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Insights into casualties from the 2016 Kaikoura Earthquake

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ABSTRACT

The 16th November 2016 Kaikoura Earthquake caused 2 deaths and 624 injuries, making it the largest earthquake casualty event in over 80 years outside of the Canterbury Earthquake Sequence. Data on casualties (deaths and injuries) were sourced from the Accident Compensation Corporation (ACC). The ACC is New Zealand's publicly funded accidental injury insurance scheme. ACC data includes all victims that sought medical treatment for injuries resulting from the Kaikoura Earthquake through primary (e.g. GP clinics, physiotherapy clinics) and secondary (e.g. hospitals) health care systems but it does not contain victims that were administered first aid outside of the health care system. The context of casualties from the Kaikoura Earthquake were analysed by considering epidemiological, seismological and engineering perspectives. Of the 626 casualties, 67.4% were female, similar to that observed during the Canterbury Earthquakes. Four percent of victims were aged less than 19, 73% were aged 20-64, and 23% were aged 65 and above. Forty five percent of casualties were a direct result of the earthquake shaking, either from the victim being thrown around or objects hitting them, while 44% of casualties resulted from the action of the victim (e.g. trying to evacuate the building or moving to help another person), and 9% were from post-earthquake actions such as clean up or tsunami evacuation.

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Ninety one percent of injuries were considered minor and could be treated by a doctor at local clinics while 8% were considered moderate and required specialist hospital. The most common type of injury was soft tissue (77%), followed by lacerations (10%) and fractures or dislocations (5%). Nearly 90% of the casualties occurred at the victims home, a reflection of the earthquake occurring just after midnight on a Sunday night. A better understanding of risk factors related to casualties can be used to help prioritise casualty prevention measures such as education and building codes.

1 INTRODUCTION

The 14 November 2016 M7.8 Kaikoura Earthquake was one of the largest earthquakes to occur in a populated part of New Zealand in many decades (Kaiser et al., 2017). Ground motion intensities reached or exceeded MMI9 around the fault ruptures in the rural settlements of Kaikoura, Ward and Waiau, and MMI7 was observed in Wellington City (Bradley et al., 2017, Goded et al., 2017). Long duration (>30s) shaking of MMI4 or above was felt across all of New Zealand (Goded et al., 2017).There was widespread damage to buildings from Christchurch in the south to Wellington City, but only one building collapsed (Henry et al., 2017, Dizhur et al., 2017). This paper analyses the casualties (fatalities and injuries) that were caused by the Kaikoura Earthquake and reports on the context in regard to social (demographic and behavioural), engineering and seismological perspectives.

2 CASUALTY DATA

Data on casualties were sourced from the Accident Compensation Corporation (ACC) which is New Zealand's publicly funded accidental injury insurance scheme. ACC covers medical treatment, rehabilitation and lost salaries for all accidental injuries and deaths in New Zealand, which includes natural disasters. Therefore any person that was injured or killed and received medical treatment from the Kaikoura Earthquake through the primary (e.g. GP clinics, physiotherapy clinics) and secondary (e.g. hospitals) health care systems is covered by the ACC and recorded in the ACC claims database. The ACC database does not contain victims that were administered first aid outside of the health care system and subsequently not reported (e.g. received first aid at home). Nonetheless the ACC database on casualties from the Kaikoura Earthquake represents a near complete picture of casualties from the earthquake, and due to the coverage represents a globally unique dataset on earthquake casualties. Claims data from ACC was requested through the RHISE research group (Research into the Health Implications of Seismic Events) which has an MoU with the ACC to undertake research on earthquake casualties (Ardagh et al., 2012). Claims were queried that had a date of injury on the 14th to 21st November (to capture the event and clean up) and contained the words "earthquake" or "shaking" in any of the free field descriptions of injury cause. A total of 626 claims were provided by ACC. This included 2 deaths and 624 injuries. The data included fields on date/time of injury, location of injury (e.g. home, commercial, road, etc), cause of injury (free text), injury type (ACC codes), injury description (free text), demographics of the victim including age at time of injury, sex, ethnicity, and home address.

2.1 Coding of Casualty Data

Further processing of the data was undertaken to code the injury context similar to that undertaken by Johnston et al. (2014) for the 2010-2011 Canterbury Earthquakes.

2.1.1 Casualty Context

This process involved coding the free text field of the cause of injury as either primary direct (unavoidable causes, e.g. wardrobe fell on leg), primary action (potentially avoidable casualties that occurred due to the person moving, e.g. fell down stairs while evacuating building), secondary (any casualty that occurred after the shaking stopped, e.g. stepped on broken glass while cleaning up after earthquake), mental health (mental health related context caused by earthquake, e.g. post-traumatic stress caused by earthquake) or not-earthquake related (contained key words but not related to earthquake, e.g. had to work longer hours because of the earthquake and strained back).

2.1.2 Casualty Severity Classification

Each casualty was classified into one of the RiskScape Casualty States (CS) as defined in Cousins et al. (2008). This classifies casualties into five Casualty States (CS) ranging from CS1: Light injury treated by first aid, CS2: Minor injury that can be treated by doctor, CS3: Moderate injury that requires treatment at hospital, CS4: Severe injury requiring intensive care at hospital, CS5: dead.

2.1.3 Geocoding of Injury Location

One significant limitation of the ACC data is that the location data of the claim information contains three different fields of varying quality. The victim records their home address, the accident location as a free field text such as “Wellington” or “1 Willis Street, Wellington City” and the accident scene from a predefined list (e.g. “home”, “commercial location”, “recreation/sport venue”, “road” etc). None of this is ideal for identifying the exact building or site of the injury across the entire dataset. Since the Kaikoura Earthquake occurred just after midnight on a Sunday night, we assume that any claim that reports the scene as “home” occurred at the home address of the victim unless the description of the injury reports otherwise (e.g. “was in Wellington for work and the earthquake struck”). A total of 563 (90%) of casualties were reported as occurring at home and these casualties have been geocoded to enable mapping of casualty location.

3 RESULTS

3.1 Geographic Distribution

Casualties were reported across most of New Zealand, from Southland in the south to Far North District in the north. The majority (more than 500 of 626) of the casualties occurred in districts within 100 km of the source faults where MMI6 or above was reported, with 88 (14.2%) occurring in Kaikoura district, 86 (14%) in Wellington City, 75 (12.5%) in Marlborough, 74 (11.8%) in Christchurch City, 45 (7.2%) in Lower Hutt City and 35 (5.6%) in Hurunui District. Figure 1 shows the distribution of casualties where the victim reported their home as the place of injury.

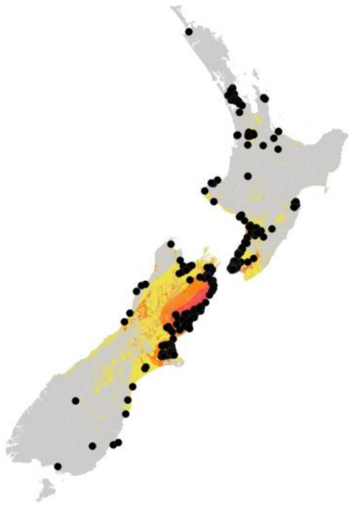

Figure 1: Map of 563 (of 626) casualties with geocoded locations (i.e. occurred at home). Colours show shaking intensities estimated from GeoNet ShakeMap (Horspool et al., 2015) with red as MMI8+, orange as MMI7, yellow as MMI6.

3.2 Ground Shaking Distribution

Using the ShakeMap of the Kaikoura Earthquake generated by GeoNet (Horspool et al., 2015) the instrumental MMI value at the location of casualty was extracted. For the 10% of casualties that had no geocoded location, the MMI value at the centre of the town where the casualty occurred was used to assign MMI for that claim. Earthquake casualties occurred from MMI 4 to MMI9, the maximum MMI for the event. Over 2 million people were exposed to MMI5 and MMI4 across the central and upper North Island. Injuries from those areas were often due from people being awoken by the earthquake and taking action and then being injured by these actions (e.g. getting out of bed, or running and tripping). The most casualties occurred in MMI7 (Table 1) which was the intensity felt across most of the Wellington region. MMI8 and MMI9 were mostly reported across the upper South Island.

*Table 1: Number of Casualties per MMI band**

MMI Band	No. of Injured	% of Injured
< 5	69	11.0
5	33	3.0
6	172	27.5
7	207	33.1
8	110	17.6
9 +	35	5.6

*Estimated using ShakeMap

3.3 Location/Building Use Type

The scene of casualty that was reported by the victim is from a predefined list provided by ACC. For the Kaikoura earthquake 563 (90%) of casualties were reported to occur at home, reflecting the night-time event, while 17 (2.7%) were at commercial locations, 8 (1.3%) were at recreational venues, 11 (1.8%) were on the road, and 27 (4.3%). It is expected that if the event occurred during a work day the home numbers would be much lower and commercial numbers would be much higher.

3.4 Demographic Distribution

During the Kaikoura earthquake, 422 (67.4%) of the casualties were female, which is remarkably similar to the 2010-2011 Canterbury earthquakes (Johnston et al., 2014) which reported 64% and 65% for the 2010 Darfield and 2011 Christchurch earthquakes respectively. One interpretation of this is that females are more likely to help others during an earthquake and put themselves into risky positions. Further analysis is required to cross-correlate gender with the injury context to validate this hypothesis.

Four hundred and fifty five (72.7%) of the casualties were people aged between 20 and 64, while 146 (23%) were elderly and only 25 (4%) were children aged less than 19. Again this is similar to both the 2010 Darfield and 2011 Christchurch earthquakes age distributions of casualties (Johnston et al., 2014).

Primary ethnicity is self reported by the victim (Table 2) on the ACC claim form. Seventy percent (438) of casualties were NZ European, 9.4% (59) were Maori, 6.7% (42) were European and 5% (31) were Asian. Further work is required to normalise the demographic (age, sex, ethnicity) by population data from the Census to identify if certain demographic groups are over- or under-represented in the casualty statistics.

Table 2: Number of Casualties by Primary Self-Identified Ethnicity

Ethnicity	No. of Casualties	% of Casualties
Maori	59	9.4
Pacific Islander	14	2.2
Asian	31	5.0
NZ European	438	70.0
European	42	6.7
African/Middle Eastern	5	0.8
Other/Not Stated	37	5.9

3.5 Behavioural Context

The context of injury was determined using the free text description of the injury by the victim. The assignment of the context was undertaken using the guidelines developed from analysis of injuries in the 2010-2011 Canterbury Earthquakes (Johnston et al., 2014). Approximately 45% of the casualties were due to primary direct causes, 45% from primary action and 9% were from secondary actions following the earthquake (Table 3). In comparison, the 2010 Darfield Earthquake had 17% from primary direct, 45% from primary action, 22% from secondary actions, and the 2011 Christchurch Earthquake had 44% from primary direct, 18% from primary action, and 26% from secondary actions.

Table 3: Number of Casualties per Context Classification

Context	No. of Casualties	% of Casualties
Primary Direct	282	45.0
Primary Action	281	44.9
Secondary	57	9.1
Mental Health	5	0.8
Not Earthquake Related	1	0.2

Further breakdown of sub-classes within these show that within the primary direct context, 37% of total injuries were caused by the victim being thrown or falling due to the shaking , and 8% of total injuries were from the victim being hit by contents mainly wardrobes or wall hangings. Less than 1% of total injuries were from non-structural or structural elements in the building (Table 4).

Table 4: Number of Casualties per Primary Direct Context

Primary Direct Context	No. of Casualties	% of Casualties
Structural System	1	0.2
Non-structural System	3	0.5
Building Contents	48	7.7
Trip/Fall/Thrown by Shaking	230	36.7

Of the people injured by primary direct actions (i.e. action of the person) the action was coded into 15 different action categories. Twelve percent of total injuries were from the victim getting out of bed during the shaking, 8% were due to running for safety, 8% due to evacuating the building during shaking and 7% from helping children (Table 5).

Table 5: Number of Casualties per Primary Direct Context

Primary Action Context	No. of Casualties	% of Casualties
Took cover under table	5	0.8
Took cover under door frame	23	3.7
Going/running for cover/safety	50	8.0
Going/running for door frame	1	0.2
Helping child	43	6.9
Helping others	4	0.6
Helping animal	3	0.5
Evacuating/exiting building	50	8.0
Jumping down/over something	2	0.3
Getting out of bed	77	12.3
Getting up (unspecified)	9	1.4
Stopping/saving object from falling	11	1.8
Avoiding object falling on them	0	0.0
Stopping object or avoiding object falling on them	2	0.3
Opening doors during earthquake	1	0.2

Of the sub-classes of secondary context injuries, 1% of total injuries were from people evacuating from a potential tsunami following the earthquake, and 1% were from assessing damage or clean-up (Table 6).

Table 6: Number of Casualties per Secondary Context

Secondary Context	No. of Casualties	% of Casualties
Tsunami evacuation following earthquake	7	1.1
Checking damage/on people/on animals/clean-up	9	1.4
Car Accident	1	0.2
Evacuating building after earthquake	2	0.3
Post-earthquake conditions (e.g. boiling water)	1	0.2

3.6 Medical Context

3.6.1 Injury Severity

The casualties were mapped to the RiskScape casualty states which vary depending on the level of treatment required (Table 7). None of the ACC data was categorised as Casualty State 1 (First Aid) as all ACC claims received medical treatment from at a minimum a doctor and this is a significant limitation of using the ACC data. Over 91% of casualties were treated by a doctor, 8% required treatment at a hospital, none required intensive care, and there were 0.3% (2) deaths. There seems to be a general order of magnitude reduction in number of casualties for each increasing casualty state.

Table 7: Number of Casualties per RiskScape Casualty State

Casualty Classification	No. of Casualties	% of Casualties
1 - First Aid	0	0.0
2 - Doctor	568	91.6
3 - Hospital	50	8.1
4 - Hospital Intensive Care	0	0.0
5 - Dead	2	0.3

The majority (77%) of casualties were soft tissue injuries such as sprains, strains and contusions, 10% were lacerations or punctures, 5% were dislocations or fractures (Table 8). The site of primary injury occurred mostly on the back (24%) or neck (11%), followed by knees (9%), head (8%) and leg (6%). This is consistent with the type of injury being dominated by soft tissue injuries such as straining of the back.

3.6.2 Injury Type

Table 8: Number of Injured People per Injury Type

Injury Type	No. of Casualties	% of Casualties
Burns	1	0.2
Concussion	6	1.0
Dental	8	1.3
Fracture/Dislocation	31	5.0
Gradual Onset	3	0.5
Laceration/Puncture	64	10.2
Hernia	1	0.2
Pain Syndromes	3	0.5
Soft tissue (contusion, sprain, strain)	484	77.3
Trauma induced hearing loss	1	0.2
Other	24	3.8

4 CONCLUSION

This paper presents a first insight into the distribution and context of casualties caused by the 2016 Kaikoura Earthquake. Some variables such as distribution of sex and age are consistent with that observed during the 2010-2011 Canterbury Earthquakes, while other observations such as the behavioural context of injuries and occurrence of injuries event at low to moderate shaking intensities (MMI5 and below) are unique to this event. Further work will normalise the casualty statistics with the exposed population to determine odds ratios that can be used to identify risk factors for casualties. The Kaikoura Earthquake data will also be integrated with that from seven other earthquakes in New Zealand since 2010 to develop an earthquake casualty forecast model for New Zealand.

5 ACKNOWLEGEMENTS

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