THE NEW ZEALAND MEDICAL JOURNAL
Journal of the New Zealand Medical Association

Preventability of pre-hospital trauma deaths in southern New Zealand

James A Falconer

Abstract

Aim To assess the preventability of pre-hospital trauma deaths in the Otago and Southland regions of New Zealand.

Methods A retrospective audit was carried out of all post-mortems from trauma deaths that occurred in these regions between January 2000 and December 2004. The injuries documented in the post-mortem reports were scored using the Abbreviated Injury Scale (AIS) 2005 and from this an Injury Severity Score (ISS) derived. Based on the ISS groupings of Sampalis et al, a probability of the preventability of death was then determined.

Results A total of 362 deaths were identified. Post-mortems were available for 245; 54 were excluded and 191 had their post-mortems scored according to the AIS 2005 with derivation of an ISS. Of these, 19 (10%) were classified as having survivable injuries, 66 (35%) potentially survivable injuries and 106 (55%) non-survivable injuries. The majority were aged 35 years or younger (51%), male (71%) and suffered significant injuries to multiple regions (76% to two regions, 51% three or more regions) and were the result of a motor vehicle accident (70%).

Conclusions In trauma-related deaths in southern New Zealand, the majority of patients who die before reaching hospital do so from non-survivable injuries; however, a significant proportion has either potentially survivable or survivable injuries. These results are very similar to comparable international studies and suggest that there should be further attempts at improving pre-hospital care while also aiming to improve primary prevention. Further research is required.

Trauma is the leading cause of death in New Zealand from age 1 through to 34 years, the third most common cause of death from age 35 to 54, and overall the fourth most common cause of death in all age groups.[1]

In 2004 there were 1723 trauma-related deaths in New Zealand, of which 628 were in the 0 to 34 age range. With the exclusion of pregnancy, trauma is the leading cause of hospitalisation from age 5 to 45 years.[1] Despite the significant impact on the health system and wider society, there have been no studies of the preventability of trauma deaths in New Zealand.

A preventable death has been previously defined as "a fatal outcome occurring in patients with survivable injuries".[2] However the preventability of trauma deaths is more difficult to quantify, and the published percentage of those deemed preventable varies widely, anything from 2-39%.[3,4] Therefore to define the degree of preventability for this study the ISS groupings derived by Sampalis et al[2] have been used, these groupings have previously been used by several other studies.

Studies on the preventability of trauma deaths have been undertaken elsewhere; however New Zealand is unique in many regards, certainly culturally and geographically. However, perhaps the biggest difference is New Zealand's relatively low population density of 15 people per square km, similar to Norway and Finland but significantly less than the OECD average of 33 people per square km.[5] This low population density is even more pronounced in the southern regions, where expert medical personnel and care can often be several hours' road travel away.

This study was done in an attempt to determine if there was excess pre-hospital trauma mortality in the study region. A determination could then be made regarding further research into the component aspects of any excess trauma, and possible preventive strategies.

Methods

After approval from the Lower South Regional Ethics Committee, the names and identifiers of all people who died of an external cause in the Otago and Southland regions (as defined by the New Zealand Local Government Act 2002 No84[6]) from the year 2000 to 2004 were obtained from the New Zealand Health Information Service (NZHIS). A similar dataset was obtained from the Accident Compensation Corporation (ACC), New Zealand's national no-fault personal insurer, after approval from ACC's own ethics committee.

The two datasets were required as the NZHIS data is based on where the patient was domiciled at time of death: therefore those that died in the study regions but were not domiciled there were missed. ACC data is based on location of death; however their database is not as inclusive as that of the NZHIS.

The two datasets were then cross-matched, and all non-trauma deaths (e.g. medical causes, suicide, drowning) and deaths outside the study area excluded. The resultant dataset was then sent to the Department of Justice, Coronial Service to ascertain if a post-mortem had been performed. Those patients who had not had a post-mortem were then excluded, as were those from early 2000 whose post-mortems had been archived and could not be obtained within the study budget. The post-mortems for the remaining patients were obtained from the Department of Justice, Coronial Service. Each post-mortem was reviewed and scored according to the AIS 2005.[7]

The AIS is an anatomically-based scoring system, which classifies the most severe injury for each of six body regions (head/neck, face, chest, abdomen, extremities and external) by increasing severity from 1 to 6. An AIS score of 1 represents an injury such as an abrasion whereas an AIS score of 6 is a non-survivable injury. The ISS is calculated from the sum of the square of the three most severely injured body regions per patient and provides a summary score with a range from 3 to75. An AIS score of 6 in any single body region is automatically scored as a maximal ISS of 75.

All data collection and scoring was carried out by the author to prevent any inter-observer variation, and the scores were then checked by a dedicated trauma co-ordinator. Any discrepancy between scores was then discussed with a final score being arrived at by consensus agreement.

The ISS was used to determine the preventability of the trauma deaths as there was no available physiological data, and it has been previously demonstrated that ISS has "validity comparable to that of a chart review by a committee of experts".[2] Cases were classified as survivable (9-24), potentially survivable (25-49) and non-survivable (>49) based on the ISS groupings of Sampalis et al.[2]

Results

A total list of 362 patients was initially sent to the Department of Justice. No post-mortems had been done on 72 (20%) patients, a decision left to the discretion of the Coroner involved on a case-by-case basis. A further 45 (12%) had post-mortems that had been done in early 2000 that had subsequently been archived.

Post-mortems were obtained on 245 patients and subsequently 54 (15%) patients were excluded as they either: died in hospital, out of the study area, from suicide or non-

trauma related causes. The remaining 191 post-mortems became the study dataset. These were scored according to the AIS 2005 with derivation of an ISS. This revealed 19 (10%) had scores that suggested that they had survivable injuries, 66 (35%) had scores suggestive of potentially survivable injuries and 106 (55%) had non-survivable scores. Of the 106 with non-survivable scores, 90 actually had a maximal ISS of 75.

The pattern of injuries in the different regions scored by the AIS 2005 is illustrated in Table 1. The head/neck and chest regions were most frequently the areas with the highest single AIS scores, and combined accounted for 74% of all the study patients. The head/neck region had the single largest number of AIS 6 scores, which denotes a non-survivable injury. The 16 patients (8%) who had an external AIS score of 6 were motor vehicle accidents with secondary drowning or incineration. In some patients two or even three regions had equally high AIS scores.

Table 1. Highest AIS† score by anatomical region

Region	Highest AIS Score				Total (%)
	3	4	5	6	
Head/Neck	4	10	19	42	75 (39)
Face	0	0	0	0	0 (0)
Chest	1	16	22	26	65 (35)
Abdomen	0	1	3	1	5 (2)
Extremities	0	0	0	0	0 (0)
External	0	0	2	16	18 (10)
Two equal regions	2	13	3	5	23 (12)
Three equal regions	3	2	0	0	5 (2)
Totals	**10**	**42**	**49**	**90**	**191**

†Abbreviated Injury Scale.

The multiplicity of injuries in the study population is illustrated in Table 2. Only those regions with AIS scores of two or greater are included.

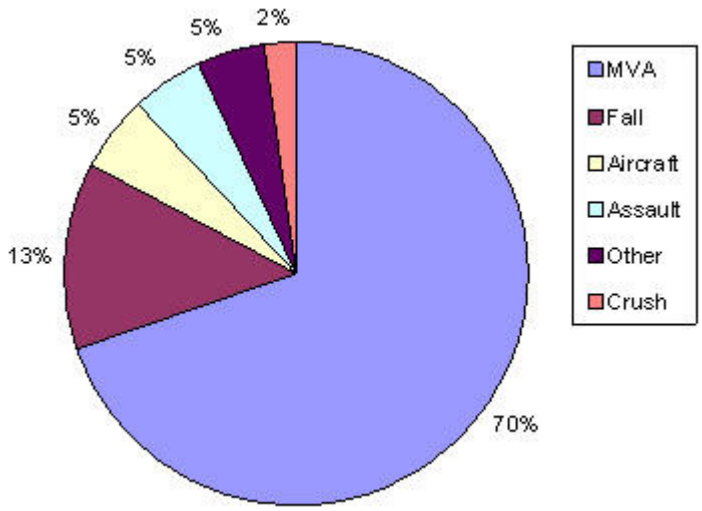
Table 2. Number of regions with AIS† Score ≥2 per post-mortem

Variables	1	2	3	4	5	6	Total
Patients	46	47	51	28	18	1	191
Percentage	24	25	27	15	9	1	100

†Abbreviated Injury Scale.

The causes of death are shown in Figure 1. The predominant cause of death in this study was from motor vehicle accidents (MVAs), with falls from a height the next most common. The falls were commonly leisure-related and reflects the study area's rugged geography, with many of them mountaineering in nature. The mountainous nature of the region was also reflected in the deaths attributable to light aircraft accidents with 11 deaths from just 6 accidents. Five of these deaths arose from a single scenic flight aircraft accident.

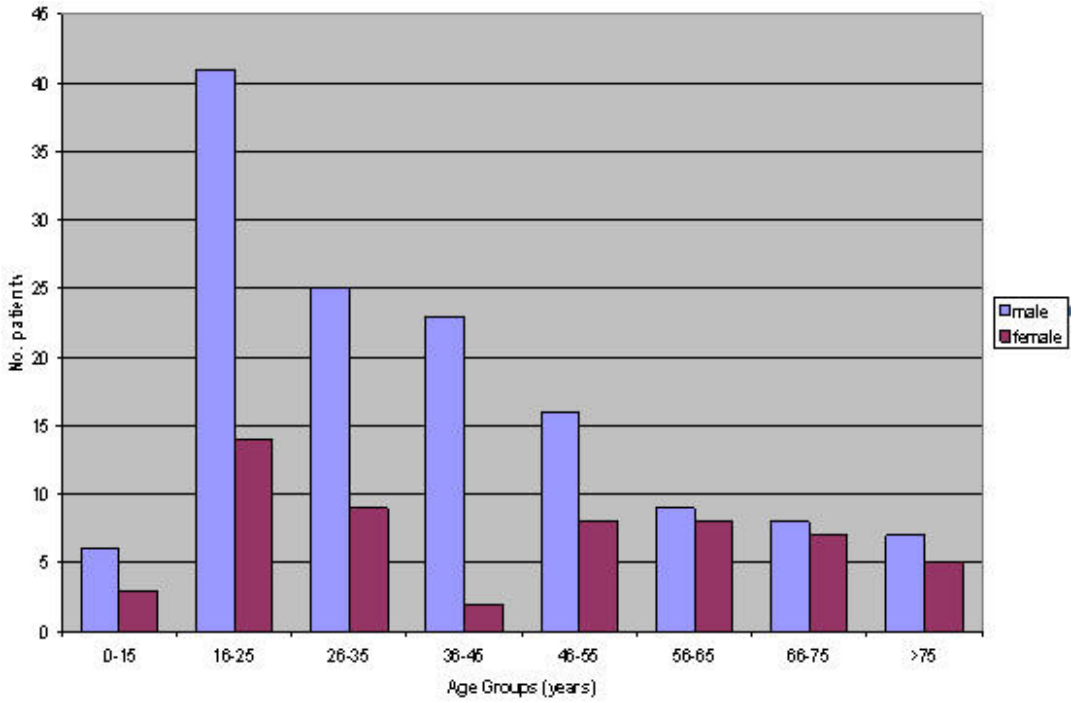
Figure 1. Cause of death



MVA=motor vehicle accident.

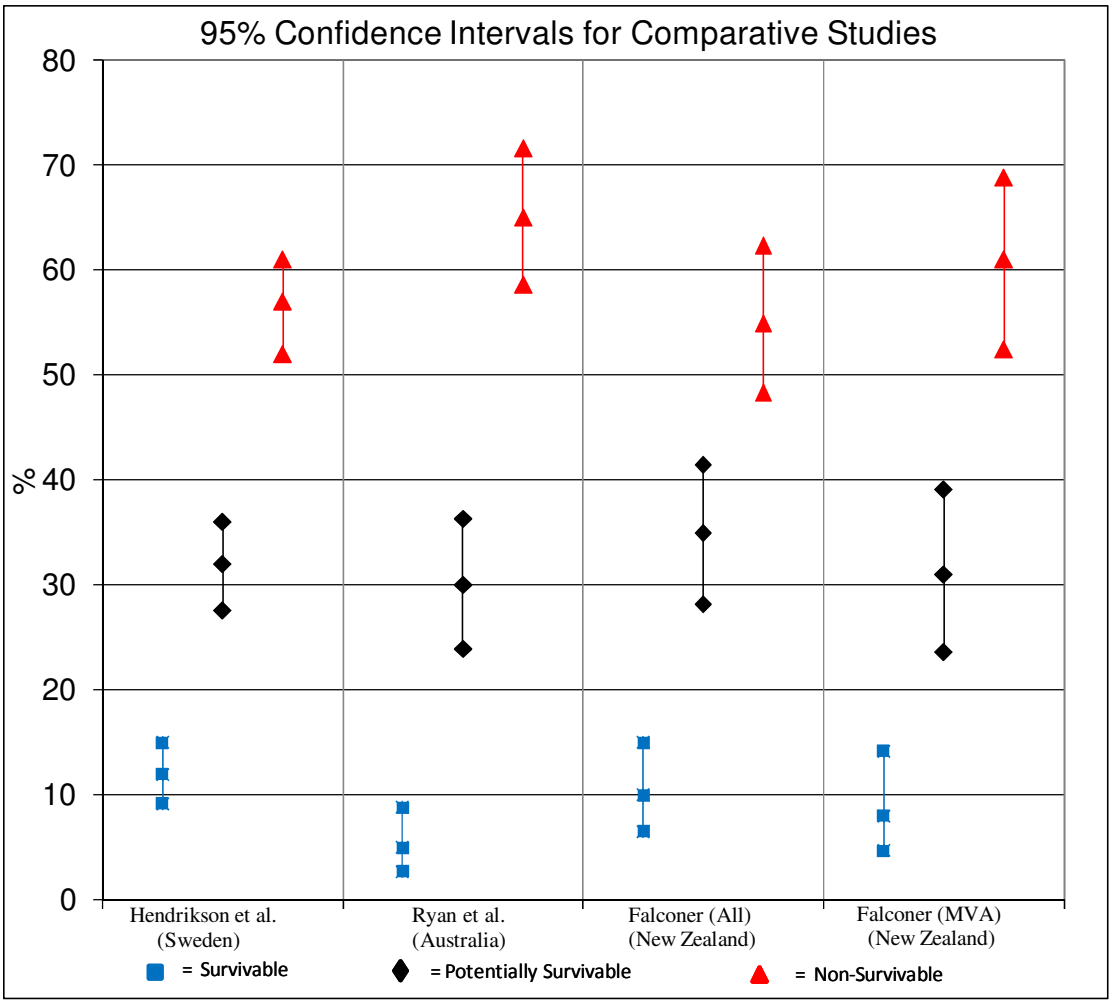
Demographic breakdown of the study population is shown in Figure 2. Fifty-one percent of the study population were aged 35 years or younger. Males outnumbered females at a ratio of 2.4:1, and accounted for 135 (71%) of the total study population. There was also a preponderance of young males, with 74% of those aged between 16–45 years being male.

Figure 2. Trauma deaths by age



These results are similar to those obtained in studies undertaken in Australia[8] and Sweden,[9] all of which were attempting to determine the preventability of trauma death using AIS and ISS. However the Australian and Swedish studies only looked at motor vehicle accidents, therefore to aid comparison between similar study populations the motor vehicle accident subset from this study has been graphed separately from that of 'all trauma' which includes this subset as part of the total study population. The 95% confidence intervals for all of these studies have been graphed (Figure 3) and illustrate the very similar results.

Figure 3. 95% confidence intervals for comparative studies



Discussion

Trauma is a significant cause of death in New Zealand. This is illustrated by data from the Injury Prevention Research Unit at Otago University in Dunedin,[1] and supported by the findings of this study where the majority (51%) of the study population were

aged less than 35 years, and 71% were male. These results illustrate the significant cost of this disease to the New Zealand Health system, and underscore the impact it has on the wider New Zealand society.

The preventability of trauma deaths is difficult to quantify, and there are widely divergent figures quoted in the literature (2–39%).[3,4] This variability is likely multifactorial with possible variables including: geography, demographics, methodologies, trauma systems and injury patterns. This is all complicated by the fact that what may be medically preventable in an ideal situation, may actually be non-preventable in a 'real world' scenario, where constraints such as physical isolation, availability of limited resources and prevailing weather all impact on outcomes.

Yet the results of this study are very similar to other studies of a similar nature done in Australia[8] and Sweden;[9] despite the obvious geographical and population differences. The ranges for each category from all three studies being: survivable (ISS 9–24) 5–12%, potentially survivable (ISS 25–49) 30–35% and non-survivable (ISS >50) 55–65%.

However, of note is that the Australian[8] and Swedish[9] studies only related to motor vehicle accidents, whereas this study was trauma deaths of all causes. However 70% of trauma deaths in this study were also as the result of a motor vehicle accident and if this subset is extracted, then an even tighter correlation to the Australian[8] and Swedish[9] studies is obtained, with ranges for each category in this subset being: survivable (ISS 9-24) 5–12%, potentially survivable (ISS 25-49) 30-32% and non-survivable (ISS >50) 57–65%. This tight correlation of ranges for each category is reflected in the consistency of the ranges for the 95% confidence intervals between the studies.

With regard to motor vehicle accidents, New Zealand as with other OECD countries has had a declining mortality for many years, this is a reflection of many things including: improved vehicle safety, public education (e.g. seatbelts/alcohol) and hazard mitigation works on dangerous stretches of road. However when analysis was attempted to see if this declining overall mortality was reflected in this studies population, the results did not reach statistical significance in the relatively short period of this study.

The majority of the study population suffered significant (AIS≥2) injuries to multiple regions, as defined by the AIS 2005 scoring system, with 76% injured in two regions and 51% in three or more.

Not surprisingly the head/neck and chest were the most common sites of fatal injury accounting for 74% of the total fatalities, and the head/neck was the single most lethally (AIS score 6) injured area (21%). This multiplicity and pattern of injuries further supports the suggestion, based on the injury severity scores, that the majority of pre-hospital trauma deaths in this study are not survivable.

Given that the majority of patients in this study had non-survivable injuries, then there is significant justification for continuing preventative measures such as improved road configuration, driver/pilot education and also general public education with regard to simple first aid and injury prevention. However given the marked number of young people killed in motor vehicle accidents combined with New Zealand's relatively low driver licensing age (15 years as compared to other OECD countries which are on

average 17-18 years), then consideration should be given to modification and improved young driver licensing and education.

However in this study there are still a significant proportion of patients who had survivable or potentially survivable injuries, who died. The cause for this is likely to be multifactorial and may reflect retrieval times, time delay until victim found, experience of initial attending medical staff, causation of injury, or other as yet undefined causes. This area is one which requires further detailed study with the prospect that potentially remedial causes of preventable deaths may be identified and subsequently ameliorated.

New Zealand still lacks a national trauma database, something which has been recommended and promoted both by clinicians and health officials for at least the last decade. If implemented a national trauma database would allow "quality assessment, standardisation and coordination of care"[11], and therefore potentially lead to significant improvements in the provision of trauma care in New Zealand.

The benefits of a trauma system are perhaps best illustrated by the continued decline in mortality in the state of Victoria, (Australia) after the implementation of the Victorian State Trauma Registry[12] in 2001.

There are several factors that limited this study. The retrospective nature of this study and the fact that it is limited to post-mortem reports without any access to data that would allow assessment of the patient's physiological state. There was also no access to the patients past medical history, Police or ambulance reports.

As the study data was derived solely from post-mortem reports it was unable to be ascertained whether the patient was dead at the scene, or died in transit to hospital. This would have been extremely useful information to extract, as it would then allow a much more accurate assessment of the practical preventability of pre-hospital trauma deaths. This is important as with New Zealand's rugged and sparsely populated geography then many of these patients were possibly not found for sometime after their accidents.

There are several well recognised limitations when classifying injuries according to the AIS and ISS scoring systems. These are that:

- Spinal injuries are often not described in detail in post-mortem reports, therefore skeletal injuries are recorded but not the potential spinal cord injury underlying this. (This is of particular relevance in the cervical spine.)
- There is only one injury scored per injury region which can therefore underestimate the severity of injuries in a patient who has multiple severe injuries in the same region.
- These scoring systems give no weight to physiological variables.
- Equal weighting is given to each of the regions in the scoring system.
- Only the injuries from the three most severely injured regions contribute to the ISS.

Conclusion

The Otago and Southland regions of New Zealand have a significant trauma burden, primarily from motor vehicle accidents and involving young people. Falls, aircraft accidents and interpersonal violence also cause significant mortality.

The majority of all trauma patients in this study suffered non-survivable injuries, similar to comparable international studies. However, there are still a significant number who suffered potentially survivable and survivable injuries, who died. Therefore while there needs to be attention to primarily preventing these accidents, there still needs to be further analysis of those who die of potentially survivable or survivable injuries.

This analysis needs to be undertaken in an attempt to identify remedial causes of death and consequently potentially avert future unnecessary loss of life.

Funding: We thank Emergency Care Co-ordination Team (ECCT), Otago District Health Board: Provision of funding for copies of post-mortem reports from the New Zealand Department of Justice, Coronial Service.

Author information: James A Falconer, Registrar, Emergency Department, The Canberra Hospital, Canberra, ACT, Australia

Acknowledgements: I thank Associate Professor D Richardson (NRMA-ACT Road Safety Trust Chair of Road Trauma & Emergency Medicine, Canberra Clinical School, The Canberra Hospital) for his reviews and advice on the preparation of this paper; Rebekah Ogilvie (Trauma Coordinator, Shock Trauma Service, The Canberra Hospital) for her time and effort in reviewing the scoring of the post-mortems; and Dr Matthew Ryan (Staff Specialist Emergency Medicine, Nambour Hospital, Queensland) for reconfiguring his study data to allow a direct comparison of survivability with the groupings used in this study.

Correspondence: Dr James A Falconer, Registrar, Emergency Department, The Canberra Hospital, PO Box 11, Woden, ACT 2606, Australia. Email: falconer386@yahoo.co.nz

References:

1. Gulliver PJ Simpson JC (editors) (2007) Injury as a leading cause of death and hospitalisation. Fact Sheet 38. Injury Prevention Research Unit. (Updated April 2007). http://www.otago.ac.nz/ipru/FactSheets/FactSheet38.pdf
2. Sampalis JS, Boukas S, Nikolis A, Lavoie A. Preventable death classification: Inter-rater reliability and comparison with ISS-based survival probability estimates. Accid Anal Prev. 1995;27:199-206.
3. Limb D, McGowan A, Fairfield JE, Pigott TJ. Prehospital deaths in the Yorkshire Health Region. J Accid Emerg Med. 1996;13:248-250.
4. Hussain LM, Redmond AD. Are pre-hospital deaths from accidental injury preventable? BMJ 1994;308:1077-80.
5. Pink B (editor) New Zealand in the OECD. Statistics New Zealand: 4-5 (Released 17-7-2009, cited July 2009). http://www.stats.govt.nz/~/media/Statistics/publications/product%20development%20and%20publishing/nzintheoecd.aspx
6. New Zealand Local Government Act 2002 No. 84 (Updated July 1 2009, cited July 2009) http://www.legislation.govt.nz/act/public/2002/0084/latest/DLM174258.html

7. Gennarelli TA, Wodzin E, editors. AIS 2005. Barrington, IL: Association for the Advancement of Automotive Medicine; 2005.
8. Ryan M, Stella J, Chiu H, Ragg M. Injury patterns and preventability in prehospital motor vehicle crash fatalities in Victoria. EMA 2004;16:274-279.
9. Henriksson E, Ostrom M, Eriksson A. Preventability of vehicle-related fatalities. Accident Analysis and Prevention 2001;33:467-475.
10. Christey GR. Trauma Care in New Zealand: It's Time to Move Ahead. World J Surg. 2008;32:1618-1621.
11. Victorian State Trauma Registry 2006-07 Summary report. (Released August 2008, cited July 2009). http://www.health.vic.gov.au/trauma/06-07sumrep.pdf
12. Papadopoulos IN, Bukis D, Karalas E, et al. Preventable prehospital trauma deaths in a Hellenic urban health region: an audit of prehospital trauma care. J Trauma. 1996;41:864-9.
13. Civil I. Trauma: still a problem in New Zealand. N Z Med J. 2004, 117(1201). http://www.nzmj.com/journal/117-1201/1042/content.pdf