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Mapping gender variation in the spatial pattern of alcohol-related mortality: A Bayesian analysis using data from South Yorkshire, United Kingdom

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ABSTRACT

Gender variation in the spatial pattern of alcohol-related deaths in South Yorkshire, UK for the period 1999 and 2003 was explored using two Bayesian modelling approaches. Firstly, separate models were fitted to male and female deaths, each with a fixed effect deprivation covariate and a random effect with unstructured and spatially structured terms. In a modification to the initial models, covariates were assumed estimated with error rather than known with certainty. In the second modelling approach male and female deaths were modelled jointly with a shared component for random effects. A range of different unstructured and spatially structured specifications for the shared and gender-specific random effects were fitted. In the best fitting shared component model a spatially structured prior was assumed for the shared component, while gender-specific components were assumed unstructured. Deprivation coefficients and random effect standard deviations were very similar between the gender-specific and shared component models. In each case the effect of deprivation was observed to be greater in males than in females, and slightly larger in the measurement error models than in the fixed covariate models. Greater variation was observed in the spatially smoothed estimates of risk for males versus females in both gender-specific and shared component models. The shared component explained a greater proportion of the male risk than it did the female risk. The analysis approach reveals the residual (unexplained by deprivation) gender-specific and shared risk surfaces, information which may be useful for guiding public health action.

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1. Introduction

Alcohol consumption contributes directly to a range of adverse health outcomes through its toxic effects. Alcohol-related causes of death mediated through these toxic effects include acute alcohol poisoning, alcoholic liver cirrhosis, alcoholic pancreatitis, alcoholic gastritis and alcoholic cardiomyopathy. Across Europe, spatio-temporal patterns in alcohol-related mortality are complex with increases in some countries, including the United Kingdom (UK), and decreases in others (Office for National Statistics, 2010; Leon and McCambridge, 2006). The harmful use of alcohol is widespread within the UK (Jones et al., 2008) despite efforts to address the problem (Ministers Strategy Unit, 2004; Department of Health, 2007; BMA Board of Science, 2008). In 2004 it was estimated that 38% of men and 16% of women aged 16–64 years had an alcohol use disorder, implying a total burden of approximately 8.2 million people in England alone (Department of Health, 2005). The rising prevalence of binge drinking, defined as drinking more than eight units on at least one day in the past week for men and more than six units on at least one day for women (Goddard, 2006), is of particular concern since this

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pattern of alcohol consumption increases the risk of death both from alcohol-related causes, as well as from causes not directly related to alcohol (Laatikainen et al., 2003).

Several national reports have highlighted the above issues and suggested possible ways to reduce alcohol-related harm (Ministers Strategy Unit, 2004; Department of Health, 2007; BMA Board of Science, 2008). Options to reduce alcohol-related harm range from population wide interventions to approaches targeting individuals at high risk. Targeted approaches need to first identify individuals at high risk and one method is to identify geographical areas with high rates of alcohol-related disease. Further investigation and additional resources could then be focussed on these areas in order to understand reasons for high rates and attempt to reduce alcohol-related harm.

Certain sections of the population may experience greater than average risk of alcohol-related mortality, including younger age groups and those who experience greater levels of socioeconomic disadvantage (Harrison and Gardiner, 1999; Martikainen et al., 2003; Erskine et al., 2010). The association with socioeconomic deprivation is seen for both men and women (Erskine et al., 2010). However, men drink more than women and alcohol-related mortality is higher amongst men (Goddard, 2006; Erskine et al., 2010). The evidence suggests that there ought to be similarities as well as differences in the geographical pattern of alcohol-related mortality for men and women.

In this paper, we illustrate a number of options for comparing the spatial patterns of alcohol-related mortality in men and women. We examine a range of Bayesian models based on differing prior specifications for the underlying spatial structure in mortality, and different assumptions regarding the shared nature of risk factors between men and women. We examine the effect of explicitly modelling area-level socioeconomic deprivation as a covariate, as well as presenting the residual spatial pattern in mortality once deprivation is adjusted for.

2. Methods

2.1. The data

We obtained counts of alcohol-related deaths for the period 1999–2003 for the 94 'Standard Table Wards' of the county of South Yorkshire in England, by five year age band and by sex. Standard Table Wards (hereafter called 'wards') are a standard geographical unit for the purposes of aggregating 2001 Census information. Deaths were allocated to wards based on the deceased's usual place of residence. We calculated ward-level expected numbers of deaths for males and for females by applying the overall South Yorkshire age sex specific rates to the ward-level denominator populations. We used as our denominator the estimated 2001 ward-level population counts that were obtained from the 2001 Census, and assumed that these were valid estimates for the whole period 1999–2003. For each ward we calculated the standardised mortality ratio (SMR) as the ratio of observed to expected mortality counts.

Alcohol-related mortality was defined according to the Office for National Statistics agreed set of ICD (International Classification of Diseases) codes (Office for National Statistics, 2006). This categorisation includes only those causes of death regarded as being most directly attributable to alcohol consumption. Deaths in our data set were coded using the ICD9 system for the years 1999 and 2000, and the ICD10 system for the years 2001 to 2003. See Appendix A for the ICD codes used to define alcohol-related mortality.

We constructed a measure of socioeconomic deprivation at Census Output Area level. Output Areas are the smallest areas of Census enumeration and consist of approximately 125 houses. We based our deprivation measure on the UV67 Census Table, which reports for each Output Area a cross tabulation of the number of households by the number of four selected deprivation related characteristics present per household. The four household level characteristics were: (1) a member of the household aged 16–74 (who is not a full-time student) is either unemployed or permanently sick; (2) no member of the household aged 16 to pensionable age has at least 5 GCSEs (grade A–C) or equivalent AND no member of the household aged 16–18 is in full-time education; (3) a member of the household has general health 'not good' in the year before the Census or has a limiting long term illness; (4) the household's accommodation is either overcrowded OR is in a shared dwelling OR does not have sole use of bath/shower and toilet OR has no central heating. For each Output Area we took the mean number of characteristics per household as the measure of deprivation for that area.

Each ward comprises a unique set of contiguous Output Areas, and all ward and Output Area boundaries are non-overlapping. Within South Yorkshire the number of Output Areas per ward ranges from 22 to 115 with a mean of 46.

2.2. Analysis stage 1 – modelling male and female mortality separately

In the first stage of the analysis we modelled deaths in males and females separately. For each gender in turn we assumed the following mixed effects model for the observed counts,

$$O_i|\boldsymbol{b} \sim \text{Pois}(\mu_i) \tag{1}$$

$$\log(\mu_i|\boldsymbol{b}) = \log(E_i) + \alpha + \beta x_i + b_i, \tag{2}$$

where i indexes the 94 wards, O_i and E_i are the observed and expected counts for ward i, x_i is the ward-level UV67 measure of socioeconomic deprivation entered as a fixed effect with corresponding regressor β, α is an intercept term and $\boldsymbol{b} = (b_1,\ldots, b_{94})'$ are ward-level random effects.

Because we had deprivation scores at a finer spatial resolution than ward level we were able to enter the deprivation covariate x_i into the model in two ways. In the first instance we calculated for each ward the sample mean of the UV67 scores for the Output Areas comprising the ward, and entered these into the model as quantities assumed to be known with certainty. In the second instance we assumed a measurement error model for the deprivation covariate. Given Output Area level deprivation scores y_{ij}

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