RESEARCH REPORT

Trends in head injury mortality among 0–14 year olds in Scotland (1986–95)

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Study objective: To examine the trends in childhood head injury mortality in Scotland between 1986 and 1995.
Design: Analysis of routine mortality data from the registrar general for Scotland.
Setting: Scotland, UK.
Subjects: Children aged 0–14 years.
Main results: A total of 290 children in Scotland died as a result of a head injury between 1986 and 1995. While there was a significant decline in the head injury mortality rate, head injury as a proportion of all injury fatalities remained relatively stable. Boys, and children residing in relatively less affluent areas had the highest head injury mortality rates. Although both these groups experienced a significant decline over the study period, the mortality differences between children in deprivation categories 1–2 and 6–7 persisted among 0–9 year olds, and increased in the 10–14 years age group. Pedestrian accidents were the leading cause of mortality.
Conclusions: Children residing in less affluent areas seem to be at relatively greater risk of sustaining a fatal head injury than their more affluent counterparts. While the differences between the most and least affluent have decreased overall, they have widened among 10–14 year olds. The decline in head injury mortality as a result of pedestrian accidents may be partly attributable to injury prevention measures.

While unintentional injury mortality rates have fallen in Scotland, England, and Wales, there are groups of children within the population at greater relative risk.[1 2] Boys and children residing in less affluent areas seem to be at higher risk of death due to injury than children residing in more affluent areas.[1 2] Differences in injury rates between children in the most and least affluent areas are increasing in England and Wales.[2] In Scotland, while no such widening in rates appears to have occurred, those residing in areas of relatively greater deprivation have significantly higher injury mortality rates.[1]

Head injury is the commonest cause of death in children aged 1–15 years in England and Wales.[3] While a peak in the age specific incidence of fatal or hospitalised head injury rates occurs in young adulthood (15–30 years), there are more accident and emergency (A&E) presentations due to head injury in children under 10 years old than in any other age group.[4] In Scotland, children in the 0–14 years age group account for approximately 50% of head injury A&E presentations and 20% of head injury deaths in neurosurgical units.[5] This study investigated the trends in head injury mortality in children in Scotland with particular emphasis on socioeconomic variations. Its purpose was twofold: to determine whether head injury mortality in Scotland was declining in common with the decline in all cause unintentional injury mortality and to investigate the extent to which trends in head injury were contributing to socioeconomic inequalities in health.

METHODS

National mortality data for the period 1986–95 for children aged 0–14 years were obtained from the registrar general for Scotland. These data included an International Classification of Disease (ICD) Version 9 external cause of injury code (E-code) and a more limited nature of injury code. Deaths given a nature of injury code of either skull fracture or intracranial injury were included in the analysis. The E-codes selected were: pedestrian accidents (E8147), falls (E8800–8889), assaults (E9600–9699), road traffic accidents (excluding pedestrians) (E8100–8199), pedal cycle accidents (E8261, E8136, E8196), suicides and self inflicted injuries (E9500–9599), injuries of undetermined intent (E9800–9899), firearm missile accidents (E9220–9229), being struck or hit by a falling object (E916, E9169–9179), railway accidents (E8000–8079) and other miscellaneous causes (E8282, E9190–9199, E9289, E9290). Road traffic accidents (excluding pedestrians) and pedal cycle accidents were grouped together as "other road traffic accidents". Suicides, injuries of undetermined intent, firearm missile accidents, being struck or hit by a falling object, railway accidents and other miscellaneous causes were grouped together as "other".

Socioeconomic status was recorded using the Carstairs and Morris deprivation index.[6] This scale has seven points, ranging from the most affluent (one) to the most deprived (seven). The deprivation categories were combined into three groups—deprivation categories 1–2 (most affluent), 3–5 (intermediate), and 6–7 (least affluent). Census derived population estimates were used to calculate deprivation specific rates. Age specific mortality rates and proportional declines in these rates over the study period were calculated. Linear regression was used to represent the linear component of the mortality profile over the study period. This methodology was previously developed as part of the EURORISC project.[7 8] The mortality rates for the first two years (1986/87) and the last two years of the study period (1994/95) are shown for illustration but linear regression takes account of all intervening time points. Two year time points were used to minimise variability between years and are used throughout for consistency. The following statistics are quoted: the adjusted R^2 and the associated p value. The adjusted R^2 shows the extent to which the two variables are related, and is expressed as a percentage. The p value indicates the significance of the relation. The statistical significance level was set at 5%. Unadjusted odds ratios were calculated to assess the differences in the incidence of

Table 1 Number of head injury deaths and mortality rates among 0–14 year olds in Scotland (1986–95)

Year	Number of head injury deaths	Annual mortality rate (per 100 000)
1986	40	4.1
1987	45	4.7
1988	29	3.0
1989	28	2.9
1990	26	2.7
1991	29	3.0
1992	34	3.5
1993	18	1.9
1994	24	2.5
1995	17	1.8

head injury mortality between groups where numbers permitted.

RESULTS

A total of 290 children resident in Scotland died as a result of head injury between 1986 and 1995. This was 30% of all injury deaths to children resident in Scotland and represents a mean annual head injury mortality rate of 3 deaths per 100 000 over the study period. Of the 290, 79 deaths (27%) were coded as skull fracture and 211 (73%) were coded as intracranial injury. Table 1 shows the number of head injury deaths and corresponding mortality rates for the study period. A significant linear decline was observed in the total head injury mortality rate between 1986/87 and 1994/95, falling by 52% from 4.4 to 2.1 deaths per 100 000 (adjusted R^2 78%, p=0.03) (table 2). A significant linear decline was observed in the skull fracture mortality rate between 1986/87 and 1994/95, falling by 84% from 1.9 to 0.3 deaths per 100 000 (adjusted R^2 73%, p=0.04). Although intracranial injury mortality did not show a significant linear decline, the rates nevertheless fell by 28%.

While head injury as a proportion of all fatalities remained relatively constant at approximately 30%, the proportion of all head injury fatalities coded as skull fractures fell from 44% (37 deaths) in 1986/87 to 15% (6 deaths) in 1994/95. The incidence of skull fracture death was lower than that of intracranial injury throughout the study period and by 1994/95 the likelihood of skull fracture death was significantly lower than the likelihood of intracranial injury death (OR=0.17, 95% CI 0.05 to 0.57).

Older children (10–14 years) accounted for the largest proportion of head injury deaths, with 109 (38%) fatalities (table 2). Although head injury mortality decreased by over 40% in each age group over the study period, only the 5–9 year olds experienced a significant linear decline in rates (adjusted R^2 82%, p=0.02).

A total of 185 (64%) of the head injury deaths were in boys. The likelihood of head injury mortality was higher in boys than in girls throughout the study period although this was not statistically significant (OR=1.65, 95% CI 0.78 to 3.46). A male excess was observed in each age group (table 2). Although head injury mortality rates for both sexes declined between 1986/87 and 1994/95, a significant linear decline was only observed among boys, with a fall of 53% from 5.7 to 2.7 deaths per 100 000 (adjusted R^2 80%, p=0.03). A substantial (but non-linear) decline in the female mortality rate of 50% from 3 to 1.5 deaths per 100 000 was observed.

The mean annual head injury mortality rate was highest in deprivation category 6–7 (5.1 deaths per 100 000) and lowest in deprivation category 1–2 (2.1 deaths per 100 000). Each of

Table 2 Number of head injury deaths and head injury mortality rates by age and male/female rates ratio in the 0–14 years age group in Scotland (1986–95); with linear regression results (adjusted R^2 and associated p value)

Age (y)	Mean annual population (000s) 86–95	86–87	94–95	1986–1995 Total deaths (%) Mean annual rate per 100 000	Rates ratio male:female	Mortality rate per 100 000 1986/87	Mortality rate per 100 000 1994/95	Difference 1986/87–1994/95	Adjusted R^2 (%) (regression coefficient)	Associated p value
0–4	324.1	322.9	322.9	106 (37) 3.3	1.4:1	4.0	2.0	–50%	46 (–0.4)	0.127
5–9	321.7	315.9	326.6	75 (26) 2.3	2.1:1	4.1	1.4	–66%	82 (–0.7)	0.022
10–14	320.3	334.6	323.2	109 (38) 3.4	1.8:1	4.9	2.9	–41%	41 (–0.4)	0.145
Total (0–14)	966.1	973.4	972.7	290 (100) 3.0	1.7:1	4.4	2.1	–52%	78 (–0.5)	0.030

Table 3 Head injury mortality rates by age and Carstairs deprivation categories in the 0–14 years age group in Scotland (1986–95); with linear regression results (adjusted R^2 and associated p value)

Age group and deprivation category*	Mean annual population estimates (based on 1991 census)	Mortality rate per 100 000 1986/87	Mortality rate per 100 000 1994/95	Difference 1986/87–1994/95	Adjusted R^2 (%) (regression coefficient)	Associated p value
0–4 years						
Depcat 1–2	59 954	3.3	1.7	–48%	–10 (–0.3)	0.486
Depcat 3–5	194 681	2.1	2.3	+10%	–3 (0.2)	0.420
Depcat 6–7	62 601	8.8	1.6	–82%	82 (–1.8)	0.022
5–9 years						
Depcat 1–2	63 256	0.8	0.8		–31 (–0.1)	0.846
Depcat 3–5	193 610	5.2	1.6	–69%	45 (–0.8)	0.129
Depcat 6–7	60 728	4.1	1.7	–59%	75 (–0.7)	0.037
10–14 years						
Depcat 1–2	65 508	3.1	0.8	–74%	11 (–0.5)	0.308
Depcat 3–5	191 641	5.2	2.4	–54%	17 (–0.5)	0.271
Depcat 6–7	54 818	7.3	4.6	–37%	33 (–0.7)	0.182
Total (0–14 years)						
Depcat 1–2	188 718	2.4	1.9	–21%	–7 (–0.1)	0.450
Depcat 3–5	579 872	4.1	2.1	–49%	31 (–0.4)	0.192
Depcat 6–7	178 147	6.7	2.5	–63%	85 (–1.1)	0.016

*Deprivation categories represent: depcat 1–2 – most affluent, depcat 3–5 – intermediate, depcat 6–7 – least affluent.

Table 4 Number of head injury deaths and head injury mortality rates by cause of injury in the 0–14 years age group in Scotland (1986–95); with linear regression results (adjusted R^2 and associated p value)

Cause of injury	1986–1995 Total Deaths (%) Mean annual rate per 100 000	Rates ratio male:female	Mortality rate per 100 000 1986/87	Mortality rate per 100 000 1994/95	Difference 1986/87–1994/95	Adjusted R^2 (%) (regression coefficient)	Associated p value
Pedestrian accident	118 (41) 1.2	1.5 : 1	2.3	0.6	–74%	89 (–0.4)	0.010
Other road traffic accident	89 (31) 0.9	1.6 : 1	1.2	1.0	–17%	–33 (0.01)	0.927
Falls	32 (11) 0.3	2.5 : 1	0.4	0.2	–50%	22 (–0.04)	0.243
Assault	24 (8) 0.3	1.5 : 1	0.3	0.2	–33%	–17 (–0.03)	0.561
Other	27 (9) 0.3	2 : 1	0.2	0.2	0	–32 (0)	0.865
Total	290 (100) 3.0	1.7 : 1	4.4	2.1	–52%	78 (–0.5)	0.030

Mean annual populations: 1986/95 – 966119, 1986/87 – 973410, 1994/95 – 972676.

the three combined deprivation categories experienced proportional decreases in head injury mortality between 1986/87 and 1994/95, although the only significant linear decline was in deprivation category 6–7 (table 3). The risk of head injury death was higher in children in deprivation category 6–7 than among children in deprivation category 1–2 in 1986/87 but the excess was not significant (OR=2.54, 95% CI 0.90 to 7.22). The risk of head injury death among children in deprivation category 6–7 was still slightly higher than the risk in deprivation category 1–2 in 1994/95, but again not significant (OR=1.32, 95% CI 0.36 to 4.93).

Further examination of deprivation category by age group showed that there were significant linear declines in head injury mortality in category 6–7 among 0–4 and 5–9 year olds, but not in 10–14 year olds (table 3). While there were decreases in the other deprivation categories in each of the age groups they did not display significant linear trends. Although the incidence of fatal head injury remained higher in deprivation category 6–7 than in deprivation category 1–2 the gap decreased among children aged 0–9 years but appeared to widen among children aged 10–14 years.

The main causes of head injury mortality were pedestrian accidents, and "other road traffic accidents" (vehicle occupant accidents and cycle accidents) (table 4). Pedestrian accidents were the main cause of death for both sexes. While the head injury mortality rates as a result of pedestrian and "other road traffic accidents", falls and assaults all decreased over the study period, only the pedestrian accident rate showed a significant linear decline (table 4). A disproportionate number of male children were fatally injured as a result of each of the four leading causes of head injury. There was a significant linear decline in the pedestrian accident head injury mortality rates between 1986/87 and 1994/95 for both male and female children. The male rate fell by 77% from 3 to 0.7 deaths per 100 000 (adjusted R^2 83%, p=0.02) and the female rate fell by 73% from 1.5 to 0.4 deaths per 100 000 (adjusted R^2 79%, p=0.03). Assaults were a particular feature of head injury mortality for infants and the incidence of this injury type increased over the study period but did not display a significant trend.

DISCUSSION

Linear regression analysis showed that head injury mortality rates among Scottish 0–14 year olds decreased significantly between 1986 and 1995. The largest decline was observed in skull fracture head injury fatality. Male children experienced higher rates of fatal head injury throughout the study period for total head injury mortality, and for the four leading causes of head injury death. This gender difference is in keeping with the results of other studies demonstrating a higher incidence of injury among males for both general and cause specific injury.[9–11]

Although children residing in areas of relatively greater deprivation seemed to experience higher head injury mortality rates, the difference in rates between children in the most and least affluent areas decreased over the study period. However, this varied by age group. The socioeconomic divide seems to have decreased among children aged 0–9 years, but to have increased among 10–14 year olds. This is a similar pattern to the trends in all cause injury mortality in Scotland, in contrast with the pattern of increasing socioeconomic divide suggested in all injury mortality in England and Wales.[1 2] Our results should, however, be interpreted with caution as deprivation scores are a measure of "area" deprivation and may not be directly comparable with the individualistic measure of social class adopted in England and Wales.

Key points

- Head injury mortality rates among Scottish children decreased between 1986 and 1995.
- While the differences in head injury mortality between the most and least affluent children decreased overall, they widened among 10–14 year olds.
- Pedestrian accidents were the leading cause of head injury mortality, but did decrease significantly during the study period.
- The decline in pedestrian head injury deaths could be partly attributable to road safety initiatives.

Pedestrian and "other road traffic accidents" accounted for almost three quarters of head injury fatalities, possibly reflecting the severity of such injury events.[12] Encouragingly, head injury deaths as a result of pedestrian accidents had decreased significantly over time. "Other road traffic accidents" did not significantly decline. The reasons for any change are likely to be multifactorial. Initiatives such as the introduction of urban traffic calming schemes, cycleways, airbags, seatbelts and cycle helmet use may have been influential. Changing travel patterns (specifically a decrease in the number of vulnerable road users) may also have played a significant part in this decline. More children may be travelling by car or may be accompanied by adults more often than in the past.[13] The UK-wide National Travel Survey indicates that the number of children (5–15 years) travelling to school by car increased from 12% in 1975/76 to 26% in 1994/96 and the number of 5–10 year old children travelling to school unaccompanied fell from 20% in 1985/86 to 11% in 1994/96.[14] However, walking remained the main means of travel to school for 5–15 year old children in 1994/96 accounting for 53% of the total.[14]

The increase in head injury mortality among infants as a result of assault merits further investigation. Detailed examination of the aetiology of cause specific head injury mortality, such as the nature of falls or the origins of assaults, was not possible using the routine data available to us.

Finally, an improvement in the case fatality rate due to improved medical treatments or better diagnosis may also have contributed to the observed decline in head injury mortality, a hypothesis that has received some support

elsewhere.[15] This could particularly be the case for the apparent decline in skull fracture mortality.

The use of routine mortality data for epidemiological analyses has its drawbacks. Sources of possible error include classification and coding errors. Furthermore, multiple injury deaths do not identify the separate injuries involved. We cannot exclude the possibility that some multiple injury deaths involving skull fracture and intracranial injury were not included in the analysis, resulting in an underestimation of head injury mortality.

In summary, these data show a temporal decline in head injury mortality in Scottish children between 1986 and 1995. Although children residing in less affluent areas remained at higher risk of sustaining fatal head injuries than their more affluent counterparts throughout the study period, the gap between the two groups narrowed. None the less, while the differences between the most and least affluent decreased overall, they widened among 10–14 year olds. The decline in head injury mortality as a result of pedestrian accidents may be partly attributable to the implementation of a range of road safety measures over the past two decades.

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Conflicts of interest: none

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