BRIEF REPORT

Differential ranking of causes of fatal versus non-fatal injuries among US children

M F Ballesteros, R A Schieber, J Gilchrist, P Holmgreen, J L Annest

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See end of article for authors' affiliations

Correspondence to:
Dr Michael F Ballesteros,
Division of Unintentional
Injury Prevention, National
Center for Injury Prevention
and Control, Centers for
Disease Control and
Prevention, 4770 Buford
Highway, NE, Mailstop
K-63, Atlanta, GA 30341,
USA;
mballesteros@cdc.gov

Objective: Leading causes of fatal and non-fatal injury among US children aged <15 years were compared.

Method: A descriptive study was conducted using nationally representative data on injury related deaths (National Vital Statistics System) and on non-fatal injury related emergency department visits (IEDV; National Electronic Injury Surveillance System-All Injury Program). Data were accessed using a publicly available web based system.

Results: Annually, an estimated 7 100 000 pediatric IEDV and 7400 injury deaths occurred. The overall non-fatal to fatal ratio (NF:F) was 966 IEDV:1 death. Among deaths, the leading causes were motor vehicle traffic occupants ($n = 1700$; NF:F = 150:1), suffocations ($n = 1037$; NF:F = 14:1), and drownings ($n = 971$, NF:F = 6:1). Among non-fatal injuries, falls (estimated 2 400 000) and struck by/against (estimated 1 800 000) were the most common causes, but substantially less lethal (NF:F = 19 000:1 and 15 000:1, respectively).

Conclusions: The leading causes of pediatric fatal and non-fatal injuries differed substantially. This study indicates the need for consideration of common causes of non-fatal injury, especially falls.

The high number of deaths from injury among US children has been a major factor in prioritizing injury as a public health problem. While injuries are the leading cause of death among US children between 1 and 14 years of age,¹ these deaths only represent a small fraction of those injured.² Injury accounts for one third of all emergency department visits among children younger than 15 years, making injury the leading cause of emergency department visits in this age group.³ The distribution by cause of non-fatal injuries has not received the same consideration as that of fatalities when setting public health priorities for research and programs. Currently available fatal and non-fatal injury data from nationally representative surveillance systems can now enhance our ability to consider both. This study compared the leading causes of fatal and non-fatal injury among children in the US.

METHODS

Data were obtained from the Web based Injury Statistics and Query System (WISQARS), a Centers for Disease Control and Prevention (CDC) web based interactive platform recently enhanced to include non-fatal injuries (<http://www.cdc.gov/ncipc/wisqars>). WISQARS allows for querying by age, race/ethnicity, sex, state (fatal data only), year, injury cause, injury intent, and disposition at emergency department discharge (non-fatal data only). National mortality data from 1999 (the latest reporting year available) were based on the National Vital Statistics System of the National Center for Health Statistics, CDC.⁴ Annual non-fatal national estimates of hospital emergency department visits were based on the National Electronic Injury Surveillance System-All Injury Program (NEISS-AIP), which is a probability sample representative of US emergency departments for the first 12 months of available data, July 2000 through June 2001.⁵⁻⁸ NEISS-AIP is a collaborative effort between the National Center for Injury Prevention and Control, CDC and the US Consumer Product Safety Commission.

We reviewed data for children younger than 15 years of age to determine the leading causes of fatal and non-fatal injury,

regardless of intent. For each cause, we assessed cause specific lethality by computing the ratio of non-fatal injuries (expressed as injury related emergency department visits; IEDV) to the number of deaths (non-fatal to fatal ratio, NF:F). Age specific mortality rates were calculated using 1999 US Census Bureau population estimates. Non-fatal injury rates were calculated using the average US Census Bureau population estimates for 2000 and 2001, since the non-fatal data spanned two calendar years. Coefficients of variations and 95% confidence intervals around national estimates of numbers and rates were calculated using a direct variance estimation procedure that accounts for sample weights and the stratified sample design.⁷

RESULTS

The 58.6 million US children younger than 15 years of age accounted for an estimated 7.1 million IEDV (95% confidence interval 6.0 to 8.3 million) and 7365 injury deaths during a 12 month period. This resulted in an overall NF:F of 966 IEDV:1 death.

The leading causes of pediatric fatalities and non-fatal IEDV differed substantially (table 1). Among injury related fatalities, those related to motor vehicle traffic occupant deaths, inhalation/suffocations, and drownings accounted for 50% of all deaths. The respective NF:F for motor vehicle traffic occupants and suffocations were 150:1 and 14:1. Drownings accounted for 971 deaths and was the most lethal cause (NF:F = 6:1). Among non-fatal injuries, falls were the leading cause, with more than 2.4 million IEDVs. This was almost 40% higher

Abbreviations: CDC, Centers for Disease Control and Prevention; GES, National Automotive Sampling System General Estimates System; ICD, *International Classification of Diseases*; IEDV, injury related emergency department visits; NEISS-AIP, National Electronic Injury Surveillance System-All Injury Program; NF:F, non-fatal to fatal ratio; NHAMCS, National Hospital Ambulatory Medical Care Survey; WISQARS, Web based Injury Statistics and Query System

Table 1 Leading cause of injury related emergency department visits (IEDV) and injury related deaths, ages 0–14, US

IEDV rank	Fatal rank	Injury cause	No of IEDV*	No of fatalities†	IEDV/1 death
1	10	Fall	2413888	127	19007
2	11	Struck by/against	1757870	114	15420
3	15	Overexertion	448303	0	–
4	13	Cut/pierce	433017	56	7732
5		Bites/stings‡	431147	–	–
6	8	Pedal cyclists§	321000	173	1855
7	1	MV traffic occupant	254767	1700	150
8		Foreign body¶	228308	–	–
9	7	Other transportation**	169875	241	705
10	5	Fire/burn	135707	686	198
11	9	Poisoning	122432	130	942
12	4	Pedestrian††	49310	733	67
13	2	Inhalation/suffocation	14188	1037	14
14	6	Gunshot/firearm‡‡	12153	489	25
15	3	Drowning/near-drowning	6102	971	6
16	14	Machinery	4199	22	191
17	12	Natural/environment	3467	96	36
		Other/unspecified/unknown	306047	1031	297
		All	7111780	7365	966

*Estimates based on NEISS-AIP data (July 2000 to June 2001).

†Based on 1999 National Vital Statistics data.

‡In WISQARS fatal data are included with natural/environment.

§Includes all pedal cyclists (traffic, non-traffic, unspecified).

||Non-fatal include only motor vehicle (MV) traffic occupants (excludes non-traffic and unknowns), fatalities include MV traffic occupant and unspecified traffic fatalities, of which most were occupant related.¹²

¶In WISQARS fatal data are included with suffocation.

**Includes motorcycle, railway, and air transport crashes.

††Includes all pedestrians (traffic, non-traffic, unspecified).

‡‡Includes handgun, rifle, shotgun, BB gun, and airgun.

than the second leading cause, struck by/against (1.8 million IEDVs); however, these two causes were substantially less lethal, with NF:F = 19 000:1 and 15 000:1, respectively. Overexertion accounted for 448 000 IEDVs, but was not associated with any deaths.

Transportation related injuries, which included injuries to motor vehicle traffic occupants, pedal cyclists (principally bicyclists), and pedestrians, were an important cause of pediatric injury morbidity and mortality. In this age group, non-fatal pedal cycle injuries resulted in about 25% more IEDV than motor vehicle occupant injuries. Pedestrian injuries were the most lethal transportation cause (NF:F = 67:1).

Injury mortality rates and IEDV rates varied by age and cause (tables 2 and 3). Motor vehicle traffic occupant mortality rates were highest for infants and 14 year olds. Infants younger than 1 year and, to a lesser degree, children older than 13 years had high suffocation fatality rates. Drowning and pedestrian mortality rates were highest for children between 1 and 2 years of age. IEDV rates for falls were highest among children between 1 and 2 years of age. Struck by/against IEDV rates were highest among children between 1 and 3 years old, and after 11 years of age, it was the leading cause of IEDV. In contrast, overexertion IEDV rates generally increased with age. Among transportation related causes, motor vehicle

Table 2 Annual injury related fatality rates* per 100000 population by cause, ages 0–14, US, 1999

Age (years)	MV traffic occupant†	Inhalation/suffocation	Drowning	Pedestrians‡	Fire/burn	Firearms
<1	4.48	14.06	2.25	0.34§	1.39	0.21§
1	2.42	2.37	5.96	2.50	2.34	0.29§
2	2.50	1.12	4.07	1.84	2.32	0.45§
3	3.06	0.85	2.02	1.49	2.29	0.51§
4	2.39	0.60	1.35	1.30	2.00	0.47§
5	2.11	0.51§	1.05	1.28	1.39	0.39§
6	2.31	0.30§	1.04	1.32	0.96	0.38§
7	2.70	0.25§	1.12	1.27	1.14	0.40§
8	2.87	0.38§	1.00	1.18	0.90	0.49§
9	2.40	0.45§	0.79	1.01	0.50	0.36§
10	2.43	0.67	0.77	0.84	0.84	0.27§
11	2.77	0.98	0.87	1.21	0.59	0.67
12	2.42	1.25	1.01	0.83	0.44§	1.14
13	3.43	1.21	1.01	1.01	0.31§	2.19
14	5.42	2.00	0.98	1.49	0.39§	4.37
0–14	2.91	1.77	1.66	1.25	1.17	0.84

*Rates calculated from 1999 National Vital Statistics data and 1999 population estimates.

†Includes motor vehicle (MV) traffic occupants and unspecified traffic fatalities, of which most were occupant related.

‡Includes all pedestrians (traffic, non-traffic, unspecified).

§Rate is unstable because of a sample size of fewer than 20 deaths.

Table 3 Annual non-fatal injury rates* per 100000 population of emergency department visits by cause, ages 0–14, US, July 2000 to June 2001

Age (years)	Falls	Struck by/against	Overexertion	Cut/pierce	Bites/stings	Pedal cyclist†	MV traffic occupant‡	Foreign body	Other transport	Fire/burn
<1	3415	985	111	166	260	28	219	322	35	390
1	7207	2872	574	642	1123	65	263	638	128	867
2	6729	3390	610	684	1257	168	378	1005	223	374
3	5165	2852	354	654	1056	237	397	917	236	304
4	4372	2696	242	670	983	399	396	646	279	200
5	4113	2818	233	640	848	504	359	484	255	174
6	3734	2639	295	744	764	692	379	328	253	143
7	3467	2768	301	736	714	699	471	307	229	148
8	3488	2971	527	885	741	665	393	254	284	114
9	3485	2858	758	785	677	800	466	245	306	123
10	3633	3088	884	855	658	791	479	200	360	143
11	3785	3508	1165	854	561	797	497	200	362	128
12	3481	3749	1502	912	489	811	498	127	430	139
13	3157	3790	1773	905	495	764	550	128	425	113
14	2854	3885	2020	898	470	703	740	135	507	168
0–14	4117	2998	765	738	735	547	434	389	290	231

*Rates calculated from NEISS-AIP data (July 2000 to June 2001) and the average of 2000 and 2001 population estimates.

†Includes all pedal cyclists (traffic, non-traffic, unspecified).

‡Includes only motor vehicle (MV) traffic occupants (excludes non-traffic and unknowns).

§Rate is unstable because of a sample size <20 cases or coefficient of variation >30%.

occupant IEDV rates increased with age, while the pedal cycle IEDV rate was highest in those between 9 and 12 years.

DISCUSSION

This study indicated that for every pediatric injury related death approximately 1000 injured children received emergency department treatment. Stated in other terms, about 0.1% of children died from their injuries. Rates of IEDV and injury related mortality varied by cause of injury and age.

This study found that the large number of injuries caused by falls, struck by/against, and overexertion accounted for more than 60% of all pediatric IEDV, yet were rarely fatal. Fall injury rates were highest among infants who are vulnerable because of their limited coordination, exploratory nature, and potential home hazards, while struck by/against and overexertion injury rates were most pronounced in older children who tend to be more active and involved in sports.

Results from this analysis were comparable to those generated by other databases. While NEISS-AIP estimated that children younger than 15 years of age account for 7.1 million IEDV, data from the 1999 National Hospital Ambulatory Medical Care Survey (NHAMCS) estimated this as 8.2 million,^{9–10} a 13% difference. The NHAMCS estimate would be expected to be higher because it includes repeat emergency department visits for the same injury incident and it includes cases where the reason for the visit was an injury as well as those with injury diagnoses, while the NEISS-AIP estimate includes only the initial emergency department visit for an injury incident and only those cases with injury diagnoses as determined by an attending physician. The other major surveillance systems available for comparing injuries and deaths relate to traffic crashes. The National Highway Traffic Safety Administration tallies traffic related fatalities using the Fatality Analysis Reporting System and estimates non-fatal traffic related injuries using the National Automotive Sampling System General Estimates System (GES). Compared with our results, the NF:F ratios generated by these systems were similar for motor vehicle traffic occupants, but substantially different for pedal cyclists and pedestrians. These differences are attributable to discrepancies in non-fatal injury data. Fatality Analysis Reporting System results are similar to the vital statistics fatality data¹¹; however, the NEISS-AIP capture of non-fatal transportation injuries is more complete than GES. GES is based on police incident reports and includes only those crashes that occur in traffic and that are

reported to the police. Compared with GES,¹² NEISS-AIP records 7.1% more injured motor vehicle occupants, 60% more traffic related pedestrians injured, and over four times more traffic related pedal cyclists injured.

The fatal and non-fatal injury related databases used in our analysis provide timely data for the injury pyramid. These databases can be used to indicate the annual incidence of the top three levels of the injury pyramid, namely deaths, hospitalizations, and emergency department visits. These databases cannot be used to indicate the bottom level of the pyramid: total episodes of injuries (including those untreated). Hospitalization estimates can be determined from the emergency department disposition field; however, with the 12 months of data for this analysis, we did not address the issue of hospitalizations because the estimates can be unstable for less common injuries. A more detailed analyses of hospitalizations by external cause and intent of injury will be possible as more years of NEISS-AIP data become available.

This study has several limitations. First, the injuries included only those treated in hospital emergency departments; injuries that were treated in outpatient clinics or doctors' offices, or not medically treated were not included. Second, the NEISS-AIP provides only national estimates and does not allow for estimates by region, state, or local jurisdiction. Third, non-fatal causes were based on *International Classification of Diseases* (ICD)-9 codes,^{8–12–13} while fatal data were based on ICD-10 codes.¹⁴ ICD-10 is more detailed, with 3000 more categories for all causes of death, and some of the rules for coding and for selecting the underlying cause of death have been changed to favor case ascertainment of injury.¹⁵ However, when analyzing the ICD-9 based 1998 mortality data, there were only minor differences in injury cause rankings and rates. Finally, these mortality and morbidity data were compared for different time periods. However, given the magnitude of these findings, our results would not likely differ if the same year of data had been available for both fatal and non-fatal injuries.

IMPLICATIONS FOR PREVENTION

Public health policy has been largely influenced by mortality data. New nationally based interactive databases now permit public health professionals to fully consider the importance of non-fatal injuries in developing priorities.

While our study indicated that falls constitute a large proportion of non-fatal injuries among children, causal factors

Key points

- Although less devastating than deaths, non-fatal injuries occurred much more frequently, and their leading causes differed. For every pediatric injury death, approximately 1000 injured children received emergency department treatment.
- Among children, the leading causes of fatal injuries differed from leading causes of non-fatal injuries, indicating the need to consider causes of non-fatal injuries when prioritizing public health research and programs.
- Falls accounted for over 2.4 million pediatric emergency department visits and struck by/against accounted for 1.8 million pediatric emergency department visits each year. Further study into the etiologic factors is warranted to identify areas amenable to preventive measures.

such as playgrounds, sports, falls from beds or furniture, stairs, or falls from heights could not be determined. Development of preventive measures to address falls will require a better understanding of these etiologic factors.

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Authors' affiliations

M F Ballesteros, Epidemic Intelligence Service, Division of Applied Public Health Training, Epidemiology Program Office and Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia
R A Schieber, J Gilchrist, Division of Unintentional Injury Prevention, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia
P Holmgreen, J L Annett, Office of Statistics and Programming, National Center for Injury Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia

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