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The impact of car ownership and public transport usage on cancer screening coverage: Empirical evidence using a spatial analysis in England

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ABSTRACT

A spatial analysis has been conducted in England, with the aim to examine the impact of car ownership and public transport usage on breast and cervical cancer screening coverage. District-level cancer screening coverage data (in proportions) and UK census data have been collected and linked. Their effects on cancer screening coverage were modelled by using both non-spatial and spatial models to control for spatial correlation.

Significant spatial correlation has been observed and thus spatial model is preferred. It is found that increased car ownership is significantly associated with improved breast and cervical cancer screening coverage. Public transport usage is inversely associated with breast cancer screening coverage; but positively associated with cervical cancer screening. An area with higher median age is associated with higher screening coverage. The effects of other socio-economic factors such as deprivation and economic activity have also been explored with expected results. Some regional differences have been observed, possibly due to unobserved factors.

Relevant transport and public health policies are thus required for improved coverage. While restricting access to cars may lead to various benefits in public health, it may also result in worse cancer screening uptake. It is thus recommended that careful consideration should be taken before implementing policy interventions.

1. Introduction

Screening is an important tool to detect cancer at early stage and is estimated to save thousands of lives in England every year (Public Health Outcomes Framework, 2014). While the benefit of screening is significant, there are various barriers preventing people attending the screening; and thus the screening uptake can differ significantly from one area to another.

A number of factors have been identified to have an impact on screening uptake in previous studies, such as deprivation (measured by employment, car ownership, and accommodation arrangement) and distance to screening locations (Maheswaran et al., 2006). The latter is often viewed as a part of broader spatial or geographic accessibility issue (Neutens, 2015), which this paper sought to focus on. There are some empirical evidence on the effect of spatial accessibility on screening. For instance Dai (2010) found that living far to the clinics would discourage women to attend mammography screening in Detroit, USA. However it is interesting to note that once other socio-economic factors were controlled for, such as median income, geographic access would become less statistically significant or insignificant. Similarly, Vallee et al. (2010) found that geographic access measured by density of general practitioners and gynaecologists within an area has little impact on cervical screening overall after average income was adjusted in France. Focusing on colorectal cancer screening in the USA, Mobley et al. (2010) found better geographic access measured by distance to closest facility is associated with poorer screening in 12 states while improved screening in 19 states, after adjusting area-wide deprivation. Thus their results are mixed. A recent study by Henry et al. (2013) found that geographic access which was measured by both the number of mammography facilities and travel time was not associated with late-stage diagnosis after adjusting deprivation in 10 states in the USA. Their study did not look at the effect of car ownership, and thus it is probably the access to cars play an important role, considering there is usually strong correlation between car ownership and deprivation.

There are also evidence on the impact of geographic access from other screening types other than cancer. For instance, Cullinan et al. (2012) found that increased travel distance to screening hospital site could reduce screening uptake rates for gestational diabetes mellitus in Ireland, even deprivation has been adjusted. This finding is however not fully consistent with other studies on cancer screening (which requires long term commitment), as most previous studies discussed above seem to suggest that geographic access measured by travel distance or time has little impact on screening attendance once other socio-economic factors such as deprivation were controlled for. This

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indicates that, for cancer screenings, it may not be the travel time or distance in itself but other factors that play a role in screening uptake.

Indeed, most previous studies on geographic access and health care rely on travel time or distance based method to measure geographic access (Neutens, 2015). However, geographic access in general does not only concern travel time or distance. From transport point of view, mode of travel, i.e. how people travel, should also be considered, as it can affect the travel experience from one spatial location to another. For example, as argued by Neutens (2015), a person taking public transport for long commuting should not necessarily be considered willing to travel in long distance to explore health care opportunities if the person does not have access to a car in rural areas. This suggests that it is important to consider transport modes that are available to people when one looks at geographic access to health care facilities, such as cancer screening. Car ownership is typically correlated with level of deprivation, and considering the fact that previous studies often found geographic access has little effect on cancer screening after accounting for deprivation and even health insurance status, transport mode availability can be an important factor.

There however seems to be a dearth of literature on the effect of different transport modes on the cancer screening uptake. In particular, how access to private cars and public transport may play a role in cancer screening coverage is less studied. One exception is a study by Woolley et al. (2007) who reported that car accounts for around 59.9–75.4% among those who attend cervical screening while bus only accounts for 7.1–15.1% in parts of the United Kingdom. However, such and similar studies (e.g. Frew et al. (1999), who reported that 80.5% travelled by car, followed by 9.2% by bus) primarily focus on estimating the *costs* of transport among those *attendees*; and while costs may indeed have an impact, it does not offer further insights on which transport mode (e.g. car, bus) is preferred by those who were invited to attend screening, and subsequently how the choice/availability of different transport modes can affect cancer screening uptake. Coughlin and King (2010) looked at the impact of commuting time to work as well as the use of public transport on breast and cervical cancer screening, at the county-level in the USA. They found that no significant association is observed between breast/cervical cancer screening and either the use of public transport or access to a car. However, the transport and health settings in the USA may be considerably different than Europe, and there seems to have been limited evidence from Europe. With the exception such as Coughlin and King (2010), previous studies are mainly based on individual level data, and as such they did not control for area level "system-wide effects". An aggregate area-wide analysis is vital to understand what factors are associated screening uptake rate, partially because it could be difficult to obtain detailed data from those women who ignore the invitation letters in the case of an individual level analysis. In addition, an area-wide analysis enable us to examine the spatial pattern across the whole country, instead of having to focus on groups of people from a limited number of areas as often in the previous individual-level analyses due to higher cost.

An area-wide analysis is also essential to avoid the atomistic fallacy which refers to the fallacy of drawing inferences at aggregate level based on individual level data (Diez-Roux, 1998). For example, a person's travel behaviour does not only depend on the characteristics of the individual, but also on the culture and general travel behaviour of the local community (e.g. carpooling, use of services such as Uber so a person could travel in a private car they do not own, local people's general attitude towards screening), local crime rate, and relevant transport and health care policies in a local authority. Also regional differences (e.g. London vs. other regions in England) may also have an impact and should be controlled for. Such complex spatial variations could be controlled for by a spatial analysis using an aggregate area-wide level data. Finally, previous studies are also typically based on data with relatively small scale, in terms of number of participants and locations, and as such sample bias may occur.

The objective of this paper is to explore the impact of car ownership and public transport on cancer screening uptake by employing a spatial analysis within England, while controlling for ethnicity, age profile and other relevant socio-economic factors. It is believed that this paper contributes to the literature in the broad area of transport modes and health care access which tends to be less studied. It adds to the debate regarding what role car or public transport has in public health. The rest of the paper is organised as follows: firstly, the data and statistical methods are described; it is then followed by the modelling results and discussion. Finally, conclusion is drawn and future research direction is offered.

2. Materials and methods

2.1. Data description

The study area covers all district-level areas (e.g. districts, London Boroughs, unitary authorities) in England. Data on cancer screening coverage and related socio-economic factors are made available at district level. There are currently 326 districts in England, with population ranging from 2203 (Isles of Scilly) to more than a million (Birmingham) according to the Census 2011 data.

There are primarily two sources of data employed in this study. The UK government publishes data on key public health indicators through Public Health Outcomes Framework (2014). The data obtained include the coverage (take-up rate) of cervical and breast cancers, which are the main subjects to be examined in this paper. Women who are registered with a general practitioner (GP) are invited to attend screening in their local screening unit. For breast cancer, women are typically screened every three years; and for cervical cancer, they are screened every three or five years depending on their age in England. Screening coverage is measured by the proportion of people in an area eligible for screening and are screened adequately. In order to ensure the data are consistent with other sources of data such as UK Census 2011 as described below, cervical and breast cancer coverage data for the year 2011 have been used. In addition to cancer screening coverage, fuel poverty (measured by "the percentage of households in an area that experience fuel poverty" – a household was defined as fuel poor where they are on "low income" but require "high costs" of fuel) has also been extracted and controlled for in the following analysis. Fig. 1 shows the spatial distribution of breast and cervical cancer screening coverage in England:

Car ownership, public transport usage, and other relevant socio-economic factors that may affect the cancer screening uptake are obtained from the *UK Census 2011*. The census data contain various useful socio-economic data, such as household car ownership, the usual transport mode for travel to work, economic activity, ethnicity, age, and level of deprivation. These socio-economic factors are hypothesised as potential influencing confounding factors on cancer screening uptake. In the census, a household is defined as "deprived" if they meet one of the following characteristics: employment (any member of a household, who is not a full-time student, is either unemployed or long-term sick); education (low qualification and no person aged 16–18 is a full-time student); health and disability (any person in the household has general health that is 'bad' or 'very bad' or has a long term health problem); and housing (overcrowded or no central heating). A person aged 16 to 74 is considered as economic active if the person was working or looking for work in the week before census. The proportion of people travelling to work by public transport (i.e. underground/metro/light rail/tram, train, bus/minibus/coach - the census data contains mode share for each district) is commonly used as a proxy for public transport usage in the literature (e.g. Wang et al. (2014)), and as such it has been employed in this paper. However it should be noted that consequently travel information regarding some minority of women, e.g. young women and those who are not employed or work at home, has not been covered in this variable. This may less be an issue in this study since those who are invited for cancer screening are required to be