THE IMPACT OF ACCIDENT PREVENTION INITIATIVES ON RECENT TRENDS IN INEQUALITIES IN ACCIDENT MORTALITY

Final report to NHSE, Trent
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Patricia Coleman
Jon Nicholl

Contact details:
Prof. Jon Nicholl,
Medical Care Research Unit,
ScHARR,
University of Sheffield,
Regent Court,
30 Regent Street,
SHEFFIELD,
S1 4DA

e-mail: j.nicholl@sheffield.ac.uk
tel: 0114 222 0752
fax: 0114 222 0749
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SUMMARY

Deaths from accidental causes show one of the steepest socio-economic gradients of all conditions. Reducing mortality and morbidity from accidental causes has been one of a small number of priority health areas identified by consecutive governments in the UK\(^1\)\(^2\) during the past ten years. An independent inquiry into health inequalities, also a key area of current public health policy in the UK, published in 1998\(^3\), concluded that the evaluation of public policies in the light of their likely impact on inequalities in health was ‘crucial’.

To link these important areas of government health policy, we have carried out a study using routinely available data to measure the impact of selected accident prevention measures introduced over the last thirty years on mortality in different socio-economic groups, (defined by their occupational classification (OC)) in the UK population. The accident prevention measures examined included examples from each of three main categories into which interventions are usually categorised: Education, Engineering and Enforcement, to represent the different levels of choice available to individuals at the point of take up. The hypothesis we have examined was that interventions with most discretion (i.e. educational measures) were more likely to be taken up by OC I, II, and III, than III, IV and V, and therefore to widen inequalities. The accident types and intervention measures we have examined are:

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Intervention</th>
<th>Periods compared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric shocks</td>
<td>Pre-fitted plugs</td>
<td>1970-90 vs 1994-99</td>
</tr>
<tr>
<td>House fires</td>
<td>Smoke alarms and flame-resistant materials</td>
<td>1970-87 vs 1991-99</td>
</tr>
<tr>
<td>Childhood poisonings</td>
<td>Child-resistant medicine containers</td>
<td>1970-72 vs 1994-99</td>
</tr>
</tbody>
</table>

In England and Wales, the numbers of deaths registered from accidental causes decreased between 1970 and 1999\(^4\) but as reported previously in children\(^5\) the difference in adult mortality rates for all accidents between manual and non-manual OCs is widening. We found no clear evidence in the data to support the hypothesis that the differential take up of educational measures was contributing more to the widening inequalities than other types of measure.

Differences between OCs in motor vehicle occupant death rates remained stable during the 1980s when seat belt wearing was voluntary, but widened after the 1983 legislation requiring front seat belts to be worn. Of course, these patterns are confounded with changes in vehicle ownership and hence exposure to risk. The rates for death from electric shocks following...
legislation requiring plugs to be fitted to electrical goods sold in the UK, and in children following legislation requiring child-resistant tops to be fitted to some medicines, resulted in small non-significant reductions in the OC differentials, whilst the differentials in death from house fires may have widened with the voluntary introduction of smoke alarms. However, neither educational measures promoting the wearing of bicycle helmets nor legislation requiring motor-cyclists to wear helmets changed the relative patterns of mortality in manual and non-manual OCs.

The main difficulty encountered in this study, which is a barrier to implementing the recommendation of the independent inquiry into health inequalities “…to evaluate policies for their impact on health inequalities”3 is a lack of appropriate socio-economic indicators in health data and inconsistencies in the recording of occupation between the Census data and the deaths data. The classification of women’s social class is particularly problematic. The classification is not sufficiently sensitive to capture the significant changes in women’s employment in the last thirty years, and this probably explains why much of the work on inequalities in adult health using OC in the UK12,13 has excluded women altogether.

Given that reducing inequalities in health is an important policy area, it is essential that any differences in the impact of ‘discretionary’ and ‘non-discretionary’ intervention measures introduced to prevent accidents should be monitored across different social groups. Inadequacies in the socio-economic data that are currently available are preventing policy decisions being properly informed, and the development and use of better social class data should be a priority for the future.
1. INTRODUCTION

1.1 Relevance to UK health policy

This study addresses two important policy issues for improving the health of the UK population. Firstly, it is a study of accidents, and reducing mortality and morbidity from accidental causes has been one of a small number of priority health areas to be included in the White Papers published by consecutive governments during the past ten years. Secondly, it examines inequalities in health which are a key priority area in public health policy. An independent inquiry into health inequalities commissioned by the government and published in 1998 concluded that the evaluation of public policies in the light of their likely impact on inequalities in health was ‘crucial’.

In England and Wales, deaths from all accidental causes declined steadily throughout the 20th Century but the overall trends obscured marked differences between sub-groups of the population, and between specific causes. The largest decline was in accidents attributed to fires (82%) and the least in poisonings (41%). In all age groups, the decrease was greater in men than in women. However, the patterns vary considerably by age, with little change at all in the rates for young people aged 15-24 years since 1900. Accidents therefore remain an important cause of early mortality, resulting in 20% of all years of life lost, and an important cause of disability and general morbidity especially among young people.

The accidental mortality rate in children in different social classes shows a steeper socio-economic gradient than any other cause of death. Furthermore, the reduction in the accidental death rate in those aged 0-15 years, reported in a study that compared data at the beginning and at the end of the 1980s, was much less for children of fathers in unskilled occupations (occupational class (OC) V)(2%) than for children of father in professional occupations (OC I) (32%), and during that 10 year period the gap in accidental mortality between children in the manual and non-manual occupational classes, increased from 3.5 to 5 times.

Most of the work published on inequalities in accidents in the UK relates to children. Studies of health inequalities in adults have usually focussed on all causes, or chronic diseases such as cancer, CHD or respiratory illnesses, or access to health care services, but some cause-specific studies have included accidents. It has been reported that inequalities between occupational classes in accident rates for men widened from a relative rate of less than three between Class V and Class I in 1970-72, to over 4 by 1991-93. However, no studies have yet examined inequalities in accidents in women, nor in relation to specific causes of accidents, nor the impact of a range of different policy interventions on accidental deaths in a total population.
1.2 Health inequalities

Several conceptual models have been developed which might help explain why health inequalities occur\textsuperscript{15,16}. For example, inequalities may be due to

\textit{Artefact} – Health and social class are variables constructed artificially to explain otherwise undifferentiated social phenomena. An association between the two may be an effect of the application of the explanatory framework and of little causal significance.

\textit{Selection} – Inequalities in health arise through a process of ‘health migration’. Those in good health are socially mobile upwards relative to those in poor health. This may be intra-generational or, in genetic models of health, inter-generational.

\textit{Cultural/behavioural} – Health inequalities stem from differences in individual lifestyles. At an aggregated level, behaviour patterns observed in lower occupational classes are less likely to be associated with good health than those in higher occupational classes.

\textit{Environmental} – Inequalities between OCs result from differential exposure to dangerous or unsafe work, home, leisure, and travel environments.

\textit{Economic/behavioural} - Occupational classes are chiefly distinguished by differences in income and it is these differences in income which lead to different opportunities and lifestyles and hence to health inequalities.

The economic models of health inequalities have several different forms. For example, it might be argued that it is simply the absolute difference in income which results in differences in diet, environment, access to safety measures, and so on. Alternatively it could be argued that it is the difference in the pattern of income in manual OCs (who have their highest income when young and fit, dropping off later) compared to that of non-manual groups (usually increasing slowly throughout working life) in relation to age-related behaviours, that is the key feature. Another possibility is that psychological responses to income and wealth lead to different expectations of the future and to different behaviours. In all these economic theories, however, it is the difference in income which is the common underlying cause of the health inequalities\textsuperscript{17}.

Changing health inequalities

The different theories of the causes of health inequalities lead to different predictions about how the inequalities might change over time as other circumstances change. If inequalities are artefactual or the cause of class differences rather than their effect, then we might expect that inequalities would change little, if at all.

Social/cultural theories about different lifestyles argue that any changes would be slow. Furthermore - the theory of risk homeostasis\textsuperscript{18} - that individuals have an inherent appetite for risk which doesn't alter, so that accident prevention constraints to reduce risk of injury in one direction stimulate compensatory changes in behaviour in the opposite direction - suggest
that fundamental socially or culturally determined risk acceptance levels (or appetites) cannot be altered and therefore we should expect little change in accident differentials irrespective of measures taken to improve safety unless access to these measures also depends on income.

On the other hand, theories which are fundamentally economic, e.g. about the environment or about patterns or levels of income leading to different patterns and levels of risk taking, suggest that as income inequalities change so we might expect changing accident differentials - but again independently of measures taken to improve safety.

Categorisation of accident prevention measures

Interventions in accident prevention are commonly classified into 3 ‘E’ groups:

**Engineering** – environmental, for example road humps and smoke detectors, or product modification such as child-resistant bottle tops on medicines.

**Enforcement** – regulations backed up by penalties for non-compliance, for example Health and Safety at Work legislation, vehicle licensing, seat belt laws, rules in sports;

**Education** – encouraging safe behaviour through communication, for example Stop, Look and Listen road safety media campaigns, hazard warning signs.

To a greater or lesser extent the measures grouped under these three ‘E’ categories depend for their effectiveness upon individual participation. The degree of compliance with a particular measure also depends to a greater or lesser extent on individual choices. Some measures require ‘choice’ i.e. engaging actively with the intervention, others do not, requiring only passive acceptance of a condition that is given. Along this ‘choice line’, educational initiatives offer the most discretion over action, and engineering measures like physical modifications to the road or home, offer the least. Assuming equal access to the benefits of physical changes to the environment, it is reasonable to assume also that everyone is likely to be affected by such changes to a similar degree, irrespective of other factors like gender or social class. This is not the case for all engineering of course since access to new and perhaps safer products probably depends on disposable income and lifestyle. Neither is it the case for legislative measures such as the UK seat belt laws or the statutes on firearms. Such measures carry penalties to deter or limit certain behaviours and apply formally to everyone covered by the law. However, the decision to engage positively with the law resides with the individual.

**Study aims**

These types of choice may be made differently by different socio-economic groups. As the British Medical Association (BMA) put it “general safety campaigns that target the whole population may be preferentially taken up by people from more affluent areas, thus worsening the health divide”\(^{20}\). More generally, the patterns of inequality in accident mortality observed
and the subtlety of possible action associated with this ‘choice line’ suggest another explanatory model of health inequalities i.e. that of ‘differential response’.

Bearing these issues in mind, the objectives of this study were

1) to examine recent trends in all-cause and cause-specific accident inequalities

and 2) to examine to what extent the patterns of inequality in accident mortality observed are consistent with differential take up of accident prevention interventions by different occupational social classes.
2. METHODS

2.1 Overview

Individual level data which include a social class indicator were not available to examine morbidity or processes of care such as hospital admissions or A and E attendances. Consequently the study focused only on deaths from accidents using the annual numbers of deaths from injury and poisonings recorded routinely by cause and nature of injury by the Office for National Statistics (ONS).

These data include an occupational class classification of the deceased. Using population estimates from the 1971, 1981 and 1991 censuses, we have compared trends and changes in accidental death rates between occupational classes (OCs). For selected causes in which known interventions were introduced during the study period we have examined the effect of the interventions on relative OC accident mortality rates by comparing periods of time before and after the interventions were introduced.

2.2 ONS Data

Data on all accidental deaths recorded by ONS (formerly OPCS) was supplied for the years 1970-1972 and 1979-1999 inclusive. The data covered all deaths where the primary underlying cause of death was coded as accidental injury or poisoning (ICD9 and ICD8, E800 - E949)

The data included:

- year of death registration
- age
- sex
- place of accident
- 4 digit underlying cause of death code - ICD9 (1979-99) or ICD8 (1970-72)
- 4 digit Nature of Injury code (ICD9 or ICD8)
- occupational class of deceased (or mother)
- occupational class of husband (or father)

2.3 Interventions

The following National Agencies/Departments were contacted for information about the introduction of significant accident prevention initiatives, and the dates they were implemented.

Health & Safety Executive (HSE)
Health Education Authority (HEA)
Department of the Environment, Transport and the Regions (DOT)
Department of Trade and Industry Consumer Safety Unit (DTI)
Royal Society for the Prevention of Accidents (ROSPA)
Home Office
To maximise the likelihood of detecting changes over time, we identified interventions that had widespread national exposure or application, and focused on Transport and Home accidents which are the settings where most deaths from accidental causes occur.

2.4 Exclusions

Occupational class was recorded for very few deaths between 1973 and 1978 and these years were therefore excluded. In addition, due to the industrial action of the Registrars of births and deaths in 1981, the data for that year are considered to be unreliable and these data have also been omitted from all the analyses presented below.

Persons 75 and over are not normally given an occupational classification in death registration data, and therefore deaths over this age were also excluded.

2.5 Occupational class

In order to conform to the classification of the population in census data, the occupational class used was the occupational class of the deceased, or if this was missing or if a child ≤16, the occupational class of the husband or father. For children with a missing occupational OC of father, occupational class of mother was used, if available. The large numbers of women who are classified as 'unoccupied' in the ONS mortality data were retained in this class since this is how their occupation is classified in the population census data. Nevertheless, it must be recognised that there are considerable difficulties with this. Firstly ‘unoccupied’ includes both those who are actively seeking paid employment and those who are not, perhaps due to other commitments to home or family. Secondly, the definitions of ‘unoccupied’ in ONS data (not employed for more than half their working life) and in census data (not employed in the last week) do not correspond.

The occupational classification was coded for analysis as detailed in Table 1.

### Table 1 Occupational classifications

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>I and II professional, managerial, technical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>IIIN skilled non-manual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>IIIM skilled manual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>IV and V partly skilled or unskilled</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td>Other Armed forces, Inadequately described, carers, students, no occupation, etc.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.6 Population data

In order to calculate accidental death rates per year, population census data by age, sex and OC was also supplied by ONS. These data were obtained for the 1971, 1981 and 1991
censuses. Using age groups 0 - 15, 16 - 24 and 10 years age bands to 74, the proportions of each age-sex group falling into each of the five occupational classes at each census were calculated. For non-census years these proportions were estimated by interpolating between 1971 and 1981, and between 1981 and 1991, and by projection for 1970 and 1992 and beyond. The non-census year estimates were obtained by linear interpolation (and projection) between the log proportions in the census years. So, for example, the estimated proportions of the \( (ij)^{th} \) age-sex group falling into the \( k^{th} \) occupational class in the \( t^{th} \) year between two censuses at times \( t = 1 \) and \( t = 10 \) is given by \( P_{ijkt} = (P_{ijk1}/K)(P_{ijk10}/P_{ijk1})^{t-1/9} \), where \( K \) is a scaling constant to ensure \( \Sigma P_{ijk} = 1 \). For the projection for 1970 \( t = 0 \), and for the projections beyond 1991 \( t = 10+ (\text{year} - 1991) \).

These census year proportions and non-census year estimated proportions were then applied to ONS’s age-sex population estimates for 1970-72, and 1979-1999, to give estimated population numbers in each age, sex and occupational class for each year.

In the census data supplied by ONS children were not assigned an occupational class and consequently estimates of the proportions of children in each occupational class were obtained from other published sources\(^{21,22,23}\).

2.7 Mortality rates

Crude mortality rates, \( R_{ky} \), per \( 10^6 \) persons per year, \( y \), in each occupational class, \( k \), were calculated from (1)

\[
R_{ky} = \frac{\sum_{ij} d_{ijky}}{\sum_{ij} n_{ijky}} \quad (1)
\]

where \( d_{ijky} \) is the number of deaths and \( n_{ijky} \) the estimated population in age group \( i \), sex \( j \), occupational group \( k \), and year \( y \).

Occupational classes have different age-sex profiles that have changed over time. Since age and sex are important determinants of accident death rates, it follows that comparisons of crude accident death rates over time within OCs or between OCs are potentially confounded with these changes in the age-sex profiles.

We have therefore made these comparisons using directly age-sex standardised rates, \( S_{ky} \), calculated as

\[
S_{ky} = \sum_{ij} W_{ij} \frac{d_{ijky}}{n_{ijky}} \quad (2)
\]

where \( W_{ij} \) are a set of weights for combining the age-sex specific rates.

We have also calculated directly age-standardised rates for examining trends in men and women separately. We have used the age-sex profile for the 1991 census year to generate
the age-sex and age-standardisation weights (Table 2), eg. for the age-sex standardisation weights

\[ W_{ij} = \frac{\sum_{k} n_{ijk1991}}{\sum_{ijk} n_{ijk1991}} \]

Table 2  Age-sex standardisation weights (from 1991 census data)

<table>
<thead>
<tr>
<th>Age</th>
<th>M</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-15</td>
<td>0.105</td>
<td>0.100</td>
</tr>
<tr>
<td>16-24</td>
<td>0.078</td>
<td>0.074</td>
</tr>
<tr>
<td>25-34</td>
<td>0.084</td>
<td>0.083</td>
</tr>
<tr>
<td>35-44</td>
<td>0.074</td>
<td>0.074</td>
</tr>
<tr>
<td>45-54</td>
<td>0.062</td>
<td>0.062</td>
</tr>
<tr>
<td>55-64</td>
<td>0.053</td>
<td>0.055</td>
</tr>
<tr>
<td>65-74</td>
<td>0.043</td>
<td>0.052</td>
</tr>
</tbody>
</table>

2.8 Causes of accidents

Comparisons in fatal accident trends between occupational classes have been made for all accidents and six specific groups shown in Table 3.

Table 3  Accident types studied

<table>
<thead>
<tr>
<th>Accident group</th>
<th>ICD9 and ICD 8 codes</th>
</tr>
</thead>
<tbody>
<tr>
<td>All accidents</td>
<td>E800 - E949</td>
</tr>
<tr>
<td>Childhood poisonings aged 0 - 4</td>
<td>N960 - N979 = medical poisoning</td>
</tr>
<tr>
<td>House fires</td>
<td>E890, E895; or E894, E897, E898, E899 and place of accident = home; or ICD9 = E898.0</td>
</tr>
<tr>
<td>Motor-cycle riders</td>
<td>E810 - 825 and 4th digit = .2 or .3</td>
</tr>
<tr>
<td>Electric shocks</td>
<td>E925 and (4th digit = .0 or place of accident = home)</td>
</tr>
<tr>
<td>Pedal cyclists</td>
<td>E810 - E825 and 4th digit = .6; or E826 - E829 and 4th digit = .1</td>
</tr>
<tr>
<td>Car occupants</td>
<td>E810 - E825 and 4th digit = .0 or .1.</td>
</tr>
</tbody>
</table>

These causal groups were chosen to examine the hypothesis that different types of intervention have different effects on occupational class accident differentials. The interventions relevant to the specific groups are shown in Table 4.
### Table 4  Interventions which have been evaluated

<table>
<thead>
<tr>
<th>Setting</th>
<th>Group</th>
<th>Interventions</th>
<th>Category</th>
<th>Dates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transport</td>
<td>Pedal cyclists</td>
<td>Voluntary helmet wearing increasing</td>
<td>Educational</td>
<td>3% of child cyclists in 1991, 20% in 1995. 16% of all 1994.</td>
</tr>
<tr>
<td>Home</td>
<td>Electric shock</td>
<td>EU legislation requiring all new electrical goods to have a pre-fitted plug</td>
<td>Enforcement and Engineering</td>
<td>The Plugs and Sockets Safety Regulations 1994; implemented February 1995</td>
</tr>
</tbody>
</table>
2.9 **Analysis**

**Trends**

Age-sex standardised mortality rates for all persons aged 0-74, and age standardised mortality rates by sex, were calculated for all accidents and for specific types of accident occurring over the period of 30 years from 1970-1999 inclusive.

For all-cause and motor vehicle occupant accidents trends in annual accident rates are shown. For three other causes (death from house fires, electric shock, and childhood poisonings) per capita accident rates for the three year periods 1970-72, 1979-81, 1982-84, 1985-87, 1988-90, 1991-93, 1994-96, 1997-99, have been calculated in order to examine trends.

These eight periods of three years have also been used for testing whether the different occupational classes have experienced different patterns of change in accident mortality rates. The tests have been carried out for men and women separately using Poisson modelling for the estimated mortality rates in each age strata and testing whether the differences in rates between three-year periods differed between OCs.

For the purposes of reporting these different patterns, however, relative rates in different OCs for four time periods have been compared in the tables shown here: the three time periods around the census years 1970-72, 1980/82, and 1990-92 and the last projected period 1997-99.

Whilst an appropriate measure of exposure for house fires, electric shocks, and childhood poisonings might be a population count, for pedal cyclists, motor-cyclists and car occupants, vehicle kilometres travelled would be more appropriate. Unfortunately these are not available by age, sex and occupational class. We have therefore used the proportion of deaths due to head injuries rather than other injuries to examine trends in pedal- and motor-cycle fatal accidents since the focus in these cases was on the effects of helmet wearing. In effect, death from other injuries is used as a proxy measure of exposure. Head injury deaths were defined as those with ICD8 or ICD9 Nature of Injury codes: 800-804, 850-854, 873, 920, or ICD9 = 925. Although there may be some arbitrariness about which of several injuries in multiply injured patients is assigned as the underlying cause of death, and there may be some 'fashions' which have changed with time in coding underlying cause of death, there is little possibility that this has differed between OCs. Hence the comparisons between classes in the proportion of deaths due to head injury should be free from any bias.

For vehicle occupants, we have only been able to calculate the per capita fatal accident rates and it should be borne in mind that trends in these rates are confounded by trends in exposure and that these almost certainly differ between OCs.
Effect of interventions

In order to examine the effect of the specific interventions we have focused on, the trends in accident rates before and after the intervention was introduced, have been compared. In effect, the question we have asked is whether any difference in temporal pattern between OCs is mainly due to a difference before and after the introduction of the intervention. This has been tested by splitting the deviance or log-likelihood explained by differences in temporal patterns between OCs into two components - due to differences before and after the intervention and a residual. Some of the interventions have been introduced over a long period of time - such as seat belt laws and cycle helmets - and hence the before and after periods really represent periods when the level of intervention was low or high. For the same reason, the three-year period when the intervention was being introduced has been omitted. The test period for each intervention are set out below.

<table>
<thead>
<tr>
<th>Cause of accident</th>
<th>Intervention</th>
<th>Periods compared</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric shocks</td>
<td>Pre-fitted plugs</td>
<td>1970-90 vs 1994-99</td>
</tr>
<tr>
<td>House fires</td>
<td>Smoke alarms and flame-resistant materials</td>
<td>1970-87 vs 1991-99</td>
</tr>
<tr>
<td>Childhood poisonings</td>
<td>Child-resistant medicine containers</td>
<td>1970-72 vs 1979-99</td>
</tr>
</tbody>
</table>
3. RESULTS

3.1 All accidents

For the study years 1970-72, 1979-99 there were 186,536 deaths from accidents in people aged 0-74. The total number of accidental deaths declined from 11658 in 1970 to 6411 in 1999. This decline was apparent in all social classes (Fig 1). However, the largest declines were in male manual workers (OCs IIIM and IV and V) (Fig 2) and in females in 'other' occupations (Fig 3) most of whom were classified as 'unoccupied'.

These changes in the numbers of accidents partly reflect changing patterns of occupation which have resulted in large reductions in the numbers of men in manual work, and large increases in the numbers of women in paid occupations.

Thus when trends in accident rates are examined (Figs 4-6) we can see that although there have been reductions for men in all OCs these are certainly no greater in manual occupations, and similarly there is little evidence of substantial reductions in death rates in 'other' and 'unoccupied' women. Indeed the projections beyond 1991 suggest that there could have been a rise in the accident rate in this group. This might not be unreasonable since the socio-economic make-up of 'unoccupied' women may have changed since the early 70’s and 80’s with a shift to a lower socio-economic composition.

Although there were reductions in accidental death rates in most occupational classes, the biggest proportional falls were usually in the higher OCs. Consequently, accidental rates relative to the highest occupational class show a rising trend (Fig 7). For men these rises, representing widening inequalities in accident rates, were apparent in all occupational groups (Fig 8) and typically show an increase in the relative rate between 1970-72 and 1990-92 of about 30% (Table 5). These different temporal patterns in the different OCs were highly statistically significant ($X^2_{28} = 594.0, p<0.001$)

Table 5  All-cause accident rates in men, relative to OCI + II, for four time periods.

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<td>IV &amp; V</td>
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<td>1.8</td>
<td>2.3</td>
<td>2.7</td>
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</table>

For women the picture was more mixed (Fig 9 and Table 6). This may represent differences in the pattern of change in accident risk in men and women or could be the result of the acknowledged difficulties in coding women’s occupational class. Nevertheless, there was still strong evidence that women in different OCs had experienced different temporal patterns of accidental death rates ($X^2_{28} = 100.9$)
Table 6: All-cause accident rates in women, relative to OCI + II, for four time periods

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Fig. 1 All accidents – numbers of deaths 1970-72 and 1979-99 by occupational class

Fig. 2 All accidents – numbers of deaths in men 1970-72 and 1979-99 by occupational class

Fig. 3 All accidents – numbers of deaths in women 1970-72 and 1979-99 by occupational class
Fig. 4 Age-sex standardised death rates for all accidents 1970-72 and 1979-99 by occupational class

Fig. 5 Age standardised death rates for all accidents in men 1970-72 and 1979-99 by occupational class

Fig. 6 Age standardised death rates for all accidents in women 1970-72 and 1979-99 by occupational class
Fig. 7  Age-sex standardised death rates for all accidents 1970-72 and 1979-99 by occupational class, relative to occupational classes I and II (1.00)

Fig. 8  Age standardised death rates for all accidents in men 1970-72 and 1979-99 by occupational class, relative to occupational classes I and II (1.00)

Fig. 9  Age standardised death rates for all accidents in women 1970-72 and 1979-99 by occupational class, relative to occupational classes I and II (1.00)
3.2 Motor Vehicle Occupants (MVOs)

Trends

Since 1970 there has been a continuous decline in the number of motor vehicle occupant deaths, despite increasing numbers of motor vehicles and vehicle kms travelled. This decline has occurred in all OCs (Fig 10). There has also been a steady decline in rates of MVO deaths in men (Fig 11), but no clear pattern in women (Fig 12). It is particularly interesting to note how the MVO death rate was relatively high in OC I and II in 1970 but by 1999 was relatively low. This probably results from the changing patterns of car ownership and use, and hence exposure, in the different OCs. Reflecting these patterns, relative to occupational classes I and II, there has been a general increase in the rates of MVO death in men in lower OCs (Fig 13 and Table 7), but not in women (Fig 14 and Table 8).

Table 7  Motor vehicle accident death rates in men, relative to OC I and II.

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Table 8  Motor vehicle accident death rates in women, relative to OC I and II.

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These patterns probably reflect changing patterns of car ownership and car travel, with relatively constant levels in OCs I, II and IIIN but increasing ownership and use in OCs IV and V over this period. This possibility raises two important questions. Firstly, in what sense does a widening accident death rate between higher and lower social classes represent a widening inequality? If it is caused by widening opportunities for leisure, travel, sport, and so on then a widening accident inequality may actually still represent increasing equity.

Secondly, if there are widening inequalities in MVO death rates which only represent widening exposure to travel as an MVO, is this the sole cause of the widening all-accident mortality discussed above?
Interventions

Between 1970 and 1982 there was a gradual increase in voluntary seat-belt wearing, so that seat belts were being worn in about 40% of all trips by front-seat occupants in 1982. This increased to approximately 95% following legislation in 1983. Did the enforced compliance with the safety intervention affect relative MVO mortality rates?

Tables 7 and 8 clearly show that between 1970 and 1982 when seat-belt wearing increased voluntarily there was no widening of the relative MVO mortality rates between OCs. However, between 1980 and 1992 after front seat-belts became compulsory there was a substantial increase in the relative rate in men in OCs IV and V + other and a smaller increase in women. For both men ($F_{4, 20} = 14.5, p<0.001$) and women ($F_{4, 20} = 4.66, p<0.005$) there is strong evidence that there were real differences in the temporal patterns of MVO death rates in the different OCs.

Of course, it is possible, or even likely, that these widening differentials during the 1980s reflect the rapid growth of car-ownership in lower OCs during this decade. However, similar changes were also taking place during the 1970s, and during that decade no effect was observed. Thus there is no evidence in these data of any differential effect on occupational class inequalities in MVO death rates caused by voluntary or enforced seat-belt wearing rules. Any such effect was smaller than the effect of other changes such as due to changing exposure.
Fig. 10  Numbers of all accidental deaths in motor vehicle occupants aged 0-74 years, 1970-72 and 1979-99 by occupational class

Fig. 11  Age standardised rates of accidental death in all male motor vehicle occupants 1970-72 and 1979-99 by occupational class

Fig. 12  Age standardised rates of accidental death in all female motor vehicle occupants 1970-72 and 1979-99 by occupational class
Fig. 13 Age standardised accidental death rates for all male motor vehicle occupants 1970-72 and 1979-99, relative to occupational classes I and II (1.00)

1983 Compulsory seat belt wearing for drivers and front seat passengers
1989 and 1991 Compulsory seat belt wearing by rear seat passengers
1993 Consolidation of seat belt laws

Fig. 14 Age standardised accidental death rates for all female motor vehicle occupants 1970-72 and 1979-99, relative to occupational classes I and II (1.00)

1983 Compulsory seat belt wearing for drivers and front seat passengers
1989 and 1991 Compulsory seat belt wearing by rear seat passengers
1993 Consolidation of seat belt laws
3.3 Non-motor vehicle accidents

The relative all-accident death rates by occupation class shown in Figs 8 and 9 have been recalculated excluding deaths in motor vehicle occupants because of the substantial and differential changes in MVO exposure since 1970. The relative rates for men (Fig 15) and women (Fig 16) show a similar pattern to the picture including the MVOs, with a constant and significant ($\chi^2_{28} = 425$) widening across all OCs for males and a mixed but still significant ($\chi^2_{28} = 95.6$) picture for females. The increase in the inequality is, however, less than when the MVO deaths were included and the relative rates between 1970-72 and 1990-92 typically only show an increase of about 20% (see Tables 9 and 10).

Table 9  All non-motor vehicle occupant accident deaths rates in men, by OC relative to OCI and II.

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Table 10  All non-motor vehicle occupant accident deaths rates in women, by OC relative to OC I and II.

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Fig. 15  Age standardised accidental death rates for males other than motor vehicle occupants 1970-72 and 1979-99, relative to occupational classes I and II (1.00)

Fig. 16  Age standardised accidental death rates for females other than motor vehicle occupants 1970-72 and 1979-99, relative to occupational classes I and II (1.00)
3.4 Adult non-motor vehicle accidents

The changes in non-MVO fatal accident inequalities have also been re-calculated to check that they are not simply a reflection of the well-known changes in children's accident inequalities\textsuperscript{6}. Tables 11 and 12 show the adult rates (16+) and it is clear that the widening inequalities have occurred for adults as well as children.

Table 11 All non-motor vehicle occupant deaths in adult men, by OC relative to OC I and II.

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Table 12 All non-motor vehicle occupant accident deaths rates in adult women, by OC relative to OCI and II.

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3.5 Other RTA deaths

3.5.1 Pedal cyclists

While exposure for MVO deaths has increased over the last 30 years, exposure for (pedal) cyclist deaths has declined, and this may partly explain why the number of cyclist deaths decreased from 1062 in 1970-72 to 484 in 1997-99. This changing pattern of exposure may have differed between OCs and therefore a simple comparison of pedal cyclist death rates by OC is unlikely to reflect differences in risk.

Because the central aim of this study is to examine the effects of interventions, we have focused on deaths from head injuries which might have been prevented by cycle helmets. Fig 17 shows that the decline in pedal cyclist deaths has been greater for deaths from head injuries (-64% between 1970-72 and 1997-99) than for deaths from other injuries (-33%). This suggests that helmets may be a contributory factor to the overall decline in pedal cyclist deaths.

However, there is no evidence of a difference between OCs in changes over time in head injury deaths relative to deaths from other causes ($\chi^2_{14} = 16.4, p = 0.29 \text{ for men}; \chi^2_{14} = 12.4, p = 0.55 \text{ for women}$). The proportion of cyclist deaths classified in ONS data as due to head injuries was constant at around 70% for non-manual, manual, and other classes from 1970 to 1990, and since then has steadily declined to about 55% at the same rate and to the same extent in all OCs (Figs 18 and 19).

During this period helmet wearing increased from about 4% of cycle trips in 1991 to 20% in 1995, and thus the explanation that helmets are the cause of the decline in pedal cycle deaths seems to satisfy one of Bradford Hill’s criteria (dose-response), but because the decline in the head injury death rates is estimated to be the same in all OCs, which may not have taken up helmet wearing equally, it may fail another test (specificity).

Indeed there is no evidence at all in these data of any difference between OCs in the change in the proportion of head injury deaths between 1970-90 and 1994-99 ($F_{2,10} = 0.05, p>0.5$ for men; $F_{2,10} = 2.07, p>0.1$ for women).

3.5.2 Motor-cyclists

A similar analysis can be undertaken for motor cyclists although here the focus is on an earlier period around 1973 when motor-cycle helmet wearing became compulsory.

Once again, deaths of motor-cyclists have shown a very steep decline, from 2160 in 1970/72 to 1432 in 1997/99 (-34%). This decline has also been in deaths attributed to head injuries (-72%) rather than other injuries (+30%) (Fig 20). Interestingly, the major part of the decline in head injuries has occurred since helmet wearing became compulsory, and coupled with the similar picture of decline in pedal cyclists suggests that a changing pattern of tertiary
prevention of death in patients with head injuries by improved medical care is a more likely explanation of what is going on.

Figs 21 and 22 show the decline in head injury deaths as a proportion of all motor-cycle deaths. It will be seen that all OCs have enjoyed this decline to a similar extent and there was little evidence of any difference between OCs for both men ($\chi^2_{14} = 22.3$, $p = 0.07$) and women ($\chi^2_{14} = 21.5$, $p = 0.08$). Nor was there any evidence of a differential effect between manual and non-manual classes between 1970-72, before helmet wearing became compulsory, and 1979-80, after the law changed. ($F_{2,12} = 0.73$, $p>0.1$ for men; $F_{2,12} = 0.58$, $p>0.1$ for women).
Fig. 17 Numbers of accidental deaths in bicyclists by head and non-head injuries 1970-72 and 1979-99

Fig. 18 Deaths from head injuries in male bicyclists as a proportion of all causes of death by manual, non-manual and other occupational classes

Fig. 19 Deaths from head injuries in female bicyclists as a proportion of all causes of death by manual, non-manual and other occupational classes
Fig. 20  Numbers of accidental deaths in motor cyclists by head and non-head injuries 1970-72 and 1979-99

Fig. 21  Deaths from head injuries in male motorcyclists as a proportion of all causes of death by manual, non-manual and other occupational classes

Fig. 22  Deaths from head injuries in female motorcyclists as a proportion of all causes of death by manual, non-manual and other occupational classes
3.6 Electric shocks

Another enforced or legislative intervention was introduced to help prevent the risk of electrical accidents due to faulty wiring of electric plugs. In 1995 it became compulsory for all new electrical goods sold in Britain to be pre-fitted with a plug. However, prior to this there had already been a substantial decline in electric shock deaths from 194 deaths in 1970-72 to 71 deaths in 1991-93. Although this declined still further to 41 deaths in 1994-96 and 53 in 1997-99, this decline appears to be part of the long term trend.

The decline in the numbers of deaths appears to be similar in all OCs (Fig 23). However, when rates of death from electric shock are examined it appears that for men rates were increasing in manual and other OCs relative to non-manual until 1988-90 when the relative risk exceeded 2.0, but that after 1990 the trend had reversed and the relative risk had declined to less than 1.0 in 1997-99 (Fig 24, Table 13). Since this period exactly spans the run-in and introduction of the new legislation, there is at least the possibility that the enforced interventions contributed to reducing the widening inequality. However, there were too few deaths for there to be any reliable evidence that there was any change in the temporal patterns at the time of the introduction of the legislation ($F_{2, 10} =0.57$, $p>0.1$)

**Table 13 Rates of death by electric shock in men, by OC relative to non-manual workers.**

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It is also interesting to note that in 1970-72 the rates in manual and other OCs were less than those for non-manual classes (as for MVO death rates). This may also reflect a difference in exposure.

No rates have been given for women because there have been so few deaths recently - there have been, for example, only 2 deaths recorded in manual class women since 1991.
Fig. 23 Numbers of accidental deaths from electric shocks 1970-72, 1979-1999

Fig. 24 Rates of accidental death from electric shock in males in manual and other occupations relative to non-manual (1.00)

1994 - The fitting of electric plugs on electrical appliances for sale in the UK becomes law
3.7 **House fires**

As well as causing death from electric shock, faulty wiring can also be the cause of domestic house fires. Other important causes include open fires and smoking. However, it is generally agreed that when a fire occurs, the prevention of serious injury or death, is best accomplished by smoke alarms and reducing the amount and toxicity of the smoke.

Two different interventions have addressed this issue since 1980. Firstly, there has been a gradual increase in the fitting of smoke alarms which is estimated to have risen from 15% of households in the UK in 1988, 45% in 1994, to 79% in 1997. Secondly, legislation was introduced between 1988 and 1993 requiring all household furniture for sale to be made of flame retardant materials.

During this period there has been a 47% fall in home deaths from fire and flames from 403 in 1979 to 215 in 1999, and this decline appears to have been proportionally similar in all OCs (Fig 25). Rates of death for both men and women have also shown some decline (Figs 26 and 27), but the greatest decline appears to have been in non-manual OCs. This is reflected in the relative rates which show an increasing risk of death from house fires in manual and other OCs relative to non-manual (Figs 28 and 29, Tables 14 and 15), and there is very strong evidence of a different temporal pattern of decline in house fire death rates for men in different OCs ($X^2_{14} = 78.0$, $p<0.001$) but weaker evidence for women ($X^2_{14} = 21.9$, $p=0.08$).

These widening differentials appear to have been particularly marked since 1990, and there is a significant change in the pattern of differentials between 1970-1987 and 1991-1999 in men ($F_{2, 10} = 7.1$, $p<0.01$) but less evidence in women ($F_{2, 10} = 3.38$, $p<0.08$). It is possible therefore that the voluntary introduction of smoke alarms has widened differentials.

**Table 14** Deaths from house fires in men by OC relative to non-manual workers.

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</tbody>
</table>

**Table 15** Deaths from house fires in women by OC relative to non-manual workers.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Manual</td>
<td>1.0</td>
<td>1.3</td>
<td>1.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Other</td>
<td>2.7</td>
<td>2.8</td>
<td>3.3</td>
<td>4.4</td>
</tr>
</tbody>
</table>
Fig. 25 Numbers of deaths in house fires for persons aged 0–74 years, 1970–72, 1979–99, by occupational class

Fig. 26 Age standardised rates of accidental deaths in house fires for males by manual, non-manual and other occupations

Fig. 27 Age standardised rates of accidental death in house fires for females by manual, non-manual and other occupations
**Fig. 28** Rates of accidental death in house fires in males in manual and other occupations relative to non-manual (1.00)

**Fig. 29** Rates of accidental death in house fires in females in manual and other occupations relative to non-manual (1.00)
3.8 Childhood poisonings

The Child Safety and Medicines Act of 1975 enforced the use of child-resistant containers for aspirin and paracetamol. This law reflected the general move towards using child-resistant containers for all medicines and poisons during the 1970s.

There has been a 75% fall in the estimated rates of poisoning from medicines from 5.31 deaths per million children aged 0 - 4 in 1970/72, prior to the introduction of the Act, to 1.35 deaths per million in 1979-1999 afterwards.

The fall was similar in manual and non-manual OCs (Table 16), but was slightly larger in the ‘other’ group, so that the rate in ‘Others’ relative to non-manual classes declined from 5.5 to 3.9. However, there was no reliable evidence that the pattern of change differed between the OCs ($X^2 = 0.66, p > 0.5$).

Table 16 Rates of poisoning by medicines per million children aged 0 - 4 by occupational class of father (or mother).

<table>
<thead>
<tr>
<th>Period</th>
<th>Non-manual</th>
<th>Manual</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>1970 - 72</td>
<td>2.32</td>
<td>5.73</td>
<td>12.9</td>
</tr>
<tr>
<td>1979 - 99</td>
<td>0.61</td>
<td>1.41</td>
<td>2.36</td>
</tr>
<tr>
<td>% change</td>
<td>-73.7%</td>
<td>-75.4%</td>
<td>-81.7%</td>
</tr>
</tbody>
</table>
4. DISCUSSION AND CONCLUSIONS

4.1 Trends

In England and Wales, the number of registered deaths from accidents in the thirty year period from 1970 to 1999, has been declining steadily. However, the pattern for all accidental deaths conceals considerable variation in the death rates between different OCs. This seems to be true for adults as well as for children, and for men and women separately.

The widening inequalities in fatal accident rates for the manual OCs IIIM, IV, and V, compared to those in the professional and managerial OCs I and II, evident from the beginning of the 1980s, coincide with a rapid increase in exposure to the risk of accidents as occupants (drivers and passengers) of motor vehicles (MVOs). However, changes in MVO death rates do not account wholly for the patterns observed.

Similarly, for non-motor vehicle occupant deaths the known widening in the accidental death rates in children between manual and non-manual occupational classes does not explain the overall pattern of increasing inequality which is evident in adults also.

There are differences in how the occupational class indicators are attached to death data and to census data that raise particular difficulties in the 'other' occupational class category, especially since ‘unoccupied’ includes both unpaid workers and the unemployed. This makes it particularly difficult to examine trends in OC-specific rates for women. Nevertheless, it seems that for women inequalities between the manual and non-manual occupation classes are either not increasing or increasing less than for men.

Looking at some specific causes which are probably not confounded with changing exposure, widening inequalities in accident rates were observed for deaths from fire and flames, and from medical poisonings in children (0-4 years). However, deaths from electric shocks did not exhibit a clear pattern, and, no widening in inequalities between occupational classes in the risk of death following head injury, in either bicyclists or motorcyclists, was evident.

4.2 Interventions

Considering the effect of the interventions we selected to study, the results reveal a mixed picture.

Between 1970 and 1982, use of seat belts in motor vehicles was not mandatory, but no widening of inequalities in fatal accident rates for occupants of motor vehicles between the occupational classes was evident. However, widening inequality in deaths in MVOs was seen following the compulsory seat belt legislation introduced between 1983 and 1992. These results may of course be confounded with changes in exposure, and this raises an important question relating to the difference between inequality and inequity. If the widening inequality in MVO death rates is due to increasing exposure in lower OCs resulting from widening
ownership and use of cars is this a worrying trend which should be addressed, or does it represent increasing equity?

Since 1988, the wearing of cycle helmets in the UK has been encouraged actively through various ‘give-away’ campaigns and in road safety literature, aimed at changing behaviour through education. The latest reports from observational studies indicate that in the mid-1990s, around 20% of bicyclists were wearing protective helmets\textsuperscript{24}. It might be expected that educational measures such as promoting helmets are more likely to be taken up by those in non-manual occupations. However, this is not supported by our analyses that do not reveal that any larger reduction in head injury death rates occurred in non-manual compared to manual and other groups. Legislation requiring the wearing of motorcycle helmets introduced in 1973 was associated with a consistent decline thereafter in death rates from head injuries compared to non-head injuries, and the risks were similar across all social classes. Thus, we found no evidence that either the educational measures promoting the use of bicycle helmets, nor legislation requiring motorcyclists to wear helmets resulted in a disproportionate benefit to non-manual compared to manual occupational classes.

For other causes of death from house fires, electric shocks, or medical poisonings in children there was some weak and non-significant evidence suggesting that legislative and voluntary interventions might have different effects. There has been a significant widening of differentials in deaths from house fires since domestic smoke alarms began to be introduced voluntarily, but during this period statutory requirements for flame retardent furniture materials were also introduced. There was no clear evidence for deaths from electric shock, though the trends were consistent with a reduction of inequalities following the legislation requiring pre-fitted plugs. Equally the legislation requiring child-proof caps on common household medicines was also associated with a small but non-significant reduction in fatal accident differentials.

4.3 Methodological issues

Because of the many influences on recorded accident rates from dynamic changes in exposure to risk from changing lifestyles, changes in risk-taking behaviour, product and environment engineering, as well as the classification and recording of data, isolating the impact of specific policy changes is difficult. Our choice of interventions was influenced by the need to examine measures that would be expected to have an impact on causes responsible for sufficient deaths such that any differential effect for sub-groups of the population might be detectable in national mortality data. Furthermore, because of lack of appropriate exposure data to enable risks for different OCs to be calculated, we have had to focus on accident types for which the essential ‘exposure’ is the population at risk - such as home fires, childrens poisoning, and electric shocks.

Second, because census data from 2001 are not yet available we have had to project estimates of the OC population numbers from the 1991 census results in order to calculate
OC-specific death rates for the later years. This sort of projection can be unreliable, and consequently we have shown in the tables the trends using data from around the 1971, 1981, and 1991 censuses.

Thirdly, the classification of women by OC in the Census and the ONS data is inconsistent between the two data sets. The problems are known\(^1\), and have been discussed in detail elsewhere\(^2\) but importantly for this study, an OC is only assigned for women at death registration if they were ‘occupied’ (employed) for more than half their working life, whereas the population data in the Census asks about employment in the last week. This made the calculation of population-based death rates for women very difficult, and this has to be taken into account in assessing the reliability of the results. The changing working patterns for women have meant that there has been a dramatic shift out of the ‘other and unoccupied’ occupational class category since 1980 which do not reflect a shift in social class and this also makes the results difficult to interpret.

Indeed classifying deaths by the occupation of the deceased (or husband or father if that is not recorded, or mother if that is not recorded) makes it impossible to distinguish the relative social position of the ‘household’ although in our opinion this is the most appropriate unit of analysis to give a reliable social class indicator based on occupation.

Finally, we have used per capita accident death rates as a proxy for accident risk. But of course, if different OCs are more likely to die with the same injury (due to poorer health generally), then we can’t say with confidence that inequalities in accidental deaths observed are due to outcomes or incidence. However, it is likely that any effect of poorer health on outcomes has remained fairly stable over time, and hence the widening inequalities we have identified do represent a widening risk of accidental death either because of a widening risk of accidents or a widening of health differentials generally.

### 4.4 Conclusions

Despite these difficulties, we can reach some tentative conclusions and recommendations.

There is no clear evidence that discretionary interventions (such as seat belts 1970-1982; cycle helmets 1986-1999) have contributed to widening inequalities, so the hypothesis that interventions with most choice of action contribute to widening inequalities between the social classes resulting from greater uptake by those in non-manual occupations OC I, II and IIINM, than in manual or other classes, is not proven.

It is unfortunate that we can’t obtain clear answers to such important questions about equality and equity in health because of inadequacies in how the data is recorded. This is especially so given the opportunities available now to improve and standardise how data are recorded across different Agencies/department through information technology.

We have only examined mortality, but information technology also offers the possibility of standardising and improving the data about non-fatalities. This might be feasible, for example,
by extending the face-to-face questionnaire used by the Home Accident Surveillance System (HASS) and the Leisure Accident Surveillance System (LASS) which currently asks ‘are you employed?’ to include an occupational indicator of social class.

Given that reducing inequalities in health is an important policy area, it is essential that any differences in the impact of ‘discretionary’ and ‘non-discretionary’ intervention measures introduced to prevent accidents should be monitored across different social groups. Inadequacies in the socio-economic data that are currently available are preventing policy decisions being properly informed, and the development and use of better social class data should be a priority for the future.
ACKNOWLEDGEMENT

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