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Spatial variability in socio-demographic factors affecting participation in the Australian national bowel cancer screening program

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ABSTRACT

Objectives: The objective of this paper is to analyse the socio-demographic and spatial patterns associated with bowel cancer screening in Australia. Despite the importance of screening in reducing mortality via early intervention, it remains the case that overall screening rates are uneven between different socio-demographic groups and geographic regions. Notwithstanding this, there is limited knowledge in Australia regarding the interplay between socio-demographics and geography in relation to bowel cancer screening. Thus, this paper explores the socio-demographic and spatial patterns of screening participation across Australian regions to better inform public health policy and programs.

Study design: This is a nationwide ecological study based on aggregate spatial data.

Methods: An ecological study is conducted using bowel cancer screening rates and selected socio-demographic data measured at the Statistical Area 3 level. Geographically weighted regression software is used to conduct global and spatial regression analysis.

Results: The global regression results show that higher rates of screening participation were associated with employment/education disengagement and volunteering while in contrast, lower rates of participation were associated with higher rates of indigenous populations, people with chronic health conditions, and people with poor English skills. Considering the spatial analysis, the analysis shows that once the spatial non-stationarity in the data is considered the influence of the variables shown to be significant in the global model, has significant spatial variability.

Conclusion: From a public health perspective, addressing shortfalls in bowel cancer screening participation is an important priority. In order to understand differences in participation rates it is important to consider both socio-demographic factors as well as the geographic or spatial distribution of these factors.

1. Introduction

Bowel cancer is a significant public health concern in Australia, and early detection through screening programs is crucial for improving patient outcomes [1]. The Australian National Bowel Cancer Screening Program has been implemented as a vital tool for early diagnosis and intervention. The program involves the delivery, via mail, of a faecal sample collection kit, which once completed is returned to a pathology lab. Despite the program's importance, there are substantial disparities in the uptake of screening across the country [2]. Understanding the socioeconomic and demographic factors that influence participation in the program and their spatial variability is essential for developing targeted strategies to increase screening rates and reduce health inequalities [3]. Notwithstanding this, there is limited knowledge in Australia regarding the interplay between socio-demographics and geography in relation to bowel cancer screening. Thus, this paper explores the socio-demographic and spatial patterns of screening participation across Australian regions to better inform public health policy and programs.

2. Methods

2.1. Study design

An ecological analysis of the spatial distribution of bowel cancer screening participation was undertaken using the 2021 Australian Bureau of Statistics SA3 regions. Statistical Area 3 (SA3) regions are aggregate geographic regions intended to represent the functional zones of regional towns and cities or groups of interconnected suburbs around commercial or transport hubs within large urban areas [4]. The analysis

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examined the relationship between the rate of bowel cancer screening and a range of socio-demographic variables.

2.2. Data sources and measures

The geographically linked dataset used in this paper was derived using the QGIS software (https://www.qgis.org/en/site/). The dependent variable was the rate of participation in the Australian national bowel cancer screening program. The data was obtained from the Australian Institute of Health and Welfare and measures the participation rate of all men and women aged between 50 and 75 who were invited to take part in the screening program between 2018 and 2020. The socio-demographic variables were chosen with reference to data availability and within the context of the existing conceptual and empirical research [5–9]. All the independent variables were obtained from the Australian Bureau of Statistics 2021 Census of Population and Housing. All variables were measured at the Statistical Area 3 level. The socio-demographic variables included:

- % With chronic health conditions
- % With poor English skills
- % Not engaged in education or employment (work/employment disengagement)
- % Who volunteer regularly
- % Indigenous population

2.3. Data analysis

The main analysis was performed using the Multi-Scale Geographically Weighted Regression software downloaded from the School of Geographical Sciences and Urban Planning at Arizona State University (https://sgsup.asu.edu/sparc/multiscale-gwr). The analysis uses the geographically weighted regression (GWR) functionality within the software to construct Gaussian regression equations using the dependent and independent variables listed above. In traditional regression models, the relationship between the independent and dependent variables is assumed to be constant across all observations. However, in many cases, there may be a spatial relationship between the observations, such that the strength and direction of the relationship between the predictors and the dependent variable vary based on the location of the observations. In these cases, geographically weighted regression is used to analyse the relationship between a dependent variable and one or more independent variables while considering the spatial or geographic relationships among the data points. The GWR software estimates and evaluates local models by fitting a regression equation to every feature (in this case each SA3) in the dataset. It constructs these separate equations by incorporating the dependent and independent variables of the features falling within the neighbourhood of each target feature. The output from GWR includes estimates and fit statistics for a global model, together with local estimates and fit statistics for each separate feature.

3. Results

Overall, 43.8% of people invited to participate in the bowel cancer screening program completed the required faecal sample collection and returned the kit for pathology testing. The global regression results (Table 1 in Supplementary Material) show that ignoring any impact of spatial non-stationarity, higher rates of screening participation were associated with employment/education disengagement and volunteering while in contrast, lower rates of participation were associated with higher rates of indigenous populations, people with chronic health conditions, and people with poor English skills.

The geographically weighted regression provided an improved model with a higher R^2 and AIC (Tables 1 and 3 in Supplementary Material), with tests for spatial variability being significant (Table 3 in Supplementary Material). All the variables included in the model were significant on the Monte-Carlo test for spatial variability (Table 2 in Supplementary Material).

The results from the geographically weighted regression are presented in map form in Fig. 1. Each choropleth map contains the distribution of the locally estimated coefficients. Where the local coefficients are all positive (% Not engaged in education or employment, % Who volunteer regularly) the mapping scale is presented as gradations in red from the highest coefficient (dark red) to the lowest (pale red). For negative coefficients (% With chronic health conditions, % With poor English skills, % Indigenous population), the gradient is presented in blue from highest (dark blue) to lowest (light blue). Where the coefficients range across positive and negative values, as in the case of the intercept, the gradient is presented across a blue-to-red scale.

Considering the spatial distribution of the local parameter estimates, the analysis shows that once the spatial non-stationarity in the data is considered the influence of the variables shown to be significant in the global model, has significant spatial variability. Put simply, clusters of regions exist across Australia whereby the presence of a given socio-demographic profile will have differing impacts on the rate of bowel cancer screening.

4. Discussion

Despite the recognised importance of early detection, the success of the Australian National Bowel Cancer Screening program has been hindered by low rates of participation. Significantly, the results from the regressions undertaken illustrate that while a range of socio-demographic factors may be important in understanding differences in participation, it is also the case that the impact of these factors reflects widespread spatial heterogeneity in the relationship with screening rates.

This spatial heterogeneity suggests that public health programs designed to increase program participation may be wise to move beyond a simple focus only on socio-demographic factors by also focusing on the way these factors may be spatially concentrated. That is, it may be wise to question whether an approach that focuses on socio-demographic groups (such as indigenous people or low-income people) regardless of their geographic location is the most efficient approach, or whether approaches that are tailor-made to consider the socio-geographic patterns of participation (i.e account for both socio-demographic factors and geography) maybe more effective at lifting participation rates. This debate between people-based and place-based policy interventions has been an important part of regional economic development planning, with proponents arguing that the most likely 'best solution' will be a mixture of both, tailored to meet the particular situation [10].

The findings of the paper need to be considered in the context of certain limitations. Firstly, as the analysis present is an ecological study care must be taken not to equate aggregate outcomes to individual outcomes (ecological fallacy) [6]. Secondly, the results and their interpretation are limited by the Modifiable Area Unit Problem [11]. The unit of measurement chosen for this analysis was the Statistical Area 3, however, it is possible that a finer level of aggregation would have resulted in different statistical and spatial patterns.

From a public health perspective, addressing shortfalls in bowel cancer screening participation is an important priority. However, as the findings of this paper suggest, understanding uneven participation rates is dependent on uncovering both the socio-demographic drivers as well as the geographic or spatial factors. As such, it would be prudent to consider approaches that both improved access to screening services, especially in regions with low participation and targeted education or information campaigns focusing on target demographic groups.

Notes

The study design for this research utilised spatially aggregated

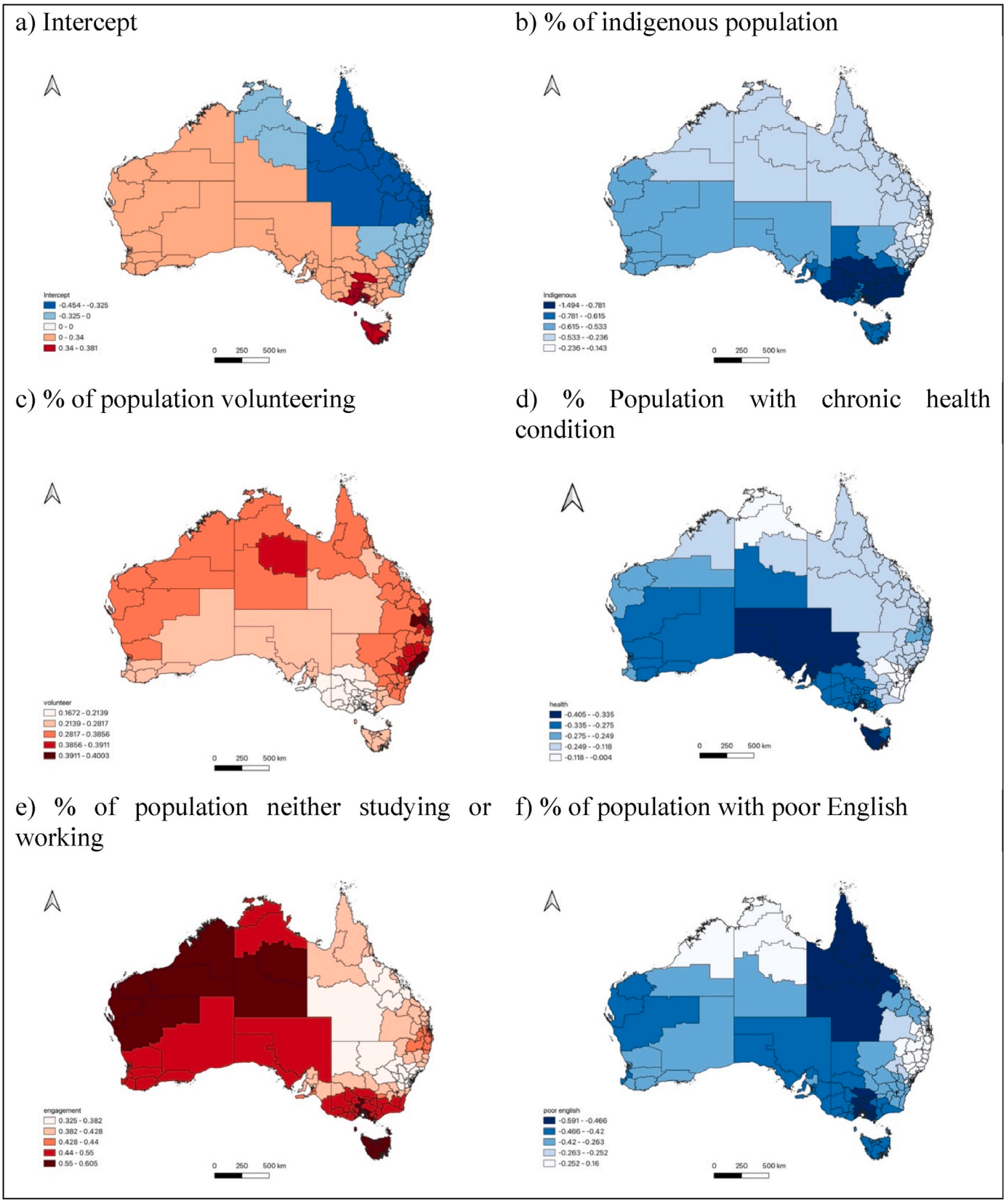

Fig. 1. Spatial distribution of the local parameter estimates for the independent variables.

administrative data sets and consequently did not require ethics approval.

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The author has not identified competing interests.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.puhip.2023.100452.

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