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Suicide risk in small areas in England and Wales, 1991–1993

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Abstract *Background* There is growing evidence that areas characterised by high levels of social fragmentation have higher suicide rates. Previous ecological studies have focused on relatively large geographic areas and/or examined associations in all age groups combined. *Methods* Negative binominal regression was used to assess age- and sex-specific suicide rate ratios for a range of census-derived indicators of the social, health and economic characteristics of small areas (mean population aged ≥15: 4500) in England and Wales. *Results* Indicators of social fragmentation (e. g. proportion of people living alone or population mobility) were most consistently associated with suicide risk. For example, across quartiles of wards ranked according to increasing proportions of single-person households, age- and sex-adjusted suicide rate ratios were: 1.00, 1.05 (1.00, 1.11), 1.14 (1.08, 1.19) and 1.42 (1.36, 1.49). Associations were strongest in 15 to 44 and 45 to 64 year-olds. Associations with social fragmentation persisted after controlling for the effect of other area characteristics. *Conclusions* Targeted mental health promotion and social policy initiatives to reduce area-health inequalities in suicide might usefully focus on areas with high levels of social fragmentation.

Key words suicide – ecological study – socio-economic environment – social fragmentation – socio-economic deprivation

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Introduction

The incidence of suicide exhibits marked geographic variability. In Britain, for example, there are 5- to 10-fold differences in rates between local authorities [1, 2]. Some of these differences may be due to variations in the characteristics of people living in particular areas (compositional effects). In addition, features of the area itself may influence suicide risk (contextual effects). For example, area of residence could influence either the likelihood of developing mental illness or levels of social support for the mentally ill, both of which in turn increase suicide risk. Recent analyses provide some support for area (contextual) influences on both overall health [3, 4] and, more specifically, mental illness [5], indicating that there may be features of the community environment over and above individual risk factors that influence suicide rates.

Previous studies have shown that socio-economically deprived areas tend to have higher suicide rates [6, 7]. However, there is growing evidence that area measures of lack of social integration, such as the proportion of people living alone, may be stronger predictors of area levels of suicide mortality [8–11]. Such findings are in keeping with Durkheim's hypothesis that geographic differences in suicide rates were influenced by, amongst other factors, the extent to which individuals were integrated within society [12]. He noted that in highly integrated societies with strong social bonds and a high degree of social cohesion – as indexed by high levels of marriage and religious beliefs – suicide rates were low.

To date most ecological studies of the influence of social fragmentation on suicide in Britain have either fo-

cused on relatively large geographic areas, such as local authorities or parliamentary constituencies (average population aged ≥ 15: 73 000) [8, 9], and/or have not investigated whether associations vary between different age groups [9, 10]. There is no evidence as to what geographical scale may be important in assessing contextual influences upon a population's suicide experience, or mental health in general. Large areas, however, may be composed of many smaller communities with wide ranging differences in their social and economic characteristics associated with suicide risk. Such heterogeneity may mask important small-area influences on suicide.

We investigated the association between an area's suicide mortality and indicators of socio-economic deprivation and social fragmentation in 9264 small areas in England and Wales (mean population aged ≥15 = 4467) and explored the effect on such associations of controlling for other risk factors. We looked at different age and sex groups separately to investigate whether such associations differ with age and sex.

Methods

Data Sources

Mortality and population data

Data on suicide and undetermined deaths (ICD9 codes E950–959 and E980–989 excluding E988.8) by postcode of usual residence (as recorded on the death certificate) were obtained from the ONS for the period 1991–1993. We restricted the analysis to this 3-year period to reduce the effect of temporal changes in area characteristics, in particular levels of unemployment, following the census. Each postcode was assigned to a ward and ward population figures from the 1991 census were used as denominators (see below). Deaths with missing or incorrect postcodes were excluded from the analyses.

Health, social and economic measures

Ward-based data on area characteristics were obtained from the 1991 census. Two aggregate measures of a ward's socio-economic characteristics were derived:

- Townsend deprivation index [13] – an indicator of socio-economic deprivation based on census-derived area levels of: (a) economically active unemployed people, (b) households with no car, (c) overcrowded households and (d) households not owner occupied, and
- Social fragmentation score [14] – a census-derived aggregate score based on area levels of: (a) single-person households, (b) households privately renting, (c) population mobility (people with a different address in the year before the census) and (d) unmarried adult population.

Each score is calculated by summing the standardised normal deviates of its components. Because of their highly skewed distributions, four component variables – households privately renting, population mobility, overcrowding and unemployment – are log-transformed before computing their standardised normal deviates.

The social fragmentation score has been used in previous analyses of this issue [8, 14]. Whilst it is difficult to capture the extent to which geographic areas are conducive to social integration using routinely collected census data, the score is based on variables thought to contribute to this phenomenon. For example, residential mobility (population turnover) was previously used as an area measure of "social disorganisation" and was found to be associated with higher rates of schizophrenia, major depression and substance abuse disorder [15]. Other factors such as church membership and substance misuse, noted by Durkheim and others, may also contribute to area levels of social integration. There is, however, a lack of good quality ward-based measures of these exposures.

To further explore the relationship of these aggregate measures with suicide, we also examined associations with their eight components separately (i. e. unemployment, car ownership, etc.) and a range of other risk factors identified from the literature as being associated with either individual or area-based risk of suicide. These factors were: (a) percentage of lone-parent households – an additional possible indicator of social fragmentation [16]; (b) percentage of people with limiting long-term illness [17]; (c) standardised mortality ratios (SMRs) of cirrhosis deaths in 1988–1994 (deaths ICD9 coded 571) as a proxy for alcohol misuse [18]; (d) percentage of social class IV and V households [19]; and (e) population density as a measure of urbanicity [20, 21].

Data analyses

Analyses were based on 9264 electoral wards in England and Wales. The 25 City of London wards were excluded as they had no or very few inhabitants. These wards occupy only a small area in the business centre of London and include few residential areas.

Associations between suicide and area characteristics were assessed in negative Binomial maximum-likelihood regression models adjusting for age (as three groups 15–44, 45–64 and 65+) and sex. Negative Binomial regression is Poisson regression with an additional Gamma distributed parameter to adjust for overdispersion (extra-Poisson variation) in the data. We tested for evidence of overdispersion with Likelihood Ratio Tests comparing the fits of Poisson and negative Binomial models (null hypothesis Hø: extra-Poisson variation = 0) [22].

Models were repeated to include and test for evidence of interactions between the area characteristics and age/sex. Associations were subsequently examined in age- and sex-specific models using the following age categories: 15–44, 45–64 and 65+. These groups were selected because recent secular trends in suicide mortality differ by age/sex with rises in young (15 to 44-year-olds) male suicide and falls in most other age groups. Trends in suicide rates have, however, been broadly consistent within each of these six age- and sex-groups studied here. These groups also correspond to early working life, late working life and the post-retirement period.

Estimated rate ratios for suicide were calculated across quartiles and in relation to a 1 standard deviation increase in each risk factor. To assess linearity across quartiles, estimates of linear change in suicide risk in relation to change in risk factors were also calculated by fitting the quartiles of the exposure variable as a linear term in the model. Likelihood ratio tests were performed comparing the goodness of fit of models including the quartiles of the exposure variable as a linear term and as categorical variable.

To assess possible confounding, we examined area associations with each of the area characteristics before and after controlling for the effect of all other characteristics. In multivariable models examining the effects of the aggregate measures (Townsend index and social fragmentation score), the component parts of each score were omitted. Adjusted estimates for each aggregate score were obtained after controlling for the effect of the component parts of the other (not the aggregate score) as well as the rest of the risk factors. All analyses were repeated at the parliamentary constituency level (569 areas, mean population aged ≥15 = 72739).

Results

Table 1 summarises the number of deaths, population and area characteristics of the wards included in the small-area analyses. A total of 16 215 suicides occurred in the period 1991–1993. Postcode was missing or incorrect in 87 cases (0.5 % of all male deaths and 0.6 % of all

Table 1 Summary statistics for the number of suicide deaths, population and socio-economic area characteristics of all wards in England and Wales (n = 9264 excluding 25 City of London wards)

	Mean	SD	Median	Range	
Number of suicide deaths in people aged 15+	1.74	1.96	1.00	0.00	16.00
Number of people aged 15+	4467	3459	3580	58	35 090
Socio-economic area characteristics					
Single-person households (%)	25.03	6.75	23.90	4.87	63.80
Households privately renting (%)	10.46	8.21	8.16	0.64	94.41
Population mobility (%)	9.54	3.57	8.81	2.82	45.60
Unmarried adult population (%)	39.73	7.19	38.12	17.03	75.36
Social fragmentation score (based on z-scores for the above four measures)	0.00	3.10	−0.56	−7.56	16.58
Not owner occupied households (%)	30.46	15.61	27.76	0.58	98.95
Overcrowded households (%)	1.70	1.59	1.29	0.00	29.80
Households with no car (%)	27.04	14.75	23.45	3.39	95.08
Unemployed economically active population (%)	9.61	5.57	7.80	1.88	49.31
Townsend deprivation index (based on z-scores for the above four measures)	0.00	3.49	−0.80	−6.93	15.40
Lone-parent households (%)	3.04	2.15	2.38	0.00	17.50
Population with limiting long-term illness (%)	11.70	3.45	11.19	2.41	31.64
Cirrhosis mortality, 1988–1994 – SMRs	0.91	0.87	0.81	0.00	6.98
– (number of deaths)	(2.26)	(2.65)	(1)	(0)	(24)
Social class IV and V households (%)	17.97	7.94	17.19	0.00	80.00
Population density – people/hectare	19.72	25.91	9.20	0.02	216.46

female deaths), which were excluded from the analyses. Across wards, the number of suicide deaths ranged from 0 to 16. There was ≥ 1 suicide death in 70 % of all wards. More than half of all suicides were recorded in males aged 15–44. In this age group, around half of all areas had ≥ 1 death. In female age groups, however, as many as 85 % of all areas had no deaths (i. e. around 1400 areas with non-zero rates).

The social fragmentation score ranged from –7.56 to 16.58 and the Townsend deprivation index from –6.93 to 15.40. There were, as expected, high correlations between each of the aggregate scores and their components. With the exception of proportion of unmarried population, the correlations between the components of the two aggregate scores were, however, generally low. The correlation between the social fragmentation score and the Townsend deprivation index was 0.46, p-value < 0.001. While the highest social fragmentation scores were to be found in urban areas, several rural and more geographically remote areas also scored higher than average, particularly in the North and South West of England and North Wales. Spearman's correlation with population density was 0.22, p-value < 0.001. In contrast, Spearman's correlation between the Townsend deprivation index and population density was 0.53, p-value < 0.001.

Table 2 shows rate ratios (95 % CI) of suicide in all age/sex groups combined across quartiles of wards and in relation to 1 standard deviation increase in each risk factor controlling for age and sex. With the exception of population density (which showed a "U"-shaped association with suicide), there was an increase in rate ratios across quartiles of all risk factors with some evidence of an exponential increase in quartile four – the quartile with the highest levels of the risk factor. Associations were strongest for levels of single-person households, unmarried population and the social fragmentation score. We found strong evidence for interactions between the risk factors and age and sex, indicating that the strength of the associations varied in the different age/sex bands. For example, there were interactions between social fragmentation and both sex (p-value < 0.001) and age (p-value < 0.001). Similarly, for Townsend deprivation index, the interaction effect with age was significant (p-value < 0.001), but not with sex (p-value: 0.54). We, therefore, examined associations in males and females aged 15–44, 45–64 and 65+ separately.

Table 3 presents age- and sex-specific estimates of rate ratios of suicide (and 95 % CI) associated with an SD increase in each risk factor before and after controlling for all other factors in a multivariable model. Since, in general, trends across quartiles of wards with increasing levels of each explanatory factor were consistent with the linearity assumption, we only present estimates of rate ratios associated with an SD increase in the risk factors. Furthermore, evidence of over-dispersion was found in the unadjusted models in all age/sex groups. However, apart from males aged 15–44, this was not the case in models controlling for the effect of all area characteristics.

Increases in nearly all the factors examined were significantly associated with an increased risk in the two younger age groups in both males and females. Associations with social fragmentation components were generally stronger in those aged 45–64. The strength of associations with the Townsend deprivation components decreased with increasing age. With the exception of 15 to 44-year-old men, associations with the social frag-

Table 2 Age- and sex-adjusted rate ratios (and 95 % CI) of suicide associated with quartiles of increasing levels and 1 SD increase in each risk factor

	Quartile 1	Quartile 2	Quartile 3	Quartile 4	1 SD increase	P-value for non-linearity[a]
Single-person households	1.00	1.05 (1.00, 1.11)	1.14 (1.08, 1.19)	1.42 (1.36, 1.49)	1.17 (1.15, 1.18)	< 0.001
Households privately renting*	1.00	1.05 (1.01, 1.10)	1.14 (1.09, 1.19)	1.32 (1.26, 1.38)	1.11 (1.09, 1.13)	0.02
Population mobility *	1.00	1.13 (1.08, 1.19)	1.15 (1.10, 1.21)	1.40 (1.34, 1.46)	1.12 (1.11, 1.14)	< 0.001
Unmarried population	1.00	1.05 (0.99, 1.11)	1.14 (1.08, 1.20)	1.42 (1.35, 1.49)	1.16 (1.14, 1.17)	< 0.001
Social fragmentation score	1.00	1.14 (1.09, 1.20)	1.25 (1.19, 1.32)	1.48 (1.42, 1.55)	1.15 (1.14, 1.17)	0.18
Not owner occupied households	1.00	1.12 (1.06, 1.17)	1.22 (1.17, 1.28)	1.35 (1.29, 1.41)	1.12 (1.11, 1.14)	0.90
Overcrowded households *	1.00	1.05 (1.00, 1.11)	1.15 (1.09, 1.21)	1.30 (1.24, 1.36)	1.09 (1.08, 1.11)	0.10
No access to car	1.00	0.99 (0.93, 1.05)	1.07 (1.02, 1.13)	1.29 (1.22, 1.36)	1.14 (1.12, 1.16)	< 0.001
Unemployed population*	1.00	1.03 (0.98, 1.09)	1.11 (1.05, 1.17)	1.32 (1.26, 1.39)	1.12 (1.11, 1.14)	< 0.001
Townsend deprivation index	1.00	1.05 (0.99, 1.11)	1.13 (1.08, 1.19)	1.34 (1.28, 1.41)	1.13 (1.11, 1.14)	< 0.001
Lone-parent households*	1.00	1.03 (0.97, 1.09)	1.05 (1.00, 1.11)	1.23 (1.17, 1.29)	1.10 (1.08, 1.12)	< 0.001
Limiting long-term illness	1.00	1.08 (1.03, 1.14)	1.18 (1.12, 1.24)	1.29 (1.23, 1.36)	1.09 (1.07, 1.11)	0.91
Cirrhosis mortality	1.00	0.93 (0.88, 0.98)	1.02 (0.97, 1.08)	1.19 (1.13, 1.25)	1.11 (1.09, 1.13)	< 0.001
Social class IV and V	1.00	1.08 (1.03, 1.13)	1.14 (1.09, 1.20)	1.25 (1.19, 1.30)	1.09 (1.07.1.11)	0.73
Population density*	1.00	0.84 (0.79, 0.90)	0.91 (0.86, 0.97)	1.01 (0.96, 1.07)	1.05 (1.03, 1.07)	< 0.001

* These variables were firstly log-transformed using the natural logarithm because of their skewed distributions

[a] P-value of Likelihood Ratio Test for non-linearity comparing the goodness of fit of models including the quartiles as a categorical variable and as a linear term. A significant result indicates non-linearity

Notes: (1) P-values for linear trend were < 0.001 in all models, (2) P-values of Likelihood Ratio Test for null hypothesis Hø: extra-Poisson variation = 0 were < 0.001 in all models

mentation score or one of its component measures were generally the strongest seen in the unadjusted models. In fact, in those aged 65+ few other factors were associated with an increased suicide risk.

In models controlling for the effect of all other risk factors, the social fragmentation score or its components were still strongly related to an increased suicide risk. In four of the six age/sex groups, associations with the social fragmentation index were stronger than any of its components. The components of the index most consistently associated with increased suicide risk were the proportion of single-person households and population mobility. Associations with the Townsend deprivation index and its components either weakened or reversed in the models controlling for the effects of the other factors examined. In males, there were some strong inverse associations with population density in the adjusted models. Similarly, in females, the strong univariable associations with population density attenuated.

Associations with area level characteristics were generally stronger at the ward than the constituency level of investigation across all age/sex groups for all area characteristics investigated here (full results not shown). For example, an SD increase in levels of the social fragmentation score was associated with a 7 % (4 %, 9 %) increase in suicide rates in males aged 15–44 when measured at constituency level, but 12 % (10 %, 14 %) increase when measured at ward level. Similarly, in females aged 15–44, these figures were 17 % (13 %, 21 %) at constituency level and 20 % (16 %, 25 %) at ward level.

Fig. 1 presents estimates of rate ratios (and 95 % CI) of suicide across deciles of wards with increasing levels of the social fragmentation score in males and females aged 15–44, 45–64 and 65+. Increases in social fragmentation were linearly associated with increases in suicide rates in all age/sex groups.

Discussion

Main findings

In univariable analyses, most of the area measures of socio-economic deprivation and social fragmentation were associated with increased risk of suicide. The social fragmentation score and its components were the factors most strongly and consistently related to increased risk of suicide in each of the age/sex groups examined. Although associations were generally weaker in those aged 65+, indicators of social fragmentation were the main factors for which we found some associations in this age group. Furthermore, as found previously [8], associations with social fragmentation persisted after controlling for the effect of socio-economic deprivation and other risk factors, but this was generally not true for indicators of socio-economic deprivation.

Limitations

In any ecological study, associations observed at an area level do not necessarily imply that such factors are asso-

Table 3 Rate ratios (and 95% CI) of suicide in males and females aged 15–44, 45–64 and 65+ associated with 1 SD increase in the risk factor before and after controlling for all other factors

	Unadjusted	Adjusted**	Unadjusted	Adjusted**
	Males aged 15–44		Females aged 15–44	
Single-person households	1.16 (1.13, 1.18)	1.18 (1.11, 1.26)	1.22 (1.17, 1.27)	1.10 (0.97, 1.24)
Households privately renting*	1.05 (1.02, 1.07)	0.98 (0.94, 1.03)	1.17 (1.11, 1.22)	1.12 (1.03, 1.22)
Population mobility *	1.07 (1.04, 1.09)	1.01 (0.98, 1.05)	1.14 (1.09, 1.19)	0.98 (0.90, 1.06)
Unmarried population	1.15 (1.13, 1.17)	1.04 (0.97, 1.11)	1.22 (1.17, 1.27)	1.05 (0.92, 1.21)
Social fragmentation score	1.12 (1.10, 1.14)	1.15 (1.11, 1.18)	1.20 (1.16, 1.25)	1.18 (1.11, 1.26)
Not owner occupied	1.14 (1.11, 1.16)	0.92 (0.88, 0.96)	1.16 (1.12, 1.21)	0.96 (0.88, 1.05)
Overcrowded households *	1.10 (1.08, 1.13)	1.01 (0.97, 1.05)	1.17 (1.12, 1.22)	1.06 (0.98, 1.14)
No access to car	1.19 (1.16, 1.22)	0.94 (0.86, 1.03)	1.23 (1.17, 1.28)	0.99 (0.82, 1.19)
Unemployed population *	1.18 (1.15, 1.20)	0.98 (0.91, 1.04)	1.20 (1.15, 1.25)	0.96 (0.85, 1.10)
Townsend deprivation index	1.16 (1.14, 1.19)	0.88 (0.83, 0.94)	1.20 (1.15, 1.26)	1.00 (0.87, 1.12)
Lone-parent households *	1.17 (1.14, 1.20)	1.18 (1.12, 1.25)	1.16 (1.10, 1.21)	1.09 (0.98, 1.22)
Limiting long-term illness	1.17 (1.14, 1.20)	1.05 (1.02, 1.08)	1.14 (1.08, 1.19)	1.08 (0.98, 1.20)
Cirrhosis mortality	1.14 (1.11, 1.17)	1.05 (1.02, 1.08)	1.14 (1.08, 1.20)	0.99 (0.94.1.05)
Social class IV and V	1.18 (1.15, 1.21)	1.12 (1.07, 1.16)	1.11 (1.05, 1.16)	1.03 (0.95, 1.11)
Population density *	1.07 (1.03, 1.10)	0.87 (0.83, 0.92)	1.19 (1.12, 1.26)	0.99 (0.90, 1.10)
	Males aged 45–64		Females aged 45–64	
Single-person households	1.18 (1.14, 1.22)	1.10 (1.01.1.19)	1.26 (1.20.1.32)	1.20 (1.05.1.38)
Households privately renting *	1.17 (1.13, 1.21)	0.98 (0.93.1.04)	1.17 (1.10.1.23)	0.99 (0.90.1.09)
Population mobility *	1.21 (1.17, 1.25)	1.12 (1.06.1.18)	1.22 (1.15.1.28)	1.11 (1.02.1.22)
Unmarried population	1.17 (1.14, 1.21)	1.10 (1.00.1.22)	1.22 (1.16.1.28)	1.04 (0.89.1.22)
Social fragmentation score	1.20 (1.17, 1.24)	1.24 (1.18.1.30)	1.24 (1.18.1.29)	1.28 (1.19.1.38)
Not owner occupied	1.15 (1.11, 1.18)	1.06 (1.00.1.13)	1.10 (1.05.1.15)	0.92 (0.83.1.02)
Overcrowded households *	1.10 (1.06, 1.13)	1.02 (0.97.1.08)	1.09 (1.04.1.15)	1.00 (0.92.1.10)
No access to car	1.11 (1.07, 1.15)	0.87 (0.76.1.00)	1.15 (1.09.1.21)	0.93 (0.75.1.15)
Unemployed population *	1.10 (1.06, 1.14)	1.04 (0.95, 1.13)	1.10 (1.04.1.16)	0.94 (0.81, 1.09)
Townsend deprivation index	1.12 (1.09, 1.16)	1.06 (0.96, 1.15)	1.12 (1.06.1.17)	0.85 (0.73, 0.98)
Lone-parent households *	1.07 (1.03, 1.11)	0.99 (0.92, 1.07)	1.08 (1.02.1.14)	1.10 (0.98, 1.25)
Limiting long-term illness	1.05 (1.01, 1.09)	1.03 (0.96, 1.11)	1.07 (1.02.1.13)	1.07 (0.96, 1.20)
Cirrhosis mortality	1.08 (1.04, 1.12)	0.99 (0.95, 1.03)	1.17 (1.10.1.24)	1.06 (0.99, 1.13)
Social class IV and V	1.06 (1.03, 1.10)	1.04 (0.98, 1.10)	1.02 (0.97.1.08)	1.01 (0.93, 1.11)
Population density *	1.01 (0.97, 1.05)	0.89 (0.83, 0.95)	1.15 (1.07.1.22)	1.00 (0.89, 1.11)
	Males aged 65+		Females aged 65+	
Single-person households	1.05 (1.00, 1.10)	0.98 (0.87, 1.10)	1.17 (1.11, 1.23)	1.24 (1.08, 1.43)
Households privately renting *	1.11 (1.05.1.16)	0.99 (0.91, 1.07)	1.16 (1.10, 1.23)	0.96 (0.87, 1.07)
Population mobility *	1.10 (1.05, 1.16)	1.08 (1.00.1.16)	1.16 (1.10.1.23)	1.01 (0.92, 1.10)
Unmarried population	1.05 (1.00, 1.09)	1.13 (0.99, 1.29)	1.14 (1.09, 1.20)	0.99 (0.84, 1.16)
Social fragmentation score	1.08 (1.04, 1.13)	1.12 (1.05, 1.19)	1.17 (1.12, 1.22)	1.13 (1.05, 1.22)
Not owner occupied	1.04 (1.00, 1.09)	1.06 (0.97, 1.16)	1.04 (0.99, 1.10)	1.02 (0.91, 1.13)
Overcrowded households *	1.00 (0.95, 1.04)	0.97 (0.90, 1.05)	1.07 (1.01, 1.12)	1.07 (0.97, 1.17)
No access to car	0.99 (0.95, 1.04)	0.92 (0.77, 1.11)	1.04 (0.98, 1.10)	0.92 (0.74, 1.14)
Unemployed population*	1.00 (0.96, 1.05)	1.09 (0.97, 1.23)	1.01 (0.96, 1.07)	1.11 (0.96, 1.29)
Townsend deprivation index	1.01 (0.97, 1.06)	1.04 (0.92, 1.18)	1.04 (0.99, 1.10)	1.14 (0.98, 1.31)
Lone-parent households *	0.97 (0.93.1.02)	0.92 (0.83, 1.02)	0.97 (0.91, 1.03)	0.92 (0.81, 1.04)
Limiting long-term illness	0.98 (0.94, 1.03)	0.99 (0.90.1.09)	0.94 (0.88, 0.99)	0.87 (0.77, 0.98)
Cirrhosis mortality	1.00 (0.94, 1.05)	0.98 (0.92, 1.04)	1.07 (1.01, 1.14)	1.01 (0.94, 1.08)
Social class IV and V	1.00 (0.95, 1.05)	1.02 (0.95, 1.10)	0.92 (0.87, 0.98)	0.96 (0.88, 1.06)
Population density *	0.93 (0.88, 0.98)	0.90 (0.82, 0.98)	1.09 (1.02, 1.16)	0.99 (0.89, 1.11)

* These variables were firstly log-transformed using the natural logarithm because of their skewed distributions

** Associations controlling for the effect of all other single risk factors in multivariable models. Where the aggregate scores were included, the component parts of these were not

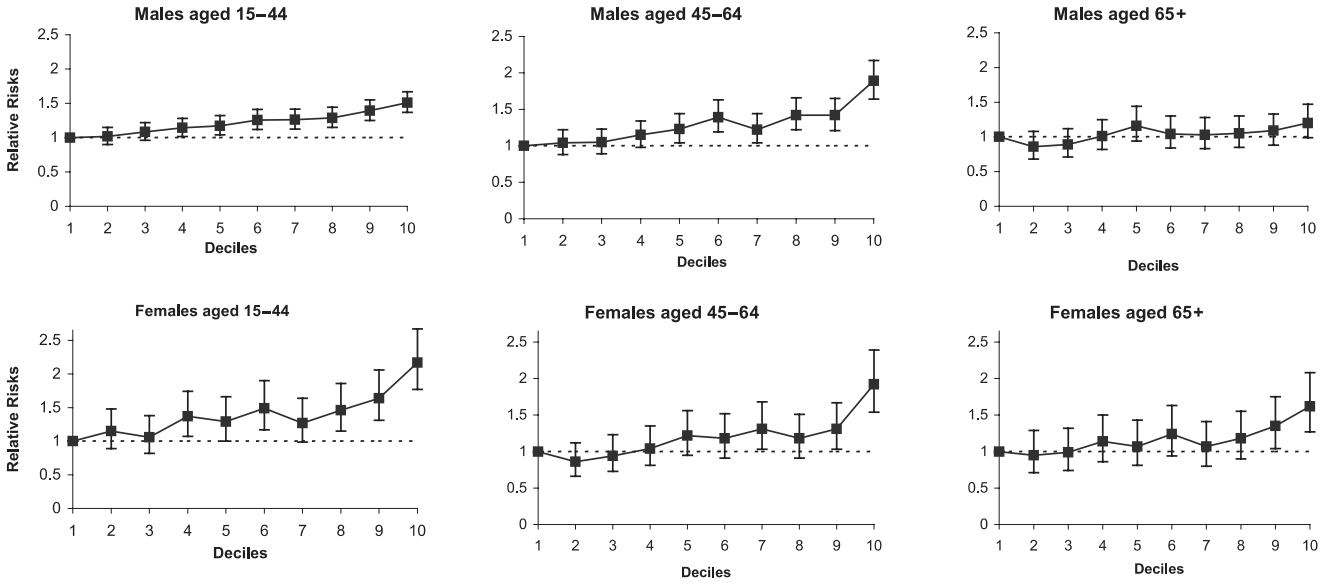

Fig. 1 Rate ratios (and 95% C. I.) of suicide across deciles of wards with increasing levels of social fragmentation in males and females aged 15–44, 45–64 and 65+

ciated with an individual's risk of suicide. However, the purpose of our study was to investigate possible area characteristics associated with high rates of suicide rather than identify individual-level risk factors. Furthermore, age- or sex-specific data were not available for most of the area characteristics. As we used these indicators to describe the overall social and economic environment of each area, we are not concerned that these exposure measures are not age- and sex-specific.

The suicide experience of an area could be a product of both compositional effects (the concentration of high-risk individuals) and contextual effects [the influence of the area characteristics (context) upon individuals that would otherwise be expected to have similar rates]. Some evidence for such area level effects on an individual's suicide risk has been previously reported in the USA for area indicators of socio-economic status, racial concentration, residential stability and family structure [23]. In our analysis, it was not possible to determine the extent to which area characteristics themselves influence an individual's risk of suicide or whether the associations reflect the effect on suicide rates of areas having higher concentrations of high-risk individuals. It is possible that people at increased risk of suicide are attracted to areas characterised by high levels of social fragmentation because of the anonymity in such areas or the presence of hostels and cheap housing.

While cities/towns with high student populations would probably score high on the social fragmentation score, this does not limit our findings. Areas where there are large numbers of students are likely to be socially fragmented for other residents, as frequent population movement of students in and out of these areas will lead to a diminished sense of community. Furthermore, student suicides are only likely to contribute to a small extent to total suicides in our first age-group (15- to 44-year-olds). Associations with social fragmentation were observed in all age/sex groups. These were linear across deciles of increasing social fragmentation (and not only in the highest quartile of social fragmentation where city centres with high student populations would be).

Suicide risk and social fragmentation

There is increasing health policy interest in social capital [24], and the influence of an individual's social and economic environment on health, although there is debate concerning the definition and policy implications of this currently popular concept [25] and its association with suicide has not been investigated. A recent study in the US quantified the notion of social capital by measuring people's membership in voluntary groups and level of trust in other people across States and found some significant associations with levels of mortality [26]. In keeping with these notions, Durkheim's [12] influential sociological study of suicide also recognised that factors which increase an individual's integration within society – achieved amongst other things through family cohesion – may protect against suicide.

Person-based studies in Britain [27, 28] and the US [29, 30] have reported increased risks of suicide in unmarried, divorced and widowed people. The protective effect of marriage may be produced by the sense of social and emotional stability and conformity with societal norms amongst the married. There is also growing evidence that such measures of social fragmentation, or lack of social integration, may also be important predictors of an area's suicide mortality. As early as 1955, Sainsbury reported high correlations in London Boroughs between suicide and measures of social isolation such as divorce and living alone [31]. Ashford and Lawrence, using 1961–1971 census data, found that the characteristic most consistently related to a Local Authority's male and

female suicide rates was the proportion of people living alone [9]. Congdon, using the same census-derived aggregate index of social fragmentation (originally termed "anomie" score) used in the analyses presented here, showed that social fragmentation was more strongly associated with suicide mortality than socio-economic deprivation in the 32 Boroughs of London [14]. More recently, Whitley et al. reported that, at a parliamentary constituency level (mean population aged 15+: 73 000), high levels of social fragmentation (as indexed by the same census-derived score used in our analyses) were associated with increased suicide mortality independently of socio-economic deprivation. Moreover, areas experiencing increases in social fragmentation between 1981 and 1991 also experienced increases in their suicide rates [8].

The present analysis confirms these findings at a smaller level of geographical aggregation. Associations were generally stronger at the ward than the constituency level of investigation. While smaller geographical units (e. g. electoral wards) depict better the socio-economic environments experienced by their populations, as suicide is rare, several areas record no deaths. There is a trade-off between geographical and temporal aggregation. Whilst several years can be aggregated to increase the number of deaths observed in the study period, this increases the possibility of temporal changes in area characteristics, particularly for measures such as unemployment. Furthermore, standard errors of small-area Standardised Mortality Ratios (SMRs) are greatly affected by varying area population sizes, especially for a rare event like suicide. However, we are only presenting associations across quartile/decile and SD increases in the levels of the risk factors. One approach to address this problem when reporting or mapping estimates for individual areas at a small-area level is to use random effect smoothing methods (such as empirical Bayes estimation) [1].

In general, indicators of social fragmentation were most consistently associated with an increased risk of suicide across all age and sex groups both before and after adjusting for the effect of other risk factors. In fact, we found that the aggregate social fragmentation score is generally as good or even better predictor of an area's suicide mortality than any other single area-based measures of social fragmentation. Although associations were generally weaker in those aged 65+, indicators of social fragmentation were the main factors associated with suicide risk in this age group. This probably indicates the lesser importance of social and economic factors in explaining small area variations in suicide in the elderly. Other factors, such as bereavement [32] and acute ill health [33], may be important. Surprisingly though, in contrast to the younger age group, we did not find any strong associations between suicide and area levels of long-term illness in the older male age group and an inverse association in the older female age group. Of note, in the younger age groups, there were also positive associations with levels of lone-parent households – an additional possible indicator of family breakdown or lack of family cohesion [16].

Suicide risk and socio-economic deprivation

Positive associations between socio-economic deprivation and suicide mortality have previously been shown [6, 7]. Likewise, the univariable analyses here demonstrate a strong relationship between suicide and a range of indicators of socio-economic deprivation including the Townsend deprivation score and its component parts as well as concentration of social class IV and V households, particularly amongst those of working age. In fact, there was some evidence that the strength of associations decreased with increasing age. However, in general, these associations did not persist in fully adjusted models. For example, the strong associations found between suicide and unemployment levels in the 15- to 44-year-old males and females were attenuated after controlling for the effect of the other area characteristics. Our finding of an ecological association between unemployment and suicide is in contrast with previous ecological studies in Britain and elsewhere [34, 35]. Unlike cohort studies [36, 37], ecological analyses generally fail to show any strong geographic associations between an area's suicide rate and its unemployment levels. In fact, an ecological study of suicide at county district level in England found that areas with the lowest increases in suicide rates in males aged 15–44 between 1981 and 1991 were those that experienced the greatest increases in unemployment [10].

Suicide risk and other risk factors

Person-based studies indicate that alcohol is associated with an increased suicide risk [18]. In the absence of area-based alcohol consumption data, we used cirrhosis mortality as a proxy of alcohol misuse. We found relatively weak associations between cirrhosis mortality and suicide, which were attenuated in the fully adjusted models. Long-term illness has also previously been shown to influence suicide risk in person-based studies [17]. Surprisingly, associations with long-term illness were only found in the younger age groups.

Previous studies in England and Wales have shown urban-rural differences in suicide rates [2, 20, 21]. In agreement with their findings, we found that suicide rates tend to be higher in highly dense areas in both sexes, but high rates are also found amongst males living in sparsely populated areas. There was some evidence that controlling for the effect of socio-economic area characteristics explained suicide excess more in urban areas than rural areas (as indexed by population density).

Conclusions

A recent report by the Department of Health in Britain recognised suicide, and mental health in general, as one of the major contributors to area inequalities in health [38]. In the context of addressing area inequalities by identifying area-based targets, it seems that for suicide prevention the focus should be areas with high levels of social fragmentation.

Further research, using person-based as well as area-based data is needed to further investigate these ecological associations. Such research should seek to clarify the extent to which observed associations reflect compositional effects, perhaps arising from the drift of individuals at increased risk of suicide to such areas, or similarly a drift of low-risk individuals out of such areas, or alternatively, whether they reflect true area influences on suicide risk.

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