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## ORIGINAL ARTICLE

# A quantification of preventable unintentional childhood injury mortality in the United States

A Philippakis, D Hemenway, D M Alexe, N Dessypris, T Spyridopoulos, E Petridou

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**Objective:** To calculate the preventable fraction of unintentional childhood injury deaths in the United States.

**Design:** Ecological study of cause specific unintentional childhood injury mortality rates across the 50 states (and the District of Columbia) of the United States (US) over the 10 year period 1989–98.

**Methods:** The internet accessible database from the National Center for Injury Prevention and Control was used in order to estimate unintentional childhood (0–14 years) injury mortality rates by external cause and time trends over the study period for each of the US states and for the four major geographical regions of the country. In the principal analysis, a calculation was made of the fraction and absolute number of unintentional childhood injury deaths that could have been prevented annually if the mortality rate in the region with the lowest rate also existed in the remaining three. In another scenario, the lowest external cause specific unintentional childhood injury mortality rates from the 50 US states and the District of Columbia were summed to provide the “ideal” lowest conceivable unintentional childhood injury mortality rate from all causes. Ecological correlations between unintentional childhood injury mortality rates from specified external causes, median income, and percent of the population with a college degree were made.

**Main outcome measures:** Unintentional childhood injury mortality rates by cause.

**Results:** Unintentional childhood injury mortality rate declined by 3.5% per year in the country as a whole. If every region of the US had experienced the same injury rate as the Northeast, then one third of all unintentional childhood injuries would not have occurred.

More optimistic scenarios indicate that up to two thirds of all unintentional childhood injury deaths could be prevented. Across states, unintentional childhood injury mortality is strongly inversely related to median income.

**Conclusions:** About one third of all unintentional childhood injury deaths in the US are preventable with the means and resources available in the Northeastern states. Among the relevant characteristics in the Northeast region, in comparison with other US regions, are the higher education level of parents, the lower gun ownership, the higher population density that implies shorter distances traveled by cars, a better developed emergency medical system, and the existence of several injury prevention programs.

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As the leading killer of children in the United States (US), injury related deaths are of central importance to public health. More children die each year from injuries than from all other diseases combined; for children aged 0–14 that amounts to over 15 000 deaths annually.<sup>1</sup> Non-fatal injuries also cause a tremendous socioeconomic burden; nearly one child in four is injured each year seriously enough to require medical attention, resulting in \$17 billion dollars in medical costs.<sup>2</sup>

In the present study, we have analyzed the trends in unintentional childhood injury deaths in the US for the last decade (1989–98) and have attempted to estimate the number of preventable unintentional deaths among US children 0–14 years old.

## METHODS

The superiority of primary injury prevention over secondary prevention and treatment is widely accepted. Preventability implies a potential for the reduction of incidence. However, because incidence data are frequently not available or of questionable validity, many exercises on the preventability of various diseases have relied on cause specific mortality data, which are generally accurately reported, at least in developed counties.

The National Center for Injury Prevention and Control publishes on the internet extensive and detailed information

concerning deaths from *unintentional* injuries by external cause using the *International Classification of Diseases*, 9th revision.<sup>3</sup> We have used this database to estimate unintentional childhood (0–14 years) injury mortality rates by external cause for each of the 50 US states plus the District of Columbia and for the four major geographical regions of the country (West, Midwest, South, Northeast). Data for the 10 year period 1989–98, inclusive, were used. We did not stratify by age and gender, as a preliminary analysis indicated that it would have marginal consequences, and would only complicate the interpretability of preventable fraction estimates. Moreover, the numbers were too small to allow reliable age specific prevention fractions. External causes were classified into: motor vehicle; other transport; poisoning; fall; fire or burn; drowning or submersion; machinery; firearm; and other. In some analyses, due to the low number of deaths in some of the states, external causes were further grouped together to increase the stability of estimates, into: transport (combining motor vehicle and other transport); fire or burn; drowning or submersion; firearm; and all other (including poisoning, fall, and machinery).

In one analysis, we estimated trends of childhood mortality from unintentional injury in the four major geographical regions over the 10 year study period. We log transformed mortality rates and the regression coefficients are expressed in percent annual decline of the region specific mortality rate.

For descriptive purposes we also present unintentional childhood injury mortality rates for the “tail” years of the study, that is, the first three years (1989–91) and the last three years (1996–98). We also compared external cause specific unintentional childhood injury mortality rates across the four geographical regions using data from the whole 10 year period, because deaths for individual years were quite small for some external causes.

We have replicated the analysis by using Poisson modeling of number of deaths, rather than focusing on rates. This analysis accommodates the fact that rates may rely on very different underlying populations, but it is less straightforward. The results, however, of the two analyses were essentially identical (data not shown).

In the principal analysis, we calculated the fraction and absolute number of unintentional childhood injury deaths that could have been prevented annually if the mortality rate in the region with the lowest rate also existed in the remaining three. In another scenario, the lowest external cause specific unintentional childhood injury mortality rates from the 50 US states and the District of Columbia were summed to provide the “ideal” lowest conceivable unintentional childhood injury mortality rate from all causes. In all calculations, rates concerning the 10 year study period were used.

Finally, we undertook partial ecological correlations across the states between unintentional childhood injury mortality rates from specified external causes, median income, and percent of the population with a college degree on the other, to determine whether income or educational status (as reflected by these two indices) is a better predictor of unintentional childhood injury mortality at the population level. Partial correlation measures the strength of the relationship between two variables, controlling for the effect of one or more other variables. Data concerning median income and percent of the population with a college degree were retrieved from the US Census Bureau.<sup>4</sup>

## RESULTS

Table 1 shows unintentional childhood (0–14 years) injury mortality rate (per 100 000 person-years) in the four major geographic US regions, as well as in the country as a whole. Two sets of figures are given for each region, one concerning the beginning of the study period (1989–91) and the other the end of this period (1996–98). To assure stability, three year averages were used. The annual decline across the US, as well as the decline in each of the four major geographical regions, is shown with the respective 95% confidence intervals. Unintentional childhood injury mortality rate declined by 3.5% per year in the country as a whole and the decline was sharper in the Northeast region, even though this region had already had the lowest rate.

In table 2, the unintentional childhood injury mortality rate by region is broken down by principal external cause

averaged over the whole 10 year study period. In absolute terms, childhood mortality from motor vehicle injuries is responsible for most of the regional variability in unintentional childhood injury mortality; in relative terms unintentional childhood firearm injury mortality has the highest variability.

In table 3, the number and fraction of unintentional childhood injury deaths that could have been prevented is shown for two scenarios. In scenario A, all four regions have the same unintentional childhood injury mortality rate as the Northeast region, which had the lowest rate. Under that scenario, more than 2000 unintentional childhood injury deaths annually could have been prevented, representing more than one third of the total. Scenario B is probably less realistic: it considers as preventable injury deaths in excess of those that would have occurred if the “minimal” unintentional childhood injury mortality existed in every region. The minimal unintentional childhood injury mortality is calculated by adding the lowest external cause specific rates observed in any of the 50 US states (and the District of Columbia). Under this optimistic scenario, more than 4000 unintentional childhood injury deaths, representing close to two thirds of the total, could be prevented.

In table 4 we explore, in an ecologic correlation over the 50 US states and the District of Columbia, whether median income or percentage of the population with college degree is a better predictor of unintentional childhood injury mortality. With respect to percentage of the population with a college degree, partial correlation coefficients are generally negative, but only with respect to fires and burns is the estimate statistically significant ( $r = -0.31$ ;  $p = 0.03$ ). In contrast, median income is significantly inversely associated with unintentional childhood injury mortality overall and from specific causes with the exception of mortality from fires and burns. The results are, however, limited by the inherent correlations of the data in adjacent time periods, which is likely overestimating the partial correlations reported in table 4.

## DISCUSSION

In this paper we calculated the fraction of unintentional childhood unintentional injury mortality that could have been prevented if all four geographical regions of the US had the same unintentional childhood injury mortality rate as the Northeast region. We have found that every year more than 2000 unintentional childhood injury deaths, or more than one third of the total, were preventable. Indeed, the decline by 3.5% per year of the unintentional childhood injury mortality rate in the country as a whole, over the 10 year study period, is compatible with the estimated preventable fraction. We have also found evidence that, except for fire and burn deaths (which is essentially unrelated to median state income), median income is more strongly inversely related to unintentional childhood injury mortality than

**Table 1** Childhood (0–14 years) unintentional injury mortality rate (MR, deaths per 100 000 person-years) in four major geographic regions in the US in 1989–91 and 1996–98 and regression derived annual percent change (95% confidence interval, confidence interval (CI), and p value)

Region	1989–91		1996–98		Percent annual decline of MR			
	Annual No of deaths	MR	Annual No of deaths	MR	Point estimate	95% CI	p Value	
West	1571	12.8	1312	9.6	4.0	3.0	5.0	0.0001
Midwest	1735	13.2	1420	10.6	2.9	1.9	3.9	0.0005
South	3041	16.3	2653	13.1	3.1	2.3	3.9	0.0001
Northeast	985	9.8	673	6.4	5.7	4.9	6.6	0.0001
Total US	7332	13.5	6058	10.5	3.5	2.9	4.2	0.0001

**Table 2** Childhood (0–14 years) unintentional injury mortality rate (deaths per 100 000 person-years) according to the principal external cause of death in four major regions in the US during the 10 year period 1989–98

Region	Motor vehicle	Other transport	Poisoning	Fall	Fire/burn	Drowning/ submersion	Machinery	Firearm	Other	Total
West	5.0	0.3	0.2	0.2	0.8	2.1	0.1	0.3	2.3	11.3
Midwest	4.7	0.3	0.2	0.2	2.0	1.5	0.2	0.3	2.3	11.8*
South	6.3	0.3	0.2	0.2	2.0	2.4	0.1	0.5	2.5	14.5
Northeast	3.1	0.1	0.1	0.3	1.6	1.0	0.1	0.1	1.4	7.8
Total US	5.0	0.2	0.2	0.2	1.7	1.9	0.1	0.3	2.2	11.9*

\*Minor discrepancies due to rounding errors.

**Table 3** Percent potential reduction of unintentional childhood (0–14 years) injury mortality rate (MR) and annual number of preventable deaths (N) in four regions in the US, on the basis of: A=the lowest total rate noted in the Northeast region and B=the minimum achievable total rate (sum of the minimal state and external cause specific rates)

Region	Average yearly MR	Average No of yearly deaths	A		B	
			%*	N	%*	N
West	11.3	1480	30.9	458	62.0	918
Midwest	11.8	1571	33.5	526	63.4	997
South	14.5	2831	46.1	1304	70.3	1991
Northeast	7.8	815	0.0	0	45.0	367
Total US	11.9	6697	34.9	2289	63.8	4273

\*Minor discrepancies due to rounding error.

educational level, as reflected in the percentage of the population with a college degree.

Our study was inspired by similar exercises focusing on the preventability of human cancer by exploiting the international variability of cancer incidence by site.<sup>5</sup> The underlying assumption in such studies is that most of the variability is of environmental etiology; this assumption seems valid with respect to unintentional injuries. An estimate of preventable unintentional childhood injuries in European Union countries using a similar design was recently undertaken by Petridou *et al.*<sup>6</sup>

It is not easy to disentangle into simple components the injury prevention ethos that has been responsible for the lower unintentional childhood injury mortality prevailing in the Northeast region, but several characteristics and examples can be invoked. Among the relevant characteristics in the Northeast region, in comparison to other US regions are the higher education level of parents, the lower gun ownership, the higher population density that implies shorter distances traveled by cars (and, thus, lower person-miles at

risk), a better developed emergency medical system, and the existence of several injury prevention programs.<sup>4 7–11</sup> Also, the states in the Northeast region have a history of working intensively on child injury prevention issues beginning with the strategy of the Statewide Childhood Injury Prevention Project (SCIPP) at the Massachusetts Department of Public Health in 1979, which later blossomed into the Northeastern Injury Prevention Network.<sup>8</sup>

As examples, one can cite the Harlem Hospital Injury Prevention Program and the Massachusetts Home Hazards Reduction Program.<sup>9 10</sup> The first program demonstrated that a more than 40% decrease in child injury admission to Harlem Hospital could be achieved through safety education.<sup>9</sup> In the second program, households that reported participatory exposure to the interventions had higher safety knowledge and behavior scores than those that received other community exposure or no exposure to intervention activities.<sup>10</sup>

Our study suggests that one third of unintentional childhood injuries in the US could be prevented with existing means and resources. The optimistic scenario is not currently

**Table 4** Average annual unintentional injury childhood mortality rate (MR) among US children during the decade 1989–98 by type of injury and partial correlation coefficient over the 50 US states and the District of Columbia with median income and % of population with college degree\*

Type of injury	Transport injuries	Fire/burn	Drowning/ submersion	Firearm	All other	All injuries
MR	5.2	1.7	1.9	0.3	2.7	11.9
Partial correlation with median income	−0.60	−0.02	−0.31	−0.47	−0.42	−0.51
p Value	0.0001	0.89	0.02	0.0006	0.002	0.0002
Partial correlation with % college graduates†	−0.13	−0.31	−0.13	−0.06	0.04	−0.15
p Value	0.37	0.03	0.36	0.70	0.77	0.29

Source: US Census and the National Center for Injury Prevention and Control, Centers for Disease Control and Prevention.

\*Mutually adjusted.

†Data from 1993 to 1998 inclusive.

### Key points

- Unintentional childhood injury mortality rate declined by 3.5% per year in the US as a whole.
- If every region of the US had experienced the same injury rate as the Northeast, then one third of all unintentional childhood injuries would not have occurred.
- More optimistic scenarios indicate that up to two thirds of all unintentional childhood injury deaths could be prevented.
- Across states, unintentional childhood injury mortality is strongly inversely related to median income.

realistic, however, because it does not take into account the fact that chance variability may have generated unusually low external cause specific unintentional childhood injury rates in some of the US states. In contrast, a preventable fraction of one third is an achievable aim that could form a policy objective.

Strengths of this investigation are the utilization of a technique widely accepted in other fields of epidemiology, and its application on a large and reliable injury database. The analysis has the inherent weaknesses of ecological investigations.<sup>12</sup> Lack of data concerning the different exposure to hazard in the US regions, along with the heterogeneity of supervision styles and key family behaviors and household practices across different US geographic regions are also limitations of our investigation.

We have also found evidence that median income is a more powerful inverse predictor of unintentional childhood injury rate than educational level. There is a rich literature pointing to higher unintentional childhood injury risk among disadvantaged socioeconomic groups,<sup>2 13 14</sup> and our study provides evidence for a powerful population-wide impact of income on unintentional childhood injury rates.

Neither the preventability of unintentional childhood injury mortality, nor its strong dependence on socioeconomic factors, is questioned. This study, however, documents at the population level the inverse association of median income with unintentional childhood injury mortality and provides a

realistic target of injury preventability at about one third of its current level in the US, or at least in some regions.

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