Does the development Glasgow's socio-spatial structure explain its excess mortality?

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1. Background

Scotland has acquired the reputation of being the sick man of Europe due to having the lowest life expectancy and the highest mortality rate in Western Europe (McCartney et al, 2012). Within Scotland, the area with the lowest life expectancy and highest mortality rates is Glasgow (McCartney et al, 2012). Traditionally Glasgow's poor health has been attributed to its high levels of deprivation. However, recent studies have found that deprivation only explains some of Glasgow's high mortality and morbidity. Between 2003 and 2007, for example, it is estimated that there were over 4,500 more deaths in Glasgow than would be expected for a city with Glasgow's age and deprivation profile (Walsh et al, 2010). Furthermore, premature mortality is 30% higher in Glasgow than in Liverpool and Manchester, two cities with very similar levels of deprivation to Glasgow (Walsh et al, 2010). The term "Glasgow Effect" has been coined to describe the higher mortality and morbidity levels experienced in Glasgow which are not attributable to deprivation (Walsh et al, 2008).

One hypothesis proposed to explain the Glasgow Effect is that Glasgow's socio-spatial structure (the geographical arrangement of relatively more and less advantaged people) developed differently to other cities with comparable deprivation levels. Whilst the link between deprived areas and poor health is well established, evidence is emerging to suggest that the wider spatial context of an area might also have an influence on residents' health (for example Cox et al, 2007; Sridharan et al, 2007). It is plausible that people living in a deprived area surrounded by more affluent areas, may have different health behaviours and outcomes to those living in a deprived area surrounded by other deprived areas. One reason for this could be that geographical concentrations of deprivation may have the negative effect of strengthening poor health behaviours (Livingston et al, 2013). Alternatively, it may be that deprived areas which are smaller and surrounded by areas of greater affluence have worse health outcomes because of the effects of such visible and proximal inequality (Livingston et al, 2013). If the physical size, concentration, and location of deprived areas are different in Glasgow to other cities this may contribute to the Glasgow Effect.

Ascertaining if the socio-spatial structure in Glasgow did develop differently to other comparable cities is not straightforward as there is no standard method of mapping which can be used to identify and track temporal changes in the spatial patterning of deprivation. Whilst comparable data for Glasgow and other UK cities are available, there are issues of the data being at different spatial scales in the different cities, boundary changes, and the modifiable areal unit problem (MAUP). All of these create a high risk that results from analysis are driven more by the underlying format of the data than by accurate representations of where deprived people lived at different time points.

2. Aim

The aim of this research was to develop and deploy a methodology to identify whether the spatial arrangement of deprivation developed differently in Glasgow between 1971 and 2011 to Liverpool and Manchester, cities with comparable levels of deprivation and similar socio-economic histories.

3. Methods

To overcome issues of scale, boundary changes, and the MAUP a mapping technique which was boundaryless was required. This would enable spatial and temporal comparisons to be made within and between the three cities. Surface mapping was identified as a technique that overcame these problems. Martin (1991 and 1996) developed this technique for the purposes of mapping population and developed software called SurfaceBuilder which enables population surfaces to be constructed from census data. SurfaceBuilder tries to re-create the real population distribution across geographical space from a set of aggregated counts attached to population weighted census zone centroids. Much of Martin's work (for example 1989, 1996, and Martin and Bracken, 1991) focussed on using this technique to produce surface maps of population and population change. However, because it works by producing surfaces from counts (in Martin's case people) it could also be used to produce surfaces of other types of population counts, such as counts of deprived people. It could thus be used to identify where, in each of the three cities at the different time points, people in deprivation were living. This technique had not been used in this way before. It was however, entirely feasible and was used to produce the maps which are discussed in the sections below.

The data required to map deprivation in all three cities needed to be available at the same point in time and comparable between the cities. Whilst measures of deprivation have significantly evolved over the last decade with the development of the Scottish Index of Multiple Deprivation (SIMD) in Scotland, and the Indices of Multiple Deprivation (IMD) in England, differences with regard to weighting and content meant they were not directly comparable (ISD Scotland, 2012; and Livingston, 2013). Furthermore, as these only originated in the 2000s they could not be used to map deprivation prior to this. One data source which does extend back in time is the UK decennial census. Although different government agencies are responsible for the census in Scotland and England, the majority of the information collected is directly comparable. Whilst the census does not provide a single, consistent, ready to use measure of deprivation, it does provide information on a number of different aspects of people's lives which could be used as indicators of deprivation such as employment, housing, car ownership, and overcrowding.

Using SurfaceBuilder, surface maps for four indicators of deprivation were created for each of the three cities in 1971, 1981, 1991, 2001, and 2011. These 60 surfaces were then transferred into ArcGIS and used to produce raster maps. Whilst the images themselves were useful, a means of formally assessing what the maps showed was required. A multidisciplinary literature search on analysing landscapes for clustering and dispersion identified landscape metrics.

Landscape metrics were developed by disciplines, such as ecology, and are "*quantitative indices to describe structures and pattern of a landscape"* (Herold et al, 2002, p34). A key feature of landscape metrics is to identify and quantify patches/clusters in the landscape being studied. Landscape metrics can be used to study any type of landscape. A further innovation

in this research was the application of these techniques to analyse patterns of deprivation. Examples of metrics being used in this analysis include: the number of patches of deprived people, mean patch size, edge density, and patch size standard deviation. By quantifying the mapped patterns, the metrics facilitated a comparison of the cities beyond the visual.

4. An examplar: male unemployment in 1971

Four measures were selected to be indicators of deprivation: male unemployment, households not owning a car, overcrowded households, and households living in social rented housing. For the purpose of this abstract and demonstrating the technique described above, male unemployment will be an exemplar. Over the 40 year study period, rates of male unemployment have been very similar in Glasgow, Liverpool, and Manchester, have followed the same trends, and male unemployment rates have been consistently higher than the national rates for both Scotland and England (figure 1). It is important to remember that this project was interested in comparing the spatial patterns of unemployment in the 3 cities, and *not* the rates themselves.

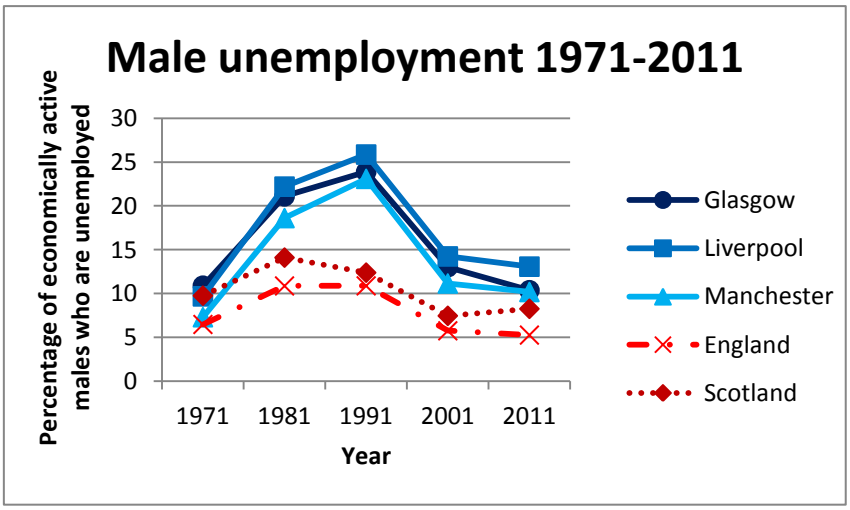

Figure 1: Male unemployment 1971-2011. (Data from UK Data Service Census Support)

Census data were downloaded from the UK Data Service via Casweb. Using SurfaceBuilder two surface maps were produced for each city at each time point: one for all economically active males and one for unemployed males. These surfaces were converted into raster maps via ArcGIS. Using the raster calculator, the map for unemployed males was divided by the map for all economically active males to produce a map which showed the rate of male unemployment in each of the raster cells. Each cell therefore had a value. However, because unemployment rates (as with all the indicators) were on a continuum, a way of ascertaining which cells had values that represented high unemployment relative to that city at that time point was required. The Jenks natural breaks classification method was used to classify the cells with households present into five classes. This is a relative classification method which is based on the distribution of cell counts. It categorises values into different classes by seeking to maximise the variance between classes, and minimise the variance within a class (McCartney et al, 2012). From this the top two classes were selected to be areas which had high unemployment relative to the rest of the city. Having classified each cell into one of

three classes (no households, not high unemployment, and high unemployment) landscape metrics could then be calculated enabling both spatial and temporal comparisons to be made within and between the cities.

This technique was used to produce figures 2 to 4, maps showing areas with the highest concentration of unemployment in Glasgow, Liverpool, and Manchester in 1971. The maps show that the spatial distrubtion of male unemployment in 1971 was different in Glasgow to Manchester and Liverpool. This was apparent visually but was confirmed by the landscape metrics. In Liverpool and Manchester the highest rates of male unemployment were spatially concentrated into a small number of patches (two in Liverpool and eight in Manchester), where as male unemployment in Glasgow was far more dispersed (95 patches). The percentage of land covered by areas of the highest male unemployment in 1971 is also higher in Glasgow as the landscape metrics calculate it to be 4% in Glasgow but only 0.2% and 0.3% in Liverpool and Manchester respectively. Whilst figures 2 to 4 show very different spatial patterns, differences were not so stark or apparent for other indicators or for male unemployment in later years. Landscape metrics were therefore essential for quantifying the patterns and enabling similarities and differences between the cities at the same and different time points to be robustly identified.

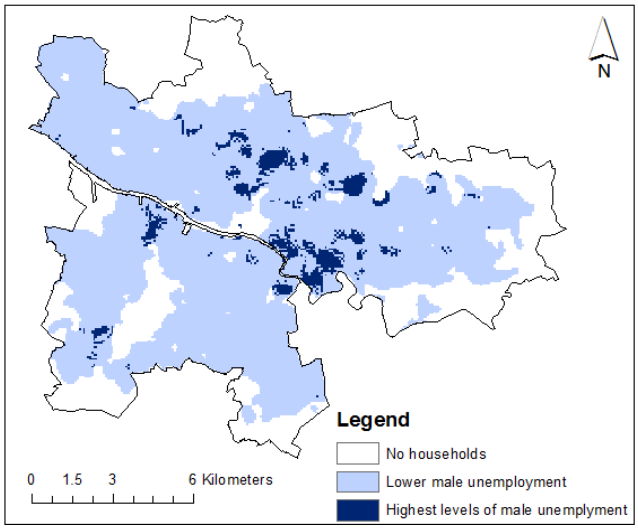

Figure 2: Male unemployment in Glasgow

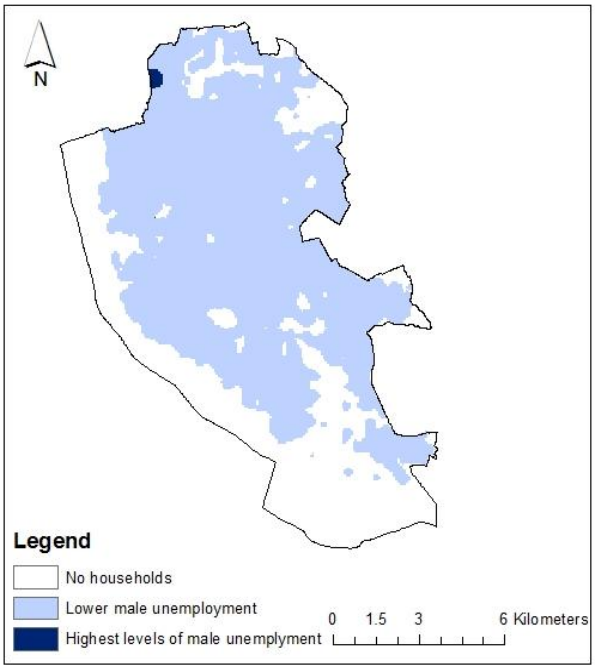

Figure 3 Male unemployment in Liverpool

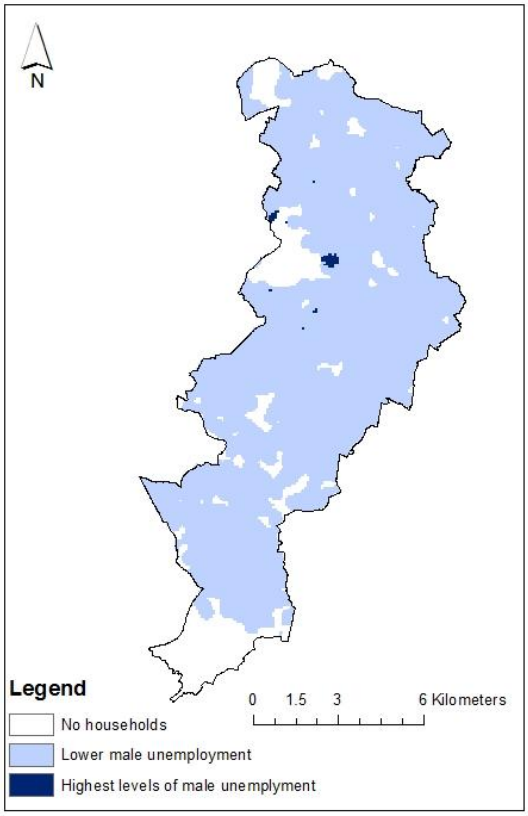

Figure 4 Male unemployment in Manchester

5. Limitations

There were a number of limitations associated with this method. The number and range of indicators of deprivation provided by the decennial censuses was limited. This was also complicated by the fact that the suitability of variables to act as indicators of deprivation

changes overtime; what might have been a good indicator of deprivation in 1971 (for example lack of an inside toilet) may not be relevant in 2011. This research was also limited by having to commence in 1971. SurfaceBuilder required population weighted centroids for small areal units, such as enumeration districts or output areas. These were not available prior to 1971. A final limitation of this method was that ascertaining the statistical significance of any between-city differences in landscape metrics used was problematic.

6. Conclusion

Using surface mapping techniques enabled modelling of the spatial arrangement of deprivation in Glasgow, Manchester, and Liverpool at decennial intervals between 1971 and 2011. These maps enabled spatial and temporal comparisons to be made and are not subject to the MAUP. An example of this technique was given in section 4 where figures 2 to 4 showed that, despite the overall rates for the three cities being very similar, the spatial pattern of male unemployment in 1971 was different in Glasgow to that found in Liverpool and Manchester.

Of all the indicators examined in this study (the others being households not owning a car, overcrowded households, and households living in social rented housing), and of all the years studied, the maps of male unemployment in 1971 showed the starkest differences between Glasgow and the other two cities. By 1981 the spatial distribution of the highest rates of male unemployment remained the most fragmented in Glasgow, and continued to cover a larger area of the city, however, the pattern in Liverpool and Manchester had become more fragmented and this trend continued to the present day. Whilst the spatial pattern of high rates of unemployment remained the most fragmented in Glasgow in 2011, differences between the three cities were far less apparent by 2011. With regard to the other indicators of deprivation there were some differences in spatial patterning between Glasgow and the other two cities. However, these differences were less apparent than for unemployment in 1971, and there significance is unclear. When the landscape metrics were plotted it was found that the trajectories of the socio-spatial patterns were relatively similar in all three cities. So whilst there do appear to be some differences between the spatial patterning of some of the indicators of deprivation, at this stage of the research it remains unclear as to whether or not this is contributing factor to the Glasgow Effect.

The latest phase of this research has been to combine all of the indicators for each city at each time point. Analysis of this is still at a preliminary stage, however what is becoming apparent is that in the earlier years of this study a much greater percentage of Glasgow is covered by areas where all of the indicators were present.

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Biography

Joanna is a third year PhD student in the Institute of Health and Wellbeing at the University of Glasgow. Joanna has an MSc in City Planning and Regeneration from the University of Glasgow, and an MRes and BA (Hons) in Geography from the University of Strathclyde.