Geographical distribution of road traffic deaths in England and Wales: place of accident compared with place of residence

Robin Haynes, Andrew Jones, Ian Harvey, Tony Jewell and David Lea

Abstract

Background There are two sources of information on road traffic mortality in England and Wales: ONS records giving the place of residence and police records giving the place of the accident. Use of the police records has been limited by the lack of an obvious denominator to control for population at risk. This study compares the two measures and explores the implications of using the same population denominator for both.

Methods The number of road traffic deaths occurring in 403 local authority districts in England and Wales during 1995–1999 was compared to the number of deaths to residents in the same period. Both numbers were related to the expected number of deaths to residents and selected environmental risk factors using regression techniques.

Results Large differences were found between the number of deaths in each district and the number of deaths to residents. The expected number of deaths to residents was the strongest predictor of both observed totals. The number of deaths in the district and the number divided by expected deaths of residents were highly predictable from road accident risk factors, but the number of deaths to residents and the conventional SMR were not.

Conclusion Information on the place of residence of road traffic accident fatalities does not show true variations in accident risk. Police records are better for this purpose. The expected number of deaths to residents estimate provides a partial but effective and unbiased control for population effects.

Keywords: road traffic accidents, Stats 19, SMR, pseudo SMR

Introduction

Road traffic accidents are the largest source of accidental deaths in young people and reducing mortality due to accidents is a public health priority in the United Kingdom.\(^1\)\(^2\) Road traffic death rates vary considerably between administrative areas in the United Kingdom, perhaps reflecting the distribution of risk factors and differential opportunities for successful intervention.\(^3\)\(^4\) Geographical inequalities in deaths due to any cause are commonly standardised for local variations in population structure and expressed as standardised mortality ratios (SMRs), in which the number of deaths is divided by the number of deaths expected if the local population had the same age-specific rates as the national population. UK mortality statistics produced by the Office of National Statistics (ONS) and assembled, for example, in the Compendium of Clinical and Health Indicators for public health specialists, are based on the place of residence of the deceased. For road traffic deaths the place of residence is not necessarily the place where the accident occurred, so ONS mortality statistics are an unsatisfactory indicator of the risks of road traffic deaths within each locality.

Information collected by the police at the scene of the accident, known as ‘Stats 19’ data, is a more promising indicator of environmental risk variations. Counts of road casualties classified as fatal, serious or minor are published by the Department for Transport\(^5\) and records are available with the grid co-ordinates of the place of the accident. On its own, the number of road traffic accident deaths in an area is a poor measure of environmental risk because it probably reflects a substantial population effect. Identifying the population at risk in an area is not straightforward because both residents and non-residents are exposed. The appropriate denominator is the expected number of deaths of residents occurring in the district plus the expected deaths of non-residents in the district. Unfortunately neither measure is available. As a result of this and other difficulties, public health specialists have concluded that they lack

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the information necessary to identify specifically local variations in the risk of road traffic mortality.  

An authoritative comparison of ONS and Stats 19 totals of deaths for England and Wales found close agreement. Examination of geographical variations, however, revealed very different distributions. Slightly over one third of deaths occurred outside the NHS region of residence (the nine English NHS regions cover large areas). Maps of age-standardized deaths of residents at the more detailed local authority district scale showed low rates in the metropolitan areas. By contrast, dot maps of the location of fatal accidents showed clusters in the metropolitan areas. The authors acknowledged that the differences between place of death and place of residence was partly due to high population densities in cities which result in a larger number of accidents but lower population-based rates, but made no attempt to control the effect.

The aim of this study is to make a more direct comparison between the place of death and the place of residence of road traffic accident fatalities in England and Wales, making allowance as far as possible for the population at risk in both sets of figures. We demonstrate that using the same denominator for both counts of deaths is justified on empirical grounds. We also identify whether Stats 19 or ONS mortality figures are more strongly related to environmental and social risk factors.

Data and methods

ONS information on road traffic accident deaths to residents of 403 local authority districts in England and Wales were obtained on disk for the period 1995–1999. Expected numbers of deaths of residents for all ages and both sexes were calculated for each local authority, using England and Wales age and sex specific rates for 1995–1999 and 1998 estimated populations. SMRs were calculated for districts by dividing observed numbers of deaths to residents by expected numbers and multiplying by 100.

Stats 19 data on fatal road accident casualties were also obtained for the same period and geographical areas. To take some account of population variations, the number of deaths occurring in each district was divided by the expected number of deaths of residents (the same denominator as for the SMR) and multiplied by 100. This ratio, comparable to the SMR, we call the ‘pseudo SMR’.

The number of deaths occurring in each district was compared with the number of deaths to residents. Maps were produced to show the geographical distribution of SMRs of residents and pseudo SMRs for deaths occurring in each district.

District measures of several environmental risk factors were assembled (their derivation is described elsewhere). Four of the measures related to road conditions: the total length of roads in the district, the proportion of roads passing through urban land, the proportion of roads classed as minor roads and the average angle of turn per km of road. Two measures represented local traffic volumes: the average daily count of vehicles at traffic census points and the number of cars per capita. The mean duration of twilight represented a physical environment risk factor. Finally, two social variables were included. These were the district rate of dangerous traffic offences and a modified version of the Townsend material deprivation score. Townsend’s index was modified because the original version included the proportion of households without a car. To avoid using car ownership in two explanatory variables, an index incorporating overcrowding, rented housing and unemployment (and excluding non-car ownership) was calculated using the same method.

Regression analyses tested the associations between the observed numbers of deaths in each district, the expected number of deaths to residents and the various environmental and social risk factors. The associations between district SMRs and pseudo SMRs and the risk factors were similarly assessed, to find out whether using expected deaths as a denominator changed any of the relationships. Logarithms of observed and expected numbers of deaths, SMRs and pseudo SMRs were used in the regressions to make these variables normally distributed.

Results

There were 15 835 deaths from Stats 19 data compared with 16 453 deaths recorded by ONS over the period 1995–1999. Both totals include deaths to non-residents of England and Wales. The ONS figures contained 957 non-residents, but the place of residence was not available in the Stats 19 figures. Excluding non-residents from the ONS data, the ratio of Stats 19 to ONS totals used here was 1.02.

The number of deaths to residents in districts ranged from 0 to 299 with a mean of 39. There were no deaths to residents in the Isles of Scilly and only one resident’s death in the City of London, both districts with few residents. Birmingham had the most residential deaths, followed by Leeds, Bradford, Manchester and Liverpool, all urban districts with large populations. Deaths from accidents within each district followed a similar overall pattern, log-normally distributed with a mean of 39 and a range from 0 to 225. The Isles of Scilly had no fatal road accidents in the period and the next most favourable district had only three fatalities. Birmingham again had the highest number, followed by the same four cities, giving the impression that both the number of residential deaths and the number of deaths in the district were highly influenced by the residential population size.

When the number of deaths to residents was divided by the number of expected deaths in each district to make the conventional indirect adjustment, the resulting SMRs ranged from 0 to 320. The geographical distribution of SMR quartiles is shown in Figure 1. Districts in the highest quartile make a broad swathe across the middle of the map from Wales to Eastern England, with other patches in the North and South West. These districts are mostly rural in character. Metropolitan districts were almost all in the lower two quartiles.

The pseudo SMRs of deaths occurring in each district ranged from 0 to 802. Figure 2, shows their distribution. Compared with
the previous figure, Figure 2 displays much more extensive and homogeneous areas of dark shading, indicating the less populated rural parts of the country with high death ratios. The major metropolitan centres all stand out as areas with lower than average pseudo mortality ratios. The single exception was the City of London, with a low population but 13 fatal accidents, which gave it the maximum ratio of 802. Many of the districts in the lowest quartile are not easily distinguishable on the map because they occupy relatively small areas. These are all urban districts with high population densities.

There were considerable variations in the ONS and Stats 19 counts between districts. The determination coefficient ($r^2$) between the two numbers at district level was 0.65. Much of the apparent correspondence between the two totals was due to the effects of population size. Controlling for variations in residential populations, $r^2$ between the SMRs and pseudo SMRs was 0.30. The ratio of deaths in the district to deaths of residents ranged from 0.38 to 13.0. Altogether 110 districts had ratios <0.75 and 118 districts had ratios >1.25.

Table 1 gives standardised regression coefficients from the regression analysis. These show the strength of association between the number of deaths in the district and the number of deaths to residents and each potential environmental factor while holding the other predictors constant. Deaths to residents were associated with three potential risk factors at the 0.05 level of significance. The strongest relationship was with the expected number of deaths based on the district’s population size and structure. They were also negatively associated with the proportion of roads passing through urban land and with the district rate of dangerous traffic offences. All the other coefficients, including the material deprivation score, were close to zero and not significant.

Table 1 shows that the expected number of deaths to residents was also the strongest predictor of the number of deaths occurring in the district, although its beta coefficient was lower than that for residential deaths. All the other potential risk factors were significantly associated with variations in the number of deaths in the district. They are listed in order of effect size. Holding all included variables constant, variations in the number of road traffic deaths in the district were positively associated with the material deprivation score, the level of car ownership, the total length of roads, the duration of twilight, the district rate of dangerous traffic offences and the average volume of traffic in the district. There were significant negative relationships with the proportion of urban land, the average road curvature in the district and the proportion of roads that were minor. Three of these significant effects were in the opposite direction to the weaker associations suggested in the model for residents.

Table 2 gives the results of the equivalent regression models when the SMR and the pseudo SMR were used as the dependent
The strongest environmental association was a negative relation with the proportion of roads passing through urban land. The expected number of deaths to residents was found to be the strongest predictor of the number of deaths occurring in the district, although it was not as powerful a predictor as it was for deaths to residents. Other measures of exposure (the number of cars per capita, the length of roads in the district and the average measured volume of traffic) were also identified as being significantly related to the place of occurrence of road deaths. The strongest environmental association was a negative relationship with the proportion of roads passing through urban land.

### Table 1: Comparison of predictors for the number of deaths of residents and the number of deaths in each district: standardized regression coefficients

<table>
<thead>
<tr>
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<th>Deaths to residents ((R^2 = 0.71))</th>
<th>Deaths in district ((R^2 = 0.77))</th>
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</table>
| **Expected deaths to residents** | Beta  
Proportion roads through urban land | 0.907 <0.001 | 0.772 <0.001 |
| Townsend material deprivation | 0.003 0.956 0.250 <0.001 |
| Average number of cars per capita | -0.100 0.102 0.247 <0.001 |
| Total length of road (km) | -0.054 0.062 -0.232 <0.001 |
| Mean twilight length (min) | 0.081 0.076 0.222 <0.001 |
| Proportion of roads that are minor | -0.055 0.100 -0.136 <0.001 |
| Dangerous traffic offences rate | -0.070 0.026 0.132 <0.001 |
| Average daily number of vehicles | -0.060 0.102 0.124 <0.001 |

### Table 2: Comparison of predictors for the SMR for deaths to residents and the pseudo SMR for deaths in each district: standardized regression coefficients

<table>
<thead>
<tr>
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<th>Deaths to residents ((R^2 = 0.45))</th>
<th>Deaths in district ((R^2 = 0.76))</th>
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| Proportion roads through urban land | Beta  
Townsend material deprivation | -0.586 <0.001 | -0.650 <0.001 |
| Average number of cars per capita | -0.087 0.297 0.287 <0.001 |
| Total angle of turn per km of road | -0.054 0.165 -0.221 <0.001 |
| Total length of road (km) | -0.028 0.577 0.112 0.001 |
| Mean twilight length (min) | 0.106 0.036 0.220 <0.001 |
| Proportion of roads that are minor | -0.080 0.076 -0.142 <0.001 |
| Dangerous traffic offences rate | -0.051 0.175 0.187 <0.001 |
| Average daily number of vehicles | -0.150 0.001 0.067 0.029 |

Discussion

Analysis of records for England and Wales over 5 years confirm good agreement between the total numbers of road traffic fatalities recorded by the ONS and in the Police Stats 19 files. Stats 19 records underestimated the number of road traffic deaths by about 4%, probably mostly because they did not include deaths occurring more than 30 days after the accident. Although the total numbers of deaths recorded in the two data sets were similar nationally, at the local level there were considerable differences. The two numbers differed by more than 25% in the majority of districts of England and Wales. Such variations indicate a considerable imbalance between the deaths of non-residents in the district (‘imports’) and the number of deaths of residents outside the district (‘exports’) in many districts. The rather weak relationship between the two deaths totals was even weaker when the effect of population size was controlled.

It is not possible to adjust Stats 19 numbers to take full account of population at risk because information on vehicle movements within and between districts is not available. The measure introduced in this study, the pseudo SMR, used the expected deaths of residents as the denominator for place of death records and therefore compared the number of deaths occurring in a district with the number of deaths expected if everybody had stayed within their own district of residence. This is not a perfect measure, but it is practicable and interpretable. Because it has the same denominator as the SMR, the two measures are readily comparable and are susceptible to the same treatment in mapping and statistical analysis. The map of pseudo SMRs displayed an even more rural distribution than the SMR map, which is the reverse of the impression given in the ONS comparative study.
Speed reductions in urban areas seem likely to be the mechanism for this protective effect. Other risk factors were the material deprivation of the district, the average road curvature (protective, perhaps because of average speed reductions), the average duration of twilight, the proportion of roads classified as minor (protective) and the district rate of dangerous traffic offences. These seem entirely plausible.

The similarity of the direction and size of environmental influences on the number of deaths in the district and the pseudo SMR demonstrates that the pseudo SMR is a close approximation to the raw number of fatal accidents in the district adjusted to take account of its empirical relationship with residential population. These results provide evidence that the expected number of residents’ deaths is a valid denominator that partially controls for the population at risk without introducing bias. Failure to control the population effect runs the risk of serious confounding.

The geographical distribution of road traffic deaths to residents was shown to be a poor indicator of the distribution of road traffic accident risks. Environmental factors that were highly associated with the occurrence of fatal road traffic accidents were weakly related, not at all related or even related in the reverse direction to the distribution of deaths to residents. The geographical distribution of deaths to residents underestimated the risks of fatal road traffic accidents in rural districts, in socially deprived districts, and in districts with higher than average proportions of car ownership, straight roads, busy roads, dangerous traffic behaviour and long twilight periods. Unexpectedly, variations in social deprivation between districts were more related to road traffic fatal accident occurrence than with deaths to residents, suggesting that social inequalities in road traffic mortality might be more due to environmental conditions in deprived areas than individual circumstances.

There are substantial inequalities in the risk of death from road traffic accidents between places in England and Wales but numbers of deaths or mortality ratios based on place of residence such as those appearing in the Compendium of Clinical and Health Indicators are not reliable indicators of variations in risk. Public health specialists and others should use records based on the location of the accident in preference. These records can be partially controlled for strong population effects without introducing bias.

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**References**