

OPERATION EARTHQUAKE 2011: CHRISTCHURCH EARTHQUAKE DISASTER VICTIM IDENTIFICATION.

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ABSTRACT

At 12.51pm on Tuesday 22 February 2011, an earthquake of magnitude 6.3 struck the Christchurch region of New Zealand causing massive destruction with hundreds of people injured and killed. The New Zealand Society of Forensic Odontology response commenced two hours after the earthquake with the implementation of the national Disaster Victim Identification (DVI) forensic odontology plan. The importance of good planning, the integration of odontology as part of the immediate response and the deployment of odontology personnel to the scene were features of this operation. Stringent quality assurance processes were integrated into the planning which assisted in the robust outcomes. Smile photograph comparisons played a role in a number of difficult identifications. In the four months following the earthquake teams of odontology personnel worked tirelessly in an effort to identify the remains of those killed during the disaster. At the conclusion of the operation 97% of the deceased have been identified and returned to their families.

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INTRODUCTION

Earthquakes and New Zealand are synonymous. New Zealand is located on the boundary of the Australian and the Pacific tectonic plates. As these plates grind into each other buckling and fragmentation occurs causing gradual changes in surface and subsurface topography. When the forces build up sufficiently rupture at the boundary occurs manifesting as an earthquake. New Zealand has a long history of devastating earthquakes causing significant destruction and loss of life.¹ Authorities have attempted to reduce the potential impacts of earthquakes through community preparedness including stringent emergency and support services training.

Unfortunately, no amount of training and preparation could have prepared the county for the devastation caused by the series of major earthquakes affecting the Canterbury region of the south island, New Zealand. At 12.51pm on Tuesday 22 February 2011, an earthquake (an aftershock following a large earthquake in September 2010) of Richter scale magnitude 6.3 (energy magnitude 6.7) struck the Christchurch region (depth 5km with its epicentre Lyttleton). The forces involved were massive and catastrophic. High ground accelerations (some in excess of two times the acceleration due to gravity) lead to the rare occurrence of the 'slapdown effect' where the surface soils lost cohesion resulting in violent ground shaking and extensive liquefaction.^{2,3} The major earthquake at 12.51pm, and the hundreds of aftershocks (many shallow and measuring over 5 on the Richter scale in strength) over the next twenty four hours, caused massive destruction in the Christchurch central business district, to Lyttleton, and to the surrounding suburbs (Fig. 1).

The severe shaking, combined with the widespread and significant liquefaction, severely compromised the city's roads, water, electrical and sewerage infrastructure and complicated the rescue and recovery operations. Many buildings either collapsed or suffered partial collapse with walls, facades and debris falling into the streets. Fire broke out in the collapsed six-story Canterbury Television Building (Fig. 2). In total 164 people were critically injured and 181 people from 22 nations died as a direct result of the earthquake and aftershocks.⁴

FORENSIC ODONTOLOGY - NEW ZEALAND

The use of forensic odontology in the identification of the deceased and victims of mass disasters has had a role in New Zealand for over seventy years. However, it wasn't until the misidentifications of casualties of the Tangiwai rail crash in 1953, that the value of forensic odontology was more formally

recognised.⁵ This was further advanced following the 1979 Air New Zealand crash on Mt Erebus in Antarctica and the formation of the New Zealand Society of Forensic Dentistry (subsequently the Society name changed to New Zealand Society of Forensic Odontology - NZSFO). Since its formation all national and international Disaster Victim Identification (DVI) responses have been coordinated at a Society level. Recently this 'central coordination' has been further facilitated by the inclusion of a Society representative as part of the National Police DVI team and as a member of the National DVI committee.

The NZSFO has a detailed DVI odontology readiness plan that is based on the guidelines of the International Organisation for Forensic Odonto-Stomatology, Interpol (DVI) and the Australian Society of Forensic Odontology and the many lessons learned by the members of the NZSFO.^{6,7,8,9} The forensic odontology response to the Christchurch earthquake commenced two hours after the earthquake with the implementation of the national DVI forensic odontology plan.

INITIAL RESPONSE

A key component of the earthquake response was the moral, legal and ethical requirement to accurately identify the deceased. Significant resources were made available to ensure optimal identification outcomes were achieved. The NZ National DVI team were activated and key personnel were in Christchurch coordinating the immediate DVI response within hours of the earthquake. The National DVI team is a squad of police with specialist DVI training and includes non-sworn scientific (pathology, odontology and fingerprint) personnel. This ready response team is well trained, is well resourced, follows international best-practice guidelines and protocols and has worked nationally and internationally. The value of such a team is well recognised as is the role of odontology in mass disaster situations.^{10,11,12} The early deployment to the disaster area ensured an organised and orderly DVI response which was a key element to the relative success of this operation.¹³ The DVI plan for Christchurch called for the use of the Christchurch hospital mortuary in the event of a mass casualty incident.

Unfortunately, the mortuary is located within the city hospital which was damaged by the

earthquake and given the risks associated with the continuous aftershocks and the hospital activity treating the injured, alternative mortuary arrangements were required. The practicality of moving the deceased to mortuaries in other cities was considered but discounted because no single mortuary had the capacity to manage the numbers involved and because of the logistic challenges of getting the deceased out of the disaster area. A field mortuary was subsequently developed in a vehicle hangar at Burnham Military Camp, some 30km to the southwest of the city. The mortuary was configured to allow the unidirectional movement of remains from the storage containers across the mortuary floor (3 lines) and back to the containers. Whilst simple in appearance, the development of this facility was a complex process taking into account the need for efficiency, privacy, shelter, security, hazard management, body storage and staff facilities.¹⁴ Co-located with the mortuary were body storage containers with the capacity of around 300 and the ability to supplement this (Fig. 3). It took the National DVI team, assisted by New Zealand Defence Force (NZDF) personnel and private contractors, two days to establish the mortuary with the first casualties entering the post-mortem (PM) examination process in the evening of 25 February 2011, three days after the earthquake.

RECOVERY

Locating and recovering the deceased victims of a disaster such as this is dangerous, time consuming and requires sound planning and organisation. It necessitates people searching badly damaged or collapsed buildings with the threat of aftershocks and further collapse. A careful and ordered approach is required to ensure the safety of those undertaking the recovery whilst balancing the community and political imperatives for speed. The difficulty and challenges of body recovery increases with the complexity of the disaster environment, especially in situations where there has been significant and sustained fire. Body recovery techniques are detailed to ensure the location and preservation of material useful in establishing identification. This is of great importance in situations where there has been fragmentation or burning of remains. The recovery phase was a coordinated response between Urban Search and Rescue teams, Police specialist search and rescue and DVI teams. Following lessons learned during other

disasters, a forensic odontologist was deployed as part of the police DVI scene teams to assist with locating, securing and preserving dental and facial material at the collapsed and burning Canterbury Television Building (Fig. 4).^{11,15,16}

POST-MORTEM PHASE

The mortuary was configured for the linear flow of casualties commencing from body storage (body registration), through property, pathology and biology, odontology, fingerprints, post-mortem quality review, body registration and then back to storage (Fig 5). In this DVI a partial medical post-mortem was completed with a focus on obtaining identification information and determining the likely cause(s) of death. The cause of death information was important as during the subsequent inquests families frequently wanted to know how their relative died. Biologists/scientists worked with the pathology and odontology teams in obtaining tissue samples for DNA testing. DNA testing was only performed if other methods of identification were unsatisfactory. Three PM lines were equipped and staffed which, to reduce bottlenecking of the process at odontology, required four odontology teams.

The forensic odontology aspects of the PM followed international 'best-practice' guidelines with two examiners trained in forensic odontology being involved with each examination. The two examiner process is an essential quality control measure which facilitates the cross-checking of findings and encourages critical thinking. There were many cases of incineration and in addition to extreme burning, significant fragmentation and comingling of remains had occurred. This necessitated careful and detailed re-evaluation of body bag contents to ensure that no dental and orofacial elements were overlooked. Once located, the dental remains required careful handling during the examination, radiography and photography process.^{17,18} The use of a mortuary 'panel of odontologists', in addition to the primary examiners, to provide assistance with identifying and characterising fragmented teeth was very useful and assisted in creating an accurate and complete post-mortem record. Examination findings were recorded on the Interpol PM forms and comprehensive digital radiography and photography were completed for each case. Recognising the importance of teeth as a source of DNA, in many cases teeth

were taken for DNA analysis.¹⁹ The choice of specimen was decided following the pre-agreed DNA protocol for the operation and in collaboration with an on-site biologist.

A separate odontology 'quality assurance section' was developed to complement the quality assurance measures of the paired examining odontologists. The odontology quality assurance section reviewed the examination information and radiographs for accuracy, legibility and completeness. If deficiencies or errors were identified these were addressed prior to the casualty being returned to the storage area. As a result of these robust quality assurance measures there was only one post-mortem odontology revisit for a minor matter.

Most of the specialist post-mortem equipment was provided by the NZDF (Dental Services) from the DVI reserve. At the peak of activity five odontology teams and a quality review dentist were working in the mortuary.

INFORMATION CENTRE

Also located in the military camp was an Information Centre which accommodated (in distinct areas) the ante-mortem (AM) section, post-mortem data entry, reconciliation, coroner's office and administrative support.

Ante-mortem data collection formally commenced two days after the main earthquake. Significant police effort was placed on locating latent fingerprints along with objects and samples potentially containing material suitable for obtaining reference DNA. The success in acquiring latent fingerprints was a key factor in the high number of identifications made using fingerprints as the primary identifier. Dental records were obtained nationally through the local network of dentists and internationally through Interpol and the network of dental associations. Many of the casualties of the earthquake attended dentists in the cordoned off central city, this along with the constantly changing missing persons list, necessitated dentists entering the dangerous disaster area, sometimes on multiple occasions to retrieve records.

The use of 'smile photograph analysis' or photographic comparison techniques has been used to assist in the identification of unknown

human remains.^{20,21} In several cases during this DVI important information directly supporting the formal identification of victims arose through the comparison of odontologic features in ante-mortem and post-mortem photographs. The key to success with the 'smile analysis' was ensuring facial photographs were collected during the ante-mortem data collection process and that, in addition to conventional post-mortem occlusal and lateral dental views, post-mortem photography simulated the angles and approaches that typically occur during social photographic sessions.

Plassdata (version 3) was utilized on networked computers and was the main repository for ante-mortem and post mortem information. Plassdata was also used to data-mine and establish preliminary reconciliation matches.

Reconciliation was progressive in that the Chief Coroner elected to complete reconciliations as soon as there was sufficient information to do this. Reconciliation was based on the primary identifiers (odontology, fingerprints and DNA) with secondary identifiers taking an important but subordinate role. Initially odontologists attended Reconciliation Board meetings but subsequently submissions to the Board were by way of a report with an odontologist being available to answer questions or clarify issues. Major efforts were made to ensure the progress through the DVI process was accurate and efficient in an effort to ensure the speedy return of the deceased to their families as soon as practical after the Reconciliation Board confirmed their identification. The last identification was made on 27 July 2011 with over 85% being completed within four weeks of the disaster.

RESULTS

At the conclusion of the DVI process of the 181 deceased, 177 (including 70 foreign visitors) had been formally identified and released back to their families. Ninety-four percent of identifications were based on single or multiple primary identifiers. Four individuals remain unaccounted for. Six percent of the identifications were based on a combination of secondary identifiers including, property, physical/visual and circumstantial evidence. When all identifications were considered 43% of identifications were attributed to fingerprints, 33% to odontology, 4% to DNA and 14% a

combination of fingerprints, odontology and DNA (Fig. 6). The relatively high identification rate by fingerprinting reflects the localised nature of the incident and the well organised and thorough approach taken by fingerprint personnel in collecting latent and post-mortem fingerprints.

If the methods of identification are further broken down into identifications on deceased with multiple DVI numbers (fragmented remains), then as expected, a greater use was made of multiple primary identifiers with 85% of identifications involving a combination of odontology and DNA with minimal contribution from fingerprints (Fig. 7). Twenty and five percent of cases respectively involved odontology and DNA alone.

Thirty-four odontologists, including five overseas dentists were involved with the DVI operation and in excess of 400 working days dedicated to the task. In addition to the forensic odontologists, considerable assistance was provided by other oral health providers (dental technicians, dental hygienists and dental therapists) and by dental auxiliaries (assistants/nurses).^{22,23,24}

CONCLUSION

This disaster reconfirms the importance of forensic odontology in the DVI process and in particular in situations where there has been significant trauma and fire. To optimise the identification outcomes it is essential that detailed forensic odontology support plans are developed and initiated early in the DVI response. The forensic odontology plan must be integrated into the overall DVI plan and key to this is the representation of forensic odontology within the organisations tasked with mounting the response. To ensure the best outcomes it is essential that a forensic odontologist works 'on-site' with the recovery teams. Unfortunately disasters do occur and they do occur close to home – is your DVI team ready?

ACKNOWLEDGEMENTS

It is important to acknowledge the tireless application of all those involved with this disaster victim identification operation. Their steadfast dedication and devotion to the task at hand is a testament to their sense of duty and compassion. It was a privilege to work with

them. Support and resources provided by the New Zealand Defence Force and the New Zealand Police were critical to the success of this operation.

To those who lost family members and friends I offer my heartfelt commiseration.

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FIGURES



Fig.1. Damaged buildings and buses, Christchurch Central Business District



Fig.4. Recovery operations at the collapsed Canterbury Television Building



Fig.2. Canterbury Television Building



Fig.3. Field mortuary, Burnham Military Camp (body storage containers on right)

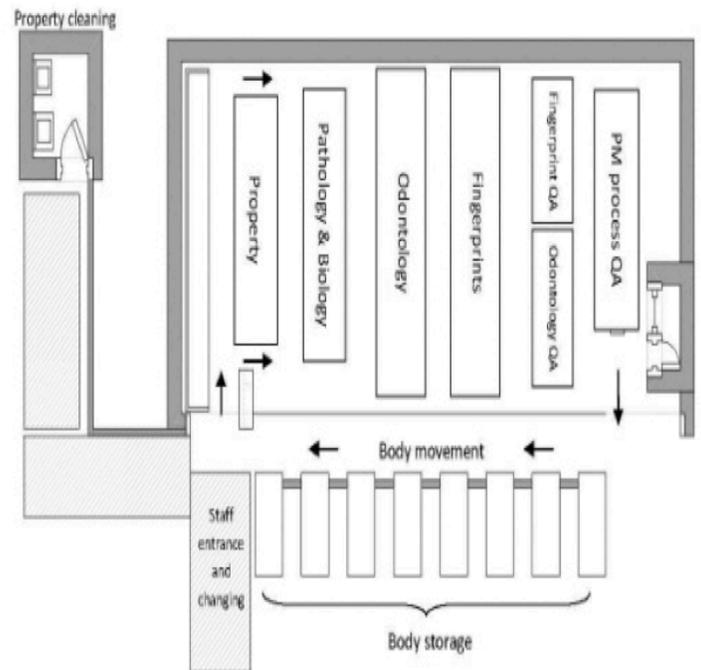


Fig.5. Schematic of the field mortuary at Burnham Military Camp

Identification method - all remains

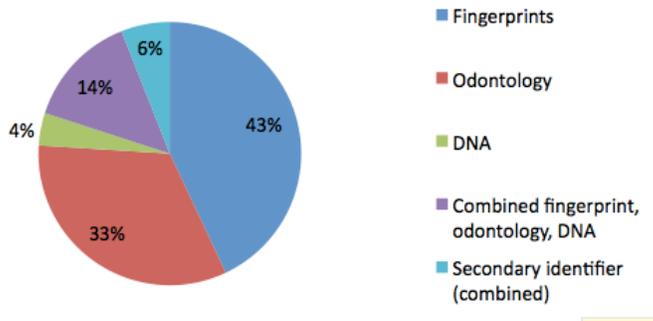


Fig.6. Identification method – All remains, showing the success of fingerprint and odontology methods

Identification method - Fragmented remains

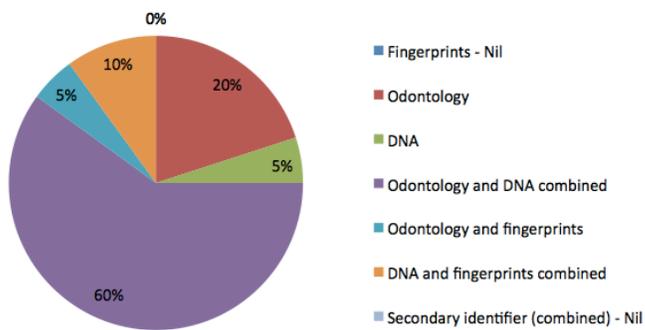


Fig.7. Identification method – Fragmented remain by method