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Socio-economic and demographic predictors of accidental dwelling fire rates

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ABSTRACT

Despite the considerable reduction in rates of fire that have been seen in the UK in recent years analysis of three years of service data from a large UK fire service reveals that there continue to be striking inequalities in the way in which fire is distributed through society. The use of principal component analysis (PCA) and ordinary least squares regression enabled the development of a model that explains around one third of the variance in rates of fire at small neighbourhood level using just three predictor variables: the proportion of residents identifying as Black, the proportion of residents who have not worked for more than five years or have never worked, and the proportion of single person households where the resident is aged under 65. The value of PCA in addressing problems of collinearity between potential predictor variables is particularly highlighted. The findings serve to update understanding of the distribution of fire in the light of the ongoing reduction in fire rates of recent years. They will help fire services to target fire safety interventions to those neighbourhoods and communities where they are most needed and have the greatest potential to bring about reductions in the rate of fire.

1. Introduction

Dwelling fires are a major cause of injury and economic loss. The UK government estimated the total cost of fire in England in 2008 to be £8.3bn ($12.7bn) [1]. Some two thirds of building fires in Britain in 2011–12 were dwelling fires, and these accounted for 76% of the 380 fire related deaths [2]. Over the same period, dwelling fires further accounted for 79% (8900) of all non-fatal fire casualties, with the vast majority of such fires (85%) attributed to accidental causes.

This paper details an analysis of fire service data which sought to establish how accidental dwelling fires are distributed through different sectors of society and to identify socio-economic and demographic factors which are associated with higher rates of dwelling fire. Drawing on existing literature, potential predictor variables are reviewed and issues involved in their operationalisation are discussed. A major problem facing those analysing the distribution of fire is the potential for collinearity between some of these predictor variables. The paper provides a useful example of the value of principal component analysis in addressing such collinearity. It further helps to update understanding of the unequal distribution of fire in the light of the ongoing reduction in fire rates, as well as identifying an important variable that has received little attention in the past, the number of single person households aged under 65.

1.1. The unequal distribution of dwelling fires

It is well established that dwelling fires are not distributed evenly through society, but that certain sectors experience disproportionate numbers of incidents. An earlier review of much of literature related to this topic found considerable evidence of a social gradient in the distribution of fire, with poverty and deprivation clearly linked to increased numbers of incidents [3]. However, many of the existing studies are now relatively old, and even some recent studies rely on data that dates from over a decade ago e.g., [4]. At the same time, the incidence of fire is changing rapidly, with the number of building fires in the UK falling by 39% in the decade to 2012 [5]. Against this changing landscape, if fire services are to target fire safety interventions effectively it is important to establish whether or not the social gradient in exposure to dwelling fires continues to exist. This paper addresses that need by investigating the distribution of accidental dwelling fires resulting in the attendance of fire fighters, using service data from one English fire service, the West Midlands Fire Service (WMFS). As well as describing a method that can be used for analysis of fire incident data in other areas, the paper provides a valuable and up to date insight into the distribution of fire in one major urban area. The findings can reasonably be transferred to areas with a similar character, and with that in mind it is useful to commence by

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briefly describing the character of the West Midlands.

1.2. The West Midlands county

The WMFS serves the area of the former West Midlands Metropolitan County in England and although that county no longer exists it is useful in the context of discussing the WMFS to refer to the West Midlands county, an area which should not be confused with the geographically larger West Midlands region.

The county covers an almost entirely urban area of 902 km^2 (348 $miles^2$) in central England and in 2011 was home to 2.74 million people [6]. It takes in the cities of Birmingham, Coventry and Wolverhampton, along with the metropolitan boroughs of Dudley, Sandwell, Solihull and Walsall, and consists of two conurbations, the larger of which is the second largest urban area in England [7]. The county demonstrates considerable diversity in both economic and demographic terms. Three of its seven local authorities have more than half their population living in the most deprived neighbourhoods in England, whilst Solihull (the only local authority in the county with substantial rural areas) is amongst the least deprived areas in England [8].

Overall, 66% of the county's population considered themselves White British at the 2011 census, with 6.7% Indian, 7.3% Pakistani, 1.8% Bangladeshi, and 6% Black African or Caribbean [6]. A more recent development, following the enlargement of the EU, is the growing number of migrant workers from eastern Europe [9]. As of 2011 the greatest number of these people were from Poland [10].

2. Methods

2.1. Overview

The study was an area based, or ecological, examination of rates of accidental dwelling fire (ADF) across the area served by the West Midlands Fire Service (WMFS). WMFS provided anonymised data on incidents of ADF attended by them between September 2010 and August 2013. These data were analysed with reference to a range of socio-economic and demographic data available from other sources, principally from the UK census of 2011 [6] and the Department of Communities and Local Government's indices of deprivation for 2010 [11].

Analysis was undertaken using SPSS 22 [12] and began with an exploration of correlation between rates of accidental dwelling fire and each of the potential predictor variables. As high levels of collinearity were found between many of the predictor variables used, principal component analysis was then undertaken to identify the main components explaining the difference between areas. Suitable variables were selected that loaded heavily on the identified components and these were used in ordinary least squares regression analysis.

2.2. Choice of geography

When undertaking an area based study such as this the size of the unit of analysis is of some importance. Larger areas are likely to be more heterogeneous and their use will mask the considerable internal variation. On the other hand, small areas, whilst exhibiting less heterogeneity, may encounter too few fire incidents to permit useful analysis, or a single incident may represent a very large proportion, giving rise to extreme outliers in the data. This may result in associations appearing stronger at larger area levels as the impact of outliers is reduced. For this study the Lower Layer Super Output Area (LSOA) was chosen as the unit of analysis as it is the smallest unit at which meaningful numbers of ADF incidents occur. The LSOA is a census unit used in England and Wales and defined by the Office for National Statistics. The boundaries of LSOAs are drawn up after the census is completed in order to allow census data to be used to define areas that were relatively homogeneous at the time of the census, with a population of between 1 000 and 3 000 people [13]. The mean LSOA population in this study was 1628 ($n=1680$, $s=298$), with a mean of 3.17 ADF incidents per LSOA ($n=1680$, $s=2.68$) across the three year period (September 2010 to August 2013) from which incident data were drawn.

2.3. Representing rates of fire

The WMFS incident data were first aggregated to provide counts of ADF incidents for each LSOA for the period September 2010 to August 2013, using the open source QGIS 2.0 geographical information system [14]. An index of ADF was then calculated for each LSOA using an approach adapted from Corcoran et al. [4]. This index represents the rate of accidental dwelling fire per household expressed as a percentage of the rate that would be expected were incidents evenly distributed.

The use of the number of households merits some further comment as it differs from Corcoran et al.'s [4] approach, which employed household population (i.e. total population living in households). In considering the rate of incidents an appropriate choice of denominator is the population at risk. In the case of accidental dwelling fire this is, strictly speaking, the number of dwellings in an area rather than the number of people. There is a very close relationship between dwellings and households in the UK census data, with the former derived from the latter. The main difference in figures comes from unoccupied dwellings, which count as a dwelling but not as a household. As numbers of households were already included within the dataset as the denominator for several other statistics (see Section 2.4) it was decided to use this figure as the basis for calculating rates of fire. Given the close relationship between the two figures the choice is unlikely to make a material difference to the study. On average the figures differ from each other by 3.1% and Pearson's correlation coefficient between them is 0.991.

A further point of note is that ideally the nominator and denominator should match, so the number of dwellings affected by fire should be used to calculate a rate, rather than the number of fire incidents affecting dwellings. Data relating to the number of dwellings affected were, however, not available. Most recorded incidents affect only a single dwelling and whilst it is possible that some affected more than one dwelling these are likely to be relatively few and to have little impact on results.

2.4. Choice of predictor variables

In surveying the existing literature to inform the choice of potential predictor variables, Jennings' [3] recent review was supplemented by additional studies drawn from the public health literature (which was out of the scope of Jennings' review), together with a number of reports from the UK government and grey literature.[1] As there is some evidence that factors associated with fire are context sensitive (e.g. Corcoran et al. report differences between Wales and Australia [15], and some marked differences have been found even between regions of the UK [16]) the focus was on UK based studies as they more closely reflect the context of this study.

The influence of poverty and social deprivation was a

[1] Literature such as reports and working papers produced and distributed outside of the traditional academic channels of peer-reviewed journal and books.