Exploring relationships between cancer screening uptake and deprivation using Geographically Weighted Regression

Alistair Geddes[*1]

[1]Geography, Social Sciences, University of Dundee

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Summary

The UK is among several countries to have screening programmes for those at average risk of colorectal cancer (CRC) – however, persistent inequalities exist in programme uptake. This paper reports a cross-sectional study of the CRC screening programme in Scotland. Primary focus was on investigating spatial non-stationarity in the relationship between local screening uptake and area deprivation, using Geographically Weighted Regression (GWR). Model results provided evidence of non-stationarity, highlighting clusters of areas where the uptake-deprivation relationship departed from the typical relationship gradient. A distinctive aspect is the attention paid to assessing GWR model sensitivity to different bandwidth sizes and parameter specifications.

KEYWORDS: CRC screening, deprivation, local places, Geographically Weighted Regression

1. Introduction

Early screening for certain forms of cancer has potential to improve cancer survival and reduce related mortalities. Colorectal cancer (CRC) is one type of cancer for which screening is important and viable, and in several countries national population-based CRC screening programmes are either underway or being implemented. Persons aged 50 or older define the population at average risk of CRC invited to participate in routine, regular screening programmes. Most programmes also impose an upper age limit.

As with screening for other types of cancer, the success of CRC screening programmes depends on their level of uptake. Screening uptake is known to be contoured by peoples' view of their own health and lives, worries about cancers and risks associated with the screening process itself. In the UK CRC programmes, sample collection kits have been designed to be easy to use, and are issued and may be returned for analysis free of charge via the standard postal delivery system. These kits are issued to all age-eligible NHS-registered recipients, to their registered addresses, which the intention that they are completed at home.

Despite these efforts to ensure screening is afforded to all who are eligible, regardless of status, in reality, uptake of the CRC programmes operating in the UK is shown to be socially and spatially uneven. Studies (e.g. Steele et al., 2014) as well as programme performance indicators show uptake is lower for males than females, for younger than older people, and for persons living in deprived areas compared to other neighbourhoods. Going further, multi-level analysis results indicate that variations in screening uptake are principally explained by individual-level characteristics (e.g. Nnoaham et al., 2010) – however area deprivation is nonetheless significant and merits further attention.

The present study had the aim of increasing understanding of the geographical dimensions of CRC screening programmes. This was a cross-sectional study of uptake of the national CRC screening programme in Scotland. Analysis for the study comprised mapping CRC screening uptake levels across neighbourhoods and exploring relationships using regression techniques. An innovation was the application of Geographically Weighted Regression (GWR) (Fotheringham et al., 2000). GWR models were created to investigate whether relationships between CRC uptake levels and other local characteristics exhibited spatial non-stationarity.

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[*] a.y.geddes@dundee.ac.uk

2. Data and Methods

A dataset was obtained from the national Scottish CRC programme covering all people in Scotland aged 50-74 years invited for screening in the two-year period 01/01/2009 – 31/12/2011. The dataset included anonymised individual-level records along with various geographic identifiers, facilitating spatial aggregation of the records for local areas. Local CRC screening uptake levels were derived as proportions of all invitees per local area recorded returning their screening kit for analysis with six months. Return of the kit was taken alone to indicate participation, in the absence of other information. Local screening uptake levels were derived for different sets of local areas within the Scottish Neighbourhood Statistics framework, including Data Zones and Intermediate Zones. The original release of these geographies were used, with Data Zones dividing Scotland into approximately 6.5 thousand neighbourhoods (target population per Data Zone between 500-1000 people), compared to approximately 1.2 thousand Intermediate Zones (mean population of 4,000 residents).

To assess the relationship of local screening uptake levels to local deprivation, the Scottish Index of Multiple Deprivation (SIMD) was used. 'Multiple deprivation' refers to geographically-based composites of deprivation, and the SIMD was designed specifically to aid assessment of concentrations of deprivations within Data Zones, though data for some component dimensions are also available for other local area geographies, including Intermediate Zones. Both the overall SIMD score of neighbourhoods and their scores on individual component domains were considered in the models.

Other covariates were also included, to safeguard against model mis-specification and guided by other studies. The latter gave evidence notably of lower cancer screening uptake among ethnic minorities, therefore data on local levels of non-white ethnicity were included in the current analysis, obtained from the 2011 population census.

GWR has been used widely, including in other health research, though not to our knowledge applied previously to cancer screening. In essence GWR involves fitting a distance-weighted local model for all study locations of interest, namely Data Zones or Intermediate Zones in this case. Recent methodological studies have highlighted the need for closer attention to the choice of bandwidth size defining the number of neighbouring locations from which data are gathered for calibrating local models, before drawing conclusions from GWR models (e.g. Paez et al., 2011). Typically automated procedures are used, involving identifying a single most optimum bandwidth for all locations with a study area of interest, but reliance on automated procedures alone is also questionable. In the current study both manually and automatically chosen bandwidths were used, moreover for both standard GWR models and so-called 'semi-parametric' GWR models, the latter referring to models containing both potentially locally-varying and fixed 'global' parameters. This led to a much larger set of model results than is commonly the case, enabling exploration of sensitivity of model results to differences both in parameter specification and bandwidth size.

3. Results

Mapping indicated considerable variation in local CRC screening uptake levels, associated with spatial variations in area deprivation. Results from conventional regression models showed statistically significant inverse relationships between local CRC screening uptake and area deprivation, and between the former and local ethnic proportions, however with relatively strong spatial clustering among model residuals also evident.

GWR model results suggested existence of spatial non-stationarity in relationship between local screening uptake and area deprivation. Mapping the local model coefficients indicated clusters of places where the relationship between local screening uptake and area deprivation was distinctive – for example in neighbourhoods in the Glasgow city area in which the relationship appeared to be clearly different from other parts of west Scotland in terms of the steepness of its gradient.

Comparison of GWR results over different bandwidth sizes and for different model specifications provided insight into the scalar dimensions of non-stationarity. In most models where area deprivation was specified as locally-varying parameter, there was indeed support for the existence spatial non-stationarity in its relationship to screening uptake. However, this also depended on the bandwidth size used, with results at lowest bandwidth sizes including small numbers of neighbourhoods providing no

support for non-stationarity.

4. Discussion

The study provides additional evidence of inequalities of CRC screening uptake and identifies local areas where uptake was low. The subtext to the study is provided by questions of whether interventions aimed at increasing screening uptake should also be targeted geographically to particular places. The GWR models provide some evidence of clusters of local areas where the relationship between screening uptake and deprivation is distinctive and departs from the 'average', typical, relationship. The composition and characteristics of these clusters merit further scrutiny, though the results from the bandwidth investigations also suggest that such attention should not be focussed too narrowly, with the need also for additional attention to scale aspects of non-stationarity. On this note, an extension to the original study using the more recently-developed multi-scale GWR framework is currently in progress.

5. Acknowledgements

6. References

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7. Biography

Alistair Geddes is a Senior Lecturer in Geography at University of Dundee. His main interests are in social and socio-environmental applications of GIS and related spatial technologies and methodologies.