Mortality from Head Injury over Four Decades in Scotland

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Abstract

Although the causes of head injury, the population at risk and approaches to prevention and treatment are continually evolving, there is little information about how these are reflected in patterns of mortality over time. We used population based comprehensive data uniquely available in Scotland to investigate changes in the total numbers of deaths from 1974 to 2012, as well as the rates of head injury death, from different causes, overall and in relation to age and gender. Total mortality fell from an annual average of 503 to 339 with a corresponding annual decrease in rate from 9.6 to 6.4 per 100,000 population, the decline substantially occurring between 1974 and 1990. Deaths in children fell strikingly but rose in older people. Deaths in males fell to a greater extent than females but remained at a higher rate overall. Initially, a transport accident accounted for most deaths but these fell by 80%, from 325 per year to 65 per year over the 39 year period. Deaths from falling and all other causes did not decline, coming to outnumber transport accident deaths by 1998, which accounts for the overall absence of change in total mortality in recent years. In order to reduce mortality in the future, more effective measures to prevent falls are needed and these strategies will vary in younger adults (where alcohol is often a factor), and in older adults where infirmity can be a cause. In addition, measures to sustain reductions in transport accidents need to be maintained and further developed.

Key words: traumatic brain injury, mortality, epidemiology, time, Scotland, road traffic accidents

Introduction

In the 1960s, the rising toll of deaths due to accidents stimulated substantial public, political and professional concern in many countries.[1] Head injuries became a particular focus following the recognition that in the majority of cases the cause of death was a traumatic brain injury. Since then, there have been substantial changes in the demographics of the population at risk, in the causes of injuries, in preventative measures, and advances in management when a brain injury occurs. However, there is little information available about how the pattern of deaths ascribed to a head injury has evolved over this time. With the exceptions of reports from the USA[2–4] and some northern European countries,[5–9] most studies have been cross-sectional surveys at a single time point.

The statistical database of the National Records of Scotland (NRS) holds data from 1974 to 2012 on all deaths in Scotland, their causes and the demographics of the victims. We used this information to investigate changes in the pattern of deaths related to head injury in Scotland over consecutive years from 1974 to 2012. Our specific aims were to determine if there had been variations over time in the annual total numbers and rates of deaths from a head injury and how the findings were influenced by the victim's age and gender, and the cause of injury.

Methods

Head Injury Deaths Data

Information on head injury deaths registered from 1974 to 2012 was obtained from nationally held records in the National Records of Scotland (NRS), which was formed on 1 April 2011 by the amalgamation of the General Register Office for Scotland (GROS) and the National Archives of Scotland. The data were provided in the form of the number of deaths by age and gender, where age was classified in 5 years intervals, starting at 0-4 years and continuing up to 80-84 years and then 85 or over.

There is not an accepted 'standard' set of International Statistical Classification of Diseases (ICD) codes that defines head injury in epidemiological studies.[10] The codes used in this study were based on comparability with the predominant practice in previous work, subject to a further scrutiny for potential relevance to death from traumatic brain injury.

Deaths in Scotland were considered to be 'head injury deaths' if the underlying cause of death was coded using one of the set of codes discussed and stated in Appendix 1. From 1974 to 1978, deaths were registered using the ICD-8 coding system, which was updated to ICD-9 in 1979 until 1999, when the system was updated again to ICD-10 codes for use from 2000 onwards. The codes studied were selected to be consistent across the successive versions of the ICD system. Nevertheless, the differences in the coding systems over these three periods may have affected the trends in head injury deaths over time and the potential impact of these changes is taken into account in the current study.

Deaths were further classified as being related to a transport accident, to a fall or to any other cause using the pre-defined groupings of their underlying cause of death codes, also shown in Appendix 1 "Classification of Type of Injury in Analysis". We excluded from our analysis deaths for which the underlying cause was classified as the ‘sequelae’ or ‘late effects’ of external causes, such as events which occurred a year or more before the death.

Population Totals for Scotland

Information on population demographics over the period of study was obtained from mid-year population estimated counts for each age-gender category publicly available from the GROS website (http://www.gro-scotland.gov.uk/statistics/theme/population/estimates/mid-year/index.html). This enabled modelling based on incidence rates of head injury in the population at risk, defined as the number of head injury deaths divided by the population size.

Statistical Analysis

Statistical analyses were conducted using the statistical software package R Version 2.15.1.[11] Additional packages used were HMisc, MASS, lmtest and splines.[12–14,11]

Analysis of the Total Numbers and Rates of Deaths from a Head Injury

Tabular summaries of the total number of head injury deaths, as well as the rate of head injury deaths per 100,000 population in Scotland were produced. Changes over time of total mortality of head injury, and rate per 100,000 population, were explored using Normal linear regression where time was transformed so that it ranged from 1 to 39 for 1974 to 2012. Fitted regression lines representing the equation of best fit to the data found by the chosen model (see Appendix 2 “Total Number of Head Injury Deaths” and “Rate of Head

Injury Death per 100,000 Population”) were estimated and plotted with 95% confidence intervals.

Analysis of the Total Number of Head Injury Deaths by Age, Gender and Cause of Injury

Tabular and graphical summaries of the annual average rate of head injury deaths per 100,000 population in different age groups, banded by decade in the successive epochs 1974-1980, 1981-1990, 1991-2000, 2001-2010 and 2011-2012 were produced.

Furthermore, the total number of head injury deaths stratified by gender and type of accident were plotted and observed.

Binomial Logistic Regression Analysis of Head Injury Deaths Caused by Different Types of Accident

Two principal specific causes of head injury death were identified for investigation from epidemiological information and inspection of data: road traffic accidents (RTAs) and falls. These accounted for 76.4% of head injury deaths over the study period. The remaining causes were spread across 37 codes; the numbers in any one group were very small and were therefore analysed as a composite group (see Appendix 1).

The three categories of injury were each considered separately in a binomial logistic regression analysis to estimate how the odds of dying from a head injury changed on average from one year to the next over the study period, taking population figures into account, for each of the 36 age-gender groups (see Appendix 2 for details). Different effects for each age-gender group across each year were allowed, due to observations of different patterns of head injury deaths in each of the groups. Regression lines representing the equation of best fit to the data found by the chosen logistic models were estimated and plotted with 95% confidence intervals (not shown in Results, see Appendix 2). The coding changes of 1979 and 2000 were adjusted for in each of the models, even if not found to be significant, in order to account for the differences in the coding systems over the time periods.

Results

Head Injury Deaths

(insert Table 1 about here please)

Table 1 shows the total number of deaths related to a head injury, the average annual number of deaths, the average population, and the rate of deaths per 100,000 population in Scotland from 1974 to 2012. The results are presented for successive epochs of (generally) five years (seven years for 1974 to 1980 and 2006 to 2012).

A total of 15,302 deaths occurred across the entire study period. From a peak of 503 annual deaths on average at the start of the study period, the average annual number of deaths fell progressively by a third to 334 in the mid-nineties. The average then rose to around 373 for the next two time bands, finally dropping to an average of 363 in 2006-2012, close to that observed in 1986-1990.

The population of Scotland also decreased from the early 1970s to 2001-5 but proportionally by a lesser extent (3%) than the number of deaths from a head injury. The population then rose to slightly below its starting total in 2006-2012 (99.8% of the 1974-1980 average).

The changes in the number of deaths and total population are reflected in the average annual rate of death from a head injury per 100,000. This fell by a third, from an initial high of 9.6, to 6.6 in the first half of the 1990s. Between the second half of the 1990s and 2001-5, the incidence rose to 7.3-7.4, around 77% of its initial level, then in 2006-12 fell to 7.0, approximately 73% of the initial level – the lowest average rate achieved across the study period with the exception of 1991-95.

The total number of head injury deaths and the rate of head injury deaths per 100,000 population over time were found to be best modelled using the following Normal linear models (see Appendix 2 “Total Number of head Injury Deaths” and “Rate of Head Injury Death per 100,000 Population” for details of model exploration and selection):

(insert Figure 1 about here please)

Figure 1 shows the absolute numbers and rates per 100,000 of head injury deaths over time along with the respective fitted regression lines corresponding to Equations 1 and 2, respectively. From Figure 1 it is clear that the numbers and rates of death from head injury per 100,000 population conform to a non-monotonic shape over the study period. This is represented by a sharp decline from a maximum of 599 in 1974, to 323 in 1995 (53.9% of the 1974 total). After 1995 there was less variation of the number of head injury deaths in Scotland. There was a small increase to 396 in 2004, before the number fell back down to 343 in 2012 (57.3% of the 1974 total). Rates of death from a head injury conformed to a similar non-monotonic pattern.

Deaths by Age, Gender and Cause of Injury

Table 2 shows the average annual number of head injury deaths for different age groups, banded by decade in the successive epochs 1974-1980, 1981-1990, 1991-2000, 2001-2010 and 2011-2012. The percentage of the total number made up by each age group is also shown.

(insert Table 2 about here please)

There was a progressive decrease in each successive epoch in the average annual number of head injury deaths in people less than 30 years old from the 1980s onwards. This was proportionately most striking in children under 10 years old in whom it fell from an annual average of 36.4 (7.2%) in 1974-1980 to 3.0 (0.9%) in 2011-2012. Conversely, in people older than 79, the number rose progressively from 28.3 (5.6%) in 1974-1980 to 96.0 (28.4%) in 2011-2012. Between these extremes, there were mixed patterns, with numbers predominantly decreasing in younger age bands and increasing in older groups.

(insert Figure 2 about here please)

Figure 2 shows the total number of head injury deaths in Scotland over time according to gender and type of accident, separately.

It is clear from Figure 2 that more males died than females in every year but that the gender gap lessened over time, especially in the early part of the study. This was reflected in a decline (48.2%) in the annual number of males dying from a head injury whereas in females there was a smaller decline (33.7%). In 1974, 439 males and 160 females died from a head injury; in 2012 the corresponding numbers were 226 and 117, respectively.

The annual number of deaths related to a transport accident fell by 80% between 1974 and 2012, from 325 to 65. This led to head injury deaths from transport accidents, having initially made up the largest number, becoming fewer than those from the other two groups. The rate of change varied little throughout the study period, without discernable sudden shifts that could be clearly associated with a single preventative intervention.

The number of deaths related to a fall did not vary much over the study period: the number was similar at the beginning (191) and end of the study (178) with an intervening decline to 107 in 1997.

The number of deaths related to all other types of accidents rose by 20% over the period of study, from 83 to 100 annually. The number was stable over the first half of the study period but peaked sharply in 1996, possibly related to the change to automatic coding that occurred in Scotland (see Appendix 1 for details). The number then declined but remained above the initial total.

Binomial Logistic Regression Analysis, Deaths due to a Transport Accident

(insert Figure 3 about here please)

Figure 3 shows that head injury deaths related to a transport accident decreased approximately linearly in both males and females between 1974 and 2012. The binomial model chosen to best fit the transport related head injury deaths over time in its simplified form is (see Appendix 2 "Head Injury Deaths Stratified by Type of Accident: Transport" for model exploration and selection):

A linear change over time for year was chosen as fitting the data best, taking into account different interactions with each age-gender group (see Appendix 2 for details), which corresponds with the patterns shown in Figure 3. The coding changes in 1979 and 2000 were included a priori as binary variables in the models examining head injury deaths by type of accident. The two coding changes in 1979 and 2000 did not to have a significant effect in the model (1979: OR = 0.96, 95% CI 0.88 to 1.05, p = 0.370; 2000: OR = 1.08, 95% CI 0.91 to 1.28, p = 0.395) in this case. This model was then used to calculate the average change per year in the odds of dying from a head injury caused by a transport accident for each age-gender group. The results are shown in Figure 4.

(insert Figure 4 about here please)

Figure 4 shows that in every age group in males, there was a significant reduction in the odds of dying from a transport related head injury per year across the study period. The greatest reductions in odds were observed in 0 to 4 year olds (6.7% reduction per year) and 65 to 69 year olds (6.2% reduction per year). Significant reductions were also seen in the majority of age groups in females, with the exception of women aged 30 to 34, 40 to 44 and 85 or over. As in males, the greatest reductions in odds were seen for the age groups 0 to 4 (7% reduction per year) and 65 to 69 year olds (7.2% reduction per year). The corresponding table of values with 95% confidence intervals is shown in Appendix 2 "Head Injury Deaths Stratified by Type of Accident: "Transport" (Table 2.1).

Binomial Logistic Regression Analysis, Deaths due to Falling

(insert Figure 5 about here please)

Figure 5 shows that in males the number of deaths related to a fall declined in the early part of the study falling from 135 in 1974 to 103 in 2012. In females the number was stable initially but increased in later years of the study. The model chosen to best fit the fall related head injury deaths over time in its simplified form is (see Appendix 2 "Head Injury Deaths Stratified by Type of Accident: Falls"):

As with the transport related deaths, a linear change over time for year was chosen as it best fitted the data when taking into account the different interactions with each age-gender group (see Appendix 2 for details), as shown in Figure 5. The coding change in 1979 did not have a significant effect in the model (1979: OR = 0.95, 95% CI 0.85 to 1.05, p = 0.313) but the coding change in 2000 had a significant influence (2000: OR = 1.26, 95% CI 1.05 to 1.51, p = 0.012). Both variables remained in the model. This model was used to to calculate the average change per year in the odds of dying from a head injury caused by a fall for each age-gender group. The results are shown in Figure 6.

(insert Figure 6 about here please)

Figure 6 shows that in males, significant reductions in the odds of dying from a head injury as a result of a fall were seen in the majority of age groups. The greatest annual reductions were observed between the ages of 5 and 14 years: 5 to 9 year olds experienced a decrease in odds of 7.8% per year, while 10 to 14 year olds experienced a decrease of 7.6% per year. The groups in which there was no significant change annually were aged between 30 to 34, and over 75 years old. In the remaining age groups, significant reductions in odds of around 2-3% per year were seen. In contrast, in females, significant changes in the odds of dying from a head injury caused by a fall were seen in only three age groups. There were significant decreases in the odds in those aged 0 to 4 years (5.2% decrease per year) and 35 to 39 years (3.9% decrease per year). In contrast, a significant increase in odds (1.6% increase per year) was seen in people aged over 85 years old. The corresponding table of values with 95% confidence intervals is shown in Appendix 2 “Head Injury Deaths Stratified by Type of Accident: Falls” (Table 2.2).

Binomial Regression Analysis, Deaths from a Head Injury from Other Causes

(insert Figure 7 about here please)

Figure 7 shows that the number of deaths from a head injury following an accident due to a cause other than a road traffic accident or fall was stable over the first two decades of the study. There was a sharp increase in 1996, due to a change in coding practice in Scotland at that time, after which the number declined slightly in males but showed little change in females.

Within each age-gender subgroup, the following model was chosen to best fit the data (see Appendix 2 "Head Injury Deaths Stratified by Type of Accident: Other"):

Fixed-effects for the coding changes in 1979 and 2000 were also included in the model a priori. The change in coding in 1979 had a significant effect in the model (1979: OR = -0.23, 95% CI -0.40 to -0.06, p = 0.007) whereas the coding change in 2000 did not (2000: OR = -0.19, 95% CI -0.42 to -0.04, p = 0.103). This model was then used to calculate the average change per year in the odds of dying from a head injury caused by another type of accident (i.e. not transport or fall-related) for each age-gender group. The results are shown in Figure 6.

However, because the model assumes a change in the effect of year at 1996, the average change per year is different before and after 1996. Therefore, Figures 8a and 8b show the average change per year in the odds of dying from a head injury caused by an 'other' cause, for each age-gender group, before 1996 and from 1996 onwards, respectively.

(insert Figures 8a and 8b about here please)

Figures 8a and 8b show that in several age groups in males there were significant changes in the odds of dying from a head injury caused a reason other than falling or transport accidents. Before 1996 there was a significant reduction in the odds (12.3%) in males aged 5 to 9. After 1996, significant reductions were observed for those aged 15 to 19 years (6.3%), 45 to 49 years (3.8%), 55 to 59 (4.4%), 65 to 69 years (4.2%) and 70 to 74 years (6.8%). In contrast, a significant change in odds of death was not seen in any of the female age groups. The corresponding tables of values with 95% confidence intervals are shown in Appendix 2 "Head Injury Deaths Stratified by Type of Accident: Other" (Tables 2.3a and b). Note that some of the estimates for certain age groups have large confidence intervals as a result of few deaths having occurred in that age-gender category.

Discussion

In summary, our findings show two distinct phases in the pattern of mortality from a head injury in Scotland. Between 1974 and 1993 there were substantial reductions in both the annual total number and the rate of deaths per 100,000 population. Thus, by the mid-90s these had declined to almost a half of their starting levels in 1974. In contrast, for the remaining period of the study there was no further decline below the levels in the mid 1990s. These patterns in the overall findings reflect evolving interactions between underlying changes in the age and gender of the victim and the cause of injury.

Factors Affecting Changes in Mortality

There was a marked change in the age distribution of people who died after a head injury. The number and the rate of head injury deaths fell successively in people less than 30 years old from the 1980s onwards. Conversely, the number of deaths in people over 79 year old rose progressively, and was not simply a reflection of the increasingly elderly population, because the rate of head injury deaths in that age group also rose by a substantial 225% - to become the highest rate of death across all ages in both genders during the entire study period.

Deaths in males from a head injury dropped substantially over time whereas in females there was only a slight decrease at the beginning of the study. As a consequence, although males had a consistently higher annual number and incidence of deaths from a head injury than females, the gender gap narrowed over time.

The influence of the cause of the injury was most clear for transport accidents. Overall, by 2011-2012, both annual numbers and rates of head injury deaths related to a transport accident had declined progressively to a fifth of their initial level in 1974. In males this decrease in the odds of dying was significant in all age groups as was the case in most female age groups also. Many measures have been introduced to improve road safety over the last four decades.[15] Suggestive legislation in Scotland (Table 3) has aimed to reduce the occurrence of accidents by improving driving standards through training, by minimising driver impairment from intoxication or distraction, by reducing traffic speed and by safer road construction. Vehicle design and the fitting and use of seat belts and other safety devices in vehicles to minimise injury in the event of an accident have been enforced. Organisations such as the Royal Society for the Prevention of Accidents[16] have conducted vigorous public campaigns for many years. The pattern of a consistent decline in fatalities suggests that it reflects a progressive, cumulative effect of the combination of measures and there was no obvious association between any single intervention and change in odds of mortality.

(insert Table 3 about here please)

Changes in the odds of dying from a head injury related to a fall were more varied in relation to gender and age. In males the odds of dying reduced significantly over time in most age groups. In contrast, in females a significant decrease was only seen in two of the 18 age groups, and in those over 84 years old there was a significant increase.

The number of deaths related to types of accidents other than falls or transport accidents was analysed separately for the first and second halves of the study period, due to an apparent discontinuity in the number of deaths in 1996, possibly reflecting a change in coding practice at that time. Reductions in the odds of dying were seen in males at most ages but not in any age group in females. Furthermore, the overall totals were stable in the two periods.

The decrease in the overall numbers and rates of death from a head injury in the first two decades of the study therefore predominantly reflected the decline in head injury deaths resulting from a transport accident, seen in both genders at most ages but especially in male children. After the mid-1990s, the decline in deaths from a transport accident continued but this contribution to total numbers and rates had become outweighed by deaths from falls and other causes. In the latter, although the odds of males dying declined at several ages, for females the overall pattern did not change. Coupled with the increasing proportion of older females among the victims, the effect was a cessation in the reduction of deaths and even a temporary increase in overall numbers and rates of death from a head injury.

Robustness of Findings

Several factors contribute to confidence in the validity of our findings. Ascertainment of numbers of deaths and their cases was through a single comprehensive national database, routinely compiled and covering all deaths in Scotland. This produced a total of 15,302 deaths for analysis over the period of study between 1974 and 2012. The population of Scotland has been relatively stable over the relevant years; in 1974 the population was 5,240,800 while in 2012 it was 5,313,600. Moreover, in the approach to the analysis, standard modelling techniques were used and only pre-specified variables were included in the models.

Confidence in our findings is supported by their derivation from investigation of data for successive years covering an extensive period of 39 years: a decade more than any other published work.

The potential for variations in approach to diagnosis of cause of death is unavoidable in a study of this kind. However, in Scotland, all deaths considered to have resulted from accidental or violent causes or the use of a vehicle should be reported to the Procurator Fiscal Service (akin to a coroner in other legal systems) and are often investigated by autopsy. We therefore consider that variations in certification are unlikely to have influenced the findings. A change in 1996 in Scotland to automatic coding (see Appendix 1 “Identification of Head Injury Deaths” for details) was associated with a ‘spike’ within the number and rate of deaths coded as being from an injury due to a cause other than a transport accident or fall. The change was not related to a specific mechanism of injury; the make up of this group covered 37 different ICD codes and the effect was most prominent for the ‘other and unspecified’ types.

Systems for translating certified causes into coding did change over the term of the study. At different times, ICD 8, 9 and 10 were in use and there are substantial differences between ICD 9 and 10 in codes applicable to head injury. Unfortunately, there is not a standard widely accepted set of codes used to define head injury in epidemiological work. In a systematic review of ICD 10 codes used worldwide to define traumatic brain injury, Chen and Colantonio (2011)[10] found markedly inconsistent approaches, with 15 uniquely different sets of definitions in 24 articles. The number of sets of codes utilised ranged from 1 to 32, with a median of 21. This study used 23 of these sets of codes, selected to be comparable to predominant practice and with the numbers produced by ICD 8 and 9 systems.

To examine the potential for an influence of the system of coding on our findings, the two changes that occurred in 1979 and 2000 were included a priori as binary variables in all of the models examining the head injury deaths caused by different types of accidents. A significant effect from the change in 1979 was found only in the subset of deaths from a cause other than a transport accident or a fall, while a significant effect of the introduction of ICD 10 in 2000 was found only in the subset of deaths from a fall.

We also investigated the effect of applying the set of ICD 10 codes used by the Centre for Disease Control whose reports of findings in the USA are the main source for comparison with our findings. In the report of Coronado et al. (2011)[4], the set of ICD 10 codes used was slightly broader than used here, equivalent to 29 of the foregoing sets. The additional categories chiefly related to facial injuries and deaths from late effects. The use of these codes for our data from 2000 onwards increased the annual total by only 5%, from an average of 400 to 420. The ICD 10 codes used by the CDC also yielded higher numbers of deaths in the USA report than in previous CDC reports.[17,18] Finally, repetition of our analysis incorporating this additional data did not result in a difference in the consequent models and results (not shown).

Comparison with other Findings

Reports by the CDC cover traumatic brain injury-related deaths in the USA over 1979 to 2007.[2–4] The annual incidence of death from a head injury in the USA was markedly higher in Scotland but fell more consistently and proportionately by a greater extent. Thus in the USA annual rates per 100,000 population were 24.6 in 1979 and fell progressively to 17.8 in 2007 (28% decline). In contrast, in Scotland the corresponding figures were 9.4 in 1979 and 7.3 in 2007 (22% decline), with all declines taking place before 1997 (minimum number in 1997) with a rise thereafter. In both countries, there were higher rates in males, and over time a decline in rates of death in younger people, and an increase in the rates in older age groups.

In the USA, firearm related events have consistently been the most common cause of head injury death, accounting for 44% of the total number of deaths in 1992, 40% between 1989 and 1998, and 35% between 1997 and 2007.[2–4] In contrast, over the whole term of the study there were only 618 deaths in Scotland from a firearm incident: 4.04% of the total over the entire period. They were, therefore, not considered as a separate category in the analysis. Deaths from a head injury related to a motor vehicle incident accounted for the second largest number of deaths in the US but declined only slightly from 34% in 1992 to 31% in 2007. In Scotland, 51% of deaths were related to a transport accident between 1979 and 1992, and the proportion fell more steeply to 28% between 1997 and 2007. Deaths related to a fall make up the third largest group of deaths in the USA and the second in Scotland and rose in each country. In the USA they accounted for 9% of the total number of deaths in 1992 rising to 17% between 1997 and 2007. In Scotland, falls accounted for 33% of the total between 1979 and 1992 and rose to 41% between 1997 and 2007. The increase was greatest in people aged 70 or older in both countries.

The role of injuries in older people in overall mortality, in particular those due to a fall, is noted in four reports from northern Europe. A report of mortality from head injury covering Denmark, Finland, Norway and Sweden from 1987 to 2001 noted a ‘considerable’, but unspecified reduction, especially in men and boys but not in people over 60 years old in either gender.[5] A study limited to Finland reported increases in numbers and rates of deaths from a head injury due to a fall between 1971 and 1995.[7] A later study of deaths from a head injury covering all causes from 1991 to 2005 reported a decline in deaths in males and that a fall was the most common cause.[9] In Germany, the mortality rate from a head injury fell continuously from 27.2 to 9.0 between 1972 and 2000, the extent of the decline was greatest in young people aged 20 to 25 whereas there was an increase in ‘advancing years’, mostly caused by a fall.[8]

Relation to Other Deaths from Injuries including Road Transport Accidents

Deaths in Scotland from all accidental causes have declined over the last 4 decades from 2,533 in 1974 to 1,247 in 2012. This reduction by a half is relatively more than the decrease in deaths from a head injury so that the proportion of all accidental deaths caused by head injury has risen, from 19.4% in 1979 to 27.5% in 2012. The corresponding graphs are shown in Figure 9.

(insert Figure 9 about here please)

Within this total, deaths from a road transport accident declined over the last 4 decades, from 829 in 1976-80, to 271 in 2006-2010 – a decrease of 67.5%. The decline in those with a head injury was relatively greater at 80%.

Implications

After a substantial decline in the first two decades of this study, there has not been a sustained change in the total annual number and rate of deaths from a head injury in Scotland. This overall picture is the product of important differences between the findings in different age and gender groups which may inform measures for prevention. Although encouraging overall, there is a concern that the decline in accidental deaths from any cause in Scotland has been proportionately greater, effectively increasing the proportion of all accidental deaths that occur from head injury. This suggests that there may be fundamental risks associated with deaths from head injury that have been inadequately dealt with such as the association between alcohol use and head injury.

To explore this area further, it may be of interest to look into head injuries and deaths from head injuries caused by assault: assaults are the second most common cause of head injury in Scotland, but only accounted for 8.08% of the total number of head injury deaths over the entire study period.

The most substantial and consistent decrease was seen in fatal head injuries related to a traffic accident. Rather than being associated with discrete identifiable interventions, this appeared to reflect an aggregation of the benefits from a range of practical, educational, and legal actions. Continued vigorous implementation and development of these will be important in order to sustain and advance on the progress already achieved.

There was no evidence of a consistent decrease over time in deaths from a head injury from other causes. In these, firearm incidents, assaults, and suicides were the only identifiable mechanisms that accounted for a substantial proportion; in the remainder, either the number of deaths was very small, or the event was not attributed to a specific mechanism.

The combination of an increase in the rate of falls in very elderly people in both genders, along with the increasing number of older people in the population, is the factor most clearly limiting further reduction of a head injury as a cause of death in Scotland. There is strong evidence that programmes aimed at preventing falls in older people can reduce the occurrence of injuries, including the most severe kinds. Prevention of falls in the elderly has been targeted by a range of service developments in Scotland.[19] It will be essential to promote the maximum efficacy of these measures and to monitor their effectiveness through further studies of the findings in deaths from a head injury.

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Author Disclosure Statement Section

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Figure 1

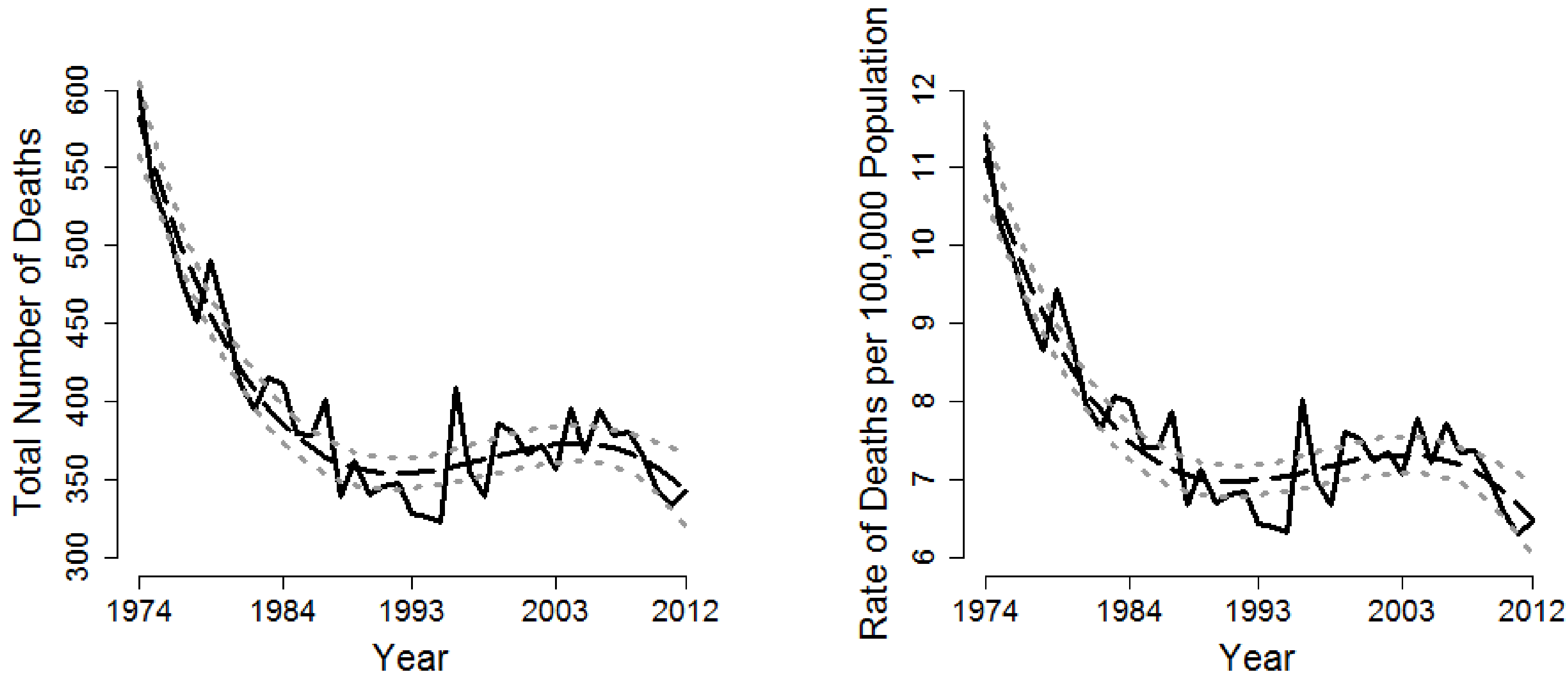

Fig. 1. Left: the annual number of head injury deaths in Scotland plotted over time from 1974 to 2012 (solid line), along with the fitted regression line representing the cubic equation found to best fit the data, shown by equation 1 (dotted line) and the corresponding 95% confidence intervals (grey dotted lines). Right: the annual rate of head injury death per 100,000 population in Scotland over time from 1974 to 2012 (solid line), along with the fitted regression line representing the cubic equation found to best fit the data, shown by equation 2 (dotted line) and the corresponding 95% confidence intervals (grey dotted lines).

Figure 2

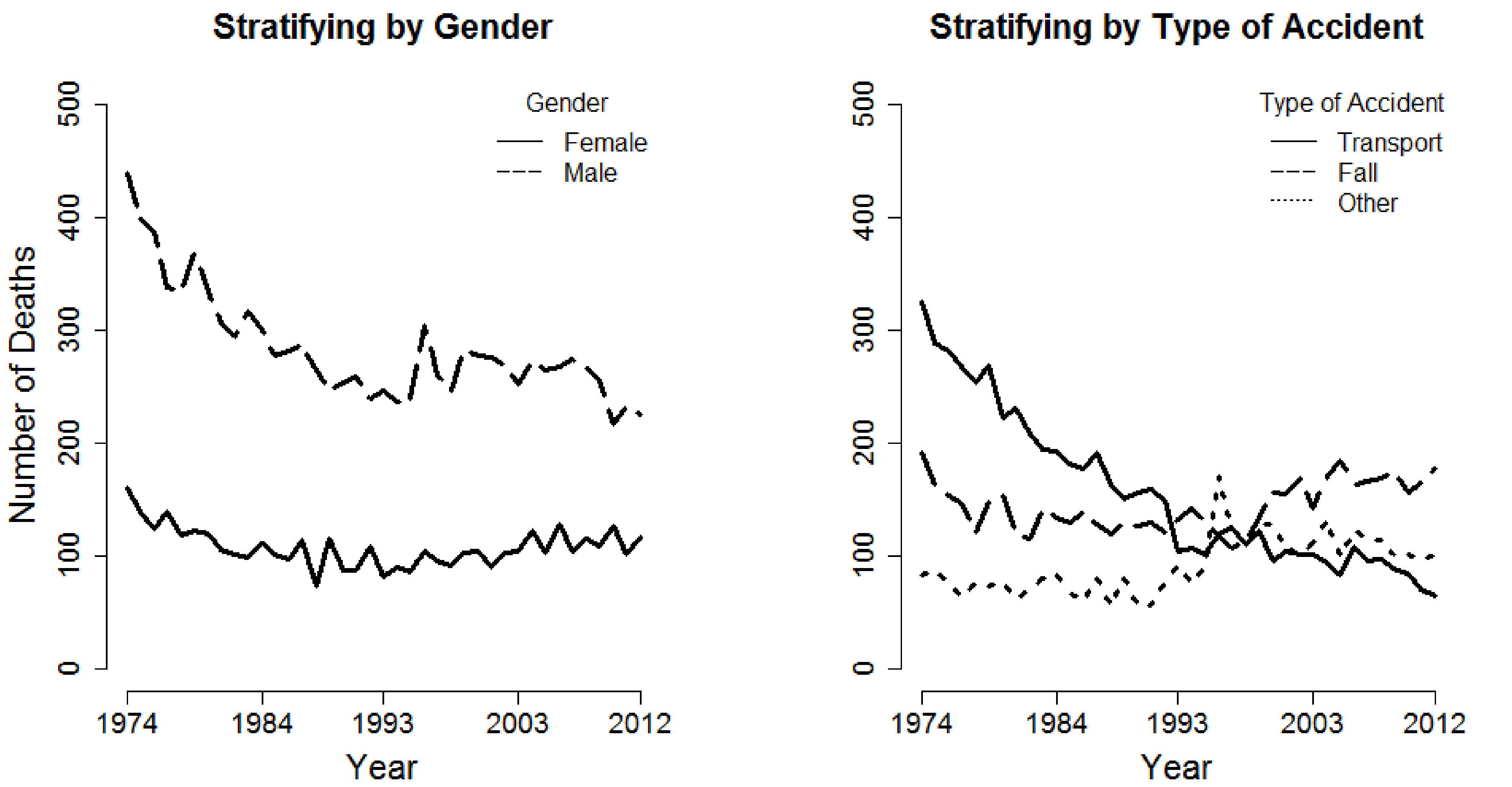

Fig. 2. The total number of head injury deaths in Scotland over time from 1974 to 2012, according to gender (left) and type of accident (right).

Figure 3

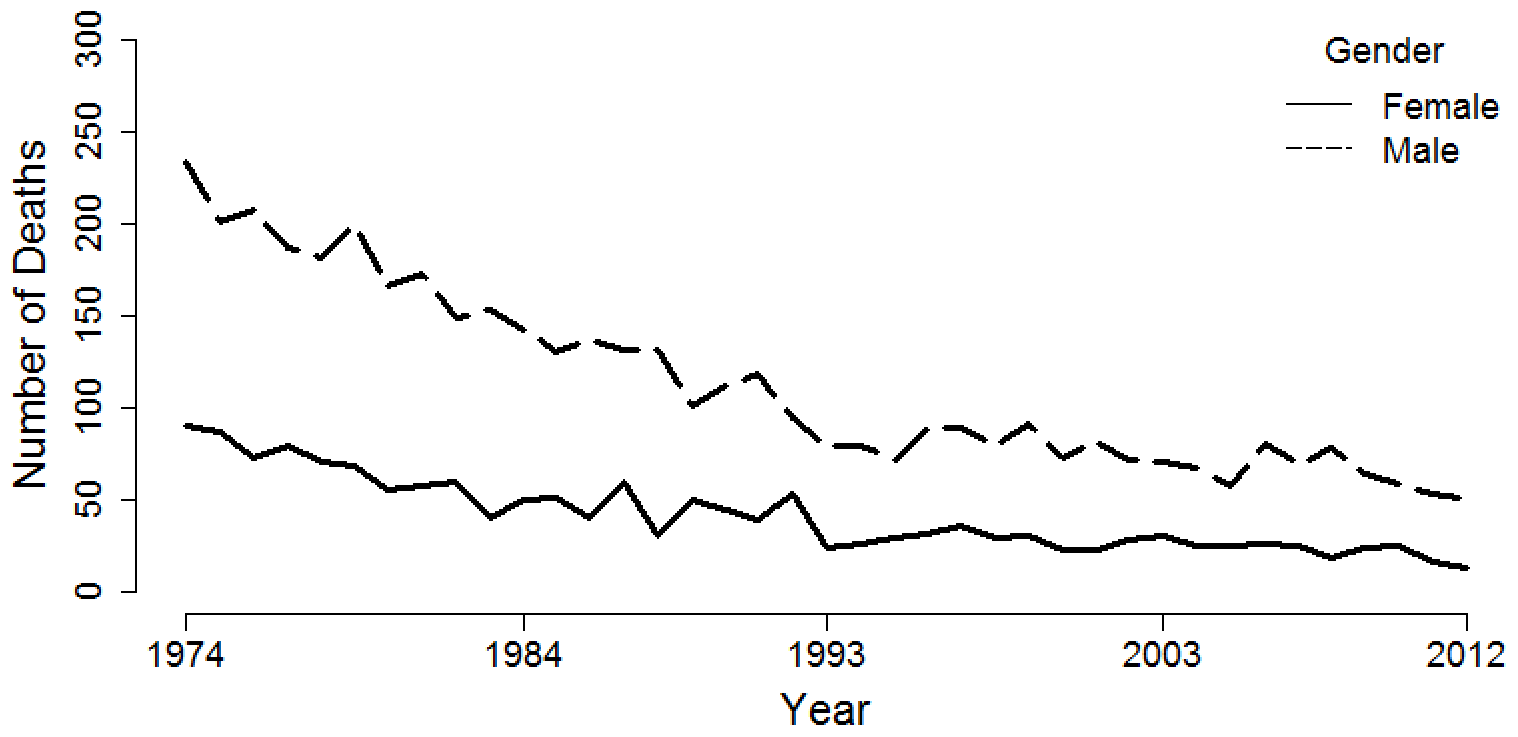

Fig. 3. The total number of head injury deaths caused by a transport accident for males and females in Scotland over time from 1974 to 2012.

Figure 4

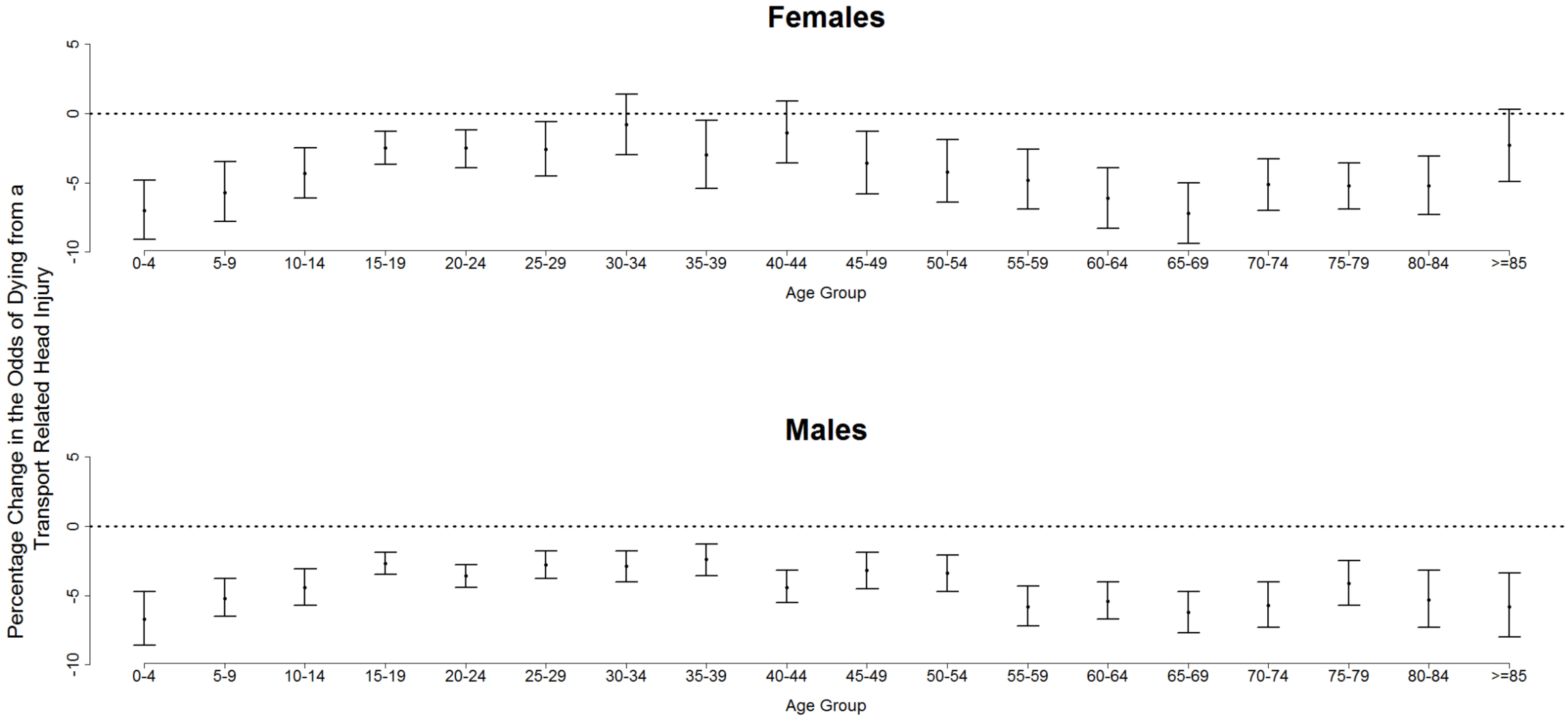

Fig. 4. The average percentage change per year in the odds of dying from a head injury caused by a transport accident over the study period, for each age-gender group, estimated using the binomial logistic regression model chosen to best fit the data, shown by equation 3. The point shows the estimate, while the bars above and below represent the corresponding 95% confidence intervals.The dotted line at 0 indicates no change in the mortality rate. If a bar lies completely above or below this line then the increase or decrease in rate is statistically significant. The corresponding table of values with 95% confidence intervals is shown in Appendix 2 (Table 2.1).

Figure 5

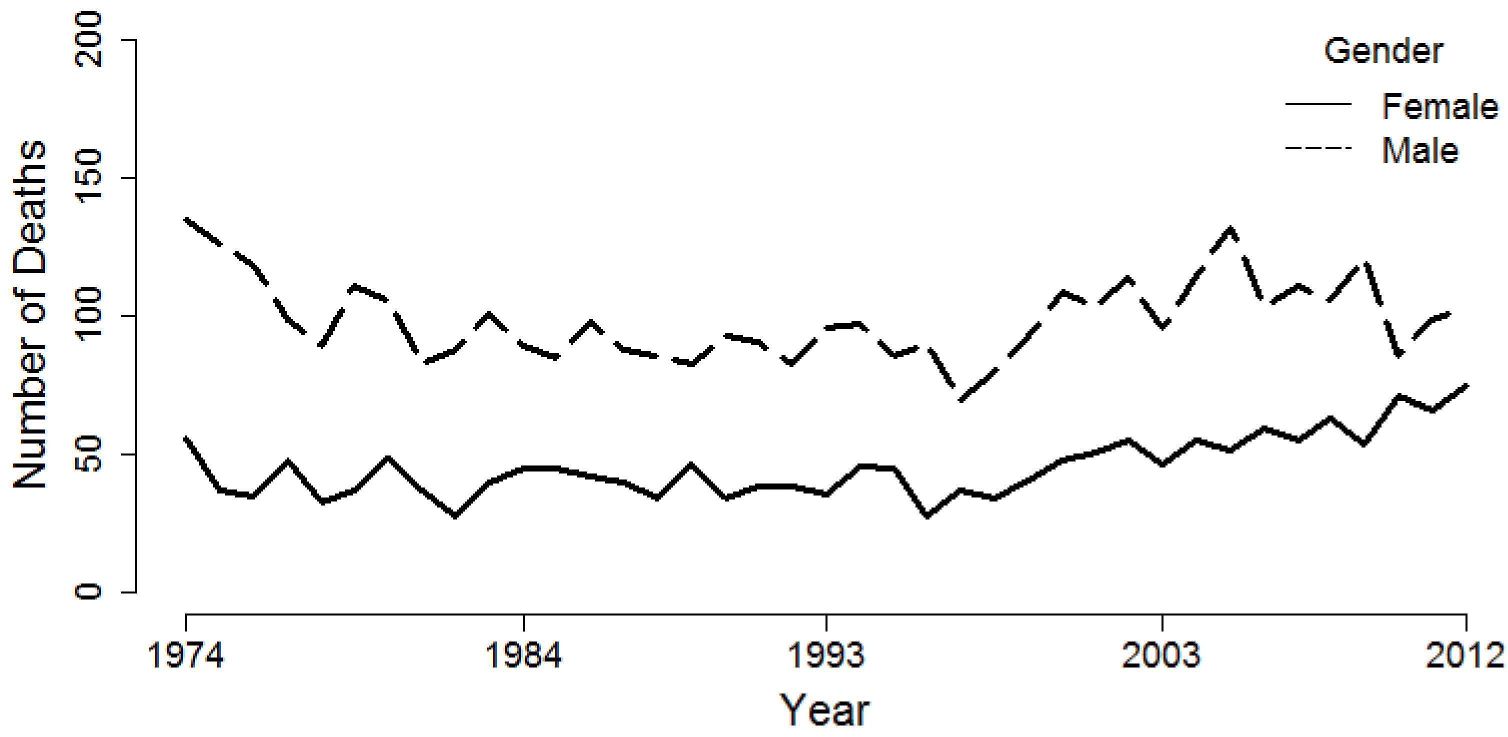

Fig. 5. The total number of head injury deaths caused by a fall for males and females in Scotland over time from 1974 to 2012.

Figure 6

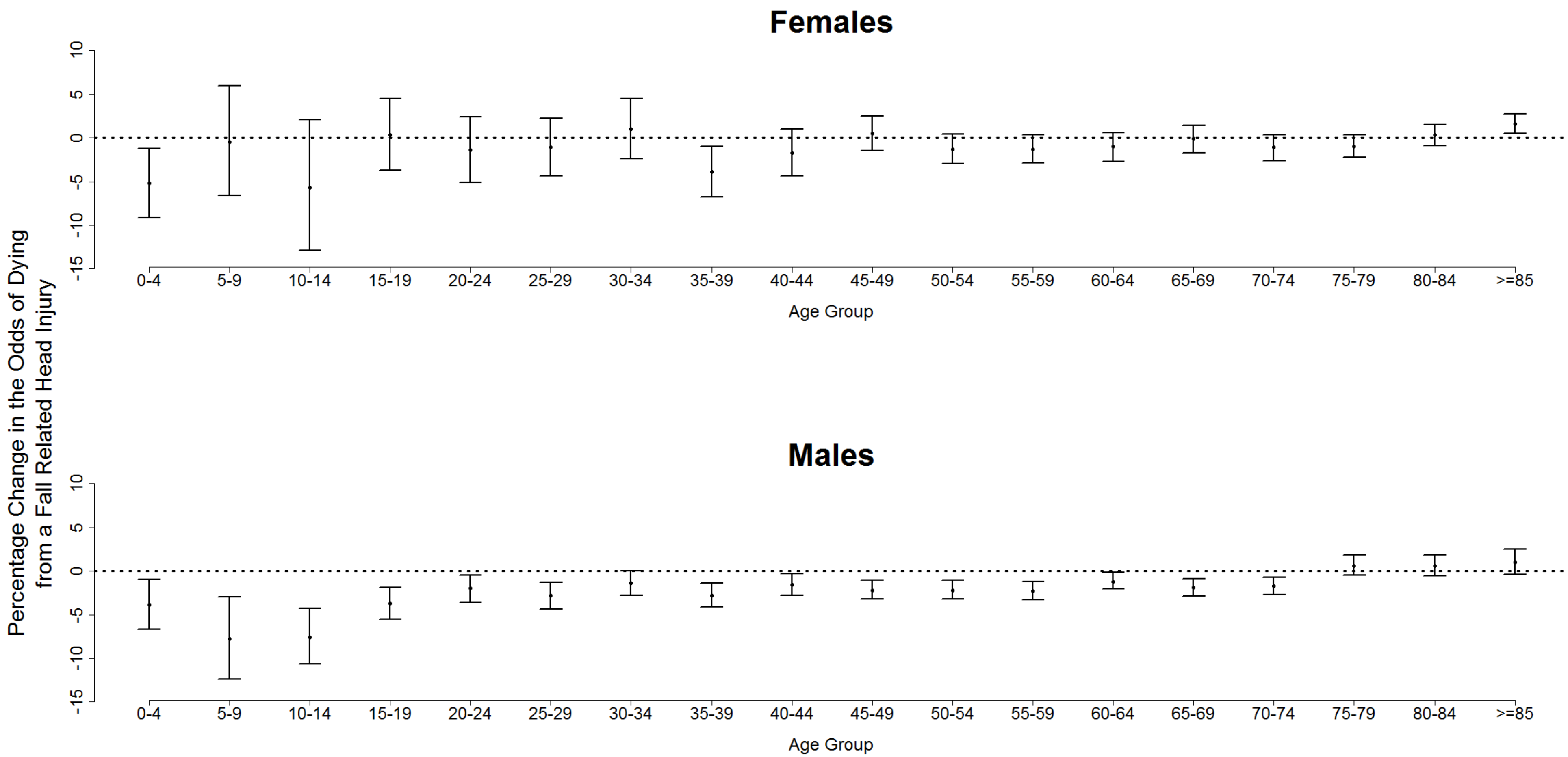

Fig. 6. The average percentage change per year in the odds of dying from a head injury caused by a fall over the study period, for each age-gender group, estimated using the binomial regression model chosen to best fit the data, shown by equation 4. The point shows the estimate, while the bars above and below represent the corresponding 95% confidence intervals. The dotted line at 0 indicates no change in the mortality rate. If a bar lies completely above or below this line it means that the increase or decrease is significant. The corresponding table of values with 95% confidence intervals is shown in Appendix 2 (Table 2.2).

Figure 7

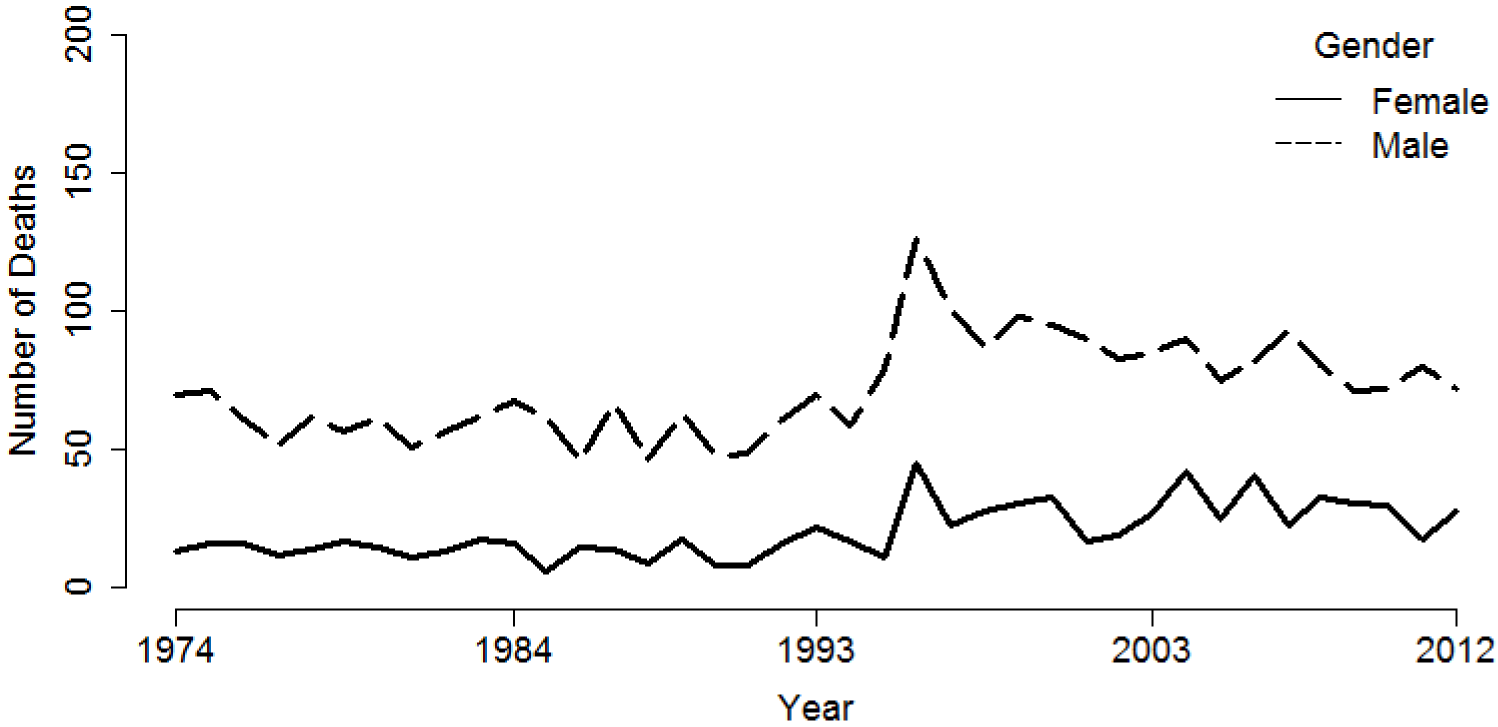

Fig. 7. The total number of head injury deaths caused by an accident other than a transport accident or fall, for males and females in Scotland over time from 1974 to 2012.

Figure 8a

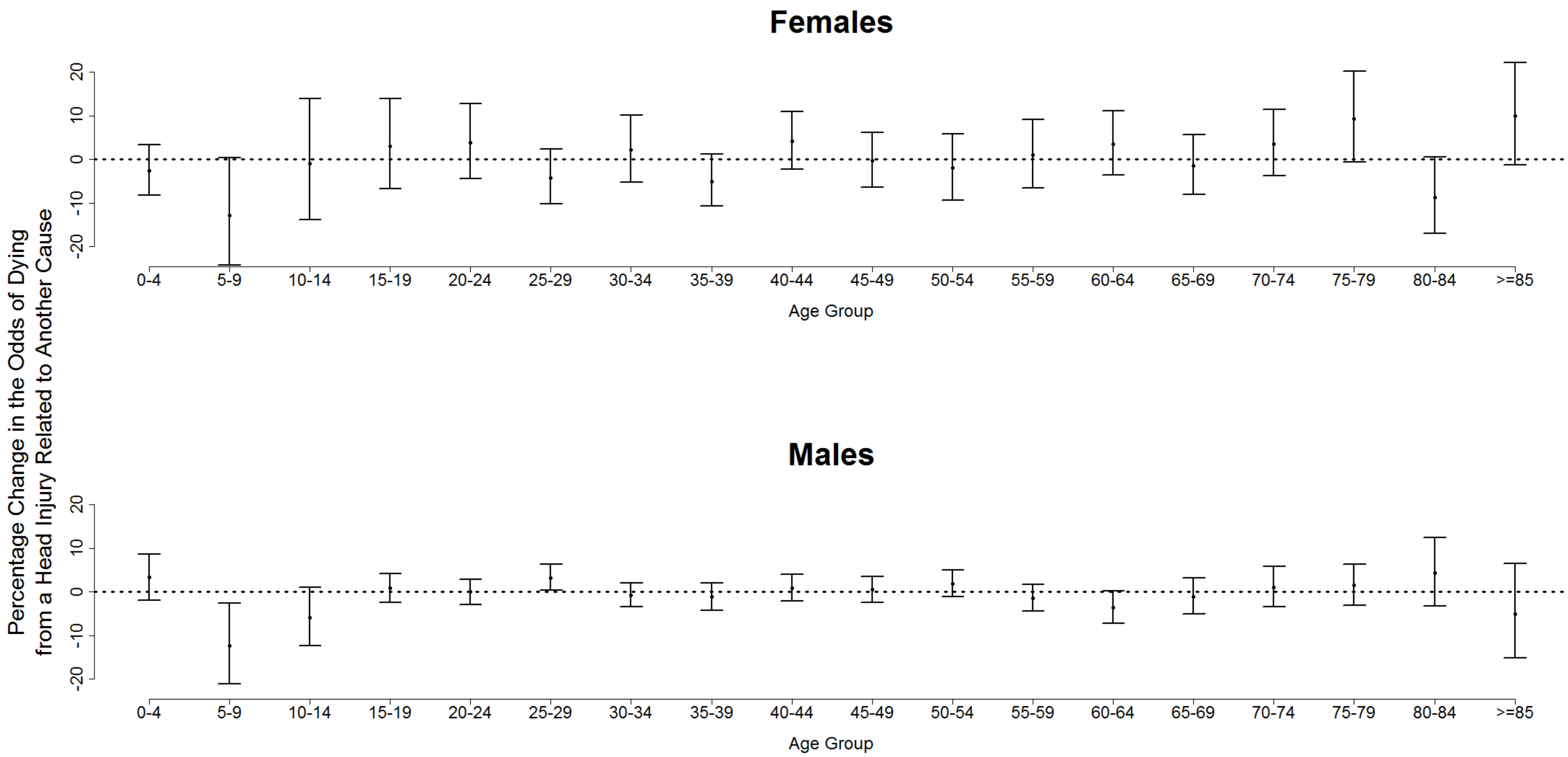

Fig. 8a. The average percentage change per year in the odds of dying from a head injury caused by an accident other than a transport related accident or a fall, for the period of 1974 to 1995, for each age-gender group, estimated using the binomial logistic regression model chosen to best fit the data, shown by equation 5. The point shows the estimate, while the bars above and below represent the corresponding 95% confidence intervals. The dotted line at 0 indicates no change in the mortality rate. If a bar lies completely above or below this line it means that the increase or decrease is significant. The corresponding table of values with 95% confidence intervals is shown in Appendix 2 (Table 2.3a).

Figure 8b

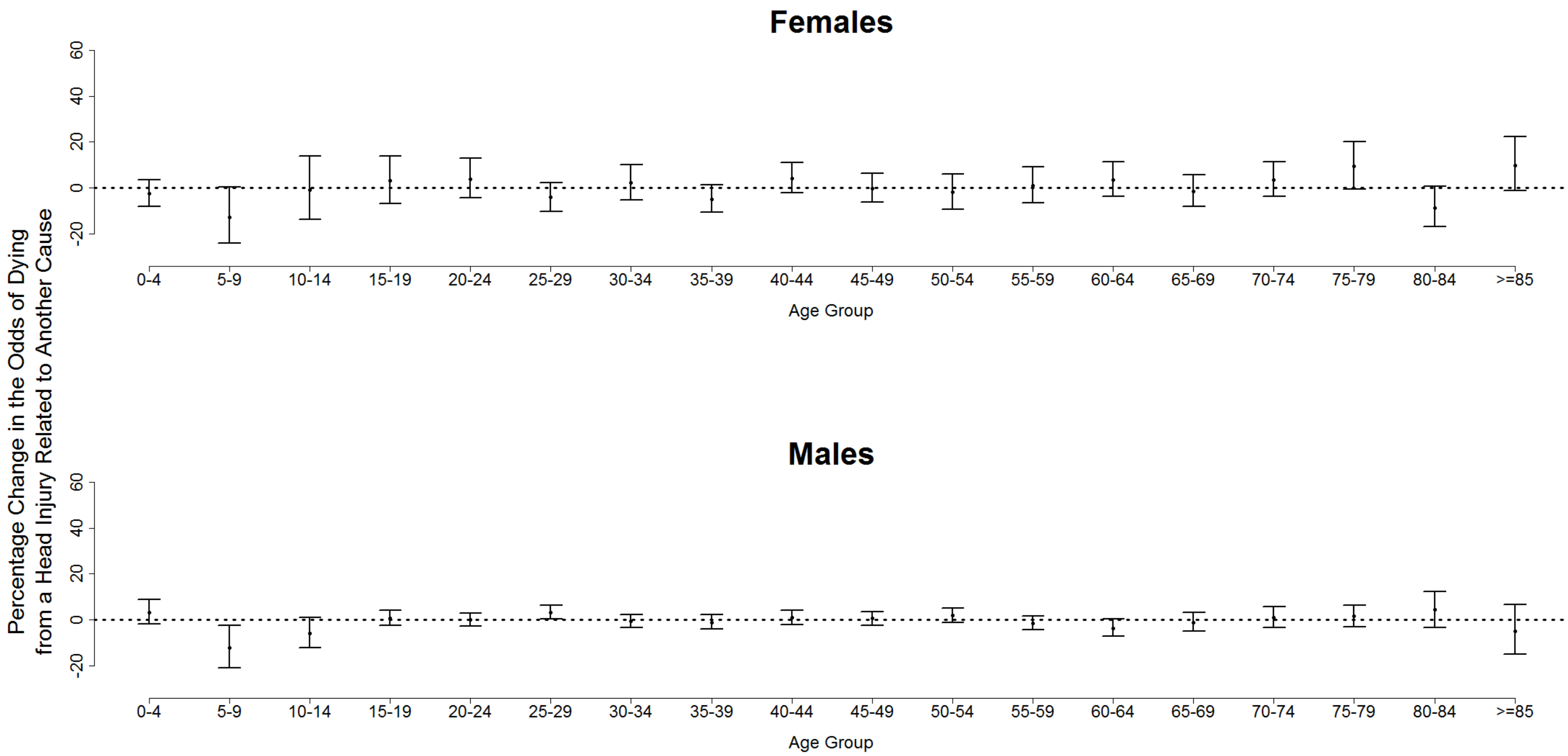

Fig. 8b. The average percentage change per year in the odds of dying from a head injury caused by an accident other than a transport related accident or a fall, for the period of 1996 to 2012, for each age-gender group, estimated using the binomial logistic regression model chosen to best fit the data, shown by equation 5. The point shows the estimate, while the bars above and below represent the corresponding 95% confidence intervals. The dotted line at 0 indicates no change in the mortality rate. If a bar lies completely above or below this line it means that the increase or decrease is significant. The corresponding table of values with 95% confidence intervals is shown in Appendix 2 (Table 2.3b).

Figure 9

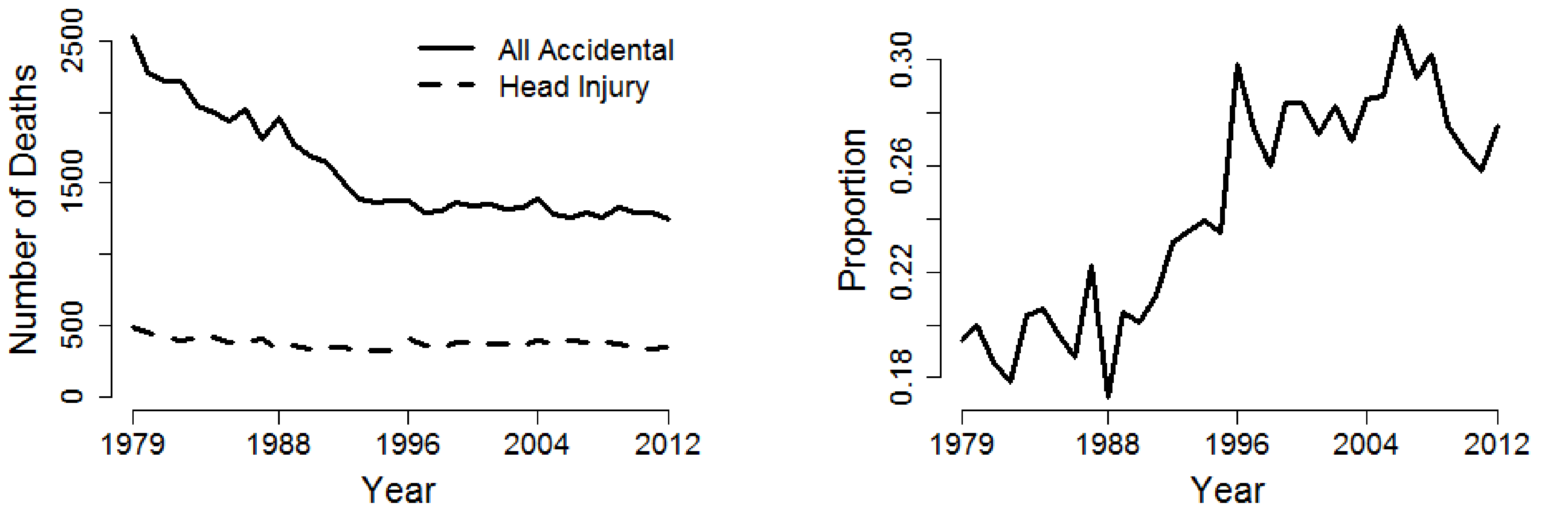

Fig. 9. Left: the total number of deaths from accidents in Scotland from 1979 to 2012 taken from the GRO for Scotland website (solid) and the total number of head injury deaths in Scotland over the same time period (dashed). Right: head injury deaths as a proportion of the total number of deaths from accidents each year over the period of 1979 to 2012. Note that the data set on accidental death from the NRS included two values of deaths for 2011 and 2012 - one based on the old coding rules and another based on the new coding rules. To keep the numbers comparable to the head injury deaths, those calculated with the old coding rules were used. Information about the change in the coding rules is available from the "accidental deaths" part of the NRS website – see http://www.gro-scotland.gov.uk/statistics/theme/vital-events/deaths/accidental-deaths/the-definition-of-the-statistics.html.

Table 1. Head injury deaths and population in Scotland from 1974 to 2012

	Period						
	1974-1980	**1981-1985**	**1986-1990**	**1991-1995**	**1996-2000**	**2001-2005**	**2006-2012**
Total Deaths	3523	2015	1821	1671	1871	1860	2541
Average Annual Deaths	503.3	403.0	364.2	334.2	374.2	372.0	363.0
Average Population	5220371	5151926	5089536	5093462	5077498	5069920	5208457
Average Rate	9.6	7.8	7.2	6.6	7.4	7.3	7.0

The total number of head injury deaths in Scotland, the average annual number of head injury deaths in Scotland, the average population of Scotland, and the rate of head injury death per 100,000 population in Scotland from 1974 to 2012 for successive epochs of 5 years (with the exceptions of 7 for the periods of 1974-1980 and 2006-2012).

Table 2. Age specific number of head injury deaths from 1974 to 2012

	Average Annual Number of Deaths (% of All Ages)				
Period	**1974-1980**	**1981-1990**	**1991-2000**	**2001-2010**	**2011-2012**
All Ages	503.3	383.6	354.2	372.4	338.5
Age 0-9	36.4 (7.2)	22.0 (5.7)	13.4 (3.8)	6.7 (1.8)	3.0 (0.9)
Age 10-19	75.3 (15.0)	51.9 (13.5)	33.6 (9.5)	26.2 (7.0)	13.0 (3.8)
Age 20-29	76.1 (15.1)	65.6 (17.1)	47.7 (13.5)	35.5 (9.5)	24.5 (7.2)
Age 30-39	53.4 (10.6)	44.4 (11.6)	37.6 (10.6)	39.8 (10.7)	30.5 (9.0)
Age 40-49	51.1 (10.2)	41.6 (10.8)	42.8 (12.1)	47.6 (12.8)	31.5 (9.6)
Age 50-59	60.6 (12.0)	44.4 (11.6)	44.8 (12.6)	49.4 (13.3)	35.5 (10.5)
Age 60-69	68.9 (13.7)	42.8 (11.2)	44.1 (12.5)	46.9 (12.6)	47.0 (13.9)
Age 70-79	53.1 (10.6)	44.2 (11.5)	48.4 (13.7)	52.2 (14.0)	56.5 (16.7)
Over 79	28.3 (5.6)	26.7 (7.0)	41.8 (11.8)	68.1 (18.3)	96.0 (28.4)

The average annual number of head injury deaths for all ages, as well as for each age group separately (with the corresponding percentage of the number for all ages), in Scotland from 1974 to 2012 for successive epochs of 10 years (with the exceptions of 7 for the period of 1974-1980 and 2 for the period of 2011-2012).

Appendix 1. Details of ICD Codes Used

Cause of Death

The NRS classifies the underlying cause of death on the basis of the information collected on the death certificate together with any additional information provided by official sources, such as the doctor who certified the death (following a request from NRS for further details), pathologists, Procurators Fiscal or the Crown Office. The certificate of the cause of death has two parts:

Part 1 shows the immediate cause of death, and then works back in time to the disease or condition that started the process - the underlying cause of death defined (on pages 33-34 of Volume 2 of the International Statistical Classification of Diseases and Related Health Problems) as: “(a) the disease or injury which initiated the chain of morbid events leading directly to death or (b) the circumstances of the accident or violence which produced the fatal injury".

Part 2 can be used to record other significant diseases, conditions or accidents which contributed to the occurrence of the death, but were not part of the main sequence leading to the death.

Identification of Head Injury Deaths

The NRS statistical database contains ICD-8 codes for deaths registered from 1974 to 1978, ICD-9 codes for 1979 to 1999, and ICD-10 codes for 2000 onwards.

Codes for the "nature of injury" were recorded as follows:

1974 to 1995, inclusive – the then GROS used a single "condensed" 2-digit code, which it devised itself, in order to identify the "group" which contained the relevant ICD-8/9 "nature of injury" code. For example, one 2-digit code was used if the ICD-8/9 "nature of injury" code was in the range [N]800 to [N]804, another 2-digit code was used if the ICD code was in the range [N]805 to [N]809, and so on. GROS did this because of the limitations of the manual systems that were used, at that time, for the coding and entry of the data. There were rules to determine which of the possible 2-digit codes should be allocated in those cases where there were two or more different types of injury.

1996 to 1999, inclusive - following the introduction of automatic coding for (most of) the data, GROS included the relevant ICD-9 "nature of injury" codes among the other "cause of death" codes that are held in the statistical database. GROS added a capital "N" as the prefix for each "nature of injury" code in the database (although it is not part of the ICD-9 "nature of injury" code) so that users of the data would not confuse these codes with the codes for external causes of death (E800 to E999).

2000 onwards - the relevant ICD-10 "nature of injury" codes (which begin with "S" or "T") are included among the other "cause of death" codes that are held in the statistical database.

Final Search Criteria

Deaths were selected if their statistical records contained one or more of the codes listed below, which indicate that a head injury caused, or contributed in some way to, the death. For 1996 to 1999, the program that produced the figures distinguished between two separate "types" of injury; and for 2000 onwards the program distinguished between five separate "types" of injury.

1974 to 1995

(1) "condensed" (2-digit) GROS-devised "nature of injury" codes 38 or 43, which correspond to ICD codes [N]800-804 and [N]850-85

1996 to 1999

(1) ICD-9 codes 800, 801, 803, 804 and 850-854, which GROS recorded in the computer database as N800, N801, N803, N804 and N850-N854

(2) ICD-9 code 802, recorded in the computer database as N802 - but only a manually-selected subset of these deaths were counted here (When the causes of the deaths which had the codes listed in (2) were examined, it was found that most could not be counted as "valid" head injury deaths for the purposes of this project - for example, were deaths caused by inhalation of blood from a fractured nose following a fall at home. Therefore, only a manually-selected subset of the deaths which had the codes listed in (2) was used to produce the "Type (2)" figures for the project.)

2000 onwards

(1) ICD-10 codes S02.0, S02.1, S02.7, S02.9, S06 (any), S07.1, S07.9, S08.8, S08.9, S09.7 and S09.8

(2) ICD-10 codes S02.2 to S02.6 - but only a manually-selected subset of these deaths were counted here (see (2) under 1996 to 1999, above)

(3) ICD-10 codes T02.0 and T02.6 - <u>if</u> the underlying cause of death was an "external" event (such as a fall, a shooting or a stabbing). (When the causes of the deaths which had these codes were examined, it was found that some could <u>not</u> be counted as "valid" head injury deaths (for the purpose of this project) - for example, deaths caused by alcoholic liver disease, for which a head injury had also been mentioned on the death certificate. Therefore, for the purpose of producing figures for this "type", the project used <u>only</u> those cases for which the underlying cause of death was an "external" event.

(4) ICD-10 codes S00.0, S00.7-S00.9, S01.0, S01.7-S01.9 - <u>if</u> the underlying cause of death was an "external" event (see (3) above

(5) ICD-10 code S09.9

Classification of Type of Injury in Analysis

We classified death as being due to a transport related accident, a fall or neither, if the ICD code for the underlying cause of death was as follows:

<u>Falls</u>

1974-78 (ICD8): E880-3887, E833-E835, E804, E822, E843, E957, E967, E987

1979-1999 (ICD9): E880-E888, E833-E835, E804, E824, E843, E957, E987, E9681

2000 onwards (ICD10): W00-W19, X80, Y01, 730

<u>Transport</u>

1974-78 (ICD8): E800-E845, E940, E941

1979-1999 (ICD9): E800-E848

2000 onwards (ICD10) : V01-V99

Other

The ‘other’ codes are codes that are not fall or transport accident codes. In this category there are four main sub groupings and a remaining ‘miscellaneous’ group.

Firearms

E922, E955, E965, E985

W33, X72, X73, X74, X94, X95, Y23, Y24

Assault (excl. firearms)

E960, E963, E966, E967, E968

X91, X97, X99, Y00, Y03, Y04, Y07, Y08, Y09

Suicide (excl. firearms)

E953, E954, E956, E958

X60, X70, X78, X81, X82, X84

Undetermined Intent

E980, E982, E983, E984, E986, E988

Y11, Y14, Y21, Y28, Y29, Y31, Y33, Y34

Miscellaneous

Any other underlying cause death – for example, the codes for cancer, circulatory system diseases (e.g. ischeamic heart disease), digestive system diseases (e.g. alcoholic liver disease), and so forth.

Appendix 2. Normal Linear and Binomial Regression Methods and Results in More Detail

Normal Linear Regression: Total Number of Head Injury Deaths

Normal linear regression models were tested to fit the total number of head injury deaths over the study period 1974 to 2012. Time in the model was set to range from 1 to 39 for 1974 to 2012. Linear, quadratic and cubic terms for year plus a natural spline (i.e. allowing curvature for the year effect) with different levels of smoothness were investigated.

First a linear time term was fitted to the data which produced an value of 0.444 and an AIC of 413.3. A quadratic time term was then added to the model which produced an value of 0.754 and an AIC of 382.4. A likelihood ratio test was carried out between the two models to see if the quadratic term added significant information to the model and the test was significant, suggesting the quadratic model fitted the data significantly better than the linear model.

A cubic time term was then added to the model which produced an value of 0.886 and an AIC of 353.4. A likelihood ratio test was carried out between the quadratic and the cubic models and was significant suggesting the cubic model fitted the data significantly better than the linear model.

A model using a natural spline with smoothness equal to 4 (knots=4) was then fitted to the data which produced an equal to 0.885 (slightly lower than that of the cubic model) and an AIC equal to 354.6 (slightly higher than that of the cubic model) suggesting that this model fitted the data less well than the cubic model. A likelihood ratio test was carried out between the cubic model and the natural spline model and the test was found to be non-significant, suggesting the cubic model fitted the data the best. The model chosen to best fit the data was therefore the cubic model (shown by Equation 1 in Results).

Normal Linear Regression: Rate of Head Injury Death per 100,000 Population

Normal linear regression models were tested to fit the rate of head injury deaths per 100,000 population over the study period. Time in the model was set to range from 1 to 39 for 1974 to 2012, as before. Linear, quadratic and cubic terms for year plus a natural spline with different levels of smoothness were investigated.

First a linear time term was fitted to the data which produced an value of 0.456 and an AIC of 101.1. A quadratic time term was then added to the model which produced an value of 0.707 and an AIC of 77.9. A likelihood ratio test was carried out between the two models to see if the quadratic time term added significant information to the model and the test was significant, suggesting the quadratic model fitted the data significantly better than the linear model.

A cubic time term was then added to the model which produced an value of 0.867 and an AIC of 47.9. A likelihood ratio test was carried out between the quadratic and the cubic models and was found to be significant, suggesting the cubic model fitted the data better than the linear model.

A model using a natural spline with smoothness equal to 4 (knots=4) was then fitted to the data which produced an value of 0.870 and an AIC of 48.2 (slightly higher than the cubic model). A likelihood ratio test was carried out between the cubic model and the natural spline model and the test was found to be non-significant suggesting that the cubic model fitted the data significantly better than the spline model. The model chosen to fit the data was therefore the cubic model (shown by Equation 2 in Results).

Binomial Regression: Head Injury Deaths Stratified by Type of Accident

It was decided a priori that each of the models relating to the three different types of head injury accident would adjust for the two coding changes that occurred in 1979 and 2000. It was also decided that age, gender, year and all possible two and three-way interactions of the subsequent three (i.e. age x year, age x gender, year x gender, and age x gender x year) would be included in each of the models to allow for different time trends in each age-gender group.

Linear, quadratic and cubic terms of year were then considered for each different category of head injury death and a model of best fit was chosen based on AIC values and likelihood ratio tests.

Transport

First a linear term of Year was fitted to the data which produced an AIC of 5441.0. A quadratic year term was then added to the model which produced an AIC of 5441.0 also. A likelihood ratio test between the two models was carried out and it showed that the quadratic year term added no significant information to the model (p=0.162). Therefore the model chosen to model the transport related head injury deaths was the linear model (shown by Equation 3 in Results).

Using this model, the average change per year in the odds of experiencing a transport related head injury death for each age-gender group were found as shown in Table 2.1 (see Results: "Transport", Figure 4 for graphical version).

(insert Table 2.1 about here please)

(insert Figure 2.1 about here please)

The fitted regression lines, along with corresponding 95% confidence intervals, representing the equation obtained by the chosen binomial model to best fit the transport related deaths data for each age-gender category are shown by Figure 2.1. These lines show how the rate of transport related head injury deaths per 100,000 population has changed over the study period for each age-gender group, as approximated using the chosen model.

Falls

First, a linear term of year was fitted to the data which produced an AIC of 5094.9. A quadratic year term was then added to the model which produced an AIC of 5096.3. A likelihood ratio test between the two models was carried out and it showed that the quadratic year term added no significant information ($p = 0.432$) and therefore the model chosen to model fall related head injury deaths was the linear model (shown by Equation 4 in Results).

Using this model the annual change in the odds of experiencing a fall related head injury death for each age-gender group were found as shown in Table 2.2 (see Results: "Falls", Figure 6 for graphical version).

(insert Table 2.2 about here please)

(insert Figure 2.2 about here please)

The fitted regression lines, along with corresponding 95% confidence intervals, representing the equation obtained by the chosen binomial model to best fit the transport related deaths data for each age-gender category are shown by Figure 2.2. These lines show how the rate of fall related head injury deaths per 100,000 population has changed over the study period for each age- gender group, as approximated using the chosen model.

Other

First, a linear term of Year was fitted to the data which produced an AIC of 4701.3. In 1996 there was a large jump in the numbers of head injury deaths caused by an 'other' cause from 90 to 171 as shown by Figure 7 in the Results. Due to this large jump in the number of deaths, possibly due to a change in Scotland in coding practice at that time (see Appendix 1 "Identification of Head Injury Deaths"), a model allowing for a change of year effect at 1996 was fitted to the data which produced an AIC of 4578.5.

A likelihood ratio between this model and the linear model was carried out and was significant, suggesting that the change of year effect at 1996 added significant information to the model ($p < 0.001$). Therefore the model allowing the change of year effect at 1996 was chosen to model the other head injury deaths (shown by Equation 5 in the Results)

Using this model, average yearly change in the odds of experiencing a head injury death related to another cause for each age-gender group before 1996 and from 1996 onwards were found as shown in Tables 2.3a and 2.3b, respectively (see Results: “Other Injury”, Figures 8a and 8b for graphical version).

(instert tables 2.3a and 2.3b about here please)

(insert Figure 2.3 about here please)

The fitted regression lines, along with corresponding 95% confidence intervals, representing the equation obtained by the chosen binomial model to best fit the other cause deaths data for each age-gender category are shown by Figure 2.3. These lines show how the rate of head injury deaths related to another cause per 100,000 population has changed over the study period for each age-gender group, as approximated using the chosen model.

Figure 2.1

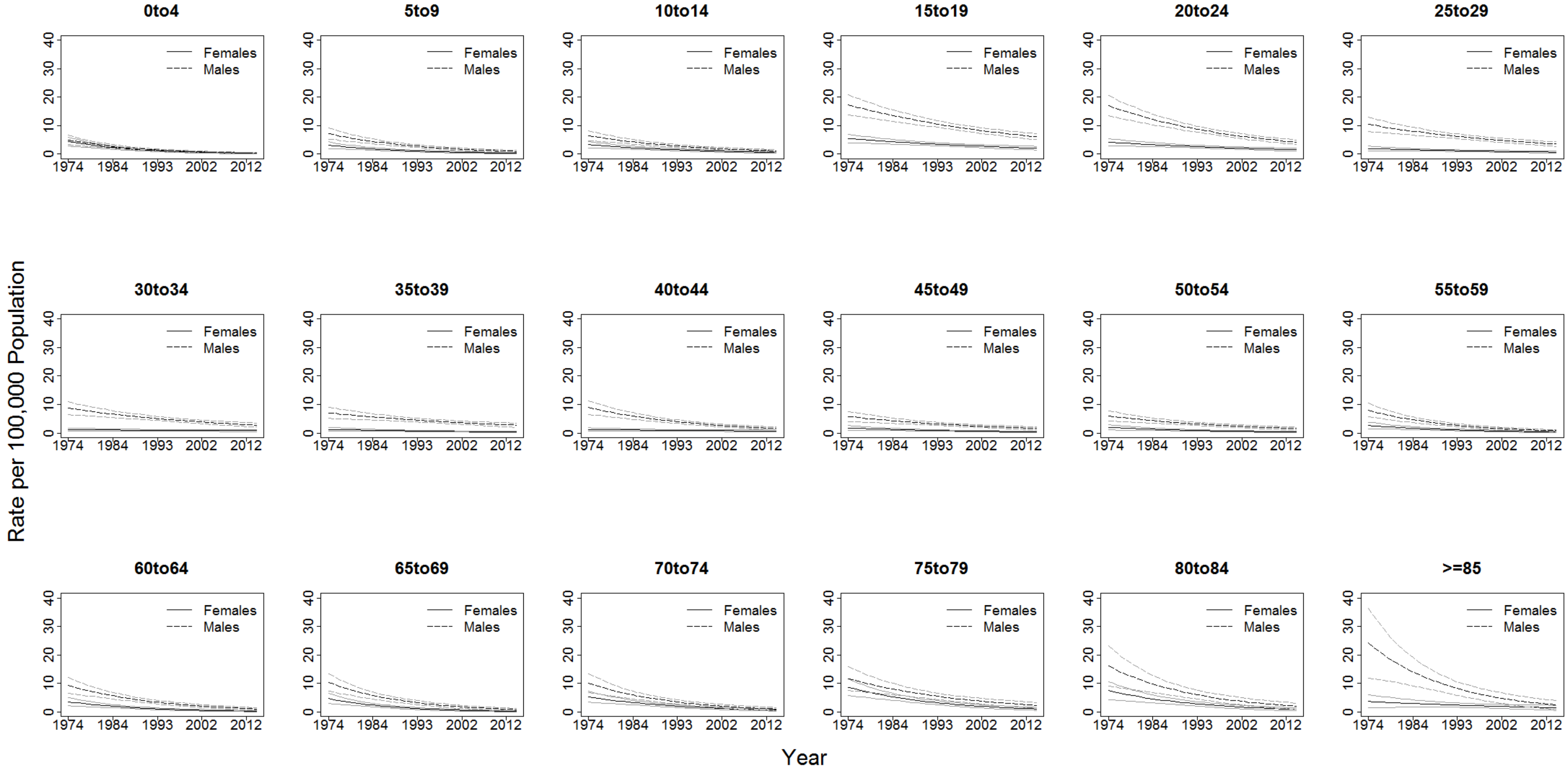

Fig. 2.1. Fitted regression lines (black), with corresponding 95% confidence intervals (grey), representing how the rate of head injury death caused by a transport accident per 100,000 population has changed over the study period, for each age-gender group, estimated using the binomial logistic regression model chosen to best fit the data, shown by equation 3.

Figure 2.2

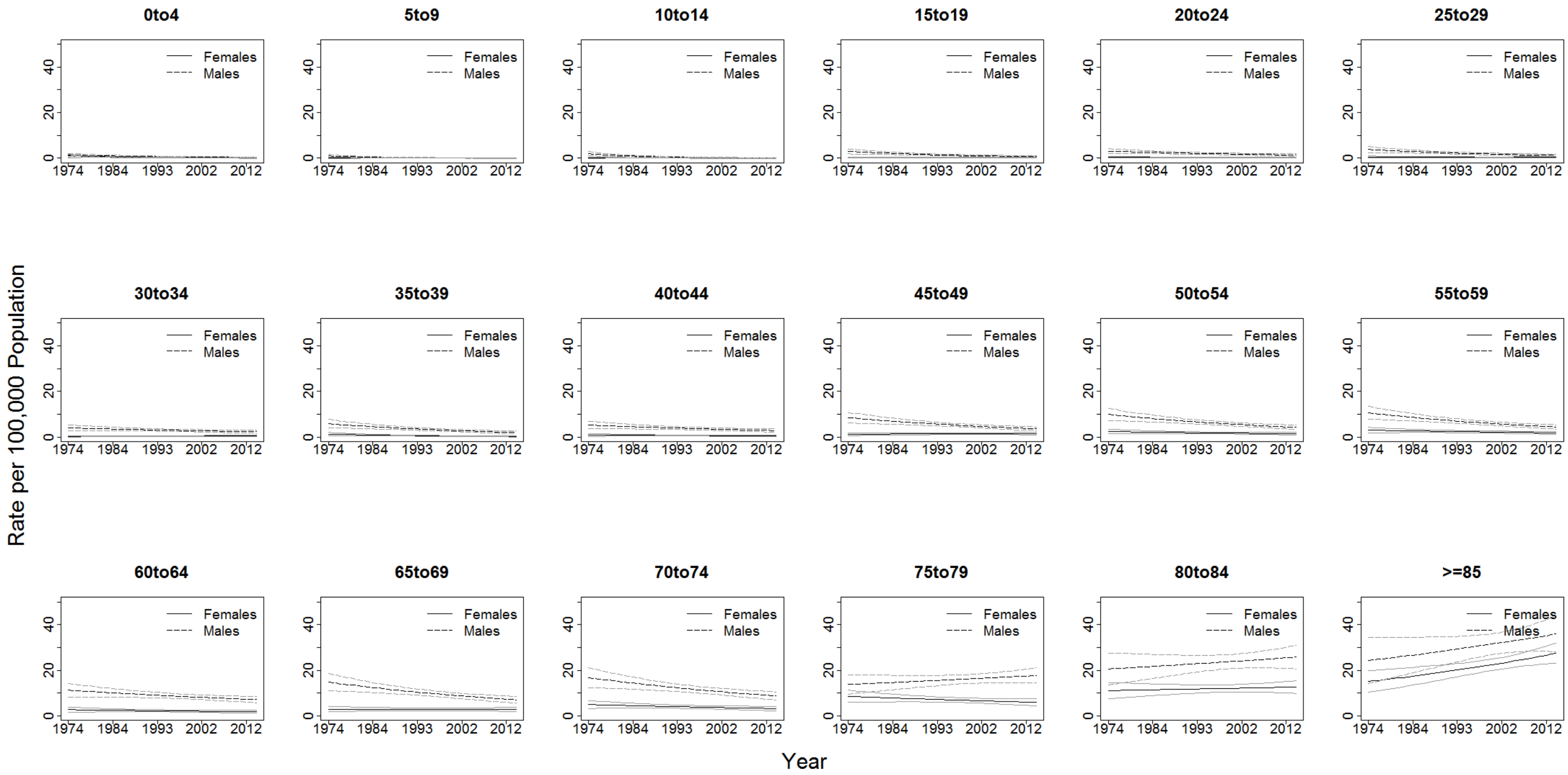

Fig. 2.2. Fitted regression lines (black), with corresponding 95% confidence intervals (grey), representing how the rate of head injury death caused by a fall per 100,000 population has changed over the study period, for each age-gender group, estimated using the binomial logistic regression model chosen to best fit the data, shown by equation 4.

Figure 2.3

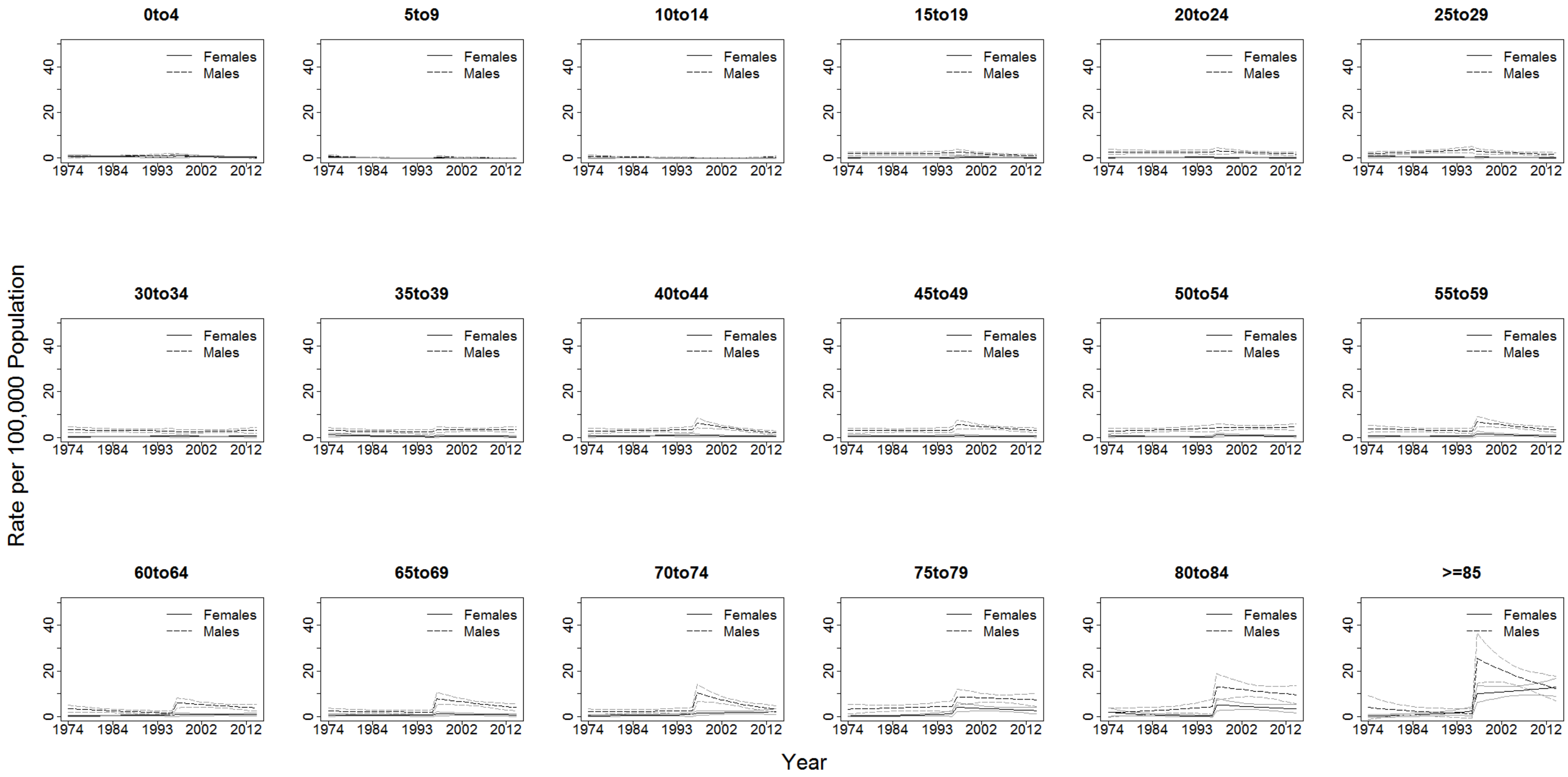

Fig. 2.3. Fitted regression lines (black), with corresponding 95% confidence intervals (grey), representing how the rate of head injury death caused by an accident other than a transport accident or fall per 100,000 population has changed over the study period, for each age-gender group, estimated using the binomial logistic regression model chosen to best fit the data, shown by equation 5.

Table 2.1. Average estimated change per year in the odds of dying from a transport related head injury

	Females		Males	
Age Group	**Percentage Change (%)**	**95% CI (%)**	**Percentage Change (%)**	**95% CI (%)**
0 to 4	-7.0	-9.1 to -4.8	-6.7	-8.6 to -4.7
5 to 9	-5.7	-7.8 to -3.5	-5.2	-6.5 to -3.8
10 to 14	-4.3	-6.1 to -2.5	-4.4	-5.7 to -3.1
15 to 19	-2.5	-3.7 to -1.3	-2.7	-3.5 to -1.9
20 to 24	-2.5	-3.9 to -1.2	-3.6	-4.4 to -2.8
25 to 29	-2.6	-4.5 to -0.6	-2.8	-3.8 to -1.8
30 to 34	-0.8	-3.0 to 1.4	-2.9	-4.0 to -1.8
35 to 39	-3.0	-5.4 to -0.5	-2.4	-3.6 to -1.3
40 to 44	-1.4	-3.6 to 0.9	-4.4	-5.5 to -3.2
45 to 49	-3.6	-5.8 to -1.3	-3.2	-4.5 to -1.9
50 to 54	-4.2	-6.4 to -1.9	-3.4	-4.7 to -2.1
55 to 59	-4.8	-6.9 to -2.6	-5.8	-7.2 to -4.3
60 to 64	-6.1	-8.3 to -3.9	-5.4	-6.7 to -4.0
65 to 69	-7.2	-9.4 to -5.0	-6.2	-7.7 to -4.7
70 to 74	-5.1	-7.0 to -3.3	-5.7	-7.3 to -4.0
75 to 79	-5.2	-6.9 to -3.6	-4.1	-5.7 to -2.5
80 to 84	-5.2	-7.3 to -3.1	-5.3	-7.3 to -3.2
85 and Over	-2.3	-4.9 to 0.3	-5.8	-8.0 to -3.4

The average change per year in the odds of dying from a transport related head injury across the study period, for each age-gender group, with corresponding 95% confidence intervals.

Table 2.2. Average estimated change per year in the odds of dying from a fall related head injury

	Females		Males	
Age Group	**Percentage Change (%)**	**95% CI (%)**	**Percentage Change (%)**	**95% CI (%)**
0 to 4	-5.2	-9.2 to -1.2	-3.9	-6.7 to -1.0
5 to 9	-0.5	-6.6 to 6.0	-7.8	-12.4 to -3.0
10 to 14	-5.7	-12.9 to 2.1	-7.6	-10.7 to -4.3
15 to 19	0.3	-3.7 to 4.5	-3.7	-5.5 to -1.9
20 to 24	-1.4	-5.1 to 2.4	-2.0	-3.6 to -0.5
25 to 29	-1.1	-4.4 to 2.2	-2.8	-4.4 to -1.3
30 to 34	1.0	-2.4 to 4.5	-1.4	-2.8 to 0.0
35 to 39	-3.9	-6.8 to -1.0	-2.8	-4.1 to -1.4
40 to 44	-1.7	-4.4 to 1.0	-1.6	-2.8 to -0.3
45 to 49	0.5	-1.5 to 2.5	-2.2	-3.2 to -1.1
50 to 54	-1.3	-3.0 to 0.4	-2.2	-3.2 to -1.1
55 to 59	-1.3	-2.9 to 0.3	-2.3	-3.3 to -1.2
60 to 64	-1.0	-2.7 to 0.6	-1.2	-2.1 to -0.9
65 to 69	-0.1	-1.7 to 1.4	-1.9	-2.9 to -0.9
70 to 74	-1.1	-2.6 to 0.3	-1.7	-2.7 to -0.7
75 to 79	-1.0	-2.2 to 0.3	0.6	-0.5 to 1.8
80 to 84	0.3	-0.9 to 1.5	0.6	-0.6 to 1.8
85 and Over	1.6	0.5 to 2.7	1.0	-0.4 to 2.5

The average change per year in the odds of dying from a fall related head injury across the study period, for each age-gender group, with corresponding 95% confidence intervals.

Table 2.3a. Average estimated change per year in the odds of dying from a head injury not caused by transport or falling, from 1974 to 1995

	Females		Males	
Age Group	**Percentage Change (%)**	**95% CI (%)**	**Percentage Change (%)**	**95% CI (%)**
0 to 4	-2.6	-8.2 to 3.4	3.3	-1.9 to 8.7
5 to 9	-12.8	-24.3 to 0.4	-12.3	-21.1 to -2.6
10 to 14	-0.9	-13.8 to 13.9	-5.9	-12.3 to 1.1
15 to 19	3.1	-6.8 to 14.0	0.8	-2.5 to 4.2
20 to 24	3.8	-4.4 to 12.8	0.0	-2.9 to 2.9
25 to 29	-4.2	-10.2 to 2.3	3.2	0.3 to 6.3
30 to 34	2.2	-5.2 to 10.2	-0.7	-3.5 to 2.1
35 to 39	-5.0	-10.7 to 1.2	-1.1	-4.2 to 2.1
40 to 44	4.2	-2.2 to 11.0	0.9	-2.1 to 4.0
45 to 49	-0.3	-6.4 to 6.2	0.5	-2.5 to 3.6
50 to 54	-2.0	-9.3 to 5.9	1.9	-1.1 to 5.0
55 to 59	1.0	-6.6 to 9.1	-1.4	-4.5 to 1.7
60 to 64	3.5	-3.6 to 11.2	-3.6	-7.2 to 0.2
65 to 69	-1.4	-8.0 to 5.6	-1.1	-5.1 to 3.2
70 to 74	3.5	-3.8 to 11.4	1.0	-3.5 to 5.8
75 to 79	9.3	-0.6 to 20.2	1.5	-3.1 to 6.4
80 to 84	-8.7	-17.0 to 0.5	4.3	-3.3 to 12.4
85 and Over	9.9	-1.2 to 22.3	-5.0	-15.2 to 6.5

The average change per year in the odds of dying from a head injury not caused by a transport or fall-related incident across the period 1974-1995, for each age-gender group, with corresponding 95% confidence intervals.

Table 2.3b. Average estimated change per year in the odds of dying from a head injury not caused by transport or falling, from 1996 to 2012

	Females		Males	
Age Group	**Percentage Change (%)**	**95% CI (%)**	**Percentage Change (%)**	**95% CI (%)**
0 to 4	-5.6	-14.7 to 4.5	-7.8	-16.9 to 2.3
5 to 9	-4.6	-28.6 to 27.4	-12.8	-28.0 to 5.5
10 to 14	5.4	-29.8 to 58.5	23.0	-4.7 to 58.8
15 to 19	-4.1	-15.7 to 9.1	-6.3	-11.8 to -0.4
20 to 24	-3.1	-18.8 to 15.7	-3.3	-7.9 to 1.5
25 to 29	-3.1	-15.6 to 11.3	-3.6	-8.3 to 1.4
30 to 34	0.5	-9.6 to 11.8	1.6	-2.9 to 6.3
35 to 39	-3.0	-12.3 to 7.3	0.2	-3.8 to 4.3
40 to 44	-2.0	-10.0 to 6.8	-6.7	-10.3 to -3.0
45 to 49	-2.4	-10.7 to 6.7	-3.8	-7.2 to -0.2
50 to 54	-4.3	-11.9 to 3.9	0.2	-3.3 to 4.0
55 to 59	-6.2	-13.3 to 1.4	-4.4	-7.9 to -0.7
60 to 64	0.6	-7.4 to 9.3	-2.8	-6.5 to 1.0
65 to 69	-2.9	-10.7 to 5.6	-4.2	-7.8 to -0.4
70 to 74	1.8	-4.6 to 8.7	-6.8	-10.7 to -2.7
75 to 79	-2.7	-7.8 to 2.7	-1.0	-5.1 to 3.3
80 to 84	-2.5	-7.8 to 3.1	-1.9	-6.3 to 2.7
85 and Over	1.6	-2.0 to 5.3	-4.4	-8.7 to 0.1

The average change per year in the odds of dying from a head injury not caused by a transport or fall-related incident across the period 1996-2012, for each age-gender group, with corresponding 95% confidence intervals.