# Changes in the geography of suicide in young men: England and Wales 1981–2005

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## ABSTRACT

**Background** Suicide rates changed considerably in men aged <45 years in England and Wales between 1980 and 2005. The impact of these changes on the geographic distribution of suicide is unknown.

**Methods** Mapping of geo-coded standardised mortality ratios for suicide in 1113 census tracts (mean population 46 000) in England and Wales, smoothed using Bayesian hierarchical models, for 15–44 year old men during 1981–1985, 1991–1995 and 2001–2005.

**Results** Young male suicide rates rose by 50% between the early 1980s and the 1990s but declined to pre-1980 levels by 2005. The spatial distribution of suicide changed markedly over these years. The 'bull's-eye' pattern of increases in suicide rates from the suburbs to the centre of London was abolished, although they persisted in other major cities. Suicide rates among young men in Wales changed from being relatively lower than other regions to being considerably higher. Similarly, by 2001–2005 suicide rates in northern and south western regions were relatively higher than elsewhere with the predominant feature being a north-west/ south-east divide in suicide. These changes in the spatial epidemiology of suicide were not explained by changes in area levels of single person households, unemployment or the unmarried population.

**Conclusion** There has been a marked change in the spatial epidemiology of suicide in young men in the last 25 years, particularly in central London where the RR of suicide has declined and Wales where risks have risen. These changes do not appear to be explained by recognised suicide risk factors and require investigation to inform prevention strategies.

## INTRODUCTION

Suicide is one of the main contributors to premature mortality in industrialised nations. Year-on-year rises in young male suicides in many countries since the 1960s led to a policy focus on suicide prevention and a considerable body of research investigating reasons for the increases. Key contributors to the rise in England and Wales are thought to be increases in unemployment, divorce and substance misuse as well as a growth in the use of car exhaust gases as a means of suicide.[1] By the early 1990s half of all suicides in England and Wales were in men aged <45 years. Since then, suicide rates in young men have declined. The decrease appears partly to have resulted from reductions in the toxicity of car exhaust fumes (due to a growing proportion of cars being fitted with catalytic convertors) and improved economic conditions.[2] By 2005, rates of suicide in 15–34 year olds were at their lowest levels for 30 years.

The impact of these changing rates of suicide on the geographic patterning of suicide in young men in England and Wales has not been investigated. A cross-sectional analysis of the spatial distribution of suicide among 15–44 year olds around 1988–1994, when suicide rates were at their highest, identified two main patterns.[3] The first feature was that suicide rates were highest in the city centres of all ten of Britain's largest cities and declined with increasing distance from the city centre—giving rise to a 'bull's-eye' pattern. The second feature was a high rate of suicide in coastal areas. In this paper we investigate how fluctuations in the rate of suicide among 15–44 year old men affected the spatial distribution of suicide between 1981 and 2005. The central time period of our analysis (1991–1995) overlaps with some of the period covered in our previous paper (1988–1994),[3] but the present analysis is at a larger scale of geographic aggregation. Our focus is on young men as they accounted for half of all suicides over the period studied and their rates have demonstrated considerably greater variability than those of older men and women of all ages.[4]

## METHODS

Deaths of men aged 15–44, coded as resulting from intentional self-harm or events of undetermined intent, were extracted from the Office for National Statistics (ONS) mortality files. International Classification of Disease (ICD) codes used to identify these deaths were ICD-9: E950-959 and E980-989; ICD-10: X60-X84, Y10-Y34, Y87.0 and Y87.2. Deaths coded to E988.8/Y33.9 were excluded since these codes are largely used for registering deaths that are eventually registered as homicides.[5] Deaths were totalled for 5-year periods from 1981–1985, 1986–1990 and so on.

Population denominator data were derived from the censuses of 1981, 1991 and 2001, and post-2001 small area population estimates. Data for 1981 were simple resident population counts. Those for 1991 have been adjusted for the undercount that especially affected the enumeration of young men with this adjustment updated following the 2001 census.[6 7] Data for 2001–2005 were derived from small area population estimates produced by ONS.[8] Data for 1991 onwards were further adjusted to account for the fact that students were counted at their term-time address; additional census statistics were used to 'move' these students to their parents' address to produce a better fit with mortality data.[9] Population counts for 1982–1990 and 1992–2000 were estimated by linear interpolation, and 5-year population-at-risk totals for men aged 15–44 were used as mortality rate denominators.

The geographical areas used in our analysis were a modified version of census 'tracts' for England and Wales, which have been designed to allow comparison of social statistics over time unlike wards and other units that change every census.[10] Population and mortality data can be aggregated to tracts providing a consistent basis for analysis of the changing geography of mortality rates. Each tract has a mean 2001 total population of 46 000. Some tracts are formed of multiple discontinuous areas—for example, those consisting of a grouping of market towns in a rural area. Although geographically distant, these are considered as a single entity in the geographical database. These 'multi-part' tracts would cause potential errors in some of the spatial analyses conducted here and for this reason these tracts were merged with others. For example, the two tracts 'Leominster urban' (market towns in the Leominster constituency) and 'Leominster rural' (the remainder of the Leominster constituency) were combined to create a single, larger, tract. This process resulted in reducing the number of tracts from 1138 to 1113 modified tracts referred to simply as 'tracts' in the following sections for simplicity.

To examine changes in the geographical distribution of suicide rates over the two decades, standardised mortality ratios (SMRs) for men aged 15–44 were calculated for tracts for suicides occurring in each 5-year period 1981–1985 to 2001–2005 using 5-year age groups. SMRs for each period were standardised to the contemporary rates for England and Wales (ie, tract SMRs for 1981–1985 were standardised using total deaths/population at risk in England and Wales 1981–1985). To account for the instability of small-area mortality rates based on small numbers of deaths, a spatial smoothing process was implemented. Two alternative methods were applied and the results compared. The first was a spatial empirical Bayes smoothing (SEBS) process as implemented in the spatial analysis software GeoDa.[11] This method smoothes the SMR for a tract towards those spatially adjacent with the degree of smoothing increasing as the rate becomes more unreliable (ie, as the rate denominator becomes smaller).[12]

The second method implemented was a Bayesian hierarchical model with a Poisson assumption on the observed number of deaths. The model allows for both global between-area variability and local variability due to spatial autocorrelation (ie, neighbouring areas tend to have similar rates). The smoothed SMR is then a weighted average of the observed SMR, the national mean and rates of neighbouring areas. The greater the uncertainty in estimating the SMR (as the denominator decreases), the more it is smoothed towards the global mean or the local mean. The extent to which SMRs are smoothed either globally or locally is determined by the relative contribution of global or local components to the total variability across areas.[13 14] We estimated the models using the Markov chain Monte Carlo methods implemented in WinBUGS version 1.4. Vague prior distributions were used and the convergence of the simulations was assessed using the Gelman-Rubin statistics[15] based on four parallel chains. Hierarchical models were also constructed to investigate the impact on the smoothed SMR of controlling for three of the main area socio-demographic characteristics previously found to be associated with suicide rates.[3] The area measures were the percentage of (a) single person households, (b) unmarried population aged over 16 years and (c) unemployment among the economically active population, and were derived from census data for 1981, 1991 and 2001 for the relevant study period.

To investigate the degree of spatial concentration/clustering of suicide rates, the spatial autocorrelation statistic Moran's *I* was calculated for tract SMRs for each time period. Moran's *I* indicates to what extent values for a geographical unit are similar to neighbouring units and varies in a similar fashion to correlation coefficients. A Moran's *I* of 0 indicates little or no autocorrelation, while a value of +1 would indicate strong positive autocorrelation suggesting that high rate areas tend to be proximal to other high rate areas and low rate areas to others low rates. As this statistic can also be biased by the instability of rates based on small numbers, a version adjusted for variance instability was calculated using GeoDa.[16] This process also calculates a pseudo p value for the null hypothesis that the value of *I* is 0 based on comparing the actual value to those obtained from 999 random re-distributions of the data.

For spatial smoothing and spatial autocorrelation calculations, a simple first order Queen's contiguity matrix was created. This creates a spatial weights matrix associating each tract with all of its immediate neighbours.

## RESULTS

### Trends in suicide in England and Wales

Figure 1 illustrates trends in crude suicide rates among men aged 15–44 years in England and Wales from 1981–2005. Trends differed in the 10-year age groups; among 15–24 year old men rates peaked in 1990 and decreased thereafter. Among 25–34 year olds, rates increased through the 1980s and 1990s, peaked in 1998 and declined thereafter. Rates among 35–44 year olds were less variable across the decades increasing during the 1980s, declining through the 1990s with slight declines in subsequent years.

Figure 2 breaks the data down by region showing quite different trends across these broad geographical areas. For example, rates in London have declined in all three age groups since 1986–1990, while in Wales rates have generally been increasing, but with a decline in the final 5-year period among men aged 15–24 and 25–34 years.

The Moran's *I* statistic for all age bands combined for 1981–1985 was 0.23, which indicates that the degree of spatial concentration (autocorrelation) of suicides was weak to moderate. This measure of concentration of high/low rates then declined to 0.12 during the late 1980s and early 1990s as suicide rates rose. Moran's *I* again increased in the late 1990s to 0.22,

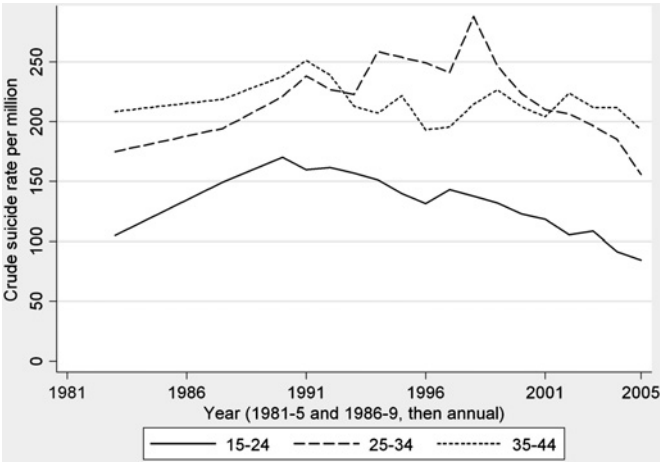


**Figure 1** Crude suicide rates 1981–2005, England and Wales, men aged 15–44 years by 10-year age groups. Note: mortality data for 1981–1985 and 1986–1989 are aggregate and are plotted to the midpoint of each period.

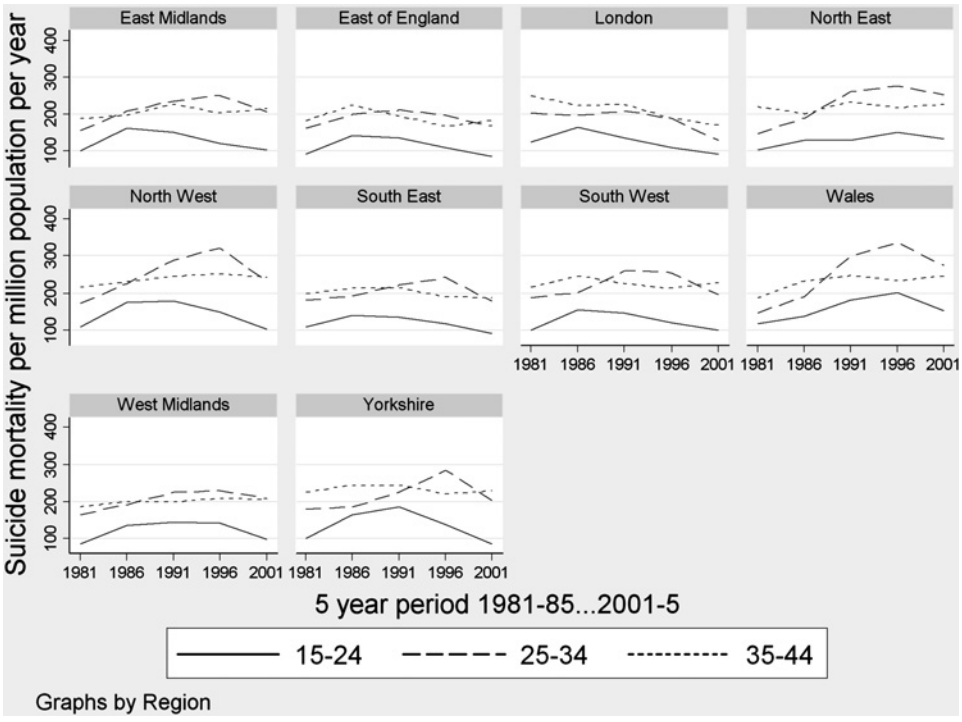


**Figure 2** Suicide rates for 5-year periods, 1981–1985 to 2001–2005, regions of England and Wales, men aged 15–44 years by 10-year age groups (note non-zero origins).

when suicide rates had begun to decline, then fell again to 0.17 in 2001–2005. The CIs around these estimates of spatial autocorrelation were very narrow (+/−0.001).

The two methods used to smooth suicide SMRs produced similar results. The correlation coefficient between the two sets of smoothed rates was 0.92 ($p<0.001$). The full Bayesian model approach produced a higher degree of smoothing, as would be expected, as it smoothes towards the global as well as local mean.

### Maps of suicide

Smoothed SMRs from the Bayesian hierarchical model are mapped in figure 3 for the periods 1981–1985, 1991–1995 and 2001–2005. Six insets showing the most populous cities/ urban areas in England and Wales are included in the maps as census tracts are small in highly populous inner city areas and patterns in the small scale national maps are difficult to distinguish. When interpreting the maps it is important to remember that SMRs were calculated relative to other areas in the same time period. Therefore, suicide rates in areas with high SMRs in 2001–2005 may, nonetheless, have declined since 1981–1985. For example, in 2001–2005 suicide rates in Wales were generally high compared to England (figure 3) but, as shown in figure 2, suicide rates in Wales generally declined between 1996–2000 and 2001–2005.

The series of maps indicate that there have been substantial changes to the geography of suicide among men aged 15–44 years during the three decades. In the early 1980s, the map is dominated by high rates (shaded red) in large inner city areas, especially London, with lower rates (shaded grey/blue) in more peripheral areas. Higher rates were also evident along the south coast of England and in other coastal and more isolated rural areas. By the early 1990s the relative inner city excess of rates in London had diminished somewhat, and lower rates (smoothed SMRs <90, shaded blue) were less widely distributed, being found largely in south eastern/central England. Relatively high rates were still found in pockets along the south coast, although they were less extensive and high rates had emerged in west Wales and were more prominent in the north west of England than they had been 10 years previously. By 2001–2005, lower rates were even more concentrated in and around London, the south and east of England. Conversely, relatively higher rates were more likely to be found in the north and south west with notably high rates (smoothed SMRs above 150) in parts of Wales, the far north and far south west of England. Some pockets of high rates persisted in coastal areas.

Smoothed residual SMRs following adjustment for census covariates are mapped in figure 4 By contrasting figure 3 with figure 4, the maps illustrate the extent to which the patterns seen in figure 3 are explained by area levels of single person households, marital status and unemployment. The maps demonstrate that the extremes of geographical variation in SMRs were reduced somewhat following adjustment for these risk factors. Reductions were most striking in the inner cities (see inset boxes), indicating that high rates in inner city areas are largely due to the socioeconomic characteristics of these areas. In some cases, adjustment actually strengthened the geographical patterns identified. For example, comparing London unadjusted and adjusted SMRs in 1981–1985, the strong 'bull's-eye' concentration of high rates was almost completely attenuated following adjustment. However, data for 2001–2005 suggest that the concentration of very low rates in London was even stronger once census covariates were taken into account and the high rates in Wales, the north and south west England persisted. In contrast, the emerging patterns of relatively high rates in Wales and the north west of England were essentially unchanged when levels of single person households, marital status and unemployment were controlled for.

In a sensitivity analysis we investigated whether the reductions in motor vehicle exhaust gas suicides in the 1990s[17] contributed to the changes in the geography of suicide in London. The changing geographical distribution of overall suicides was very similar to that for non-motor vehicle exhaust gas suicides, indicating that changes in the use, and lethality of,

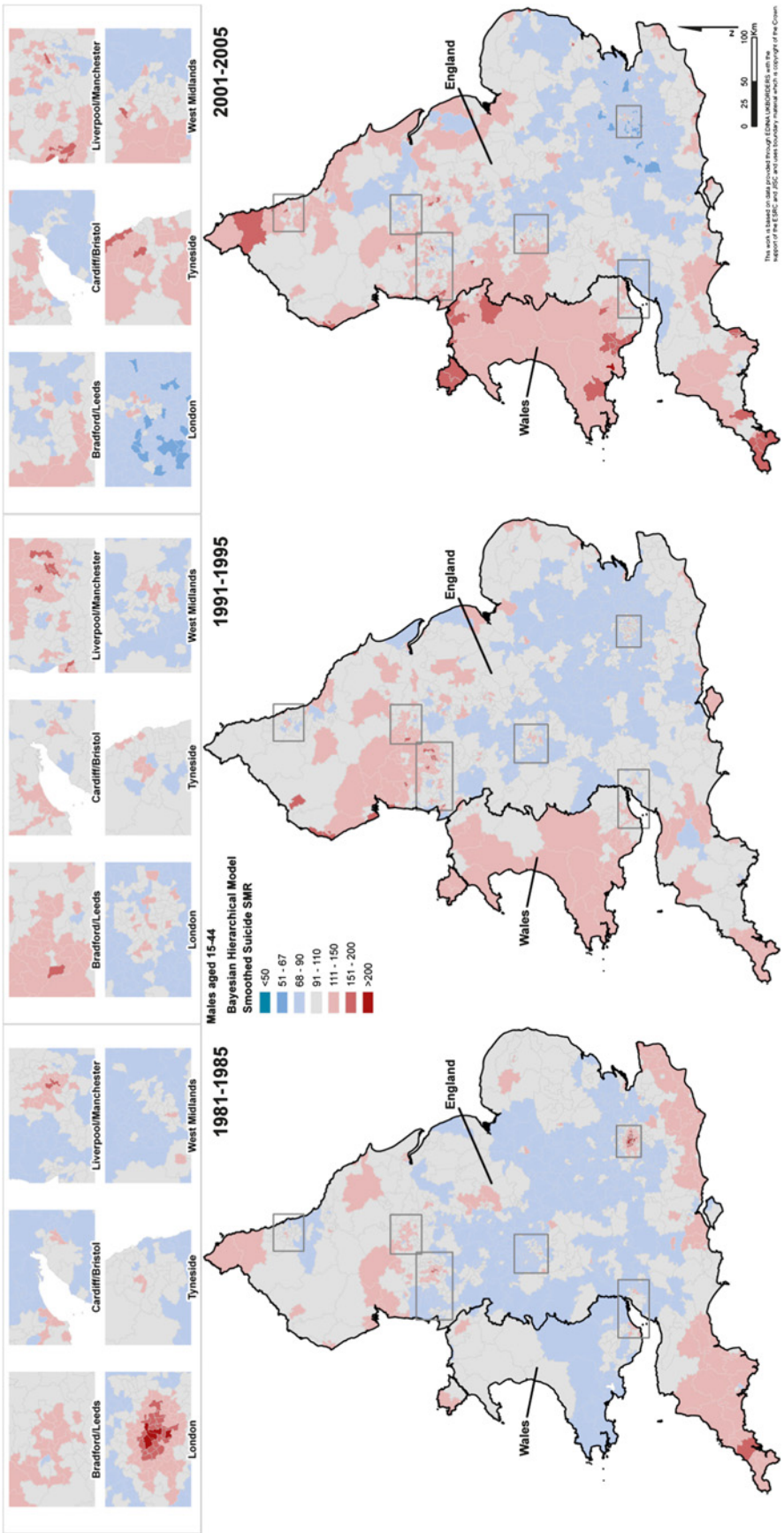


**Figure 3** Smoothed suicide standardised mortality ratios (SMRs) for men aged 15—44 years mapped across England and Wales, 1981—1985, 1991—1995 and 2001—2005.

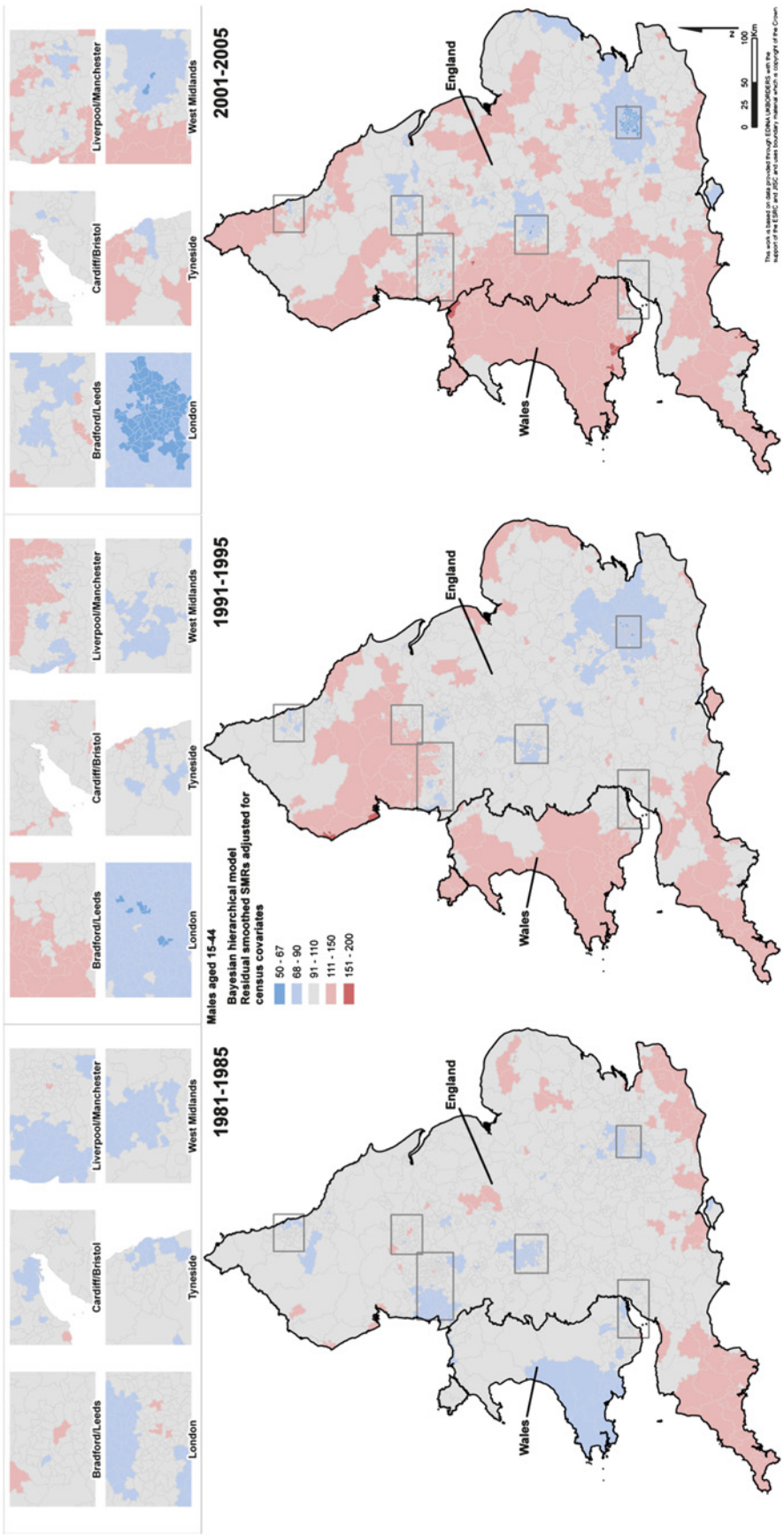


**Figure 4** Residual smoothed standardised mortality ratios (SMRs) for suicide in 15—44 year old men in England and Wales 1981—1985, 1991—1995 and 2001—2005, following adjustment for area levels of single person households, marriage and unemployment, for each of the three time periods.

this method of suicide did not contribute to the observed geographical patterning of suicide (figures available from the authors on request).

## DISCUSSION

### Main findings

The rises and falls in suicide rates in 15–44 year old men between 1981 and 2005 were accompanied by marked changes in the spatial epidemiology of suicide in England and Wales. The strong 'bull's-eye' pattern of increasing rates of suicide from the suburbs to the centre of London was abolished, but high rates of suicide persisted in the inner city area of other major cities. The residual maps (figure 4) indicated that the high rates in inner city areas were, in part, associated with high levels of single person households, low levels of marriage and high unemployment.

Suicides rates among young men in Wales changed from being relatively lower than other regions in 1981–1985 to being considerably higher. Similarly, by 2001–2005, suicide rates in northern and south western regions of England were relatively higher than elsewhere. These changes in the spatial epidemiology of suicide were not explained by changes in area levels of single person households, the unmarried population or unemployment. The pattern of high rates of suicide in coastal regions previously reported[3] for 1988–1994 was not as prominent in this analysis and did not change markedly over the time period studied.

### Strengths and limitations

To the best of our knowledge this is the first study to examine spatio-temporal changes in the distribution of suicide over more than two time periods. We used a large national dataset and the research included a period during which suicide rates doubled.

There are three main limitations to the analysis. First, we have not undertaken a formal statistical analysis of the factors contributing to the temporal changes in the spatial distribution of suicide. Our aim in this analysis was to document any geographical changes; in future work we will formally investigate factors that may underlie the observed changes. Challenges with such analyses are changes in the information collected in the 10-yearly censuses and the complexity of the statistical modelling. Second, the analysis is restricted to a single age group/sex group (15–44 year old men); we focused on this group because they comprise approximately half of all suicides in England and Wales and previous studies indicate that associations of area characteristics with suicide are strongest at younger ages.[18] Lastly, we examined changes over a relatively limited time period (20 years); analysis of secular changes over longer periods, spanning larger changes in the incidence of suicide, may yield additional insights relevant to the changing geography of suicide.

### Findings in relation to previous research

Few studies have investigated the changing spatial epidemiology of suicide. Brock and colleagues compared the geographic distribution of suicide in Britain in 1991–1997 versus 1998–2004 using combined data for all ages and for larger geographic areas than used in our study.[5] Their analysis suggested that geographical differences for men were more pronounced in 1998–2004 than 1991–1997 and they found some evidence of declining rates in inner city London. Spatial patterns for women were similar to those for men.[5] In an analysis aimed at detecting possible clustering of suicide in Scotland, Exeter and Boyle found a cluster in the same area of Glasgow in three time periods between 1980 and 2001, which was attributable to persisting high levels of socioeconomic derivation in this area.[19] Lastly, Lonnqvist compared maps of suicide for Helsinki in 1960–1961 versus 1970–1971. Over this 10 year time period, the previously high rate of suicide in the inner city was replaced by high rates in the suburbs; statistical analysis found little evidence that this change was due to alterations in the sociodemographic characteristics of the areas.[20]

In an earlier quantitative analysis[21] of changes in suicide rates in the Parliamentary constituencies (mean population around 70 000) of Britain in 1981–1985 versus 1986–1992, we found that areas that experienced the greatest increases in markers of social fragmentation also experienced the greatest rises in suicide. This effect was independent of changes in levels of socioeconomic deprivation. Studies carried out in Australia, England and Wales, and elsewhere have shown that rural areas experienced the least favourable trends in young people's suicide towards the end of the 20th century.[22 23] We have not explicitly examined this issue in our paper; however, the increases in relative incidence of suicide in Wales and the south west and north of England, predominantly rural areas, are consistent with the findings from studies examining rural-urban differences.

Time-series studies investigating factors influencing secular changes in the incidence of suicide in England in the second half of the 20th century indicate that important factors include changes in the availability of lethal methods of suicide (eg, coal gas, cars without catalytic convertors), as well as changing levels of unemployment, divorce and substance misuse.[1] Our analysis indicates that changes in the spatial distribution of these factors is unlikely to underlie the observed patterns. While we do not have data on the spatial distribution of divorce or substance misuse, our residuals analysis found no evidence that changes in the proportion of unmarried individuals greatly contributed to the observed patterns.

The striking reduction in the relative suicide rates in central London and its suburbs over the 20-year study period was not explained by changes in the number of single person households, unemployment or the proportion of unmarried individuals. One possible explanation of the different picture in London is change in the ethnic mix of London's population due to relatively high levels of immigration. In the 1981 Census, 18.2% of the population of London was born abroad. By 1991 this had reached 21.7% and by 2001 it was 27.0%. The percentages of people born outside of the UK living in inner London are higher, increasing from 24.5% in 1981, to 28.0% in 1991 to 33.8% in 2001. There are marked differences in suicide rates in different ethnic groups[24 25] and it is possible that changes in the ethnic mix of people living in London and levels of immigration have contributed to the changing patterns of risk seen there. A second possible explanation is the impact of changes in the education profile of people living in London. Census data indicate that the proportion of 15–44 year old men with degree level education living in London increased from 16% (1981) to 38% (2001), whereas figures for England and Wales as a whole show a more modest rise from 13% (1981) to 24% (2001). Educational achievement is inversely associated with suicide risk.[26 27] Lastly, the differences between London and other cities may be associated with them being in different phases of urbanisation[28] and the possible impacts this may have on geographic patterns of suicide. Across Europe, the cities of different countries have been described as falling into different phases of urban development with British, Belgian, Swiss and Dutch cities being ahead of those of many other nations in the 1970s. The changes in patterns of suicide in London may reflect the changes in factors associated with its development relative to other cities in the

### What is already known on this subject

- Suicide is a significant cause of premature mortality worldwide.
- In England and Wales, suicide rates in 15—44 year old men rose throughout the 1970s and 1980s but have declined considerably in the last 10 years.
- Previous studies indicate that the incidence of suicide is highest in inner cities and coastal regions.

### What this study adds

- There has been a marked change in the geography of suicide in young (<45 year old) men in the last 20 years.
- The previously high incidence of suicide in central London has disappeared, whereas high rates persist in other inner city areas.
- Rates of suicide have declined less in Wales than in other regions, and in 2002—2005 the incidence of suicide in Wales was higher than in much of England.

UK. It is notable that the changes in London were not particularly mirrored in Britain's other large urban centres—although there was some evidence of a reduced spatial concentration of relatively high rate areas in Manchester, there was a rise in such areas in Liverpool.

Previous research indicates that after taking account of the characteristics of individuals living in a particular place, area-level effects are weak.[29 30] Therefore, the patterns we observed are more likely to be due to changes in the characteristics of people living in areas rather than the characteristics of the areas themselves, although, of course, such characteristics are influenced by local (area level) events such as factory closures leading to rises in unemployment and fall in income and fluctuations in the house prices influencing levels of home ownership.

### Public health implications

Analyses of secular trends in the incidence of suicide generally focus on trends in overall national rates or on rates in specific age/sex groups. Our analysis shows that rises and falls in young male suicide in the 1980s, 1990s and early 2000s have been accompanied by quite marked changes in the geography of young male suicide in England and Wales. It is critical that further studies are conducted to understand better what factors have favourably influenced the geographic patterning of suicide in London. Understanding factors underlying the observed changes, if they are not simply due to changes in London's population, may be important in guiding suicide prevention activities in other cities. The relative increase in suicide in Wales compared to the rest of England also requires investigation; the changes predate the introduction of England's national suicide prevention strategy, the devolution of Welsh government and are not due to the social factors we investigated (unemployment, single person households and the proportion of unmarried individuals) so other factors are likely to be relevant. It is possible that the changes reflect other aspects of social and economic circumstances in Wales, such as family income and standard of living. The global economic crisis of 2008 and its impact on employment and standards of living means that the geography of suicide in young men in England and Wales may continue to change. Better understanding of factors contributing to the changing patterns and continued surveillance of the geography of suicide in England and Wales is critical to inform appropriate policy and prevention strategies.

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**Competing interests** None.

**Contributors** The study was designed by DG, BW and S-SC. DD, BT and BW were responsible for data extraction. BW and S-SC undertook the analysis with input from JS and DG. DG and BW wrote the first draft of the paper, which was revised by all authors. BW and DG will act as guarantors.

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