Adolescent injury morbidity in New Zealand, 1987–96

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Objectives: Adolescents are over-represented in injury statistics. New Zealand is privileged in having a hospital discharge database allowing for analysis of non-fatal injury data at a national level. An epidemiological description of adolescent injury morbidity is provided and options for prevention are discussed.

Method: People aged 15–19 years admitted to hospital for their injuries in the period 1987–96 were identified from the New Zealand Health Information Service morbidity data files. The manner, causes, and nature of injury were examined. Injury prevention strategies were reviewed.

Results: The incidence of hospitalised injury was 1886 per 100 000 person years. The victims were predominantly male (70%). The leading causes of injury were road traffic crashes, sports injuries, and self poisoning. The most common injury diagnoses were head injuries (29%) and limb fractures (21%). Road traffic crashes produced the highest proportion of serious injuries.

Conclusions: Road traffic crashes, sports injuries, and self inflicted poisoning, stood out as areas with the greatest potential for reducing the burden of injury in late adolescence. Graduated driver licensing shows promise as an injury prevention measure but remains inadequately implemented. Policies to reduce self inflicted poisoning are of unknown efficacy, and evidence is awaited on the effectiveness of measures to reduce injury in sport.

Reports describing the epidemiology of child and adolescent injury mortality in the US, England and Wales, New Zealand, and Australia have appeared in *Injury Prevention*.^{1–4} Two features stood out in these. Firstly, the dominance of adolescents (15–19 years), accounting for between 57%² and 61%³ of all injury deaths in the 0–19 years age group. Secondly, the leading causes of injury mortality varied markedly between childhood and adolescence. Notwithstanding the dominance of motor vehicle occupant fatalities in both age groups, in childhood there was a preponderance of motor vehicle pedestrian deaths, drowning, and suffocation, while in adolescence, intentional injuries were far more numerous.

Reporting on child and adolescent injury in a single paper can have the effect of diminishing the importance of injury to children, and reducing the space that can be dedicated to either age group. In light of this, the present report is restricted to the adolescent age group. Childhood injury morbidity in New Zealand has been described elsewhere.⁵

Injury is the greatest threat to the health of adolescents in New Zealand, being the cause of 76% of deaths.⁶ For adolescent males it is also the leading cause of hospitalisation (43%), while for females it is the second leading cause of hospitalisation (10%), after complications of pregnancy and childbirth (43%). When complications of pregnancy and childbirth are excluded, injury accounts for 31% of adolescent hospitalisations.⁷ For many years this age group has been greatly over-represented relative to its proportion of the total population.^{6,8}

Risk factors for injury are generally more amenable to modification than those for disease, making injury prevention a cost effective public health strategy.^{9,10} Adolescents are the target of a multitude of injury prevention strategies ranging from television advertising to graduated driver licensing. The weight of evidence supporting these initiatives varies considerably.

The peer reviewed literature contains very few papers on adolescent injury morbidity. While some individual issues are addressed (for example in Mao *et al*¹¹), we lack an overview with which to prioritise injury prevention efforts. New Zealand is fortunate in having a hospital discharge database

Table 1 Adolescent injury morbidity, 1987–96; demographic characteristics

	Hospitalisations	%	Rate/100000 person years (95% CI)
Gender			
Male	37687	70.3	2605 (2506 to 2707)
Female	15915	29.7	1137 (1072 to 1205)
Age (years)			
15	8639	16.1	1570 (1493 to 1650)
16	10037	18.7	1784 (1702 to 1869)
17	11276	21.0	1977 (1891 to 2066)
18	11759	21.9	2041 (1954 to 2131)
19	11891	22.2	2041 (1954 to 2131)
Total	53602	100.0	1886 (1802 to 1973)

CI, confidence interval.

with which to study injury morbidity. Here we use these data to describe the epidemiology of adolescent (15–19 years) injury morbidity in New Zealand and to examine the leading causes of injury in light of available prevention measures.

METHODS

The New Zealand Health Information Service (NZHIS) records all inpatient discharges from publicly funded hospitals in New Zealand ("hospitalisation" is used for hospital discharge in this paper). Over 97% of injury inpatients are treated in public hospitals.¹² The nature of injury is coded by NZHIS according to the *International Classification of Diseases Clinical Modification* (ICD-9-CM).¹³ We identified all adolescents (15–19 years) hospitalised with a primary diagnosis of injury, in the period 1987–96. We excluded readmissions and cases

Abbreviations: AIS, abbreviated injury scale; GDLS, graduated driver licensing system; ICD, *International Classification of Diseases*; NZHIS, New Zealand Health Information Service

Table 2 Adolescent (15–19 years) injury diagnoses, 1987–96

Principle injury diagnosis (ICD diagnosis code)	Hospitalisations	%
1 Intracranial injury, excluding those with skull fracture (850–854)	10131	18.9
2 Fracture of lower limb (820–829)	6865	12.8
3 Poisoning by drugs, medicinal and biological substances (960–979)	5100	9.5
4 Fracture of upper limb (810–819)	4594	8.6
5 Open wound of upper limb (880–887)	4033	7.5
6 Fracture of skull (800–804)	3456	6.4
7 Fracture of neck and trunk (805–809)	2114	3.9
8 Contusion with intact skin surface (920–924)	2091	3.9
9 Open wound of head, neck, and trunk (870–879)	2005	3.7
10 Open wound of lower limb (890–897)	1919	3.6
11 Other (830–848, 860–869, 900–919, 920–959, 980–994)	11294	21.1
Total	53602	100.0

discharged on the same day as admission (that is, day patients). Although up to three injury diagnoses can be recorded for each case, we report only the primary diagnosis. Hospitalisation rates by gender and age are presented with 95% confidence intervals.

The circumstances of injury events are coded according to the ICD *Supplementary Classification of External Cause of Injury and Poisoning*, referred to as E codes. For the cases identified above, 58 (0.01%) had a primary diagnosis of injury but no E code. Additionally, there were 1990 (3.7%) cases with an E code but no primary diagnosis of injury. These were excluded.

For the purpose of comparison, we report our results in accordance with recently developed guidelines for presenting E coded mortality and morbidity data.^{14,15} In addition to an E code, each record on the NZHS morbidity file contains a 30 character narrative field which generally provides additional information on the circumstances of injury. Where appropriate, these narratives were used to further classify cases.

Severity was assessed using the abbreviated injury scale (AIS).¹⁶ The AIS scale ranges from 1 (minor) to 6 (virtually unsurvivable). ICDMAP-90 software was used to translate ICD injury diagnoses into AIS scores.¹⁷ Certain ICD-9-CM rubrics cannot be coded on the AIS, for example “poisoning by drugs, medicinal or biological substances” (N960–N979), or cannot be converted to AIS codes using ICDMAP, for example “trauma related complications” (N958).¹⁸

RESULTS

We identified 53 602 cases of adolescents hospitalised following injury (table 1). The overall hospitalisation rate was 1886 per 100 000 person years. Seventy per cent of cases were male and there was a 30% increase in the incidence of injury across the age range. The distribution of injury diagnoses is shown in table 2.

Table 3 shows that the leading cause of morbidity was road traffic crashes, accounting for 28% of injury hospitalisations. Over half (56%) of all road traffic crashes involved motor vehicle occupants, of whom 44% were drivers. Males comprised 69% of drivers and 55% of passengers. The commonest diagnosis in road traffic crashes was intracranial injury (31%), followed by fractures of the neck and trunk (11%) and fractures of the lower limb (10%). A fifth (19.2%) of injuries involving motor vehicle occupants scored 3 or higher on the AIS.

A third (33%) of adolescents injured in road traffic crashes were either the rider (89%) of a motorcycle or the pillion passenger (11%). Males comprised 87% of cases. The commonest diagnosis was fractures of the lower limb (34%), followed by intracranial injury (18%) and fractures of the upper limb (13%). A fifth (20.8%) of motorcyclist injuries were scored AIS3 or higher.

The second leading cause, falls (unintentional), accounted for 14% of injuries. Table 4 shows a breakdown of fall cases by E code. Falls on the same level accounted for 63% of cases and the majority (54%) of these occurred during sport. The narratives showed that rugby football was the most frequently cited (26%) activity in which fall injuries were sustained, followed by skateboarding (5%). Males accounted for 95% of falls in sport and 79% of all fall cases. The more common diagnoses resulting from falls were fractures of the lower limb (25%), intracranial injury (23%), and fractures of the upper limb (18%). Eight per cent of fall injuries scored AIS3 or higher.

The third leading cause, “Struck by/against” (unintentional) accounted for 10% of injuries. Striking against (E917) accounted for 94% of cases, and the majority of these (73%) occurred during sporting activities (E917.0). Eighty five per cent of cases were male. The narratives showed that rugby football (32%) was the most frequently cited sport. The commonest diagnosis was intracranial injury (33%), followed by contusions (13%) and skull fractures (12%). Four per cent of cases scored AIS3 or higher.

Self inflicted injuries accounted for 10% of hospitalisations with the vast majority of these (92%) being due to poisoning (E950–952). Sixty seven per cent of cases were female. Paracetamol was the single most common poison cited (15%).

DISCUSSION

Motor vehicle occupants

Motor vehicle occupant injuries were found to be the leading cause of hospitalisation and they are largely responsible for the sharp increase in injury hospitalisation rates from childhood to late adolescence in New Zealand.⁵ Among the likely reasons for this is that New Zealand has one of the lowest driver licensing ages in the world (15 years) together with high rates of heavy drinking in late adolescence. A recent survey of drug and alcohol use in New Zealand showed that 49% of males and 36% of females aged 18–19 years drink heavily (six drinks or more per drinking occasion for males and four for females) at least weekly.¹⁹ A further possible explanation is increased levels of exposure to the road environment as adolescents acquire their drivers' licences, leave secondary school, and make more frequent and longer journeys. We lack quality exposure data with which to help confirm this.

Alcohol use and limited driving experience are a dangerous mixture, frequently present in serious road traffic crashes.^{20,21} While blood alcohol levels were not available in the present study, other reports show that in the period 1987–96 alcohol was a factor in 40% of fatal road traffic crashes involving adolescents.⁸ Legislation was introduced in 1989, reducing the legal blood alcohol concentration to 0.03% for drivers under 20 years of age. The effectiveness of this measure is not yet clear.

A protective factor for young drivers is supervision. Recent research on unsupervised adolescent drivers revealed an

Table 3 Injury hospitalisations among 15–19 year olds in New Zealand, 1987–96

	E code	Hospitalisations	Rate*
All external causes	E800–E999	53602	1883
Motor vehicle traffic (MVT)			
Unintentional	E810–E819	15253	536
Person injured	(4th digit codes)		
Occupant	.0, .1	7875	302
Motorcyclist	.2, .3	4795	179
Pedal cyclist	.6	578	21
Pedestrian	.7	854	32
Other	.4, .5, .8	49	2
Unspecified	.9	1102	††
MVT, all	+E958.5, E968.5, E988.5	15264	536
Pedal cyclist, other	E800–807 (.3), E820–E825 (.6), E826.1, .9, E827–E829 (.1)	1322	46
Pedestrian, other	E800–E807 (.2), E820–E825 (.7), E826–E829 (.0)	129	5
Transport, other	All	2538	89
Railway	E800–E807 (.0, .1, .8, .9)	9	0
Non-traffic	E820–E825 (.0–.5, .8, .9)	1105	39
Other road vehicles	E826.2–.8	34	1
Animals	E827–E829 (.2–.9)	1228	43
Water and aircraft	E831.0–.9, E833.0–E845.9	182	6
Firearm, all		164	6
Unintentional	E922	110	4
Self inflicted	E955 (.0–.4)	24	1
Assault	E965 (.0–.4), E970	17	1
Intent unknown	E985 (.0–.4)	13	0
Submersion			
Unintentional	E830, E832, E910	75	3
All	+E954, E964, E984	82	3
Fire/flare			
Unintentional	E890–E899	291	10
All	+E958.1, E968.0, E988.1	308	11
Suffocation, all		100	4
Unintentional			
Inhalation/ingestion	E911–E912	31	1
Other	E913	3	8
Self inflicted	E953	55	2
Assault	E963	6	0
Intent unknown	E983	5	0
Falls, unintentional	E880–E886, E888	7752	272
All	+E957, E968.1, E987	7784	273
Cutting/piercing			
Assault	E966, E974	3998	140
All	+E920, E956, E986	4663	164
Poisoning, all		5605	197
Unintentional	E850–E869	518	18
Self inflicted	E950–E952	4779	168
Assault	E962, E972	5	0
Intent unknown	E980–E982	303	11
Struck by, against, all		7175	252
Unintentional	E916–917	5101	179
Assault	E960.0, E968.2	2056	72
		18	1
All			
Unintentional	E800–E949	43235	1519
Self inflicted	E950–E959	5201	183
Assault	E960–E978	3284	115
Intent unknown/other	E980–E999	1882	66
Person years of exposure		2846630	

*Rate per 100000 persons/year; †in 1102 cases resulting from motor vehicle traffic (MVT) incidents (7% of all MVT cases), the status of the injured road user (that is, whether a vehicle occupant, motorcyclist or pedestrian) was unspecified (ICD E code subcategory .9). We reviewed the narratives for these cases and reclassified 455 of them. The remaining 647 cases were reclassified in the same proportions observed for all other cases in the 1987–96 period; ††in the calculation of rates, the 4th digit .9 codes were distributed according to the free text information and the distribution of 4th digit codes (1 through 8) in the study period; §rates based on fewer than five cases are unstable and are therefore not presented.

Table 4 Unintentional falls among 15–19 year olds (1987–96)

Fall from one level to another (E880–884)	2835
Fall on or from stairs or steps (E880)	339
Fall on or from ladders or scaffolding (E881)	143
Fall from or out of building or other structure (E882)	486
Fall into hole or other opening in surface (E883)	174
Other fall from one level to another (E884)	
Playground equipment (E884.0)	384
Cliff (E884.1)	77
Chair or bed (E884.2)	61
Other (E884.9)	1171
Fall on same level (E884–886, 888)	4917
Fall on same level from slipping, tripping, or stumbling (E885)	946
Fall on same level from collision, pushing, or shoving (E886)	
In sports (E886.0)	2641
Other and unspecified (E886.9)	111
Other and unspecified fall (E888)	1219
Total	7752

inverse relationship between age and the incidence of serious crashes.²² That is, the risk of a serious crash was highest among unsupervised 15 year old drivers, and while remaining high relative to adult drivers, the rate declined steadily through to age 19.

The New Zealand graduated driver licensing system (GDLS) was introduced in 1987, to give young people driving experience in conditions of reduced risk before full licence acquisition. Under this scheme, learner drivers (minimum age of 15 years) must be accompanied by a supervisor—at least 20 years old and holding a full licence for two years or more—and must hold a learner licence for at least six months before applying for a restricted licence. Holders of a restricted licence are required to be accompanied by a supervisor when driving at night (10 pm to 5 am), or carrying passengers.

Analysis of licensure data suggests that much of the reduction in serious injuries after introduction of the scheme was attributable to reduced levels of driving in the 15–19 years age group.²³ A more recent evaluation showed that holders of restricted licences were at lower risk of night-time crashes than drivers licensed before the GDLS was introduced. They also contributed a smaller proportion of crashes involving passengers than those licensed under the old system.²⁴

Motorcyclists

Adolescent motorcyclists have a very high risk of injury per unit of exposure.²⁵ In 1996, adolescents accounted for 31% of motorcyclist hospitalisations despite holding just 5% of motorcycle licenses.²⁶ Relative to other road users, motorcyclists suffer more serious injuries in the event of a crash.²⁷

Under the GDLS, learner motorcyclists are prohibited from driving at night, are limited to 70 km/h, to riding motorcycles with an engine capacity not exceeding 250 cc, and must not carry a pillion passenger. These restrictions apply for 18 months (or nine months if an approved rider training certificate is obtained).²⁸ Additionally, the maximum permitted blood alcohol concentration for a motorcyclist under 20 years of age is 0.03%.

Reeder and colleagues found a reduction in hospitalisations of 15–19 year old motorcyclists following the introduction of the scheme,²⁹ but acknowledged the need for further research to determine whether this was due to reduced exposure to the high risk situations targeted by the GDLS or to reduced exposure to motorcycling in general. There is some evidence many young motorcyclists do not comply with the GDLS restrictions and are rarely apprehended.³⁰ There is evidence also that many young motorcyclists are unlicensed.^{31–32} In a recent assessment

of the GDLS engine capacity restriction, Langley and colleagues argued that this may need to be refined to take into account power-to-weight ratio and style of motorcycle.³³

The minimum age of motorcycle licensure in New Zealand is 15 years, which is among the lowest in the world. In a recent New Zealand study, adolescent motorcyclists were found to be at substantially greater risk of moderate to fatal injury than older riders.³⁴ Given this and the reducing economic advantage of the motorcycle over the car as transport,²⁵ there is a strong case for increasing the minimum age of licensure for motorcycle use.

Reeder and colleagues recommended increasing the minimum age to 18 years.²⁵ They also recommended that lending or selling a motorcycle to anyone without a licence be prohibited, and that unlicensed riders be more heavily penalised.²⁵ To date these recommendations have not been acted on.

Deaths and serious injuries to motorcyclists have declined substantially over the period 1980–95.³⁵ While it is argued that the main reason for this reduction is a decline in the number of young people riding motorcycles,³⁵ the reasons for the reduced popularity of motorcycling are unknown. Concern has been expressed that high rates of injury might return if motorcycling again becomes a popular pursuit for young people. It is therefore important that research attempts to reveal the determinants of adolescent motorcycle use.

Sports injuries

The epidemiology of sports injury is poorly understood for a number of reasons, not the least of which is a lack of sports codes in ICD-9.¹³ Its successor, ICD-10,³⁶ facilitates the identification of sports injuries by providing the activity code “while engaged in sports activity” (V01–Y34 fifth digit code 0), yet it lacks codes for specific sports.³⁷ A limited number of sport specific codes were added when ICD-10-AM (2nd edition) replaced ICD-9 for coding New Zealand’s hospital discharges in July 2001.³⁸ A further difficulty is that a significant proportion of sports injuries are treated by health services other than public hospitals, the principal source of national injury data.³⁹

Notwithstanding the above limitations, sport has been identified in this study as a leading contributor to falls and striking events, most commonly rugby football. Two forms of rugby football are played in New Zealand: rugby union and rugby league. Of these, rugby union is the most popular and is generally considered to be the national sport. It is also the leading contributor to sports injury.⁴⁰ In 1993, a cohort study was undertaken to identify predictors of rugby union injury.⁴¹ The majority of injuries occurred when players from opposing teams were contesting the ball in tackles (40%), rucks (17%), and mauls (12%), all aspects of the game which involve hard physical contact and often result in players falling or being thrown to the ground.⁴² In 1995, a comprehensive injury prevention programme was introduced into rugby union,⁴³ followed in 1997 by a similar programme in rugby league. These included measures such as the compulsory wearing of mouthguards, education of coaches and players in safe playing techniques, and tighter controls on illegal and unsafe play. While the evaluation of these programmes has yet to be reported in the academic literature, there are indications of a reduction in the number of injuries reported in both sports since their introduction.

Intentional self poisoning

The percentage of female poisoning cases (67%) is identical to that found for a similar period in Victoria, Australia.⁴⁴ Intentional poisoning is the only category of injury in which adolescent females predominated. For suicide overall, males outnumbered females four to one.⁴⁵

The primary risk factor for intentional self poisoning is psychological illness, particularly affective disorders.⁴⁶ The prevalence of such conditions in females is more than twice that for

males.⁴⁷ It is not clear why females select poisoning over other available methods of self injury, but this predilection may offer protection from the more frequently fatal consequences of the violent methods preferred by males (that is, hanging and shooting). This suggests that many poisonings are not intended to be fatal, a possibility supported by a British study in which only 34% of teenagers who had poisoned themselves later said they had wanted to die and only 7% of cases were judged by clinicians to be suicide attempts.⁴⁸ The problem of distinguishing a *cry for help* from a suicide attempt is all the more vexing given that a prior attempt is a significant risk factor for completed suicide.⁴⁹

Researchers are converging on the notion that youth suicide prevention strategies have to be holistic, addressing psychological illness as well as more temporally distal factors, such as family and community bonds, physical and sexual abuse, family history of suicide, and stressful life events. The New Zealand Youth Suicide Prevention Strategy focuses on the promotion of wellbeing among children and early identification of high risk youth.⁵⁰ It will be some years before the effectiveness of this strategy can be assessed.

Attempts to explain the internationally ubiquitous spike in suicide attempts during adolescence⁵¹ require consideration of factors particular to this age group. Adolescence is a period of flux. Adolescents are seeking an independent identity, trying to find their place with friends and institutions, making a transition to new living arrangements, and experimenting with alcohol and drugs.⁵²⁻⁵³ Late adolescence is also a time when mental illness comes to light. The early signs of serious psychiatric conditions, such as schizophrenia, often become apparent in late adolescence, when cognition and behaviour is beginning to be affected.⁵⁴ In the normal range of psychological adjustment, adolescents are known to be impulsive, emotionally labile, and to have a strong need for peer approval.⁵⁵ These psychological and situational factors, combined with low levels of life skill, due to lack of experience, dispose youth, more than any other group, to the risk of injury.

Summary

Three causes of unintentional injury (motor vehicle traffic, falls, and striking against), and one cause of intentional injury (self poisoning), were responsible for over two thirds of cases in this study. Head injuries and limb fractures, together, accounted for half of the injury diagnoses, while road traffic crashes produced the highest proportion of serious or life threatening injuries (AIS3 or above). With the exception of self poisoning, males had much higher rates of hospitalisation than females. Gender differences varied by cause but were generally even more pronounced than has been observed in previous studies.⁵⁶

IMPLICATIONS FOR PREVENTION

This examination of New Zealand's recent injury control record has confirmed the magnitude of the adolescent injury problem and identified a number of areas in which improvements can be made. Policy on the prevention of self inflicted injury remains largely untested. For road users there is the partially tested and inadequately enforced GDLS. For sport, the outcomes of injury prevention programmes in rugby football have yet to be reported. The role of gender needs to be better understood so that interventions can be more effectively targeted. Finally, comparing New Zealand's rates of injury morbidity with those in other developed countries may provide clues as to the factors that predispose adolescents to harm and provide further insight into prevention options.

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Elizabeth McLoughlin, ScD, wears two hats in addition to a bicycle helmet. She is the Director of Programs at the Trauma Foundation located at the San Francisco General Hospital, and the Coordinator of the Academic Fellowship Program of the 10 year Violence Prevention Initiative funded by the California Wellness Foundation. Originally trained as a teacher, she has been working for the prevention of injury since 1973, first at a pediatric burn unit, then in a doctoral program at Johns Hopkins, then in New Zealand before coming to the Trauma Foundation in 1986. Her major concentrations have been in burns prevention, motorcycle helmet laws, injury data systems, and the prevention of violence. For fun, she biked across the United States, and voyaged under sail from Seattle, Washington to New Zealand.