. Through an analysis of the literature
across the various disciplines, from forensic sciences to emergency management and disaster planning, valuable lessons can be learned that can potentially help future identification efforts.
CHAPTER THREE – METHODOLOGY

Research Approach

This research was conducted using the qualitative research method of grounded theory (Glaser, 1998; Strauss & Corbin, 1990) and therefore did not test a hypothesis, but rather deduced and inferred the results from the data. A comparative analysis was conducted of three contemporary incidents that resulted in mass death including: the World Trade Center disaster in the United States (US) in 2001, the tsunami disaster in Southeast Asia in 2004, and Hurricane Katrina in 2005, also in the US. I analysed the DVI process of each incident for specific factors and concepts that were challenging to each in order to develop categories that were common to all three disasters. For the tsunami, I limited my research to the experience in Thailand because much of the published research is concentrated on this experience; and for Hurricane Katrina, I concentrated on the experience in Louisiana for the same reason. I subsequently compared the data from the three incidents to identify the major problems in the DVI response, similar problematic factors in the events, and the factors that the BCCS should address in its disaster response plan.

I collected the data through document review and analysis. Secondary source documentation analysis was necessary because time and monetary constraints prevented me from collecting data on the situations and events by direct observation.

Selection of Events for Research

Historically, Canada has been fortunate in terms of mass disasters. Except for several air crashes (e.g., Gander, NL, 256 dead; Swissair 111, 227 dead), this country has not had a major mass-death incident (one that involves more than 1,000 dead) since the 1917 Halifax explosion in which approximately 2,000 people died. The mass fatalities in British Columbia have been
limited to one air crash (Trans Canada Airlines Flight 810) in which approximately 62 people died and the collapse of the Second Narrows Bridge in which approximately 20 individuals died (Jones, 2009; Public Safety Canada, 2009).

However, BC is in a major earthquake zone, and there is a distinct potential for a mass-death incident from an earthquake or a resultant tsunami. Earthquakes are commonplace in BC, and approximately 800 are recorded each year throughout the province (Inter-agency Emergency Preparedness Council, 1999, p. 5). Although many of these earthquakes are too small to be felt, the probability is high that a major earthquake will occur within the next 200 years (p. 5). In the past each of the west coasts of South and North America has been hit by at least one tsunami. In 1960 an earthquake that measured 9.5 on the Richter scale struck off the South Central coast of Chile, and the resulting tsunami killed an estimated 200 people. In 1964 an earthquake in Alaska measured 9.2 on the Richter scale, and the resulting tsunami hit Port Albemi, BC (United States Geological Survey, n.d.).

Furthermore, like everywhere else, BC could face a terrorist attack. The planes that struck New York City on September 11, 2001, could just as easily have aimed at Canadian cities, including Vancouver, or the Olympics could attract terrorists as Munich did in Black September. British Columbia is vulnerable to a number of different types of incidents, and there is a significant need to plan for victim identification after an event that results in mass fatalities.

Given the lack of contemporary mass-fatality events in Canada with the number of dead in the thousands, I selected international incidents as the basis for this research. All of the events that I selected had an unprecedented number of dead, and I chose them because a similar incident could occur within British Columbia. All of the incidents also had large numbers of unidentified human remains, an intense identification aspect to the response efforts, and a significant number
of resources have been published on each of them. Different mass death events from around the world such as earthquakes, plane crashes, terrorist attacks and floods were considered for this study, however, there was insufficient published data about the DVI aspects of many of these incidents to include them within this study. In addition, I selected open disasters with unknown identities and numbers of dead because they are often the most challenging types of disasters from which to identify victims.

The Source of the Data

Royal Roads University confirmed that an ethical review was not necessary for this study because I used no human subjects in this research. I gathered all of the information from government documents, published case studies on incident-specific identification efforts, as well as scientific papers and professional conference presentations. Every attempt was made to gather all of the relevant studies pertaining to the three incidents that were selected for this study. This included a review of literature from multiple disciplines covering topics such as DNA, dentistry, government reviews, emergency management literature, scientific roundtable results, and conference proceedings. The vast majority of this material is published in peer-reviewed academic journals and on professional Web sites. Non-professional reviews and analysis of the studied incidents were not used for this study. It should be noted that there is significantly less information on the identification efforts after Hurricane Katrina than on the efforts after the World Trade Center and tsunami incidents. I obtained information on the variables that are specific to the BCCS and its involvement in mass fatalities and DVI planning directly from the BCCS.
Analysis of the Data

Given that a grounded theory approach was utilised for this research, I analysed and compared each of the incidents that were the basis for this study to find a set of common variables and patterns. The literature on each of the incidents was studied for issues that were difficult or challenging during the identification phase. In order to consistently compare the incidents, the data was organised according to the numbers of victims, the number of nationalities involved in the identification efforts, and the major issues and/or difficulties in the DVI efforts. Originally, all challenges that were encountered during the identification phase of each incident were included in the data. I entered the data that I compiled from the literature into a spreadsheet and compared the incidents with the research problem in mind to determine the main issues in each event. All literature was reviewed using this approach. Once I had reviewed and compiled the data for all references, it became clear that the issues focused on three main areas: planning and preparedness, collection of AM data, and identification methodologies. This data was then analysed and compared across the incidents to determine what lessons could be learned from past identification efforts and the subsequent recommendations that could be utilised for developing the BCCS disaster response plan.

Researcher Bias

The author of this research has a professional background in forensic anthropology with a significant amount of experience working on DNA-led identification projects in the international context. While I acknowledge that DNA-led identification projects are at times, the only method of identifying human remains, I recognize that there are other methods of identification that are equally useful, depending on the context of the disaster, the state of the human remains and the available AM data. During this study, all methods of identification were given the same
consideration. I did not prioritize projects that used DNA as the main identifier over projects that used other methods such as odontology or print analysis.

Chapter Summary

The data for this grounded theory study was deduced from information obtained in the literature published on the DVI efforts of three specific mass fatality events. While Canadian disasters would have been preferential for this study, given the lack of large-scale, mass fatality events within Canada, international events were selected. A number of different disasters were considered but the three that were chosen for this research were selected because they were deemed the most relevant considering that it was important to study events similar to those that could potentially occur in BC. Furthermore, these specific events were selected because there is a significant body of literature published on the identification efforts of these incidents.
CHAPTER FOUR – RESULTS

Keeping in mind the background of the standard identification procedures associated with mass-fatality events, the status of the plan in BC, and the literature available on the subject of mass-fatality DVI, I will now discuss specific disasters with intense DVI aspects in chronological order according to the date on which the incident occurred. Chapter 6 presents in-depth comparisons of the events and the lessons that should be incorporated in the BCCS DVI plan.

The World Trade Center

On September 11, 2001, two commercial airliners were hijacked and crashed into the two World Trade Center towers, resulting in the total destruction of both planes, the collapse of both towers, and approximately 2,749 deaths (Shaler, 2005b). Many of the human remains were highly decomposed, highly fragmented into pieces of bone ranging in size from splinters to large sections, and affected by the intense heat of the incident. They were identified by using a variety of methods, the main one of which was DNA because of the extensive fragmentation and commingling. Interpol guidelines were not followed in this event.

The New York Office of the Chief Medical Examiner (OMCE) carried out the identification efforts, with assistance from multiple federal authorities and private-sector businesses, until April 2005, at which point they were suspended. At this time 1,592 of the presumed 2,749 that died had been identified (Shaler, 2005b). Of this number, approximately 10% were identified with dental methods, 5% from fingerprints, and 81% through DNA analysis. It is important to note that in many cases more than one technique was used to secure an identification.
Planning and Preparedness

Identification of the victims from the World Trade Center was slowed because no disaster response plan was in place to address DVI and the issues that accompany the identification of large numbers of people after an incident (Shaler, 2005a). Although New York City had a disaster plan, the OCME did not and was not prepared for a mass-fatality incident of this scale (Shaler, 2005b). Furthermore, identification and the use of DNA to facilitate identification was not a part of the NYC plan, and there was no preplanning for the DNA testing strategy and how it would be carried out (Shaler, 2005b).

In addition to technical problems with the identifications, the lack of a plan led to information flow processes that were disorganized, overlapping, redundant, and inefficient (Shaler, 2005b, p. 183). There was no central repository for information in a single, easily accessible location, and problems were solved on an ad hoc basis as each issue arose. Those with managerial responsibility were incredibly busy and solved individual problems in a “vacuum” (p. 183). There was no organised workflow, it was difficult to learn specific details on samples or cases, and work was often repeated.

The lack of data transferability between laboratories was also an issue (Shaler, 2005b). Information was stored in various locations, and the databases were not linked electronically. Data on the families were stored in one agency (in Albany), whereas the World Trade Center DNA data on the remains were stored in another location (at the OCME). The two agencies were not electronically linked to share data until 2002, which caused delays in the identification process.
Establishing an accurate manifest list of the victims from this incident was difficult. There were several different types of victims, some of whom were easier to account for than others. It was possible to develop a more or less accurate list of people who were working in the buildings and who were on the planes that crashed. However, it was much more difficult to account for people who were visiting the World Trade Center, the responders who were killed in the incident, and people who were in the vicinity when the incident occurred. Several family assistance centers and call centers were set up to receive AM information, and embassies provided information on foreign victims. Initially, 6,500-10,000 people were listed as missing, but in 2002 this figure was reduced to 3,400 (Shaler, 2005b). The 2002 lists were not complete or highly accurate, however, because families who did not submit DNA samples at a collection agency were not included in the lists, the manifest list included redundant and erroneous entries, some marginalised groups had been omitted from the list (Aguirre & Quarantelli, 2005), and there were 40 cases of fraud (Shaler, 2005b, p. 172). In addition, the International Affairs Bureau of the New York Police Department (Simpson & Stehr, 2003) managed the official list. This office received reports of missing people from all sources (embassy lists, company rosters, and missing-persons reports) and compiled the information into a single list. All missing-persons reports were taken at face value, which inflated the numbers, and it took a significant amount of time and resources to cull the list and eliminate the redundancies (Simpson & Stehr, 2003). In addition, initial assumptions about the number of casualties who had been visitors to the buildings also inflated the numbers. Later analysis revealed that 98% of the victims were at work when the collapse took place (Simpson & Stehr, 2003. It was not until 2004 that a more accurate list was produced (Shaler, 2005a).
The New York Police Department was actively involved in the AM information collection, and its members did not have adequate experience or training in data collection for use with the various identification techniques or in kinship analysis (see Appendix A), to carry out this task for such a complicated disaster (Shaler, 2005b). Initially, there were no written guidelines on how the information should be collected or what information and samples were necessary for kinship analysis to identify a victim (Shaler, 2005b). The interviewers did not know what to collect or the correct questions to ask, and no one monitored the individuals who were collecting the information to check the process for errors and inaccurate data (Donkervoort, 2007; Shaler, 2005b). The process was not standardized, and multiple collections from the same families occurred.

Further problems were evident during the AM collection phase because, given that the police did not have any experience with kinship analysis, they did not know which or how many familial DNA samples were required to match family samples with victims. As a result, insufficient or no DNA reference samples were gathered for an estimated 1,500 families, and it was necessary to go back to gather the data. This was time consuming for the project and painful for the families (Shaler, 2005b). In addition to this, many of the DNA samples from both personal effects that were found or swabs that the families submitted did not contain a sufficient amount of DNA to make the identifications, which also required return visits to the families (Shaler, 2005b).

Further issues arose in collecting the AM data because all of the information was gathered by hand and subsequently transcribed (Shaler, 2005b). There was no concurrent review, and a high number of clerical errors in the collected data resulted. Consequently, a great deal of
time was spent amending the corrections (Shaler, 2005b). Shaler suggested that out of 4,500 collections, 1 in 6 had errors of some type.

Gathering direct reference samples for the victims of the incident was also problematic. Some of the personal effects recovered from suspected victims’ residences carried biological traces from an individual other than the victim (Leclaire et al., 2007). Furthermore, many personal effects that could have been used as direct reference samples were unavailable because the owners had had them and they were lost in the incident, objects were contaminated with another individual’s DNA, or it was not possible to retrieve DNA from the object (Leclaire et al., 2007). As a consequence, the identification efforts had to rely heavily on kinship analysis which is a more complicated type of analysis.

The labelling and tracking systems that were used in this incident also caused problems. Multiple systems of reference numbers were used, depending on where and how the family had submitted information and where and how many DNA samples had been submitted, and the different departments and agencies that dealt with the various aspects of identification had assigned various numbers and codes. Consequently, one family or missing person could potentially have several different reference numbers. This led to organisational problems, confusion, and conflicting and redundant information. In some cases the wrong family name was assigned to a deceased individual as a result of labelling confusion, and families were connected with the wrong body. In one particular case this occurred because a DNA sample that belonged to one deceased had been accidentally combined with the personal effects of another individual (Shaler, 2005b, p. 153). Although this kind of error is usually discovered and rectified, the error slows the process and is painful for the families of the victims.
Identification Methodology

The methods used to identify the World Trade Center victims were severely limited given the nature of the event. The impact of the incident, in combination with the abnormally high temperatures from the fuel explosion; the collapse of the towers; the prolonged exposure to different weather conditions, fire, and water; and the use of heavy equipment in the recovery process caused an extraordinarily high level of destruction to the human remains (Budimlija et al., 2003; Leclaire et al., 2007). This, in combination with the high number of deceased, complicated the identification efforts (Brenner & Weir, 2003). Rapid recovery of the remains was impossible because the process of sifting through the debris lasted 10 months (Leclaire et al., 2007). In the majority of cases, DNA was the only method of identification possible because of the state of the bodies; however, the badly degraded DNA made standard testing problematic because it was not possible to generate complete DNA profiles, and, consequently, it was necessary to find alternative methods to extract useable DNA profiles (Brenner & Weir, 2003; Leclaire et al., 2007; Shaler, 2005b).

The OCME did not have the in-house capacity to deal with DNA testing because of the volume or the complex nature of the human remains and DNA samples. The volume and intense labour that were required to test the human remains from the World Trade Center disaster exceeded the capacities of the regular channels used for DNA testing. In addition, the samples were so degraded that only certain labs experienced in analysing this type of material and bones from decomposing bodies could conduct the forensic bone DNA analysis. Because no agreements had been made ahead of time on what the labs could do this, a great deal of time was spent looking for DNA labs that could analyse the quantity of samples that were in compromised condition while ensuring quality (Shaler, 2005b).
Not only was the number of samples that had to be processed unequal to that from any previous disaster, but the samples were also extremely complicated. Appropriate DNA matching software or statistical analysis programs were not immediately available to facilitate the identifications, and there was no useable IT infrastructure to deal with the situation (Leclaire et al., 2007; Shaler, 2005a). The DNA software needed to be able to store the DNA profiles from the deceased, family samples, and personal effects in the same database to enable multiple electronic comparisons at the same time. Whereas in smaller disasters it was possible to do this type of matching manually, the large volume of samples from the World Trade Center disaster meant that this was not an option. The software used for regular cases (CODIS) was not appropriate in this situation, and it was difficult to find other software during the identification phase (Shaler, 2005b). Eventually, it was necessary to re-write and rebuild the software (MDKAP) that was used created and used during the Swissair disaster for the World Trade Center incident.

The DNA testing strategy caused further problems in that, initially, soft tissue was used for DNA analysis. However, this sampling strategy led to false associations (Budimlija et al., 2003) because of the partial nature of the remains and the soft tissue transfer and commingling that resulted from the disaster. Consequently, the DNA testing strategy used mainly bone samples to ensure accurate identification (Budimlija et al., 2003).

Furthermore, because of the type of disaster and the high level of fragmentation (over 20,000 individual pieces; Simpson & Stehr, 2003, p. 118), a single sample could theoretically be the only identifiable remains of an individual, and in some cases bodies had disappeared without a trace as a result of the impact (Brenner & Weir, 2003; Budimlija et al., 2003; Leclaire et al., 2007; Shaler, 2005a, 2005b). As a result, it was necessary to test even the smallest piece of bone
because it might be the only remaining fragment of a missing individual. Unfortunately, a larger percentage of the recovered remains yielded partial or no genetic genotypic information (Leclaire et al., 2007). Consequently, software and analysis techniques had to be developed and adopted during the identification phase to enable the further identification (Leclaire et al., 2007; Shaler, 2005a, 2005b) and matching of the remains. MDKAP, was enhanced to meet the needs of the World Trade Center incident to match large volumes of DNA profiles (Shaler, 2005b).

\textit{World Trade Center Summary}

A number of problematic issues arose in the DVI efforts after the World Trade Center incident. Although New York City was prepared for a small-scale disaster with several hundred deaths, the authorities were not at all prepared for an event of the magnitude of the World Trade Center. The lack of plans on how to proceed in such a situation was a major issue that slowed the identification efforts. Developing an accurate manifest list of the dead; gathering appropriate, adequate, and accurate AM information; and implementing a workable tracking system for the various types of information that were generated presented problems. Issues emerged in the implementation of a standard tracking procedure that resulted in the loss of bodies because the tracking numbers had changed in the movement between facilities. There was no capacity to process and analyse the DNA samples, and new mechanisms had to be developed to address the degraded and poor quality of the DNA from the remains. An incident-specific problem that challenged the identification efforts in this event include the intense fragmentation and destruction of the remains. In summary, the main problems for this disaster were as follows: (a) the lack of an overall disaster response plan to guide the process; (b) the lack of data transferability between facilities; (c) the lack of an accurate manifest list of the missing people; (d) the lack of guidelines on AM data collection and therefore inaccurate and inadequate AM
data collection by untrained individuals; (e) inaccurate data entry, transcription, and translation; (f) the lack of availability or contamination of direct reference samples for DNA analysis; (g) the lack of a standardized tracking mechanism from the beginning of the DVI efforts; (h) the limited identification methodologies because of the fragmentation of remains; (i) DNA degradation; (j) the unprecedented volume of DNA samples (AM and PM); (k) the lack of facilities to process the quantity of DNA samples and ensure quality; (l) the lack of software to analyse the highly degraded samples and carry out the complex and multiple matches; (m) the false associations that resulted from the soft-tissue DNA samples; and (n) the fact that fragmentation could mean that one bone could represent an entire individual.

The Tsunami

On December 26, 2004, the earthquake and resultant tsunami in the Indian Ocean killed an estimated 226,000 people in 12 countries. Of this number, approximately 5,000-6,000 individuals were killed in Thailand, and half of them were foreign tourists (Schuller-Götzburg, 2007; Sribanditmongkol et al., 2005; Tun et al., 2005). There was little or no fragmentation of the remains from this event, and the bodies were more or less intact (Shaler, 2005a). The recovery of most of the bodies was quick, but some remains were not found in the immediate aftermath of the incident but rather several weeks and months later.

Mainly private citizens recovered the bodies, and no records were kept on the country of origin of the deceased. The bodies were taken to temples and laid out in rows for identification by family and friends.

Several days after the disaster, the Department of Disaster Prevention and Mitigation of the Ministry of Interior (Thailand) ordered that the identification efforts be consolidated under the Royal Thai Police in some areas and the Forensic Science Institute, Ministry of Justice, in
other areas (Srībanditmongkol et al., 2005, p. 2). On January 12, 2005, the Thai Tsunami Victim Identification Information Management Center (TTVI-IMC) was established and implemented standard operating protocols by following some aspects of the Interpol guidelines (Schuller-Götzburg, 2007). The Thai initiative came about as a result of the Australian Federal Police initiative, which had been organised after the Bali bombing and was a two-country agreement. The Thai agreement after the tsunami was a 24-country agreement. The TTVI-IMC attempted to identify the deceased until December 2005 (Schuller-Götzburg, 2007), at which point it turned its efforts over to the local authorities.

Prior to the establishment of the TTVI-IMC and implementation of the Interpol guidelines, there had been an attempt to separate the Thai from the non-Thai individuals. Claims of identification based on visual recognition were accepted, and local authorities released an estimated 1,600 bodies before a formal identification system based on visual recognition by families was developed (Petju et al., 2007, p. 252). In addition, six Danish bodies were identified and released after the bodies had been tagged with number and photographs posted on bulletin boards and online.

Once the Interpol guidelines were implemented, procedures for pathology, odontology, photography, fingerprinting, reexamination, the moving of bodies, the chain of custody, and DNA testing of the AM and PM samples were established (Tsokos et al., 2006, p. 187). AM and PM data were compared using Plass Data DVI System International and the French version of AFIS software called SAGEM Morpho (Scanlon, 2008). A board of medical and police authorities reviewed the matches and accepted only three criteria as sufficient for identification (dental data, fingerprints, or DNA); they considered all other methods corroborative (Scanlon,
Once they confirmed an identification, they issued a death certificate and officially released the body to relatives (Tsokos et al., 2006).

As of November 2006, Interpol’s coordinated efforts resulted in the identification of an estimated 3,272 of the 3,680 victims officially registered. Of this number, 1,956 were foreigners and 1,316 were Thais (Schuller-Götzburg, 2007, p. 2). Dental analysis was the predominant method of identification for victims from outside Thailand and fingerprint analysis for Thai and other Asian populations (Petju et al., 2007, pp. 252-253). DNA identifications were minimal in this incident (Schuller-Götzburg, 2007; Schuller-Götzburg & Suchanek, 2007). Although an updated breakdown of identifications per technique is not available for November 2006, by June 29, 2005, 1,882 people had been identified, 1,352 (71.84%) through dental analysis, 454 (24.12%) through fingerprint analysis, 54 (2.87%) through DNA, and 22 (1.17%) through physical evidence.

Planning and Preparedness

After the tsunami the lack of a central command center and national mass-fatality plan at the beginning of the disaster response slowed the identification process (Sribanditmongkol et al., 2005; Tun et al., 2005). The lack of a plan for such a large number of deceased (Sribanditmongkol et al., 2005; Tun et al., 2005) limited the initial quality and timeliness of the response. Issues had to be worked out during the response rather than implementing a set of established procedures, and this problem was exacerbated by the absence of practical field guidelines or an international agency to provide technical support in the immediate aftermath (Morgan et al., 2006). There was confusion over the identification process and no clear command center to manage the bodies (Sribanditmongkol et al., 2005; Tun et al., 2005). There were no specific regulations related to the investigation of the deaths or disposal of the deceased,
and, initially, there was a lack of facilities for the identification efforts, including a lack of storage as well as mortuary space, documentation facilities (digital cameras), and transport and cold storage for the bodies (Perera, 2005; Sribanditmongkol et al., 2005).

The initial lack of structure and standard routines was also problematic (Perera, 2005; Tun et al., 2005; Valck, 2006). Guidelines for the investigations were changed several times, and, initially, the response of the local and international teams was largely uncoordinated (Lessig et al., 2006). Furthermore, multiple protocols were being used. Once the standard operating procedures (SOPs) were agreed upon, they were difficult to enforce (Perera, 2005). Although all of the victims were to be identified, some teams looked for missing individuals from only their own countries (Tun et al., 2005). Furthermore, newcomers maintained their way of doing things, and those who ran the site resisted what they regarded as interference (Scanlon, 2006b; Valck, 2006), which resulted in inconsistent PM data (Valck, 2006). In addition, the Interpol standards lacked information on scientific methodologies to resolve complex problems that arise from attempts to identify large numbers of missing people from disasters with open-ended populations (Tyrrell et al., 2006).

Given the lack of identification protocols in the early stages, body examinations were redundant, and different teams used different standards (Sribanditmongkol et al., 2005). The international community failed to use an effective protocol that would focus explicitly on managing numbers of deceased who were from many different cultural and ancestral backgrounds (Tyrrell et al., 2006). Furthermore, when the international teams first arrived in Thailand, coordination did not immediately go well (Perera, 2005; Tun et al., 2005). Initially, the identification efforts were blocked, and the arrival of many foreign teams caused confusion (Perrier et al., 2006; Sribanditmongkol et al., 2005; Tyrrell et al., 2006; Tun et al., 2005). The
initial misunderstandings could be resolved only with high-level diplomatic measures (Perrier et al., 2006).

Problems existed in ensuring that efficient data-management procedures were in place and ready to process and match the AM and PM data. Moreover, the lack of computerized records in some places made it difficult to match the PM and AM information (Petju et al., 2007).

*AM Information*

One of the significant issues that arose in the aftermath of the tsunami was that, because the victims were from so many different countries, it was difficult to create an accurate manifest list of people who were missing (Tyrrell et al., 2006; Valck, 2006). Sweden, for example, highly overestimated the number of dead at 2,300 when, in fact, the number was 519 (Valck, 2006, p. S16). Furthermore, more than one source reported some individuals as missing (Scanlon, 2006b; Tyrrell et al., 2006), and because many had lost their belongings, it was difficult to notify the families when a family member was found safe. Consequently, the missing persons list contained the names of people who were in fact not dead (Tyrrell et al., 2006). Some countries had a better mechanism for registering people that were likely to be included amongst the dead. The Canadian system function well because they used a case management database system called CAMANT, which is part of COSMOS (Consular Management Operations System). This system allows Canadian Foreign Affairs missions to access information in the database in real time (Scanlon, 2007, p. 223) and specific questions are built into the system that does not allow the call taker to proceed with information gathering until specific questions that identify the caller have been answered and entered into the database. As information is being taken, the
system automatically checks for duplications of birthdates and similar names to highlight the operator (Scanlon, 2007: 223).

In addition to the registered residents and tourists, large numbers of unregistered residents (Burmese migrants) were also among the victims who needed to be accounted for on the manifest list and identified (Valck, 2006). As a result of uncertainty of the victims, it was difficult to know what AM records were required. Furthermore, the development of the official list was problematic because the system used to determine who was missing functioned poorly. The police and courts maintained separate offices, and much of the information was duplicated (Perera, 2005).

The collection of AM information and details from the families of missing persons was also a major issue after the tsunami. Different countries used different methods for obtaining data, and these systems were not consistent (Valck, 2006). Because the spectrum of countries represented was wide, the DVI teams had different standards for forensic training and experience (Kieser et al., 2006). The procedures to collect AM data were slowed because, in some cases, inexperienced people such as embassy and foreign affairs staff were collecting the data from families, and there were no clear instructions on the protocol to determine which identification technique to use to collect which data (Perrier et al., 2006). Furthermore, the standards for acceptable and useable AM information differed depending on the country in which it was collected, and many of the records that were supplied had to be returned or supplemented with additional details (Tyrrell et al., 2006). In some cases it was necessary for the interviewers to return to families or homes several times before they found or received the correct AM information (Tyrrell et al., 2006).
Obtaining appropriate AM data from relevant sources overseas was also problematic. In some countries where dentists keep dental records, family practitioners were sometimes too busy to prepare adequate records or not aware of the unique requirements for DVI charting and radiographs (Kieser et al., 2006). Many of the countries that had citizens killed in the tsunami did not have adequate AM dental information for identification purposes (Kieser et al., 2006; Sribanditmongkol et al., 2005). In some cases the dental records that were available revealed that some dentists had charted only their own personal dental work rather than all the dental work present in an individual's mouth, and the information followed no standard quality or format, which was a problem for some of the US’s records (Scanlon, 2006b; Schuller-Götzburg, 2007).

There were reports of inappropriate fingerprint data being collected, and some of the transmitted fingerprints lacked standard format, quality, and information. Images that some agencies transmitted did not always have the proper scale and were therefore incompatible with the SAGEM that was used to analyse the fingerprint data. In some cases the data collectors did not know which items would hold relevant information, ignored items that contained latent fingerprints (personal effects), and used only the prints available from official records (Valck, 2006).

Some countries adopted a hierarchical, preferential approach to the AM forensic samples in the early stages and collected only certain details to the detriment of others (Tun et al., 2005; Valck, 2006, p. S17). Some countries opted for dental identification, whereas others considered DNA more productive and therefore disregarded fingerprint and dental information (Valck, 2006, p. S17).

In addition, no standard set of AM information was available for all of the victims. Although some countries such as Israel, Indonesia, Sweden, and Thailand kept certain AM
records on file for some citizens (e.g., fingerprints in Thailand; DNA via the blood bank in Sweden; dental records, fingerprints, x-rays, and blood types for the military in Israel), this was not the case for missing people from all countries (Scanlon, 2006b; Valck, 2006). This made the AM data collection for some nationalities more difficult.

In some cases, translation of data into English slowed down the process (Valck, 2006). Some abbreviations and handwriting were illegible in the AM records, which occasionally led to data-collection errors and miscommunications (Scanlon, 2006b, 2008).

Because the scale and scope of the tsunami, it was difficult to obtain many details, objects, and samples that contained useful direct reference samples and AM information because they had been destroyed or contaminated by the incident. Many houses and hotels had been completely washed away, along with all personal belongings, and in some cases entire families had died. This limited the personal effects from which AM data could be collected for DNA direct reference samples or fingerprint analysis (Valck, 2006). Furthermore, because the decedents included many relatives, it was often not possible to obtain familial reference samples for kinship analysis because the people from which the (best) samples could have been taken had also died.

The system of numbering and labelling the bodies was not well organized at the beginning of the identification process, which made it difficult to track the bodies at a later stage (Schuller-Götzburg, 2007; Sribanditmongkol et al., 2005; Tyrrell et al., 2006). The victims were not labelled in a uniform fashion and were labelled several times using different numbering systems, which led to significant organisation issues later (Schuller-Götzburg, 2007, p. 11). When bodies were brought together at one mortuary at times there were issues because more then one body had the same number. In addition some labels were illegible due to the use of non
waterproof pens and some labels fell off and were lost altogether. Reassigning numbers to cases repeatedly led to confusion (Tyrrell et al., 2006), and this issue continued into the collection and processing of DNA samples when several different numbering systems were created (Scanlon, 2006b; Sribanditmongkol et al., 2005; Tyrrell et al., 2006). No single facility had records of all of the numbers, and the inconsistent and multiple labelling systems, combined with the inconsistent chain-of-custody procedures, meant that bodies and other evidence were difficult to find and follow.

**Identification Methodology**

The environmental conditions of Thailand and prolonged exposure to tropical heat, humidity, larvae, and fungi caused rapid decomposition of the bodies and made visual identification almost impossible after 24 to 48 hours (Morgan et al., 2006). Forensic methods were the only means of identifying the majority of the bodies given the decomposition and damage to the human remains. However, the selection of identification techniques was inconsistent. Some authors suggested that certain morgues relied more on DNA samples when other methods such as photographs, fingerprints, and forensic dental examination would have been cheaper, faster, and more efficient (Tun et al., 2005, p. 457).

The immediate Thai response after the tsunami involved local identification protocols to identify bodies (Tyrrell et al., 2006). Appropriate identification methods according to Interpol’s standards were not always followed, and valuable information was often lost. Some authors have suggested that during the first two days after the tsunami, the inhabitants and sometimes the authorities in some areas (Phuket and Khao Lak), organised and quick disposal of a very limited number of bodies by cremation or burial (Huckenbeck, Thiele, Krause, Lessig, & Szibor, 2008; Kidder, 2007, p. 3; Tsokos et al., 2006, p. 185). Some reports suggest that initial efforts tried to
separate the Thai victims from the foreigners based on clothing, hair colour, and some esoteric traits such as nipple size, public-hair style, and leg-to-trunk ratio (Huckenbeck et al., 2008; Tsokos et al., 2006; Tyrrell et al., 2006). This led to potential problems because after the relatives of the victims had visually identified the bodies, they were free to take the family member home and conduct the desired burial ritual (Huckenbeck et al., 2008; Tsokos et al., 2006, p. 185).

Using DNA as an identification technique after the tsunami was a problem because it had a very low success rate (Schuller-Götzburg, 2007, p. 11). The environmental conditions of the area were harsh, and the rate of body recovery from the sea was slow. Extensive decomposition and DNA degradation resulted, and it was difficult to extract DNA (Alonso et al., 2005; Perrier et al., 2006).

In addition, a variety of nonstandard means were used to take DNA samples, often with a high potential for contamination and confusion over where the samples should be taken from the bodies. The DNA samples were also contaminated as a result of unclean equipment, putrefaction of liquids, and contaminated formalin that was used to fix the bodies (Perrier et al., 2006). DNA from one person often contaminated the soft tissue of another. In some cases, DNA from compact bone samples resulted in authentic DNA profiles, whereas the DNA from adhering soft tissue or bone marrow yielded different, incorrect profiles (Zehner, 2007). Finding a laboratory that could handle the quantity of samples and ensure adequate quality was also a problem (Schuller-Götzburg, 2007).

Tsunami Summary

The number of dead that resulted from the tsunami disaster was unprecedented, and at the time of the incident there were no local plans or protocols to facilitate the identification efforts.
The local authorities were completely unprepared for the event, and the resources were exhausted immediately. The lack of planning, logistical inadequacies, SOP problems, issues regarding what could be accepted as positive identification, and the overall plan for the process of identification were also problematic. The influx of teams from around the world with their different procedures and protocols resulted in issues, and it was difficult to create a manifest list of the missing. The inability to gather AM information from such a vast group of nationalities with different standards of health care and dental information was an obstacle, as were communication and the tracking of cases among the facilities. In summary, the following issues complicated the DVI efforts after the tsunami disaster: (a) the lack of an overall disaster response plan to guide the process; (b) the lack of consistent and standard guidelines for PM examinations; (c) problems with coordinating international teams; (d) the creation of an accurate manifest list of missing people; (e) the lack of guidelines for the AM data collection; (f) the inadequate and inaccurate AM details collected because the individual who collected the information were untrained; (g) the destruction of AM information in the disaster; (h) the problems associated with obtaining AM records from overseas; (i) the failure to collect AM data for all identification methods at one time; (j) the lack of systematic standard in terms of the AM information that was received; (k) inaccurate data entry, transcription, and translation; (l) lack of availability or contamination of direct reference samples for DNA and analysis; (m) lack of a standardized tracking mechanism from the onset of the DVI efforts; (n) over reliance on one of three primary identification techniques; (o) DNA degradation; (p) the lack of facilities to process the volume of DNA samples and ensure quality; (q) the lack of available software to analyse highly degraded samples or make complex and multiple matches; and (r) contamination of the DNA samples, which resulted in false associations.
Hurricane Katrina

On August 29, 2005, Hurricane Katrina struck the Gulf Coast of the US. An estimated 1,464 fatalities resulted from this event, 1,118 within Louisiana and 346 outside Louisiana (Boyd, 2006; Donkervoort et al., 2008; Louisiana Department of Health [LDH], 2006). The remains from this incident were largely intact; however, because of the time that it took to recover many of the bodies and the weather in the area, significant decompositional changes occurred to a high proportion of the remains. The dead from this event were primarily US residents, and American authorities, predominantly the Louisiana Family Assistance Center (LFAC), with assistance from the Department of Defense and National Disaster Mortuary Operational Response Teams handled the response to the incident (LDH, 2006).

Interpol’s guidelines were not used in this event, and methods of identification that the Interpol guidelines considered secondary (pathology, personal effects, and field case notes) were utilised to confirm identifications. Several different methods of identification were used to identify the deceased from this incident: 115 (8%) through dental records, 130 (9%) through fingerprints, 72 (5%) through DNA, 403 (28%) through pathology, 389 (27%) through personal effects, and 332 (23%) through field case notes. In most cases several techniques were necessary to confirm an identity (LDH, 2006, p. 7). DNA analysis (mostly kinship analysis) was used when all other means of identification were exhausted (Donkervoort et al., 2008; LDH, 2006).

The LFAC officially ceased operations on August 14, 2006, and the remaining identification efforts were handed over to local parishes and law enforcement agencies. At this time 1,441 (98%) individuals from the estimated 1,464 remains had been identified (LDH, 2006, pp. 5-6).
Planning and Preparedness

In terms of planning, the biggest problem in the identification efforts was that the authorities were not prepared for the vast movement of people. Consequently, the mechanism used to create an accurate manifest list of the deceased victims was limited. Communication on many levels was difficult at best as a result of the poor cell service and the inoperable phone lines, and the software that was used to manage AM and PM information and to track missing persons and identify remains was a problem (LDH, 2006).

AM Information

Compiling an accurate manifest list of the missing people and gathering the appropriate AM data for them was problematic after Hurricane Katrina. Initially, 13,197 people were reported missing to the Family Assistance Center (LDH, 2006). In fact, the actual number was much smaller, and the official death toll stabilised at 1,464 individuals according to 2006 reports (LDH, 2006). One factor that led to such high estimates was the lack of organisation of a location where the families of potential victims could report them missing. The various lists of missing individuals were in different formats and locations, and most were unofficial (LDH, 2006). In some cases family members thought that they had officially listed a relative as missing when in fact they had not. It took some time before an official list of the deceased was compiled and appropriate AM data gathering began.

Gathering the necessary AM and kinship data for the deceased individuals was challenging after Hurricane Katrina. In some cases people with little experience or background in genetics and kinship data collected the AM data, and they did not necessarily know which details to collect or which kinship samples to take from family members because they did not have experience, training, or a background in this type of work (Donkervoort et al., 2008). As a result,
it was difficult for the identification teams to interpret the pedigrees and kinship relationships because the data from the families were not clear.

Further complications arose in the AM data compilation because a large proportion of the data that doctors or dentists in Louisiana held had been destroyed in the floods. In addition, because of the vast destruction of personal property, many of the objects that would have held valuable AM information such as fingerprints or direct reference samples for DNA were either lost or contaminated (Donkervoort et al., 2008; LDH, 2006). This limited the techniques that could be used to establish identity (Donkervoort et al., 2008; March, 2006; LDH, 2006).

After Hurricane Katrina the investigators who worked on missing persons files had a difficult time making contact and scheduling appointments with relatives of the deceased because there had been such a large amount of displacement and movement of families as a result of the floodwaters. Communicating with the families of missing individuals was a challenge given the hundreds of thousands of evacuees moving around to shelters, hotels, and other unofficial locations (LDH, 2006).

Furthermore, because the phone lines were down, people had lost the use of their cell phones; for those who still had phones, cell service was spotty, which made making and receiving phone calls very difficult. Contacting relatives who could provide the necessary AM information or the DNA samples required to make kinship matches was also a challenge (March, 2006; LDH, 2006).

Gathering AM data was a problem because in the early stages a significant number of family members did not want to provide the required information for the Victim Identification Profile or a DNA sample for kinship analysis (LDH, 2006). Some of the families considered
providing this information an indication that they had given up on finding their loved ones alive (LDH, 2006).

Identification Methodology

The conditions of Hurricane Katrina made identifying the human remains from this incident difficult (LDH, 2006). The recovery operation was extensive, and in some areas the search for remains did not start until over a month later, and the complete search for and recovery of the remains took approximately a year. The bodies were immersed in water for a prolonged period of time, and the heavy machinery that was used to clear the debris and collapsed structures compromised some of the remains (LDH, 2006). The water, heat, and timeframe caused extensive decomposition, which impaired visual identification and limited the methods that could be used for identification. In many cases it was not possible to use fingerprints, scars, tattoos, and other similar data for identification that relies on soft tissue, and within months many bodies were reduced to skeletal remains (LDH, 2006). Personal effects were washed away from many of the bodies, and there was a high level of DNA sample degradation because of high temperatures and humidity (Alonso et al., 2005; Kidder, 2007).

Hurricane Katrina Summary

Hurricane Katrina involved significantly fewer problems that the other disasters, possibly because some of the lessons that were learned from the World Trade Center disaster were acted upon. The New York incident set the precedent for genetic testing, and the technology was available to facilitate identification. Compilation of appropriate AM information was difficult in the aftermath of Hurricane Katrina, and it took a significant amount of time to establish an accurate manifest list of missing people. The conditions of the disaster affected the identification methodologies that could be used. In many cases fingerprint analysis was not an option because
the recovery phase had taken such an extensive period of time that it was not possible to take PM
fingerprints. The use of odontology was also limited because of the destruction of AM records as
a result of the incident. In summary, the major problems with the DVI aspect of this incident
occurred in the following areas: (a) communication; (b) the lack of preparation of the authorities
for the vast movement of people, which made it difficult to locate families for adequate and
accurate AM information; (c) the development of an accurate manifest list of missing people;
(d) inaccurate and inadequate AM details because untrained individuals collected this
information; (e) the destruction of AM records in the disaster; (f) the difficulty of contacting
family members to obtain AM data; (g) the unwillingness of families to provide AM
information; (h) the unavailability or contamination of direct reference samples for DNA and
analysis; (i) the limited identification methodologies in some cases because of prolonged
environmental exposure; and (j) the DNA degradation in the PM samples.

Chapter Summary

An analysis of the literature published on DVI of the three incidents above provided data
on the challenges encountered in the DVI response of each context studied for this project.
While there were some incident specific issues encountered in the DVI of all three disasters, the
majority of issues were shared by at least two events. Across the three disasters, issues focused
in three main areas including: planning and preparedness, AM information and identification
methodology. Through a comparison of the data for each event, it is possible to determine
lessons that can be learned and recommendations that the BCCS can incorporate into the DVI plan.
CHAPTER FIVE – DISCUSSION AND RECOMMENDATIONS

Comparison of Incidents

The analysis of the information in chapter four clearly reveals common complications among the incidents in certain areas (Table 1). Few complications were common to all of the incidents, but a substantial number were similar in at least two of the events. For example, the creation of accurate manifests and the AM data collection were common to all events, but issues such as a lack of DVI plans, inadequate logistical plans, and nonconformity with labelling and tracking plans were problematic in two of the incidents. If the BCCS understands these issues, it will be better equipped to address them within the DVI aspect of the disaster response plan.

Table 1

*Summary of Difficulties Encountered in the DVI Efforts*

<table>
<thead>
<tr>
<th>Difficulties experienced</th>
<th>World Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Center</td>
</tr>
<tr>
<td>Planning and preparedness</td>
<td></td>
</tr>
<tr>
<td>1 No overall disaster response plan to guide the process</td>
<td>x</td>
</tr>
<tr>
<td>2 Communication problems</td>
<td></td>
</tr>
<tr>
<td>3 Lack of consistent and standard guidelines for PM examinations</td>
<td></td>
</tr>
<tr>
<td>4 Problems with coordination of international teams.</td>
<td></td>
</tr>
<tr>
<td>5 Problems with transfer abilities between facilities</td>
<td>x</td>
</tr>
</tbody>
</table>

*(table continues)*
<table>
<thead>
<tr>
<th>Difficulties experienced</th>
<th>World Trade</th>
</tr>
</thead>
<tbody>
<tr>
<td>AM data</td>
<td></td>
</tr>
<tr>
<td>6 Development of an accurate manifest list of the missing people.</td>
<td>x x x</td>
</tr>
<tr>
<td>7 Lack of guidelines regarding AM data collection</td>
<td>x x</td>
</tr>
<tr>
<td>8 Inaccurate and inadequate AM details collected due to untrained individuals collecting information.</td>
<td>x x x</td>
</tr>
<tr>
<td>9 AM records destroyed in disaster</td>
<td>x x</td>
</tr>
<tr>
<td>10 Problems obtaining AM records from overseas</td>
<td>x</td>
</tr>
<tr>
<td>11 Problems contacting family members to obtain AM data</td>
<td>x</td>
</tr>
<tr>
<td>12 Unwillingness by families to give AM information</td>
<td>x</td>
</tr>
<tr>
<td>13 Authorities not prepared for the vast movement of people therefore it was difficult to track down families to get AM data.</td>
<td>x</td>
</tr>
<tr>
<td>14 Hierarchical approach to identification methodologies resulting in data not being collected for some methods.</td>
<td>x</td>
</tr>
</tbody>
</table>

*(table continues)*
### Difficulties experienced

<table>
<thead>
<tr>
<th></th>
<th>World Trade Center</th>
<th>Tsunami</th>
<th>Katrina</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>Lack of systematic standard in terms of the AM information that was received</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Inaccurate data entry, transcription and translation</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>17</td>
<td>Non-availability or contamination of direct reference samples for DNA and analysis</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>18</td>
<td>No standardized tracking mechanism in place from the beginning of the DVI efforts.</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

**Identification methodologies**

<table>
<thead>
<tr>
<th></th>
<th>World Trade Center</th>
<th>Tsunami</th>
<th>Katrina</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Limited identification methods possible</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>20</td>
<td>Over reliance on 1 of 3 primary identification techniques</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>DNA degradation</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>22</td>
<td>Unprecedented volume of DNA samples (AM and PM)</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>Lack of facilities to process quantity and quality of DNA samples.</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>

*(table continues)*
Difficulties experienced

<table>
<thead>
<tr>
<th></th>
<th>World Trade Center</th>
<th>Tsunami</th>
<th>Katrina</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>Lack of software available for analysing highly degraded samples or for carrying out the complex and multiple matches.</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>25</td>
<td>Contamination of DNA samples resulting in false associations</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>26</td>
<td>One bone sample could represent the entirety of an individual</td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

**Issues Common to All Three Incidents**

Difficulties arose in all of the incidents in three major areas: the compilation of accurate manifest lists; the collection of appropriate, accurate, and relevant AM data; and the procurement of useable direct reference samples for DNA.

*Development of the manifest list.* Establishing an accurate manifest list of the missing people was a challenge in all of the incidents that I studied. In the World Trade Centre disaster, because the incident was somewhat isolated to a particular area and who worked in the buildings and who was on the airplanes that crashed were more or less known, this was a starting point for a somewhat accurate list. However, the identity and number of people involved in addition to the people on these lists was unknown. Some reports (Aguirre & Quarantelli, 2005) suggested that some people were not included on the official lists because factors such as the language skills and comfort level with government agencies of the remaining family members precluded their reporting the missing individuals, and they did not know how to access the system as it was set
up in New York to register the dead. In the tsunami disaster the official lists were inaccurate to some degree because of the high number of unregistered Burmese migrants who were in the area and not accounted for on the official list of the dead because they were not legally registered. In Hurricane Katrina several unregistered transients in the area were not originally included on the official lists because no family or friends reported them missing. In an open disaster, if there are no lists to form the basis of the manifest of the missing, the identification efforts rely on friends and family to report people as missing. If the deceased have no friends or family to do so, they are not accounted for on the official lists. In contrast, developing a list from an incident such as a plane crash is much more straightforward because, typically, the identities of the passengers on planes are known prior to the incident.

With regard to the tsunami disaster and Hurricane Katrina, no lists existed that could be used as a starting point for the development of the manifest of the dead because the disasters were so widespread, and anybody who was in the areas could potentially have been included with the deceased. This problem was exacerbated after Hurricane Katrina because of the multiple lists of missing people, most of which were unofficial. Families and friends were uncertain about where to report a missing person, and in some cases, although families thought that they had reported a relative as missing, that person’s name was actually not on the official list. The existence of so many different lists resulted in incomplete manifests, many of which duplicated names, but none of which were accurate and complete.

In each of the disasters people on the manifest list were not in fact deceased. Immediately after the events, the families and friends of people who were in the area of the incident might have reported these people as missing if they had not heard from them, but they did not necessarily follow up with the relevant authorities if these people were later found alive.
(Scanlon, 2007). Although many people were not accounted for in the immediate aftermath of the event, they were not actually missing and should not have been included on the list of dead. It took a great deal of time in each situation to sort through the lists and to determine who was actually missing, which names had been recorded more than once, possibly under different spellings, and at what point the majority of the missing people were represented on the official list.

**AM data collection.** Gathering appropriate and relevant AM information for the forensic identification techniques was problematic in all three incidents. In the World Trade Center and tsunami disasters, inexperienced and untrained people collected the information and had no established guidelines to follow. People who gathered information from family members were not knowledgeable in kinship analysis and did not know how many and which samples were needed for this type of analysis. In addition, they did not understand which objects would contain the types of information that were required for DNA or fingerprint analysis, and in some cases they did not collect objects that could have been used because there were no guidelines to tell them exactly what to collect, and the people who collected information did not have the experience or background to determine which objects would be useful in the DVI efforts. This resulted in gaps in the data and a lack of appropriate reference information. Oftentimes it was necessary to return to families to ask for additional information, but in some cases, particularly in the World Trade Center incident, the collectors had not recorded the contact information for families, and it was difficult to go back to resolve the problems.

The tsunami incident resulted in additional challenges because of the variety and nonconformity of the information that was received from around the world. Different formats and incomplete fingerprint and dental data were transmitted to the identification teams. If the
forms were not the same as those required to meet Interpol’s standards, it was necessary to transcribe (where possible) the information into a useable format; this process at times resulted in the introduction of additional errors into the data. The police were collecting the data and acting as the family liaison officers, and they were untrained in this job.

After Hurricane Katrina, gathering the AM data was a problem because of the collectors’ inexperience; however, there were fewer problems after the hurricane than after the World Trade Center and tsunami incidents because the recommendations from the World Trade Center Incident Kinship and Data Analysis Panel as well as those from the DNA Commission of the International Society of Forensic Genetics that were made after the tsunami incident were implemented in the AM data collection after Hurricane Katrina. More experienced people and improved forms were utilised, and, consequently, the kinship data collected after Hurricane Katrina was significantly better than they had been in previous identification efforts (Donkervoort, 2007; Donkervoort et al., 2008, p. 355). However, the main problem in this instance was that it was difficult to find family members to provide AM data and to maintain contact with them because of the vast movement of people as a result of the floodwaters. Furthermore, families were sometimes reluctant to provide information because they felt that their doing so would indicate that they were giving up on finding their relatives alive.

Destruction of AM information and direct reference samples for DNA. All three incidents revealed difficulties in gathering appropriate reference material for the forensic techniques and direct reference samples for DNA analysis. In the World Trade Center disaster, in some cases the objects that would have been used as direct reference samples were with the deceased person and therefore destroyed. Although some samples were still available from the person’s residence, in many cases they could not be used because the objects had been contaminated with another
person’s DNA or there was an insufficient amount of DNA on the object. Dental and medical records and fingerprint samples were available; however, because of the destruction to the human remains from the incident, they were of little use.

In both the tsunami incident and Hurricane Katrina, the floodwaters destroyed personal property and thus any information that could have been used as AM reference material, particularly direct reference material for DNA analysis in the Hurricane Katrina incident. Furthermore, both incidents resulted in severe damage to both homes and dentists’ offices, which might have contained valuable dental records. Consequently, this information was not available as a potential source of AM information for identification. In the tsunami experience, in many cases it was possible to obtain the dental records of foreign victims, but many of the dental records of Thai victims were destroyed. After Hurricane Katrina it was more difficult to find records that had not been destroyed because the impact of the disaster was wide, and the fatalities were mainly residents of the area.

**Issues Common to Two Incidents**

Numerous factors were common to two of the three incidents, including the lack of an overall disaster response plan, inaccurate transcription and data entry, the lack of standardized procedures for tracking and labelling information and remains, the lack of an identification methodology, and the lack of pre-organised, qualified facilities to process the quantity and quality of DNA samples.

*No disaster response planning.* In both the World Trade Center and the tsunami disasters, there was no planning for incidents of this scale and no infrastructure and capacity to cope with the situation in the immediate aftermath of the disasters. Initial chaos resulted because there was
no overall plan to enact, particularly with such large numbers of missing. Rather, in both cases the identification problems were solved as they emerged.

In the World Trade Center incident the casualties were largely (although not exclusively) US citizens, and the response and identification process was handled primarily by US authorities, including the New York Police Department and the OCME. As a result, coordinating and organizing various international teams with different standards and procedures and trying to obtain AM details for people from all over the world did not pose problems. However, this event presented organizational problems nonetheless. The OCME had no plan to deal with an event of this scale or with remains with the extent of damage from this disaster. Until this point, US authorities had planned for events of several hundred dead, not several thousand. As a result, no protocols were in place to detail the procedures and identify the protocols and standards that should be followed. Decisions in the identification process were largely made as necessary because no prior thought had been given to handling an incident with such a high number of casualties. Because of the lack of preplanning, capacities, and resources to deal with the event, they had to be assessed as necessary.

In the tsunami experience there was initially no overall protocol for identifications or standards that should be followed. Local standards were employed, but they were inadequate for the numbers and condition of the deceased as well as the international bodies that needed to be identified to repatriate them. There was no plan for the implementation of specific DVI protocols when the international teams arrived, which resulted in confusion and different standards for PM examinations. This was problematic because all identifications must be made using the same standards and protocols (Interpol, 2008).
Furthermore, in the tsunami experience there were no logistical plans to deal with fatalities of this scale, and consequently no place for storage or facilities in which to carry out the PM examinations. This resulted in the decomposition and storage of bodies in public places such as temples as the authorities scrambled to find adequate logistical supports.

Transcription and data-entry problems. Transcription and data-entry problems were issues in mainly the World Trade Center and tsunami incidents. In the World Trade Center experience, AM information was written by hand and transcribed into a computer system, which resulted in problems with reading handwriting and errors in the transcription process. Similarly, in the tsunami incident information arrived from all over the world that needed to be transcribed and entered into various databases, and it was sometimes difficult to read the transmitted files. Deciphering abbreviations and translating files into English also presented problems. These factors, in addition to user fatigue and a lack of quality control, were serious issues. Initially, there was also a lack of quality control for the information that was entered into the databases in both incidents, and errors in the information were not caught immediately, if at all.

No standard tracking and labelling system. In both the World Trade Center and the tsunami incidents, the multiple tracking sources caused confusion and mistakes in the identification efforts and at times made it impossible to follow the status of a case. Specifically in the World Trade Center disaster, families were given multiple reference numbers and were often confused about which number to use; and at the OCME, information was recorded under several different numbers for the same individual. In some cases AM information from one family was mixed with that from another family.

In the tsunami experience the numbering systems changed several times, and sometimes people were given several numbers, which made it difficult and at times impossible to track
cases and determine their status or to find cases within the process. Initially, several formats were used for the tracking numbers, which was confusing. Different facilities had different coding systems, and no facility kept a record of all of the codes. If a body was moved between facilities, previous codes were sometimes lost again, and it was difficult to track cases.

**Identification methodology.** Methods of identifying the victims varied with the incidents. Whereas DNA was vital in the DVI efforts at the World Trade Center, it did not feature as much in the tsunami or Hurricane Katrina disasters (see Table 2) because of the condition of the remains. In the World Trade Center incident, the bodies were so highly commingled and fragmented that it was impossible to use methods other than DNA testing. In many cases bodies were commingled as a result of the impact of the incident, and bones were fragmented to such an extent that the only method of re-associating them with others from the same body was to use genetics.
Table 2

Summary Breakdown of Identification Methods

<table>
<thead>
<tr>
<th>Incident</th>
<th>Dental records</th>
<th>Fingerprints</th>
<th>DNA</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>World Trade Center</td>
<td>~10.00%</td>
<td>~5.00%</td>
<td>~81.00%</td>
<td>~4.00%</td>
</tr>
<tr>
<td>Tsunami</td>
<td>71.84%</td>
<td>24.12%</td>
<td>2.87%</td>
<td>1.17%</td>
</tr>
<tr>
<td>Hurricane Katrina</td>
<td>8.00%</td>
<td>9.00%</td>
<td>5.00%</td>
<td>78.00%*</td>
</tr>
</tbody>
</table>

*28% pathology, 27% personal effects, and 23% field case notes.

Conversely, in the tsunami and Hurricane Katrina incidents, the bodies were much more intact, and other easier and quicker methods such as dental and fingerprint analysis could be utilized. In the tsunami incident, dental analysis proved to be highly successful, particularly for victims from Europe and North America whose dental records were available. The Hurricane Katrina incident also relied heavily on secondary characteristics for identification, and x-rays and other medical records were compared when they were available. This was necessary for several reasons: (a) Many of the AM dental records was been destroyed in the incident, (b) AM fingerprint information is not routinely kept for most citizens in the US, (c) direct reference samples for DNA were not available because of the floodwaters, and (d) it was difficult to locate blood relatives to conduct a kinship analysis.

Although DNA is an effective tool, it is not the first choice of methods in DVI efforts. As demonstrated after both the tsunami and Hurricane Katrina, other, quicker methods can be just as reliable in securing identification. It is important to collect AM data to facilitate DNA identification, but this method is often a last resort as a technique because it is labour intensive,
somewhat slow, and much more expensive than others. However, some situations present a limited number of alternatives, such as the World Trade Center disaster; and when bodies are compromised, DNA may be the only method that can be used for identification.

*Lack of appropriate facilities to process the DNA samples.* This was an issue in both the World Trade Center and tsunami experiences. In both incidents, to process the samples it was necessary to find a lab with previous experience in analysing bone samples. Soft-tissue samples were submitted in both incidents, but some led to false associations because of the contamination of the samples. As a result, it was necessary to rely on bone samples from the deceased, which is a more complicated process and should be conducted by a laboratory with experience in this type of analysis.

In the World Trade Center incident, further issues arose because the samples were highly degraded and often did not yield full genetic profiles. This meant that software had to be developed to produce genetic profiles from compromised samples. In addition, because of the sheer numbers of PM DNA samples, extensive matching was necessary once the profiles were obtained. The PM samples needed to be matched not only to each other, but also to the AM data from the families. Software had to be rebuilt that could process and match such large numbers of AM and PM profiles.

Similarly to the World Trade Center incident, the PM DNA samples from the tsunami experience were highly degraded because of such factors as high temperatures, high humidity levels, saltwater, and, initially, legal problems with exporting the samples. Furthermore, the authorities did not know which laboratory would be able to handle the large quantities of samples and provide accurate and high-quality results. The first laboratory that they used could not process the samples adequately, and they had to find other facilities.
Incident-Specific Issues

Finally, several factors were incident specific, including the massive fragmentation of the remains, international team coordination, and the difficulty of contacting family members to obtain AM information.

World Trade Center fragmented remains. The World Trade Center event resulted in the highest degree of fragmentation. In most disasters, with the exception of explosions, plane crashes, and other high-impact events, this extent of destruction to human remains is unlikely. However, the fragmentation limited the number of techniques that could be utilised to identify individuals. Because there were no facilities to identify the fragmented and highly degraded remains, to process them, it was necessary to use sophisticated software that could not only generate DNA profiles from highly compromised material, but also match many different fragmented profiles to identify one individual.

Tsunami international team coordination. The massive influx of international teams that used various different protocols was necessary only in the tsunami experience to identify the bodies of the large number of foreign tourists in the area at the time of the disaster, and the Thai government was unable to manage the huge number of deceased.

The involvement of international teams introduced several other problems that were limited to this incident. There was no systematic method to gather AM data, and the information arrived in a variety of formats that followed various different standards. Also, because the PM examinations had no established guidelines, the teams initially worked according to their home standards, which differed among the various countries that assisted in the DVI efforts.

Hurricane Katrina displacement. In the aftermath of Hurricane Katrina, it was difficult to find family members who could provide the AM information that was required as a result of the
displacement from the disaster. Proper communication facilities were lacking, and the authorities found it difficult to track down people to gather AM information.

Recommendations and Implications for the BCCS

As I have demonstrated in this research report, mass-fatality events that result in thousands of dead can present multiple difficulties for the DVI efforts. Although the BCCS cannot afford the expense of doing all that might have to be done in a mass-fatality situation, certain expenditures will make it possible for the BCCS to quickly and adequately respond to the DVI demands of a mass-fatality event. Based on the current research, I make the following recommendations for action that the BCCS should take to be prepared to handle DVI after a mass-fatality event:

1. Develop SOPs to guide the overall DVI process.
2. Consider the logistical requirements of the DVI efforts and establish memorandums of agreements with relevant companies and businesses.
3. Select and train core team members on the BCCS DVI protocols prior to an event; they will subsequently train new team members during the incident response.
4. Secure access and training in data-management systems prior to an incident.
5. Establish methods for the creation of an accurate manifest list of deceased individuals.
6. Establish guidelines for the collection of relevant, accurate, and standardized AM data, identify who will be asked to do this collection and prepare a training syllabus.
7. Develop a system to track and label information prior to an incident.
8. Develop operating protocols and procedures to guide the selection of the most efficient and effective identification technique based on the specifics of the situation.
9. Establish the details related to DNA analysis prior to an incident.

**Recommendation 1: Develop Standard Operating Procedures to Guide the Overall DVI Process**

Prior to a mass death incident, the DVI Task Force should establish an SOP that details the protocols and procedures that will be used in the different stages of the identification efforts, from how the remains will be collected and where facilities for analysis and storage will be, to the process of death certification and the return of remains. The SOP should provide overall structure and guidance for the process, including clearly defined roles and specific responsibilities for teams within the DVI efforts as outlined below, details on how the entire process should be run, and the responsibilities of each team. The hierarchical structure of the process should be explicitly detailed, including the identification of team leaders and who has overall responsibility for the DVI process. The SOP should be detailed to include the overall purpose of DVI efforts and provide as explicit instructions as possible for each element of the DVI process. The protocols that will be utilised in the identification efforts must be clear, with little room for misinterpretation. All team members should have the SOP prior to an event to become familiar with the details.

Different teams should be assigned different responsibilities as follows to allow the team members to focus on particular aspects of the identification efforts:

1. The AM team should be responsible for collecting the AM information required to identify the victims, preparing the missing-persons files, and notifying the relevant authorities when the identifications are completed. Team members may include non–forensic specialised people such as embassy staff, police officers, and, potentially, volunteers.
2. The PM team should be responsible for collecting relevant dental, medical, and forensic data from the bodies of deceased victims for the purpose of identification. This team should include experts from various fields, including forensic odontology, fingerprint analysis, forensic pathology, and DNA analysis.

3. The reconciliation team should be responsible for matching the AM and PM data records and making the identifications. In the case of a match, this team should submit the information to the Identification Conference for review and a final decision.

4. The identification board should make the final decisions with regard to the identification of victims and certify those decisions. It should be composed of the most experienced identification experts involved in the operation; for example, the heads of sections (pathology, odontology, fingerprints; Interpol, 2008, p. 40).

**Recommendation 2: Identify the Logistical Requirements of the DVI Efforts and Establish Memorandums of Agreements With Relevant Companies and Businesses**

Prior to an event the BCCS must consider a number of logistical details such as how the bodies will be collected, the location(s) to which they will be transported, where the analysis will be carried out, how the remains will be stored, and what equipment will be necessary. In addition, it is necessary to consider where the call centers and family assistance centers will be located, if existing call centers could be utilised, the source of the supplies (computers, phones, etc.) for these facilities and who will be carrying the various activities.

Depending on the scope of the disaster, either the bodies should be transported to a central area that is designated as the mortuary, or it may be necessary to set up temporary mortuaries in different municipalities. Facilities should be identified as temporary mortuaries,
and they must have the capacity to store a large numbers of bodies. Where large number of refrigerated containers can be obtained for the storage of the remains, where generators and fuel can be sourced, and where the remains will go once they have been identified must be considered.

The BCCS should also consider where equipment such as body bags, labelling tags, postmortem supplies, and coffins can be obtained. It is not practical to maintain a supply of this type of equipment in the volumes that are necessary after a catastrophic event. However, it would be advantageous to the BCCS to determine from where these supplies can be obtained in a short period of time should it be necessary. Memorandums of agreement regarding access and use of storage facilities and equipment should be secured before an event, not during.

Recommendation 3: Select and Train Core Team Members on the BCCS DVI Protocols Prior to an Event; They Will Subsequently Train New Team Members During the Incident Response

The protocols and procedures used for DVI after open, mass-fatality events, particularly when there are thousands of victims, are different from those used in day-to-day casework or closed disasters. Although it is not feasible to train every single person who will help with the DVI efforts, there should at the very least be a core group of people on each of the teams (including volunteers, police officers, embassy staff, forensic experts, etc.) whom the BCCS should train in the methods that will be used in a mass fatality event. These individuals need to be familiar with the BCCS’s policies and procedures, the protocols associated with BCERMS, Interpol’s DVI guidelines, and the operating procedures, forms, and databases used in the identification efforts. This training should take place prior to an event to ensure that all members of the identification efforts know their specific role within the DVI process, work towards the same goal as a team, and utilise the same guidelines and standards.
In addition, programs should be in place to keep the responders’ training current. For instance, the Justice Institute of BC could potentially offer the team members continuing and up-to-date disaster-related education. Workshops should be carried out biannually or annually to review mass-fatality protocols and procedures. Mock disaster situations should be created to test the teams’ response abilities. Selected trained individuals should subsequently train new team members as necessary during the event. For example, new members should initially team up with experienced individuals to gain an understanding of the process and procedures that the BCCS uses and the information that is required.

The BCCS should also identify groups of people who may be able to volunteer in various capacities in the aftermath of a disaster, particularly in the call center. In the past, in New Zealand the Red Cross has staffed the call center and Sweden used a private call center. The main point is that this factor must be considered prior to an event, and arrangements must be made with regard to which group of people will volunteer ahead of time so that a plan is enacted rather than created in the aftermath of an incident. It will also be necessary to check the call-out list periodically to ensure that people are still interested in volunteering.

In a situation of mass death, it is likely that outside assistance will be required for the DVI efforts. The BCCS should also consider which outside organisations will be permitted to participate and in what capacity. Incoming team members should be integrated into existing teams with trained local members to facilitate the assimilation of BCCS protocols and procedures. Experience from the tsunami illustrated that it is important to mix new team members even if they are highly experienced into existing groups to ensure that the DVI process remains consistent across teams. If newcomers join teams rather than having separate teams of newcomers and local members, it will be easier to focus on the common goal of identifying
everybody by following a standard set of established procedures. It is necessary to designate people who can act as team leaders as well as people who can organise this aspect of the response. Copies of the BCCS’s operating procedures should be prepared in advance and distributed to new team members upon their arrival.

Recommendation 4: Secure Access to and Training in a Data-Management System Prior to an Incident

The forensic identification process is data intensive, especially in situations of mass fatalities (Adams & Byrd, 2008, p. viii), and data management is therefore an absolutely crucial element of DVI. Highly specialised data are required, and sophisticated software and database programs are often necessary to facilitate identification. Massive amounts of data are generated from identification efforts and must be stored in searchable databases used for AM and PM data matching, archiving, and tracking of information. All cases should be held in one central repository to allow cross referencing and matching of separate files. The data should include case numbers, family reference information, AM and PM data on the victims, and identification information. Plans need to be established regarding who will transcribe information that could arrive in a variety of formats and may be overwhelming because of the variety and volume of data, as well as the inconsistencies. Prior to an incident the right to use an established database such as Plass Data DVI International, which can be accessed through the RCMP, should be secured and team members trained in the software by people who are experienced in using the program.

To maintain consistency, the BCCS should have qualified and designated individuals who will be responsible for entering the data into the database. Team members should know how to use this program comprehensively and be able to train others in basic functions. Plans also
need to be established for a system of quality control to monitor the content of the information entered into the database to check for missing data, duplications, and information that needs to be followed up on.

**Recommendation 5: Establish Methods for the Creation of an Accurate Manifest List of Deceased Individuals**

An accurate manifest list is an essential aspect of the response to a mass-fatality event because an inaccurate list makes it difficult to determine where to focus the AM data collection or when all of the remains have been identified. Developing accurate lists of people who have been killed in the incident was a problem in all three incidents that I studied, and although it is a key aspect of DVI, it is not an easy or automatic task. Resources need to be allocated to this area, and systems for this process to work must be determined prior to the event. Call centers and/or family assistance centers play an essential part in the establishment of the manifest because people will report missing individuals at these locations. In the case of foreign tourists among the dead, a communication system with embassies and/or foreign affairs offices is required to transfer information to the central data repository for entry into the database, and the relevant authorities need to be able to access updated information in real time over secure electronic sites.

Families of missing individuals will need to know where to report the names and specifics of missing people. Provisions should be made for centers and telephone hotlines that families can contact to report missing individuals. Details on how to contact the call center and/or family assistance center should be broadly broadcasted in several formats (e.g., radio, Internet, television), across communities, throughout the country, internationally if necessary, and in multiple languages. Families must know the AM information that is required for the identification efforts and what will or will not be useful in the process. Past experience has
demonstrated that recorded messages played while callers are on hold that inform them of the information for which they will be asked when they speak to an official speed up the registering process and limit the number of calls for purposes other than reporting missing family members (Scanlon, 2007). Research has also shown that accepting reports of missing individuals by e-mail is not efficient because often e-mails are followed up with phone calls (p. 233).

It is likely that the BCCS will not be able to rely upon a certain segment of the population to self-report missing individuals, possibly because of immigration issues, language barriers, or trust issues with government agencies. It is necessary to reach out to these groups of people through establishments such as cultural associations that might have knowledge about deceased members of different cultural groups. In addition, shelters should be contacted to determine whether homeless people who might not have been reported by family are among the dead.

The BCCS must decide how to collect the AM information for individuals who are reported missing. Using the sophisticated Canadian Foreign Affairs system (COSMOS) and the CAMANT database system worked well in generating accurate lists of missing Canadians after the World Trade Center and tsunami incidents; however, they may not be accessible to the BCCS or financially feasible to have access to the system. In addition, although these systems aid in compiling and checking AM data, they not designed to hold the PM data against which the AM details need to be electronically compared. In this regard, the Plass Data DVI System International database is more appropriate in mass-fatality situations because both AM and PM information can be entered into one database and matched electronically.

Regardless of the system that is chosen, features that force the operator to enter the information directly into the database are more practical and less prone to error than taking notes by hand and entering the details at a later date are. If handwritten information is used, it is
important to take care not to make errors in transcribing the issues. If the database system that is used does not automatically check for duplications of names and birthdays in the information that is entered, it is important that team members be charged with identifying these duplications in the database information and amalgamating files if necessary or flagging them to indicate the need for caution in managing the file. Whichever system is used requires a data-management person to check the quality of the data entered.

*Recommendation 6: Establish Guidelines to Direct the Collection of Relevant, Accurate, and Standardized AM Data*

AM information is essential to the identification efforts, and prior to an incident, guidelines need to be developed on who will collect the AM data, whether the Interpol forms will be utilised, what specific information needs to be collected on these forms, and how the logistics of the operation will be planned. For example, callers could be directed to a team of people at the call center who are designated AM data collectors, but teams of AM data collectors at family assistance centers can also collect data.

The people who collect the AM data must be familiar with the structure of the forms that will be used for the data collection, the information that is required in each field, and the best ways to collect data from traumatised families. This will include understanding the primary identification techniques, including fingerprint, odontological, and DNA analysis, and the AM samples that are required to facilitate each type of analysis, as well as the administrative data that need to be collected from all donors (name, contact information, data of birth, etc.).

It is important that the people who do this job know what they are doing so that they can gather all of the required details for both primary and secondary indicators from each family in as few visits as possible. Preferential treatment must not be accorded to one technique over
another in this phase. Potentially, any or all three of the primary indicators (DNA/dental/fingerprints) could be used during the identification efforts, and the process will be much more efficient if the data are gathered as a package rather than separately should a particular method fail. AM data collectors must also gather as much secondary information as possible to corroborate a primary identification technique.

Furthermore, the BCCS needs to be prepared to obtain AM information from international locations that may use different standards, abbreviations, and systems. Plans must be in place to ensure that records that arrive in different formats can be transcribed into one common format. The teams must be trained not only in the BCCS’s formats, but also in the formats used for the information that arrives to avoid clerical and administrative mistakes. This necessitates understanding the different writing and numbering styles as well as dealing with more complicated issues such as different systems for numbering teeth. To facilitate this, the National Institute of Justice (2005, 2006) has created charts to display format variations in AM data. Use of these charts will facilitate a standard transcription format for different transcribers. These publications also include flow charts and diagrams to help the collectors and family members understand which family members to ask for the best reference samples and the publications are worth obtaining and utilising.

**Recommendation 7: Develop a System to Track and Label Information Prior to an Incident**

In addition to an effective database system to store and access information, an efficient tracking and labelling system for both AM and PM information is vital for information management and the organisation of data. If a system is ineffective, it is difficult and at times impossible to find cases and/or samples, ascertain their status in the identification efforts, and match AM and PM information. One of various systems can be utilised. For example, the codes
can be completely numbered, or a combination of numbers and letters can be used. PAHO (2006) recommended that codes be formatted according to the place where the body was found, the recovery team/person, and the sequential body count (place + recovery + body count; i.e., Lions Gate Hospital, P. Jones, 001B). Although this system is useful because it immediately identifies the location of the body, the person who found it, and its sequential number, certain problems are inherent to this method. This type of system will not produce standard codes (because the location and names will constantly change), and the potential for errors in the process (e.g., mistakes in spelling, capitalisation) is great when words are used. In this regard, tracking systems that rely on numbers are better and generally easier to use with database systems. However, the drawback to a numbered system is that the details of a case are not necessarily immediately clear, as they are in worded codes.

Regardless of the system that is chosen, the main criteria are that it is straightforward, will not change throughout the process, will allow the assignment of new codes without duplicating case numbers, will allow numbers to be allocated at different facilities if necessary without duplication, and will provide enough information to identify to the operator the type of data (e.g., AM details, PM details, etc.). It is essential that this system be developed before an event because it will need to be implemented immediately after an incident. In addition, the codes need to be compatible with the database that is used as well as with those of other organisations involved in the identification efforts such as DNA labs, which may have their own accessioning numbers.

It is also important that the tags that are used to label the bodies with the tracking codes be durable, waterproof, and firmly attached to each individual case. For example, metal tags with the numbers impressed into the material are useful because the markings withstand water, dirt,
and other contaminants. The case numbers should be written on the outside of the body bag as well as on tags (made out of plastic or metal that will not deteriorate) and securely attached to the human remains.

**Recommendation 8: Develop Operating Protocols and Procedures to Guide the Selection of the Most Efficient and Effective Identification Technique Based on the Specifics of the Situation**

Within the first 48 hours after an event, many critical decisions on the identification process will be made, and the BCCS will face an enormous amount of pressure to identify bodies and begin to return the remains. The BCCS has decided to use Interpol’s guidelines as the basis for the structure of the identification efforts. SOPs on the protocols and methods associated with the PM teams’ examination of bodies and collection of information are also required.

The details of a disaster will dictate the appropriate or plausible techniques for identification. The state of the remains and the available AM data will have a significant influence on the decisions. The BCCS DVI plan needs to be specific enough to direct identification operations and provide strict protocols to guide the identification efforts as well as indicate what is necessary for identification (i.e., one primary and one secondary technique). Yet they also need to be flexible enough to account for incident-specific factors as well as the changing, dynamic needs of the process dictated by the availability of AM data and the condition of the remains. As demonstrated particularly in the tsunami and Hurricane Katrina response, appropriate methods for identification will modify over time depending on the state of the remains and the PM details that can be obtained.

A hierarchical approach to identification methods such as using dental records or fingerprints first (if available) and then switching to a DNA-led approach only when other methods are not available or do not work will provide the PM and reconciliation teams with
structure and guidelines. The most efficient and effective methods of identification should be
selected, and in many cases, particularly those in which the bodies are relatively complete, this
will involve odontological or fingerprint analysis. In other cases when there is extensive
fragmentation, decomposition, or a lack of reliable AM dental and fingerprint information, DNA
analysis may be a more appropriate method of identification. However, it will often be the last
choice given the expense and degree of labour that is involved. It is important that the SOP that
is developed to select the identification techniques stress the importance of using fingerprint and
odontological analysis for identification and that every attempt be made to use these techniques
before switching to a DNA-led approach.

Although some of the decisions on which methodologies to use will be incident specific,
numerous decisions can be made before an incident to guide the process. Flow diagrams and
decision trees should be prepared in advance to make the decision-making process easier. They
should illustrate particular methods in a given sequence for certain situation, whereas in other
incidents the selection method might change. For example, in a tsunami or flood with relatively
intact bodies, odontological and fingerprint analysis will be the first methods used, and only
when they fail will the emphasis shift to DNA. In an explosion with large numbers of dead in
fragmented pieces, this approach may not be appropriate; in this case, DNA may be the primary
method of identification. Therefore flow diagrams that illustrate this information should be
created ahead of time to guide the identification teams in selecting appropriate methodologies.

Recommendation 9: Establish the Details Related to DNA Analysis Prior to an Incident

Although DNA analysis will likely not be the predominant method of identification, the
disaster response plan needs to account for the specifics of this type of analysis prior to an
incident. It is a complicated and labour-intensive process that requires a great deal of preplanning
and the implementation of strict procedures and protocols. These details should not be addressed during an event; rather, they should all be established and in place in advance so that if DNA analysis is required, the plan can be implemented rather than designed as necessary.

In a mass-death situation, identification is often based either on the analysis of DNA left on objects that the deceased have used or on kinship analysis, which uses PM DNA samples taken from the deceased and matches the genetic information to DNA samples obtained from the blood relatives of the deceased (Appendix A).

Direct reference sample comparison is a relatively straightforward type of DNA analysis because the lab analyses two (or more) samples to determine whether they have the same genetic makeup (identical profiles). However, kinship analysis is much more difficult because various types of DNA (nuclear, mitochondrial, and/or Y-chromosome) are used to make an identification based on the genetic relationships between samples. This analysis requires much more work and expertise.

If the PM samples come from bones, the analysis is even more complicated because it involves additional steps that are not necessary for blood or skin-cell samples. It is therefore important that the lab that processes and matches the DNA have experience in this type of work. Furthermore, as demonstrated in the World Trade Center incident, the lab should have the capability to process highly degraded samples and generate genetic profiles from these materials should it be necessary to do so.

A database must be created to house the AM genetic information obtained from both direct reference and kinship samples, and it must be able to generate matches between the AM samples and the PM samples. In some cases this may require sophisticated matching between
multiple PM and AM samples such as the MDKAP program that was originally developed for the Swissair disaster and modified and used at the World Trade Center incident.

Prior to an incident, the BCCS and one or more labs that can handle large quantities of samples that may require complicated analysis should have memorandums of agreement. The BCCS should be sure that the laboratories are capable of conducting the various types of analysis that may be necessary and that they are accredited to do so.

In addition, it is important that legal documents that accompany DNA analysis be written prior to the incident. This includes confidentiality agreements between the various parties involved in the DNA sampling (donors, BCCS, laboratory) that specify, among other things, where the genetic information will be held, who has access to it, when it will be destroyed, and the exact purposes for which the information can be used. In addition, DNA chain-of-custody forms are also required to transfer the samples between the PM teams and the DNA lab, and the genetics lab will need to have an established and secure method of transmitting the results back to the identification teams.

Chapter Summary

This chapter has presented a comparison of the challenges faced by DVI efforts for three different types of disasters that resulted in mass death, along with recommendations for action by the BCCS to avoid similar problems in the event of a mass death situation in BC. While incident specific challenges were encountered in each context, there are also many factors common to at least two of the incidents studied. The data has shown that through a detailed study of past DVI efforts, it is possible to identify what the challenges were in order to learn from and improve DVI efforts in the future. Through an understanding of these challenges and the subsequent
recommendations to overcome these issues, the BCCS will be better equipped to handle a mass death DVI effort in the event of a disaster within BC.
CHAPTER SIX – CONCLUSION

As demonstrated in disasters in the recent past, including the events that I studied for this research project, catastrophic, mass-fatality events are not only larger than regular disasters, but also categorically different in the consequences and the corresponding response, particularly with respect to DVI. Therefore, the protocols and procedures that are used in regular death investigations or even multiple death situations are not appropriate for use in the DVI efforts in a mass-fatality event. These events require special planning and preparation designed specifically for situations with potentially thousands of deceased individuals. There is a strong possibility that British Columbia will experience a mass-fatality event in the future as the result of either a natural disaster such as an earthquake and/or the resultant tsunami or, potentially, a criminal disaster such as terrorism. The DVI aspect of the response will be the responsibility of the BCCS. This research has demonstrated that it is essential to use preemptive measures to address the complications associated with DVI on this scale.

Three large-scale mass disasters that resulted in large numbers of deaths and unidentified victims, were used for this study in order to better understand if there are common problems that are encountered in the identification phase of mass fatality management, to identify these problems and determine ways that the BCCS can avoid similar issues should there be a mass fatality event in BC. This research has resulted in key recommendations in a number of areas for relatively low-cost but practical actions to improve the capacity of the BCCS to deal with a mass-fatality situation. Specifically, this study has demonstrated that pre-planning for the response to a mass fatality is essential. Taking action now to prepare for a catastrophic event will mean that the BCCS is better equipped to avoid many of the problems that previous DVI efforts have encountered. These actions should include: (a) development of SOP's to guide the
process; (b) consideration of the logistical requirements of the DVI efforts and establishment of memorandums of agreements with relevant organisations, facilities and suppliers; (c) training of key players in the response efforts; (d) access and training in data-management systems prior to an incident; (e) establishment of methods for the creation of an accurate manifest list of deceased individuals; (f) establishment of guidelines for the collection of relevant, accurate, and standardized AM data, identification of who will be asked to do this collection and preparation of a training syllabus; (g) development of a system to track and label information prior to an incident; (h) development of operating protocols and procedures to guide the selection of the most efficient and effective identification technique based on the specifics of the situation; and (i) establishment of the details related to DNA analysis prior to an incident. Preparedness in these areas will result will be a smoother identification process that will facilitate quicker and more efficient identification and return of human remains to the respective families.

While this research has presented common problems for identification efforts after mass fatality events and recommendations to assist the BCCS with development of the mass fatality aspect of the Disaster Response Plan, there are certain areas where further research is necessary. Research into additional cost-effective and efficient methods of creating accurate manifest lists with relevant and precise AM information is important. This is a labour intensive and lengthy aspect of the identification process, yet it is essential for identification of victims. In addition, the present study should be continued as more information is published about the incidents studied herein as well as future mass fatality events. With continued work in this area and a commitment to learn from the efforts of other DVI efforts, jurisdictions will be better prepared to identify victims of a given disaster and return those individuals to their families as quickly and accurately as possible.
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APPENDIX A – PRIMARY AND SECONDARY/CORROBORATIVE IDENTIFICATION TECHNIQUES

According to the Interpol guidelines (2008) there are certain methods that can be utilised for identification purposes. Following these guidelines, identifications should always be based on primary techniques with secondary techniques used only as corroborative data.

Positive or primary methods entail scientifically establishing identity through the presence of known, unique characteristics through analyses including prints (finger, palm, foot), dental characteristics, DNA or radiographs (Dix & Graham, 2000). In order for bodily features to qualify as scientific identifiers, they need to conferring uniqueness, be stable, and also be pre-recorded as belonging to a known individual. If these factors exist, then identifications can be made through a comparison of the post-mortem features to the known ante-mortem records (Bernstein, 1997; Dix & Graham, 2000). For example, if fingerprints have been taken from an individual in life, or, they can be lifted from the individual’s personal effects, the ante-mortem prints can be compared to post-mortem prints taken from the deceased individuals to ascertain who the post-mortem prints belong to.

Presumptive or secondary identification methods are those that rely on non-unique factors such as personal effects, visual identification, medical findings or circumstantial evidence (Dix & Graham, 2000, p. 81; Interpol, 2008). The following is a brief overview of primary and secondary techniques.

Primary Identification Techniques

**Fingerprint, Palm Prints, and Footprint Analysis**

Dactyloscopic analysis is a standard tool in identification efforts and is a method that is widely and frequently used to establish or confirm identity (Feige, 2004; Interpol, 2008; NIJ, 2006). While fingerprints are the most common print used for analysis (due to being left on more surfaces), footprints and palm prints can also be analysed using the same methods if there is appropriate ante-mortem information available. The determining factor in this type of analysis is the availability of ante-mortem and prints that can be compared to one another and the expertise of the qualified fingerprint experts (Clegg, 2004; Interpol, 2008, p. 18). This method can be particularly useful for identification of children due to the frequent lack of ante-mortem dental records (Interpol, 2008).

This method of identification utilises comparisons of friction ridges, often from the finger, left by an individual during their life with prints taken during the post-mortem examination. These prints can be in the form of “latent prints” which are those left on objects that an individual used and have an uncertain donor, or those taken deliberately for identification purposes and are known to belong to a specific individual (Interpol, 2008).

The premise behind this technique is that the detail in friction ridges found on skin are unique and unchanging and the patters do not change over a person’s life time apart from in size or by accident, mutilation or skin disease (Clegg, 2004, p. 189). Friction ridges form in a random manner during foetal development and there is enough variability between ridge patterns that no two patterns are alike whether they are on different fingers of one individual or on the fingers of different individuals. Research has demonstrated that while the DNA of identical twins is the...
same, their fingerprints will be different (Clegg, 2004). Prints will remain after death until the body decomposes.

There are 4 different pattern types that can be used for describing ridge patterns known as arches, loops, whorls and composite (Clegg, 2004). Matches are made on the basis of a “points comparison” between samples. Points of comparison are used to exclude prints (prove they are not the same), or to match prints based on the fact that the same patterns are present, the patterns flow in the same direction and the patterns occupy the same relative positions to each other. If these patterns are found to be in the same relative sequence or unit relationship, then identification is assumed and the points of similarity are referred to as points of identification.

If it is possible to obtain the necessary ante-mortem and post-mortem information the examination and comparison of post-mortem and ante-mortem fingerprints can be done manually or using computerised software such as the Automated Fingerprint Identification System (AFIS). All matched that have been completed using AFIS are also checked manually by a specialist.

**Limitations**

In order for fingerprint analysis to be an applicable identification methodology, it is necessary that ante-mortem prints are available to which the post-mortem prints can be compared. In addition, the available prints (finger prints/palm prints/foot prints) must have been obtained using appropriate collection methods including listing prints with descriptions, image numbers, dates, times, names of processing officers, and evidence collection methods (Interpol, 2008, p. 21). In terms of latent prints, the degree to which the print will be visible depends on the nature of the object that has been touched. Some objects will display the fingerprint outright while other objects will require special powders and techniques to lift the print. If the print is of a poor quality, the identification can be difficult.

In addition, if the ante-mortem reference sample is based on an object that the missing person used there can be complications due to contamination (multiple people’s prints) on the object. If multiple people live at the same residence and/or use the same object, it is necessary to have reference samples from these people for exclusionary purposes. If these people are also missing and cannot provide a reference sample, it may be more difficult to determine identity using this method (Interpol, 2008).

Further issues that limit the use of fingerprint analysis in identification efforts include the difficulties associated with obtaining fingerprints from remains where the soft tissue has been compromised. Often, in cases of mass fatalities, there is damage and/or decomposition of the soft tissue (skin). There are some techniques that have been developed in order to obtain fingerprints from these types of bodies such as boiling hands to obtain a print from the second layer of skin (Scanlon, 2006a, 2008; Schuller-Götzburg, 2007, p. 11), however, there does become a point where this technique is not longer viable (Petju et al., 2007. Caution regarding fingerprint matching also needs to be exercised if the ante-mortem fingerprint that is being compared to the post-mortem print is from a different stages of an individual’s life. While the actual ridge patterns do not change, the size of the print does as an individual develops.

A further problem limitation with this method is that at present, there are no international standards for the number of points of identification required for a match between 2 fingerprints (Feige, 2004). Rather, a positive match between finger prints is based on an examiner finding
“sufficient” correspondences between the samples although what constitutes sufficient is not qualified (Cole, 2005, p. 994; Feige, 2004).

Some countries have set a minimum number of points of identification for a match, however, some organisations such as the International Association for Identification, suggest that there is no valid basis for this approach. Fingerprint examiners offer expert opinions based on their personal training and experience as to whether there is a match. The options for fingerprint analysis include:

1. There is a match between 2 fingerprints;
2. There is not a match between 2 fingerprints;
3. The comparison is inconclusive (Crimetrac, n.d.).

**Odontological Analysis**

Forensic odontology has a long history of being utilised by the forensic discipline and can be used to identify individuals that cannot be visually identified by relatives (Bernstein, 1997; Blau, Hill, Briggs, & Cordner, 2006; Kvaal, 2006; Pretty & Sweet, 2001). This method of identification is facilitated through a methodological analysis of the teeth and the surrounding structures. Identifications are reached through comparisons of ante-mortem dental information and the post-mortem dental information recorded by forensic odontologists. Through an analysis of the dental structures, the forensic odontologist will make a conclusion that falls under 1 of 4 categories:

1. Positive identification
2. Possible identification: This is not a positive ID but can help to prioritise a possible identification by other means;
3. Exclusion
4. Inadequate information for comparison (NIJ, 2006, p. 48).

In order to make this assessment the forensic dentists will analyse the dentition of the deceased individual for missing, decayed, filled, extracted and/or modified teeth. In order to classifying a victim’s dental status, all the post-mortem information regarding the condition, treatment, and position of teeth are designated using a three-digit code.

Oral features are also assessed as they can be important in the identification of individuals that have not had extensive dental treatment (Pretty & Sweet, 2001, p. 360). Individuals that have lost all of their teeth can potentially be identified based on the anatomy of the jaw bone or by dentures which may be distinguishable by shape, size, manufacturer and composition (Bernstein, 1997). While people with numerous and complex dental treatments are often easier to identify than people with little or no dental work, it is possible that even those with minimal dental alterations can be identified if they exhibit distinct characteristics and there is ante-mortem information regarding these variables (Pretty & Sweet, 2001, p. 360).

Forensic odontology is particularly useful after mass fatality events because not only do the teeth have unique identifying characteristics about them but they also tend to survive even traumatic events that are partially destructive to other parts of the body (Pretty & Sweet, 2001). Dental identification is useful in situations of decomposing corpses, skeletonised remains, charred remains, intact remains where there is no putative victim (Bernstein, 1997; Kvaal, 2006).
This method is often useful after a mass disaster incident because if the appropriate ante-mortem information is available, this technique can be efficient and reliable and identifications can potentially be made much faster and less intrusively than when using DNA technology (Blau et al., 2006; Kieser et al., 2006; Kvaal, 2006; Schuller-Götzburg & Suchanek, 2007). Furthermore, most North Americans and Europeans will have been seen by dentists who will have a record of their dentition possibly in the form of written records, x-rays, and photographs due to legislative mandates regulating dental record-keeping (Petju et al., 2007).

If there are no ante-mortem dental records available dental analysis can also be useful in determining and limiting the population to which the deceased is likely to belong through a post-mortem dental profile. Information on the individual’s age, ancestry, and sex can be determined at times based on tooth eruption status (age), and shape of jaw and teeth (ancestry; Pretty & Sweet, 2001).

Odontological information that is collected from a body can be entered into a database system that holds both ante-mortem records for potential missing individuals and the post-mortem information from bodies that have been examined. There are various different sophisticated computer software systems developed to do this including programs such as Plass Data International, “DAVID Web,” WinID and UVIS (Clement et al., 2006; Kieser et al., 2006). These programs have the potential to make matches between ante-mortem and post-mortem data, which are subsequently checked by experts. The purpose of these programs is to make the matching process more efficient. They do not replace human experts.

Limitations

In order for odontological analysis to be possible several factors are necessary. The deceased individual’s original dental records must be available and should be readable, accurate and up-to-date. If the deceased individual did not have a dentist or the information is scarce or old, this technique will have limited applicability (Bernstein, 1997). Further limitations for this technique include idiosyncratic dental records from different areas of the world (Kvaal, 2006). The standard of dental care and frequency with which people visit the dentist varies around the world and while many Europeans and North Americans will have up-to-date records, this will not be the case for every country (Petju et al., 2007). If there is no ante-mortem dental information to which the post-mortem information can be compared, then this method is not applicable.

At present there are no agreed upon international standards for forensic odontology and different protocols are used in different countries (Kvaal, 2006). This includes differences from the abbreviations used in case notes to charting of tooth condition, to standards of care. In some areas of the world, dentists will only chart their own work rather than everything in the dentition. This makes these records of limited value for DVI purposes because there is not a sufficient amount of information (Petju et al., 2007). In addition, there is no minimum number of concordant points or features observed required for a positive identification (Pretty & Sweet, 2001). In some cases, one tooth may be considered sufficient for identification if it has enough unique identifying characteristics. In other cases a compete mouth radiograph may not be sufficient grounds to produce a positive identification (p. 362).
DNA Analysis

The use of DNA to identify human remains is a proven method of identification through analysis of genetic information contained within cells in the human body that are unique to individuals (Interpol, 2008). While it is not usually the first method of choice for identification of disasters victims, it can be an effective tool if the correct resources are available. This method is particularly useful in mass fatality incidents where bodies may be fragmented or injured/dismembered/decomposed to the point where other methods cannot be utilised. DNA analysis can be used even if the human remains are small and this is often the only method available for re-associating body parts or small remains.

There are several different types of analysis that can be utilised to obtain identifications based on DNA. One method is through direct comparison of the deceased individuals DNA with either objects that they used during life or DNA samples that were taken from them during life. In this method the DNA comparisons are made to determine if two separate DNA samples originate from the same individual. In this regard, DNA profiles that are obtained from the remains of the victim can be matched against other remains found within the disaster site and/or against direct reference samples that have been obtained from personal objects belonging to the victim. Identity of DNA profiles in 2 different samples indicates that they are from the same individual (Gans & Urbas, 2002). If the profiles derived from the samples are not identical, this implies that the samples are from different individuals. Direct reference samples can include blood cards or tissue specimens that may be available for the victim or personal artefacts such as combs or tooth brushes that the victim used during life. The limitations of this method are that there are very few people that would have tissue specimens or blood cards in existence prior to before death. Furthermore, with regards to personal effects, there is a high possibility of contamination from a third person or these items may not be available.

Alternatively, indirect identifications can be made through kinship analysis. In this method comparisons are made to determine if there is a genetic match between post-mortem samples taken from the deceased individuals and reference samples gathered from family members (Gans & Urbas, 2002). In this type of analysis, the mitochondrial, Y-chromosome and/or nuclear DNA of the missing person is matched to that of the familial reference sample. The ability to match the victims DNA to their relatives will depend on the ability to obtain DNA from the deceased persons sample as well as how closely the person/people donating the reference sample are related to the deceased (NIJ, 2006).

In order for this method to be successful, the sample that is donated from the family must be from a blood relative. The closer the relative is in terms of familial relationships, the better the chances are of a successful match and while technically a minimum of one relative is necessary to make an identification, the probability of getting a successful match increases if two or more relatives donate a sample (International Commission on Missing Persons, 2005; NIJ, 2006).

Reference samples for kinship analysis should be collected from all first-degree relatives if possible and expanded outward in terms of familial relationship if these samples are not available. However, it is important to note that the type of DNA (mtDNA, Y-Chromosome) that can be matched will also depend on the relationship between the individuals that give the samples and the deceased (Prinz et al., 2007). If DNA from the victim’s children is used it is also useful to also have a sample from the victims spouse if possible (Andelinovic et al., 2005; NIJ, 2006). DNA from distant relatives can also be used as reference samples if no closer relatives are
available, however, this type of matching can be more difficult. Kinship analysis is much more complex than direct reference matching, but often it is the only method of identification after a mass fatality incident because direct reference samples are not available.

The degree of complexity of extracting the DNA from samples varies and will depend on the state and quality of the samples, and the extraction methodologies that are used (Gonzalez-Andrade, Bolea, Martínez-Jarreta, & Sanchez, 2006; Prinz et al., 2007). DNA samples can be taken from the bone, teeth or tissue samples of the deceased individual. Samples from the family are usually taken in the form of a buccal swab or blood sample.

Nuclear DNA. Nuclear DNA is contained within the nucleus of the cell and is inherited from both parents; half from the mother and half from the father (NIJ, 2006). With the exception of twins, all people will have unique nuclear DNA. Due to the manner in which this type of DNA is inherited, the nuclear DNA between blood relatives will be somewhat similar (NIJ, 2006). Consequently, nuclear DNA from the victim can be compared to the nuclear DNA of a family member to reach an identification. The best reference samples for nuclear DNA will be from:

1. Biological mother and father;
2. Spouse of MP and biological children;
3. Biological mother or father and MP children;
4. Multiple full, biological siblings of the MP (NIJ, 2003, p. 64) [Add to ref list]

Y-chromosomal DNA. This type of analysis is becoming increasingly frequent in male-specific identifications (Harvey & King, 2002). Y-chromosomal analysis allows paternal lineages to be identified and traced. This type of DNA is inherited only through the paternal line. The Y-chromosome of father and son and of full brothers will be identical (p. 475). It can only be matched through the paternal line of a blood relative however, it is particularly useful for cases where only distant male blood relatives are available for reference samples (Harvey & King, 2002). The best reference for Y-chromosomal DNA will derive from:

1. The MP’s biological father
2. The MP’s biological sons
3. The MP’s biological brothers

Mitochondrial DNA. Mitochondrial DNA (mtDNA) is inherited only through the maternal line and thus can only be matched to a maternal blood relative. The mitochondrial genome between mother and child and full siblings will be identical (Harvey & King, 2002) and this type of analysis can be used to match missing people to living relatives that are distantly removed from the deceased individual as long as they belong to the maternal line of the family (Andelinovi et al., 2005, Budowle et al., 2005). The best reference for mtDNA will derive from:

1. The MP’s biological mother
2. The MP’s biological siblings with the same mother
3. Biological children (if the MP is female; Andelinovi et al., 2005).

The weakness of Y-chromosomal genotypes and mtDNA is that because the analysis determines maternal or paternal lineages, this type of analysis cannot distinguish between
relatives of the same family (Harvey & King, 2002). In addition, Y-chromosome analysis can complicate matters when the genetic relationship is different from the purported relationship.

Furthermore, mtDNA is not as powerful as nuclear DNA for making identifications because 2 unrelated people can have similar mtDNA. However, where nuclear DNA can be easily compromised and damaged by external factors such as heat and other conditions, mtDNA is much more robust (Andelinovi et al., 2005; Budowle et al., 2005; Holland et al., 2003; Irwin et al., 2007). It preserves well in bones, can be extracted from small fragments of remains, is stable across several generations, does not mutate or change very quickly and is useful for remains that have been exposed to degrading properties (Andelinovi et al., 2005; Budowle et al., 2005). This method of matching is generally more expensive, but in many cases it is useful for remains from which nuclear DNA was not retrievable.

Limitations

It should be recognised that while DNA analysis is a powerful tool, it is not the only method for identification. Other tool such as fingerprint or odontological analysis can be much more efficient and cost effective ways of obtaining an identification given that DNA analysis and in particular kinship analysis, is labour intensive. In addition to collecting reference material and matching the victims profile to the reference samples, there need to be strict chain-of-custody protocols, and the lab that is analysing the genetic material needs to have experience conducting this type of work. Family liaison officers and ante-mortem collection teams need to be educated in DNA analysis so that they can discuss potential limitations and issues that may arise in the genetic testing process.

There are multiple factors that can challenge a DNA identification including the number of victims, the mechanism of body destruction, the extent to which the bodies are fragmented, the rate of DNA degradation, accessibility of the deceased individuals for sample collection and availability of DNA reference sample (both direct and indirect; Alonso et al., 2005, p. 541). Identifications using DNA analysis depend on the quality of the victims human remains as well the reference samples that are collected (NIJ, 2006). If an event was particularly severe, it may not be possible to get good quality or complete profiles from the victim’s sample. It may also be a challenge to obtain reference samples from either the victim’s personal effects or their blood relatives. Ante-mortem data are essential for DNA analysis and the ability of DNA to work as an identification tool will very much be dependent on the quality and availability of the ante-mortem data.

It is also important to note that profiling the DNA from the victim and the ante-mortem samples (family members or personal effects) is only one part of the process. This method of identification relies on matching of ante-mortem and post-mortem profiles in electronic databases and requires information management systems that log and track all samples, have the capabilities for searching according to different matching algorithms and the ability to evaluate the significance of each potential match (Alonso et al., 2005). This requires sophisticated databases and software. In addition, kinship matching is quite different from regular case work and the people doing this need to be experienced and trained in matching post-mortem and ante-mortem kinship profiles.

Based on the specific circumstances of the disasters a decision needs to be made at the beginning of the identification process regarding the use and purpose of DNA. Is it being used as an identification tool for every victim of the disaster or only on a certain sub-set of the victims
such as those that were not identifiable through other forensic techniques (Alonso et al., 2005, p. 541). In some cases, if it is a closed disaster, the efforts may focus on identifying each individual that is missing. In an open disaster, because the number and identities of the people involved in the incident are unknown, it may be decided to use DNA to identify every possible fragment of human remains depending on the state of remains and the applicability of other techniques (Alonso et al., 2005).

Determination of what samples to take from the deceased will be influenced by the nature of the disaster. In some situations where there are no contamination issues, decomposition issues or extensive damage to the body, soft tissue samples may be preferred as it is less labour intensive to extract DNA from these types of samples (Alonso et al., 2005). Hard tissues (bone and teeth) are preferable as sample types when there is body putrefaction present or if there is contamination of the soft tissue issues or if other environmental insults that may preclude DNA preservation in soft tissue. Sample should be taken from the least effected material.

In order to ensure accuracy in kinship analysis identifications, supplementary information is necessary. This can include extensive and detailed ante-mortem information about the deceased including information about the family tree and any non-biological relationships that exist between the deceased individual and members of the direct and extensive family (Keough, Simmons, & Samuels, 2004). Having accurate family genealogies indicating the relationship between the missing person and the donor(s) is essential. It is also important to determine if other people from the same family are missing, and if they are, they also need to be incorporated into the family tree regardless of how distant a relative they are and whether they are maternally or paternally related.

It is important to note that at times, there may be inconsistencies between the purported genetic relationship as claimed by the family and the actual genetic data. In some case, based on the genetic data that is derived from the reference samples, it may be demonstrated that the father of an individual is not the biological father of one child despite what the family may think. Great care and delicacy needs to be taken by identification teams to avoid violating the privacy of all involved, even if the people are from within the same family (Budowle et al., 2005, Donkervoort, 2007).

Secondary/Corroborative Identification Techniques

Visual Identification

While visual identification can be a useful method of identification when bodies are in excellent to good condition, this method is fraught with potential problems and there are numerous case studies of bodies that were visually identified by family members, only to be confirmed to be a different individual at a later date (Bernstein, 1997; Griffiths et al., 2003). Visual identification is a method that should be used for identification purposes in normal situations only. Mass disasters can be physically destructive and delayed recovery of a corpse can make visual identification impossible. Often, if it is the family or friends that are visually identifying the deceased, these people will be traumatised and there is a possibility that they will misidentify a body (Interpol, 2008, chapter, 4). When the numbers of deceased are high, the possibility of people looking similar or having similar embellishments such as tattoos or piercing increases. In addition, facial alternations as a result of the death process, animal activity or delayed recovery can quickly obscure visual appearance. Specifically, there are several cases from the Bali bomb and the Indian Ocean Tsunami that were identified based on a visual
confirmation but later found to be misidentified through further investigation (Griffiths et al., 2003; Huckenbeck, Thiele, Krause, Lessig, & Szibot, 2008). Consequently, because there is a high probability of misidentification of a body based on visual identification and according to the Interpol guidelines, in a mass fatality situation it is considered as a corroborative rather than a primary identification technique (Interpol, 2008; PAHO, 2006).

**Personal Effects and Medical Findings**

Personal effects including clothing, jewellery and personal belongings can be an indicator of identity, however while they may constitute valuable circumstantial evidence, they cannot be considered proof of identity (Bernstein, 1997; Sirisup & Kanluen, 2005). Making identifications based on personnel effects associated with a body can be particularly susceptible to error, particularly if this is the only basis on which the identification is made. It is possible that individuals personal belongings are located with a different individual for any number of reasons from the effects of the disaster (impact/force, etc), or people may have been collecting other individuals ID to help with the missing persons list or there may have been a theft. Medical findings that can be considered as secondary identifiers include surgical scars or medical implants (pacemakers with serial numbers, dentures or dental prosthetics with identifying marks) that are associated with a body. Again, according to the Interpol guidelines these should only be used as corroborative identifiers rather than proof of identity.
APPENDIX B – DVI ISSUES TO CONSIDER

General Considerations

1. What needs to be accomplished?
2. Who is going to do it?
3. What resources can be committed to this process?
4. How are they going to be set up?
5. How are the remains going to be brought into the morgue?
6. How will they leave the morgue?
7. What are the long-term issues that will need to be addressed?
8. Who and how will collect the ante-mortem information?
9. What are the legal issues surrounding use of private data such as fingerprints and DNA?
10. Will a complete medical and legal investigation be taking place or will the process be limited to identifications?
11. Who is the focal point for public relations and controlled release of information?
12. Will outside help be accepted? If it is, what form will this be in and who will be involved? Are the outside agencies aware of the DVI standard operating procedures of the BCCS?
13. If there are plans to have international teams assisting, is there a roster of professionals that have been trained and are familiar with the working protocols of the jurisdiction?
14. Need to have a plan for where the AM information that is collected is going to be stored. Which database will be utilised?
15. What software will be used to make identifications?
16. What software will be used to store and match ante-mortem and post-mortem data?
17. If the event exceeds the capacities of the local resources, how are you going to deal with the data? Who is going to be doing the AM-PM data matching? Do you have the capacities in-house or do you need to outsource? If you are going to get an external agency to assist, you need to have memorandums of agreements with the various agencies that will be assisting with the ID efforts (Shaler, 2005b).
18. Need to consider the families of the victims. You should have literature available that explain the DVI process. Families need to be able to believe that the identifications are accurate and correct (Shaler, 2005b).
19. As difficult as the truth may be for families, they will want to know the situation (Shaler, 2005b). You need to give them realistic expectations for the identification process (this will depend on the incident and the state of the human remains).
20. Must have family assistance centers set up with qualified people that can explain the identification process to families and provides information about what is happening with the identification process and what the plans are for the process.

21. Need to have consent forms for the families to sign.

**Incident-Specific Considerations**

1. What is the desired end statement: Is it to identify 100% of the missing or to identify every remain?

2. If remains are fragmented and commingled, will there be attempts to re-associate all of the fragments?

3. How will the samples from the deceased individuals be taken?

*Note: Adapted from Shaler (2005b).*