Modelling Best Locations for Stop Smoking Services at the Small Area Level in Leeds, UK

Melanie TOMINTZ

Abstract

Finding optimal locations for health care service provision is a constant concern of health geography. The aim of this paper is to provide a clearer understanding of the geographical variations of smoking and to locate stop smoking services more within areas of high need at the small area. Due to the fact that resources are limited, this paper estimates the smoking population at the small area level using spatial mircrosimulation. Further, location-allocation models are applied to locate facilities optimal based on the estimated smokers. Various *what-if* scenarios can be modelled and examples are highlighted which is especially supportive for health care planners.

1 Introduction

In the UK, pioneering work on the link between smoking and various health problems such as lung cancer was explored in the 1950s by DOLL AND HILL (1950). It is generally asserted that around one third of all types of cancer are associated with smoking. The main cancer type attributable to tobacco smoking (primarily cigarettes) is lung cancer. Globally, since 1985 lung cancer has been the most often diagnosed cancer with an estimated 1.35 million new lung cancer cases and 1.18 million lung cancer deaths by 2002 (PARKIN et al., 2005). Further, smoking is responsible for a high number of deaths from various other cancer types including those of the mouth and lip, and also various diseases such as cardiovascular, respiratory, circulatory and digestive diseases (OFFICE FOR NATIONAL STATISTICS, 2002). The risk of developing smoking related diseases does not only affect smokers. They can also emerge for non-smokers and therefore passive smoking is also a major concern for public health. For instance, children of parents who smoke are often exposed to passive smoke and in the UK only 20% of parents ban smoking in their home to protect their children developing smoking related diseases. Further, there is an increased health risk for children in their first 18 months of life when non-smoking mothers are passive smokers. Sir Liam Donaldson, who currently acts as the chief medical officer in England, stated in 2007 that the treatment of smoking related diseases (including hospital admissions, general practitioner consultations and prescriptions) costs the UK National Health Service approximately £1.7 billion a year. This highlights the importance of supporting smokers to give up and to prevent people from even starting the habit.

In the UK, the problems associated with smoking have been recognized and therefore the Government has introduced new policies aimed at reducing the proportion of smokers from 26% down to 21% by 2010 (DEPARTMENT OF HEALTH, 2004) which means that Leeds, which is the study area, has to reduce the smoking population by 9% (or 55,000 people) between 2006 and 2010 to meet the national target. In other words, one in three smokers would need to quit. Most people who want to stop cannot do it without support and the National Health Service in England has recognized this problem. It has invested extensively to establish stop smoking services and the first ones were set up in 1999. The services are free to use and people can self-refer or can be referred by health professionals. Sessions are run by trained advisors and consist of either one-to-one support, where a person can be treated personally, or group sessions.

The aim of this paper is to investigate the potential of spatial microsimulation to produce synthetic smoking estimates at a local geographical level in Leeds to optimize location planning for stop smoking services.

2 Data

Data on the smoking population for small areas, if it exists, is not accessible due to confidentiality reasons. Surveys are expensive and time consuming and TWIGG & MOON (2002) argued that in the mid-1990s a middle-sized health authority would have needed to allocate at least £50,000 to conduct one single survey. Therefore, there is an interest in different methods (such as microsimulation) to estimate health outcomes at the local level.

For the spatial microsimulation model, the UK census 2001 and the General Household Survey (GHS) 2006 are used to estimate the smoking population for output areas in Leeds. One output area consists of approximately 250 people. The UK census is conducted every ten years and the most recent data is available for 2001. The census holds rich data sets on demographic and economic information including age and socio-economic class for the whole population down to output areas but no information about smoking is given. The General Household Survey (GHS) on the other hand is a cross-sectional annual survey with the most recent data set from 2006 (at the time of research). The data set provides information on individuals or households at broader geographical areas (such as the regional level) containing more than 1000 variables. Demographic and socio-economic information as well as information about a person's lifestyle such as smoking and drinking is given. With the spatial microsimulation model, it is possible to combine these data to produce smoking estimates at the local level.

To optimize the location of stop smoking services it is necessary to know where current services are located. This information was given by the Leeds Primary Care Trust for the time period October 2004 until September 2007 split in three annual periods. From October 2004 until September 2005, 31 stop smoking services were running. Between October 2005 and September 2006, 51 stop smoking services offered the service and between October 2006 and September 2007, 66 stop smoking services were provided in Leeds. This shows a continued increase in the provision of stop smoking services over the years.

Further, a road network is implemented in the model to reflect real travel patterns more closely. The road network can be downloaded from Digimap in the format OS Meridian 2 in the scale 1:50000 (http://digimap2.edina.ac.uk/downloader/Downloader?tab=0).

3 Methods

3.1 Spatial Microsimulation Model

The main aim of microsimulation is to model the demographic, the social or the economic characteristics of human behaviour and thus to build up large-scale datasets based on the attributes of individuals or households. Such microsimulation models cover many policy relevant issues and are used to analyse policy impacts based on micro-units (CLARKE, 1996). Aspatial microsimulation models are used for data at the national level whilst spatial microsimulation models emphasize the importance of geography. Early microsimulation applications were aspatial which means that geography was not considered relevant for the applications. With such models it is possible to explore which people are affected by certain variable changes but not where these people live. A major reason for not using spatial models was the previous lack of good quality geographical data. Further, adding a spatial dimension is computationally intensive. Aspatial models have been built by economists concerned mainly with national simulations meaning that geography was not very important for their particular research (and often they might be unfamiliar with geographical data and methods) (BALLAS et al., 2005). BALLAS et al. (2006) reviewed the academic studies of microsimulation over 36 years and found that 41% of mainstream papers were in economics and only 3% in geography, suggesting that the use of such spatial approaches was not widespread.

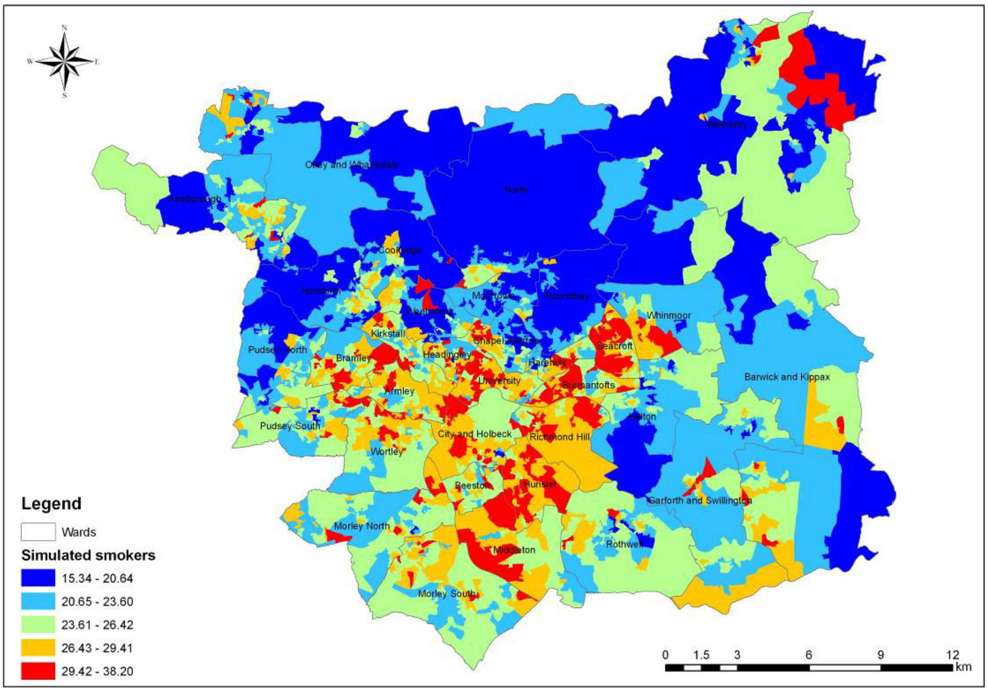

Fig. 1: Estimates of the smoking prevalence (%) for Leeds using the GHS 2006

The national or regional smoking rates are useful to have an insight into a countries' health status. However, such broad geographical scales can hide potential local variations in smoking rates. For instance, TOMINTZ et al. (2008) showed that geographical variations for smokers in Leeds exist. Therefore, applying a spatial microsimulation model is an appropriate method as different datasets and variables can be combined to model 'missing' information locally

There are various methodologies for building a spatial microsimulation model and these was summarized by BALLAS et al. (2005). Here, a static deterministic reweighting approach is applied where actual microdata are reweighted to best fit small area statistics. The results of the smoking prevalence for small areas in Leeds are shown in Fig. 1.

3.2 Location-Allocation Model

Location-allocation models are a tried and tested modelling technique for locating facilities in an optimal way given the location of demand (CHURCH, 2005). With such models it is possible to understand complex relationships between people and facilities and the variations over space and time. Here, the p-median model is used, where it is assumed that a person will be allocated to his/her nearest facility given the objective to minimise total travel costs or travel distance for all persons. Location-allocations models are created in ArcInfo based on (i) the estimated smokers from the microsimulation model for the demand item; (ii) the stop smoking services provided by the Leeds Primary Care Trust for the supply item and (iii) a road network which is used as the distance element. The p-median problem can be written as follows (CROMLEY & MC LAFFERTY, 2002): Objective function:

$$Minimize\ \ Z = \sum i \in I \sum j \in J\ a_i d_{ij} x_{ij} \quad (1)$$

Subject to the constraints:

An individual demand site must be assigned to a facility	$x_{ij} \leq x_{jj}$ for all (i, j)
Demand must be assigned to an open facility	$\Sigma_{jCJ\, xij} = 1$ for all i
Exactly p facilities must be located	$\Sigma_{jCJ\, xjj} = $ p for all j
All demand from an individual demand site is assigned to only one facility	$x_{ij} = (0, 1)$ for all (i, j)

Where:

- Z is the objective function (see equation 1)
- I is the set of demand areas and the subscript i is an index denoting a particular demand area
- J is the set of candidate facility sites and the subscript j is an index denoting a particular facility site
- a_i is the number of people at demand site i
- d_{ij} is the distance or time (travel cost) separating place i from candidate facility site j
- x_{ij} is 1 if demand at place i is assigned to a facility opened at site j or 0 if demand at place i is not assigned to that site
- p is the number of facilities to be located

4 *What-if* Scenarios

What-if scenarios are powerful ways to measure the impact of different influences. Here, the two methodologies, spatial microsimulation and location-allocation, are combined to form and explore various scenarios which are of interest to the health care planners in Leeds. One scenario, for instance, includes modelling optimal locations for current stop smoking services in comparison to existing ones for each day of the week, to explore how many smokers need to travel further than 5 kilometres to reach their nearest centre, the longest distance one needs to travel and the average distance (TOMINTZ et al., 2008). Further, how many smokers are assigned to a stop smoking centre can be estimated. Another possibility is to find best locations for additional stop smoking services to minimize the travel distance for smokers in the case where more money becomes available and more services can be opened. High on the policy agenda, and therefore interesting for the health care planners, is to target specific population groups (e.g. smokers in lower socio-economic groups or the young ones). Due to the power of spatial microsimulation it is possible to model specific groups of smokers. These results can then be implemented into the location-allocation model to investigate optimal locations for stop smoking services to target these groups specifically. The smoking ban should have a positive effect and reduce the smoking population over time. Therefore, another scenario includes measuring the impact of the smoking ban in Leeds based on evidence found elsewhere, in this case Ireland which was the first country to introduce the smoking ban.

5 Conclusion

It can be concluded that combining spatial microsimulation models and location-allocation models is valuable to support the future service provision of stop smoking services. Smokers can be targeted at the smallest geographical scale where otherwise no data is available. Due to the combination of both methods, spatial microsimulation and location-allocation models, different scenarios are created which are of interest for the Leeds health care planners who are responsible for locating stop smoking services. This should help to target smokers more effectively and help the planners reach their national target. Also population groups of interest can be targeted more easily which should help to narrow health inequalities which is also high on the policy agenda. The results are shown as maps (produced in ArcGIS) rather than numbers which is especially helpful for health care planners to interpret the results.

Acknowledgements

The research was financially supported by the White Rose Consortium through a Ph.D. course. Thanks to Prof. Graham Clarke and Dr. Jan Rigby for their support during the Ph.D. course.

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