
A decade of Intensive Care Unit trauma admissions in Auckland

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Abstract

Aims. To describe the demographics, nature and severity of injury of trauma admissions to a New Zealand urban Intensive Care Unit (ICU) over a ten year period; to determine differences in injury characteristics between patients received from inside and outside the local trauma catchment area; and to calculate incidence rates in the local population served, to identify high risk groups of patients.

Methods. We carried out a cross-sectional analysis of a prospective ICU patient registry. Data on all trauma admissions from 1988 to 1997 to the ICU of a large New Zealand urban hospital were studied with respect to age, gender, ethnicity, injury type and severity, and referral status. National Census data for the ICU catchment area were used to calculate incidence rates for local admissions.

Results. A total of 2305 trauma patients were admitted over the period of the study, accounting for 25% of all ICU admissions. The median age was 28 years and 75% were males. Blunt trauma, mostly due to motor vehicle crashes, accounted for 95% of admissions and penetrating

trauma was very rare. The median Injury Severity Score (ISS) was 26 and most life threatening injuries occurred in the head region. Referred admissions were more severely injured and had a higher prevalence of severe head injury than local admissions. The ICU trauma admission rate for local patients was 34.6 per 100 000 person-years. Males had a higher rate than females in all age groups. New Zealand Europeans made up the majority of admissions, but Maori and Pacific Island males had the highest incidence rates.

Conclusions. This study identified trauma as a major component of the ICU population. ICU trauma admissions were characterised by young males with head injuries resulting from motor vehicle crashes. Referred admissions were more severely injured than local admissions and would thus distort the estimated incidence of trauma in the local geographic region served. Calculation of incidence rates highlighted a significantly higher risk of ICU trauma admission amongst Maori and Pacific Islands people than New Zealand Europeans.

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The development of trauma centres and trauma registries has increased over the last two decades and they have become important sources of data for trauma research.¹⁻³ However, they have biases in data selection which limit their ability to generate population-based data.³ One limitation is the distorted picture of injury severity that results when data on patients from the surrounding community and patients referred for specialised services from other hospitals, are combined. Another limitation is their inability to define a distinct denominator population, which is necessary to calculate accurate and useful injury incidence rates.

Because of the structure of the public health system in New Zealand, Auckland Hospital has a well-defined exclusive catchment area for trauma. Furthermore, the Department of Critical Care Medicine (DCCM), which is the ICU for Auckland Hospital, keeps a computerised patient registry which includes data on patient domicile and inter-hospital referrals. As a result, it is possible to differentiate and compare the local and referred populations, and to calculate population-based data that have rarely been available in trauma research.

This study aimed: firstly to profile accurately the ICU trauma population from both demographic and injury

perspectives for the last ten years; secondly to investigate differences between local admissions and referred admissions; and thirdly to calculate incidence rates to identify groups of individuals at high risk of severe trauma in the Auckland region.

Methods

Auckland is a city of approximately 1 000 000 people, divided into three health areas (Northwest Auckland, Central Auckland and South Auckland). These are served by two trauma centres which have well-defined catchment areas. Auckland Hospital, a 538 bed university-affiliated acute tertiary referral hospital, covers the Central Auckland and Northwest Auckland areas, and Middlemore Hospital covers the South Auckland area. The DCCM was the only ICU providing care for trauma patients aged fifteen years and over for the Central Auckland and Northwest Auckland areas over the entire period of this study. Its computerised patient registry has included trauma variables since 1984. Patients under fifteen years are admitted to the adjacent Children's Hospital. The two other general hospitals in Auckland Hospital's trauma catchment area, North Shore Hospital and Green Lane Hospital, are not trauma centres and do not accept major trauma. At the 1991 census, a total of 512 472 people resided permanently within the Auckland Hospital trauma catchment area.⁴

Data from the computerised trauma registry on all trauma patients admitted to the DCCM between and including 1 January 1988 and 31 December 1997 were analysed. Trauma was defined as physical injury resulting from mechanical energy and trauma admission was defined as admission to hospital because of trauma. Patients with burns were not included. Patients who were treated outside of the ICU, or who died without admission to the ICU were not included. Local admissions were defined as those patients presenting first to a hospital inside the Auckland Hospital trauma catchment area. Referred admissions were defined as patients presenting first to a hospital outside the Auckland Hospital trauma catchment area before being transferred to Auckland Hospital. The majority of such referrals are made to Auckland Hospital's specialised services (most commonly neurosurgery) and were predominantly from the upper half of the North Island.

Data on demographics, source of referral, mode of injury and injury severity were analysed. For each subject, injuries were coded using the 1980 version (which has been used consistently since the beginning of the registry) of the abbreviated injury scale (AIS) dictionary.³ All subjects were allocated an External Cause of Injury (E-code) by JPG on the basis of the detailed information recorded on the database.⁶

Demographic data from the 1991 New Zealand National Census, tabulated and reproduced by the North Health Regional Health Authority,⁴ were used to calculate incidence rates by age, sex and ethnicity. Data on ethnic origin were available in the DCCM patient registry only for the nine years 1989 to 1997.

Results

There were 9420 adult (age ≥ 15 years) DCCM admissions in the ten years from January 1988 to December 1997 inclusive. Trauma was the largest single diagnostic category, accounting for 2305 admissions (24.5% of the total), followed by poisonings and overdoses (1481, 15.7%), postoperative cardio-respiratory support (1277, 13.6%) and sepsis (1014, 10.8%). Trauma was also the largest single contributor to patient bed-days (10366, 30.7%) and to patient deaths (339, 23.0%). Of the 2305 ICU trauma admissions, 2024 (87.8%) received mechanical ventilatory support, 1023 (44.4%) received inotropic support, 582 (25.2%) received tracheotomies and 1965 (85.2%) were discharged alive from the ICU.

Patient Characteristics. The median age of trauma admissions was 28 years, with a range of 15 to 95 years. As shown in Table 1, 1467 (63.6%) trauma admissions were aged between 15 and 34 years. Males accounted for 1748 (75.8%) admissions. New Zealand Europeans accounted for 64.0% of the 2034 admissions for whom ethnicity was recorded. Maori and Pacific Islands admissions accounted for 19.4% and 11.7% respectively, and the remaining 5.0% were of 'Other' ethnicity, mostly Asian.

Overall blunt trauma (regardless of intent) accounted for 2190 (95%) admissions, and penetrating trauma for only 115 (5%) admissions. Stabbings and intentional lacerations

accounted for 76 (66.1%) of the penetrating trauma admissions, and firearm and nail gun injuries for another 30 (26.1%) injuries. Nine (7.8%) cases of penetrating trauma were accounted for by unintentional lacerations.

Table 1. Demographic characteristics and mechanism of injury of local, referred and total trauma ICU admissions, Auckland 1988-1997.

	Local		Referred		Total	
	No.	%	No.	%	No.	%
Age (years)						
15-24	681	38.4	214	40.3	895	38.8
25-34	447	25.2	125	23.5	572	24.8
35-44	191	10.8	76	14.3	267	11.6
45-54	158	8.9	51	9.6	209	9.1
55-64	119	6.7	36	6.8	155	6.7
65-74	95	5.4	21	4.0	116	5.0
75+	83	4.7	8	1.5	91	3.9
Gender						
Male	1330	75.0	418	78.7	1748	75.8
Female	444	25.0	113	21.3	557	24.2
Ethnicity (2034)*						
NZ European	1064	68.2	237	49.9	1301	64.0
Maori	257	16.5	138	29.1	395	19.4
Pacific Islands	162	10.4	75	15.8	237	11.7
Other	76	4.9	25	5.3	101	5.0
Type of trauma						
Blunt	1696	95.6	518	97.6	2190	95.0
Penetrating	78	4.4	13	2.4	115	5.0
External cause of Injury						
Motor Vehicle Crash	1176	66.3	334	62.9	1510	65.5
Falls	268	15.1	73	13.7	341	14.8
Other unintentional	77	4.3	36	6.8	113	4.9
Assaults	204	11.5	82	15.4	286	12.4
Self-Harm	49	2.8	6	1.1	55	2.4
Total*	1774		531		2305	

*Denotes 9 years of data only (1989-1997 inclusive; 2034 admissions).

Motor vehicle crashes accounted for 1510 (65.5%) admissions. Of these, 881 (58.3%) were motor vehicle occupants, 300 (19.9%) were motor cyclists, 286 (18.9%) were pedestrians and 43 (2.8%) were cyclists. Of the 1181 motor vehicle occupants and motor cyclists, 830 (70.2%) were drivers.

Falls accounted for 341 (14.8%) admissions. Of these, 151 (44.3%) were falls on the same level and 190 (55.7%) were falls from a height. In 21 (6.2%) cases the height of the fall was unknown. Other unintentional injuries accounted for 113 (4.9%) admissions and included: being struck by a falling object (34), being struck by an object or person (34) and being struck by or falling from an animal (6). Assaults accounted for 286 (12.4%) admissions. Of these, 220 were blunt assaults, 47 were assaults with knives and nineteen were assaults with firearms. Self-inflicted injuries accounted for 55 admissions and included: self-harm by jumping (27), knives or cutting (14) and firearms including nail guns (11).

As shown in Table 2, the head (including the neck) was the most commonly injured body region. Of all patients, 83.1% had an injury in this body region compared with 30.3% and 20.1% to the thorax and face regions respectively. Life-threatening and critical injuries (AIS ≥ 4) were most common in the head and neck region (62.6% of patients), followed by the abdomen (10.7%) and thorax (8.9%) regions. Moderate and serious non-life threatening injuries (AIS 2 and 3) were most common in the extremities region (44.6%), followed by the thorax (21.4%) and face (14.5%) regions.

Injury severity scores extended over the full range of 1 to 75 with a median ISS of 26 and a mean ISS of 27.6. Some

patients were admitted with low ISS scores to rule out more serious injuries or to treat comorbidities or complications. Major trauma (ISS ≥ 16) was seen in 2040 (88.5%) admissions. An ISS of 25 or over was seen in 1467 (63.6%) admissions.

Table 2. Abbreviated injury (AIS-80) and injury severity (ISS-80) scores for local, referred and total trauma ICU admissions, Auckland 1988-1997.

	Local		Referred		Total	
	No.	%	No.	%	No.	%
Abbreviated Injury Scores by Body Region						
AIS Head & Neck						
0 (no injury)	357	20.1	32	6.0	389	16.9
1-3	437	24.6	35	6.6	472	20.5
4-6	980	55.2	464	87.4	1444	62.6
AIS Face						
0 (no injury)	1439	81.1	402	75.7	1841	79.9
1-3	294	16.6	40	7.5	334	14.5
4 (max. score)	41	2.3	89	16.8	130	5.6
AIS Thorax						
0 (no injury)	1189	67	417	78.5	1606	69.7
1-3	413	23.3	80	15.1	493	21.4
4-6	172	9.7	34	6.4	206	8.9
AIS Abdomen						
0 (no injury)	1468	82.8	461	86.8	1929	83.7
1-3	109	6.1	21	4.0	130	5.6
4-6	197	11.1	49	9.2	246	10.7
AIS Extremities						
0 (no injury)	933	52.6	328	61.8	1261	54.7
1-3	827	46.6	201	37.9	1028	44.6
4 (max. score)	14	0.8	2	0.4	16	0.7
AIS External						
0 (no injury)	905	51.0	296	55.7	1201	52.1
1-3	869	49.0	235	44.3	1104	47.9
4-6	0	0.0	0	0.0	0	0.0
Injury Severity Scoring						
1-8	36	2.0	3	0.6	39	1.7
9-15	210	11.8	16	3.0	226	9.8
16-24	489	27.6	84	15.8	573	24.9
25-40	816	46.0	341	64.2	1157	50.2
41-75	223	12.6	87	16.4	310	13.4

Local Admissions versus Referred Admissions. As shown in Table 1, referred patients and local patients had similar age and gender distribution. However, referred patients were significantly more likely to be Maori (29.1% vs 16.5%, $\chi^2=36.0$, $p<0.001$), more likely to be of Pacific Islands origin (15.8% vs 10.4%, $\chi^2=9.8$, $p<0.01$) and were slightly more likely to have sustained assaults (15.4% vs 11.5%, $\chi^2=5.5$, $p<0.05$) than local patients.

As shown in Table 2, referred admissions were much more likely to have sustained a life-threatening or critical (AIS ≥ 4) head injury than local admissions (87.4% vs 55.2%, $\chi^2=179.0$, $p<0.001$), and somewhat less likely to have sustained a severe thoracic injury (6.4% vs 9.7%, $\chi^2=5.0$, $p<0.05$). Abdominal injuries were not significantly different in the two groups ($\chi^2=1.3$, $p=NS$). The median ISS of referred admissions (29) was higher than that (25) of local admissions. The mean ISS of referred admissions (30.4, 95%CI 29.5 to 31.2) was significantly greater than that of local admissions (26.8, 95%CI 26.2 to 27.3) and a significantly greater proportion of referred patients sustained major trauma (96.4% vs 86.1%, $\chi^2=41.5$, $p<0.001$).

Incidence rates for local admissions. The overall ICU trauma local admission rate for the ten years of the study was 34.6 per 100 000 person-years. The male rate (53.8 per 100 000 person-years, 95%CI 51.0 to 56.7) was significantly higher than the female rate (16.7 per 100 000 person-years, 95%CI 15.2 to 18.3). As shown in Figure 1, males had a consistently higher admission rate than females

across all age groups. The ICU trauma local admission rate for Maori (123.0 per 100 000 person-years, 95%CI 110.9 to 135.1) and the rate for Pacific Islands patients (70.3 per 100 000 person-years, 95%CI 61.4 to 79.3) were both significantly higher than the rate for New Zealand European and 'Other' ethnicities combined (35.5 per 100 000 person-years, 95%CI 33.6 to 37.3). As shown in Table 3, these differences were most pronounced in the younger age groups, both male and female.

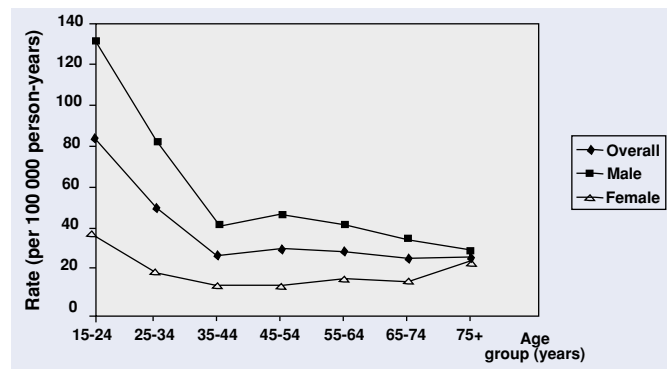


Figure 1. Incidence rates by age groups for males, females and combined genders.

Table 3. ICU trauma admission rates for local admissions per 100 000 person-years.

	Maori		Pacific Islands		NZ European / Other	
	Rate	95%CI	Rate	95%CI	Rate	95%CI
Males (Age, years)						
15-24	235.8	195.4-276.1	161.7	125.8-197.5	105.7	95.3-116.1
25-34	200.7	159.5-242.0	114.9	84.0-145.9	61.8	54.2-69.4
35-44	151.4	102.6-200.2	64.8	36.4-93.2	33.0	27.1-38.8
45-54	210.5	137.6-283.5	114.4	63.0-165.9	33.3	26.4-40.1
55-64	116.5	44.3-188.7	155.9	79.5-232.4	34.3	26.4-42.3
65-74	204.1	52.9-355.4	105.2	13.0-197.4	37.1	27.9-46.4
75+	246.9	(32.5)-526.3	63.9	(61.3)-189.0	30.5	19.6-41.5
Total Male Rate	202.3	179.7-224.7	121.2	104.1-138.3	54.0	50.7-57.2
Females (Age, years)						
15-24	51.7	32.9-70.5	35.7	19.7-51.8	34.1	28.2-40.1
25-34	58.1	36.6-79.7	27.9	13.8-42.1	13.5	10.0-17.0
35-44	37.5	15.3-59.7	15.2	1.9-28.5	11.7	8.3-15.1
45-54	33.7	6.7-60.8	5.4	(5.2)-16.1	12.4	8.3-16.6
55-64	59.2	11.8-106.7	34.2	0.7-67.7	13.0	8.1-17.9
65-74	46.6	(18.0)-111.2	16.0	(15.3)-47.2	15.2	9.9-20.6
75+	117.6	(45.4)-280.5	0.0	N/A	28.2	20.5-36.0
Total Female Rate	50.2	39.4-60.9	25.2	17.8-32.5	18.2	16.3-20.0

NB: Figures in brackets denote negative values.

Discussion

Our review of ten years of admissions to an ICU has shown that trauma accounted for a quarter of all admissions. Trauma was characterised by its occurrence in young males with blunt injuries, often to the head, mostly from motor vehicle crashes. Penetrating trauma was very rare. The main differences between referred and local admissions, as expected, were a higher severity of injury and a higher prevalence of severe head injury in the referred admissions. Our study showed that the highest incidence rates for trauma were in Maori and Pacific Islands people. Our results differ markedly from most studies of trauma in the United States. In part, this difference is because of differences in admitting practices. The practice of trauma care in New

Zealand means that only patients with a threat to life, often requiring 24 hour nursing and ventilation, are admitted to ICU, while less severely injured patients are admitted to the appropriate medical or surgical wards. This differs somewhat from trauma centres in the United States, which appear to admit a greater proportion of trauma victims (often all cases) to their centre. In a recent study⁷ comparing motor vehicle crash admissions to a US and a Canadian trauma centre, the mean ISS of admissions to the US centre was 15.6, and 31% had an ISS ≥ 16 (compared with 27.6 and 88.5% respectively in our study). The figures for the Canadian trauma centre (mean ISS 24.9; 72% with ISS ≥ 16) are much closer to, but still lower than, our own.

The difference relates to a very low New Zealand incidence of penetrating injury. In the US, penetrating injury can account for up to two-thirds of admissions to urban trauma centers.⁸ The low rate of penetrating trauma found in this study tends to mirror the findings of studies based outside the US.^{7,9-11} The major reason for this difference is the very much lower incidence of gun-related violence. Our data are thus much more comparable with non-US than US studies.

The demographic and injury profile observed in this population (ie male preponderance, youth and preponderance of blunt trauma) was similar to that found in the previously published studies of trauma in Auckland, regardless of the population studied. Specifically, a study of all trauma deaths over a one year period,¹² a study of all trauma admissions to hospital over a four week period,¹³ and a study of presentations to an Emergency Department Resuscitation Room over a one year period¹⁴ all found that young males and blunt trauma comprised a major proportion of the study populations. Despite the fact that only a minority of patients seen in hospital as a result of trauma are admitted to the ICU (in the initial data from the registry of the Auckland Hospital Trauma Service,¹⁵ of the 615 patients on the trauma registry in a six month period, only 113, or 18.4%, were admitted to ICU), the remarkable similarities observed between the basic demographic and injury characteristics suggest that the ICU trauma population is a relatively representative subset of the hospital trauma population, differing only in injury severity, but not in age, gender, or injury mechanism and type.

Separate analysis of the referred and locally admitted patients is a unique advantage of this database and the structure of the New Zealand health system. Referred admissions are predominantly transferred to Auckland Hospital to utilise tertiary neurosurgical and intensive care services for severe head injury. Therefore, a significantly higher rate of head injury was seen in the referred group. Referred patients also had a significantly higher mean ISS than local admissions, indicating that referred admissions were slightly more severely injured as a population. These findings are consistent with other recently published studies investigating differences between local and referred admissions and highlight the necessity to group and analyse these patients separately.²⁻³

The structure of the New Zealand health system means that central hospitals have discrete catchment areas for particular services, unlike some areas of the US where competing hospitals cover the same catchment area. The Auckland Hospital DCCM trauma catchment area is very well defined and did not change over the period of study. This allowed us to calculate incidence rates for the ten years that demographic data were collected (only nine years for

ethnicity). However, there are two potential sources of error in our incidence calculations. First, people not normally residing in the DCCM trauma catchment area (therefore not included in the census denominator data) who are injured inside the catchment area are included as local admissions. Second, people normally residing inside the DCCM trauma catchment area, but injured outside it, are not included in this study unless transferred secondarily to the DCCM from another hospital. It is likely that the numbers of individuals in both groups would be small and their demographic profile would be similar. In any case the groups would tend to cancel each other out. Consequently, these sources of error are likely to have little impact on overall incidence rates.

These incidence rates confirm the clinical impression that young males are vastly over represented in trauma admissions, and also show that the indigenous Maori population and the Pacific Island population have higher admission rates than Europeans. This is the first time that data investigating trauma and ethnicity have been published from adult New Zealand studies, and further work is required to confirm and explain these differences and to design and implement strategies to lessen the incidence of trauma in the high risk groups.

Trauma imposes a heavy burden on ICU services and the ICU is potentially a useful area to study serious injury. This paper has described in detail the demographic and trauma variables from a decade of data collection from an ICU in Auckland, New Zealand. By separating local and referred trauma patients we were, for the first time, able to calculate incidence rates for a severely injured population of trauma victims. Studies of trauma in the ICU enable us to focus on the most severely injured patients at high risk of death. This severe life-threatening trauma is an area where effective prevention could save lives and reduce the cost to society and the likelihood of permanent disability.

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