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Using Geographic Information Systems to investigate variations in accessibility to ‘extended hours’ primary health care provision

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Abstract

There are on-going policy concerns surrounding the difficulty in obtaining timely appointments to primary health care services and the potential impact on, for example, attendance at accident and emergency services and potential health outcomes. Using the case study of potential access to primary health care services in Wales, Geographic Information System (GIS)-based tools that permit a consideration of population-to-provider ratios over space are used to examine variations in geographical accessibility to GP surgeries offering appointment times outside of ‘core’ operating hours. Correlation analysis is used to explore the association of accessibility scores with potential demand for such services using UK Population Census data. Unlike the situation in England, there is a tendency for accessibility to those surgeries offering ‘extended’ hours of appointment times to be better for more deprived census areas in Wales. However, accessibility to surgeries offering appointments in the evening were associated with lower levels of working age population classed as ‘economically active’; i.e. those who could be targeted beneficiaries of policies geared towards ‘extended’ appointment hours provision. Such models have the potential to identify spatial mismatches of different facets of primary health care, such as ‘extended’ hours provision available at GP surgeries, and are worthy of further investigation, especially in relation to policies targeted at particular demographic groups.

Keywords: Primary health care; General Practitioners; Extended hours of provision; Spatial Accessibility; Two step floating catchment area (2SFCA) models

What is known about this topic

- Access to primary care needs to be considered in relation to other aspects of health provision
- GIS has been used to examine variations in geographical access to primary health care
- Recent UK Governments have emphasised the need for extended hours of provision for GP appointments

What this paper adds

- Network-based accessibility maps highlight the current state of extended hours provision in Wales
- This analysis can be used to compare provision for those groups who could typically avail themselves of such provision in evenings and at weekends
- These tools should inform future policy concerning the collaborative delivery of services and the exact choice of surgeries or hubs selected for extended access provision

1. Introduction

Timely access to primary health care services has been identified in a number of studies as a contributory factor influencing patient decisions to self-refer to secondary care (Flores-Mateo et al., 2012; Huntley et al., 2014; Kraajvanger et al., 2016). Poorer in-hours access, measured as the ease of getting through on the telephone, ability to see a preferred general practitioner (GP), ability to get a routine appointment, and convenience of surgery opening hours, has also been associated with an increased use of out-of-hours primary care services (Zhou et al., 2014) and a greater likelihood of both hospital admission and accident and emergency (A&E) attendance (O'Malley et al., 2013). With regard to the latter, in England in 2012-13 it was estimated that a quarter of A&E attendances (amounting to 5.8 million patients) were made by persons who had failed to obtain a convenient appointment with their GP (Cowling et al., 2014). Similarly, 7-day GP surgery opening has been shown to reduce attendance at A&E departments by 9.9% overall and by 17.9% at weekends in pilot surgeries (Dolton and Pathania, 2016).

The General Medical Services (GMS) contract, a UK-wide contract between the majority of GP surgeries and the NHS organisations in each of the respective countries (i.e. England, Wales, Scotland, and Northern Ireland), stipulates the form of primary care services delivered to patients (these are replaced by locally negotiated contracts in just over a third of surgeries in England where service provision is geared towards meeting local needs: House of Commons Library, 2018). As of March 2017, the GMS contract stipulates that the opening hours of GP surgeries (Monday through Friday) are in place from 8am to 6.30pm (so called '*core*' hours), excluding Bank Holidays. However, some surgeries may not be open throughout these hours nor necessarily offer the opportunity to make appointments within these hours – for example, a recent report by the National Audit Office found 46% of surgeries in England were closed at some point during these core hours (National Audit Office [NAO], 2017).

In England and Wales, there has been a policy impetus to extend the opening hours available for appointments. In England, for example, a number of NHS initiatives such as the *GP Access Fund* (providing monies across two waves to help improve access to general practice) and the *GP Forward View* (a five year plan for general practice published in April 2016) aim to ensure that by 2020 ‘everyone has access to GP services, including sufficient routine appointments at evenings and weekends to meet locally determined demand, alongside effective access to out-of-hours (OoH) and urgent care services’ (NHS England, 2016, p. 47). There is also a widening evidence base concerning extended access schemes and potential impacts on A&E attendance.

Recent studies have involved both regional (e.g. Greater Manchester evaluation; NIHR CLAHRC, 2015; Whittaker et al., 2016) and national (England) evaluations of moves towards extended hours provision (Mott MacDonald and SQW, 2016). The latter study involved an evaluation of the early impacts of the Access Fund programme and included an appraisal of those objectives geared towards providing additional extended hours of GP appointment time, changes in appointments during core operating hours through, for example, collaborative working across surgeries, and the impacts on reducing demand elsewhere in the system. However, nationally there remain concerns with regards to booking appointments outside of ‘normal’ working hours: 10% of patients registered in England live in areas where there is no evening or weekend access (BBC, 2018a), and only a quarter of GP surgeries in Wales offer appointments up to 6.30pm twice a week (BBC, 2018b).

Research that explores the geographical availability of primary care provision, as part of wider studies of the effectiveness of extended access to primary care services for improving health outcomes or reducing inappropriate attendance at other health services, is particularly timely. The political fallout in the lead-up to the June 2017 UK General Election between those who advocate that GP surgeries in the UK should be offering patients same day, emergency access appointments in order to alleviate pressures on NHS departments and those groups who

question the clinical and cost effectiveness of extended operating hours, has drawn attention to the need for more research on potential inequalities in primary care provision. However, despite concerns regarding a shortage of GPs in the UK, few UK-based studies have investigated detailed patterns of GP availability in relation to potential demand in order to identify any spatial mismatches between provision and needs.

Geographical Information Systems (GIS) are increasingly being used to examine potential inequity in levels of accessibility to primary care services (DeWulf et al., 2013; Higgs et al., 2017; Yang et al., 2006), and associations with neighbourhood demographic characteristics (Hyndman and Holman, 2001; Bissonnette et al., 2012; Ye and Kim, 2015). Previous studies have also shown, for example, how different GIS-based metrics can be used to understand the potential contribution of physical access to primary care on the use of emergency departments for different medical conditions (Teach et al., 2006; Ludwick et al., 2009; Fishman et al., forthcoming). In Wales, there is currently a lack of understanding of existing spatial patterns in extended hours provision; information that could inform whether and where a targeted extended hours service could be located. Thus, drawing on GIS-based techniques, this study has two principal aims: firstly to explore the extent of spatial variation in levels of accessibility to GP surgeries that offer 'extended' hours of appointment times in Wales, UK; and secondly to analyse associations between the provision of extended hours access and area-based social deprivation indices and socio-economic measures. In spite of claims of a postcode lottery of patient appointment availability in England (Torjesen, 2014), trends in geographical accessibility to GP surgeries with varying opening hours (and appointment time availability) have not been investigated in the UK in relation to potential proxies for, or actual measures of, demand for primary care services. In redressing this, the current study seeks to demonstrate how GIS can be used to investigate spatial patterns in access to free at the point of use health services in the UK, and how such techniques could enable health planners to identify those

areas where different facets of primary care provision, such as the availability of extended hours provision, needs to be enhanced given spatial variations in the socio-economic characteristics of residents.

2. Using GIS methods for measuring accessibility to healthcare

Access to health care has been hypothesised to be comprised of five dimensions; availability, accessibility, affordability, acceptability and accommodation – each of which is comprised of spatial and non-spatial factors that impact on the overall ability of individuals to access services (Penchansky and Thomas, 1981). In the context of the present study, *availability* refers to the existence (or otherwise) of primary care services that could potentially be available to patients; *accessibility* refers to the ease in which patients can use such services, which in turn is influenced by the distance between the location of the patient and these services and the time it takes the patient to reach them; and *accommodation*, which can relate to system level factors such as the opening hours of GP surgeries that impact on the ability of primary care organisations to accept patients (Higgs, 2004).

Boyle et al. (2010) have drawn attention to definitional issues and concerns surrounding the measurement of different elements of accessibility and the need to consider a ‘multi-dimensional framework’ for access. Their so-called domains of access – *physical access*, *timely access* and *choice* – which they define using 12 measures to explore variations across GP surgeries, include many that have an explicitly geographical dimension. However, they also consider a wider set of indicators of access, such as satisfaction with telephone/email access, waiting times, surgery design for physical ease of access and ability to consult with a preferred GP, which go beyond the types of considerations included in the present study but which provide a fuller picture of overall access to primary health care. Our primary concern here is

with the elements of accessibility that have a geographical focus and particularly with the use of innovative methods that utilise detailed digital datasets to analyse the possible impact of such factors on potential accessibility.

GIS-based tools including those that incorporate travel distance and time between population weighted centroids of census tracts and the nearest health facility (*proximity measures*) are commonly used to investigate spatial factors as part of wider studies of potential inequities in accessibility. These have been used in conjunction with data on non-spatial factors, such as income, health care needs and demographic characteristics that impact on the use of health services, to investigate socio-spatial inequalities in access to health facilities (Wang and Luo, 2005). The indicator most commonly used to measure potential accessibility is the physician-to-population ratio (a so-called *container-based* approach) calculated for administrative or census tracts, but this is problematic particularly where spatial units are small in area (ignoring likely cross boundary flows) or where there are wide variations in accessibility *within* such areas (Luo and Wang, 2003, Daly et al., forthcoming). Thus, the number of GPs per head of population in a census or administrative tract, although a simple access measure to calculate, is limited both with regard to the choice of GP supply measure and the population denominator used and the lack of consideration of movement of people across such artificially constructed boundaries (Neutens, 2015; Todd et al., 2015).

Recent developments in spatial accessibility methods, in the form of two-step floating catchment area (2SFCA) techniques and more recent iterations such as Enhanced 2SFCA (E2SFCA) formulations, permit the calculation of a single measure that accounts for the interaction between service supply capacity and potential demand volume within a designated travel time (or distance) threshold (Luo and Qi, 2009). Such floating catchment area (FCA) tools are increasingly being used in different health contexts to investigate variations in access to a wide range of health services such as GP surgeries (Bauer et al., 2018; Tang et al., 2017),

hospitals (Mao and Nekorchuk, 2013; Nakamura et al., 2017), and cancer screening services (Dai, 2010). However, to our knowledge, no study to date has adopted these approaches to investigate spatial variations in accessibility to GP surgeries that offer appointment times outside of ‘core’ hours. The most recent profile of primary care services in Wales has found that overall numbers of GP surgeries are declining, but that there are more GPs per surgery (Welsh Government, 2018). A particular strength of the approach taken in this study is that the supply-side variable (i.e. the number of GPs in each surgery) is incorporated into the FCA calculations. By simultaneously considering the spatial interaction between GP provision at surgeries offering appointment times outside of these ‘core’ provision hours, and potential demand for such services for particular population groups, mediated by the potential impact of distance or travel time separation, FCA methods can provide a more realistic appraisal of spatial accessibility to primary care services and their characteristics.

3. Data and Methods

3.1 GP opening hours and appointment times

This study draws on data released in February 2016 on opening hours and appointment times for 453 GP surgeries (excluding branch surgeries) in Wales (Welsh Government, 2016a). The Welsh Government began collecting management data on the ‘opening hours’ (defined as the times the surgery door is physically open and a patient can talk face-to-face to a receptionist) for every GP surgery in 2010 and data on GP ‘appointment times’ (times when the surgery offers patients consultation sessions with their GPs) in 2012. Data is collected for each of the seven health boards in Wales on the percentage of weekly core hours each surgery is open (where 100% represents the core opening hours of 52 hours and 30 minutes). In 2015, 45%

(206 surgeries) were open for 100% or more of the weekly total hours with only 4% (20 surgeries) with half day closures (closing before 2pm on one or more days a week).

The primary focus of this study is the extent to which core and extended hours primary care provision is available in Wales. Drawing on this database, surgery locations and characteristics were extracted for those surgeries offering GP appointments at least two weekday mornings before 8.30am, at least one day a week after 6.30pm (extended appointment hours), and at least two weekdays between 5pm and 5.30pm (core appointment hours). Appointments available between 5pm and 5.30pm were used to proxy for 'core' hours because, overall, 97% of GP surgeries offered appointments during this period (as of November 2015), and because the choice of appointment hours available for study was restricted by the Welsh Government database. Comparably, only 16% of surgeries offered appointments before 8.30am on at least two weekdays, whilst only 8% had extended opening hours and offered appointments after 6.30pm on at least one weekday. There was only one surgery in Wales that, as of March 2017, offered appointments on a Saturday and only two that, as of November 2015, offered appointments on alternative Saturdays (Welsh Government, 2016a). These surgeries were omitted from the current analysis.

3.2 FCA-derived accessibility scores

Alternative 2SFCA scores were calculated for each of the specified appointment time periods (i.e. before 8.30am, between 5pm and 5.30pm, and after 6.30pm) to demonstrate the utility of such tools to measure accessibility to GP surgeries with different core and extended hours of provision. The FCA accessibility analysis is implemented in two steps and computes a supply-to-demand ratio; a metric which should be familiar to those charged with estimating levels of provision of health services using administrative boundaries within 'traditional' approaches. In

this approach however the ratio is computed using a ‘floating catchment’ which, whilst acknowledging that there is a limit on how far patients travel to access health facilities, also recognises that those surgeries closer to a patients’ home within the catchment are more likely to be used than those towards the periphery, i.e. there is a distance-decay effect which weights points within the catchment based on geographical proximity. A detailed rationale and description of each stage is provided in Langford et al. (2018). In summary, the first step involves implementing a floating catchment around each surgery and calculating a GP supply to population ratio for each surgery based on a 15- minute travel time catchment area (i.e. an area equivalent to a 15-minute journey by car based on non-congestion predicted travel speeds). In this instance population demand is aggregated to lower super output area (LSOA) population-weighted centroids (of which there are 1,909 in Wales). In this example, the number of GPs at each surgery was used to compute the GP to weighted population ratio based on a linear distance-decay function. In the second step, an equivalent catchment area (i.e. 15-minutes by car) was placed around each of the LSOA population-weighted centroids and a weighted sum of GP to population ratios calculated based on all GP surgeries that fell within this arbitrary threshold. The overall FCA score therefore reflects the proportional share of GPs based at surgeries located within a reasonable travel time or distance from patient demand locations (summarised at LSOA population-weighted centroids). Travel times and catchment areas between population demand locations and GP surgery sites in Wales were computed using a detailed open-source road network dataset (OS Open Roads™). All analysis was performed using an E2SFCA plug-in developed using the Network Analyst tool in ArcMap™

10.3 (REFERENCE TO FOLLOW).

3.3 Data analysis

Three strands were used in the current analysis. First, choropleth maps were used to visually highlight spatial variations in GP accessibility in terms of both core hours (using the example of appointments available between 5pm and 5.30pm) and extended appointments available before 8.30am and after 6.30pm. Second, associations between surgery characteristics (i.e. patient numbers and patient to GP ratios) and total core hours of provision were examined using correlation analysis. In England, a comparison of those surgeries with extended weekday or weekend hours with those that remained open for fewer hours, revealed that the former tended to be larger, have a higher proportion of clinical staff who are not GPs, and serve less-deprived urban areas with a younger patient profile (NAO, 2017). In the present study, in the absence of detailed data on patient characteristics, length of core hours was also compared to levels of deprivation based upon the ranking of the 2014 version of the Welsh Index of Multiple Deprivation (WIMD-2014), the income sub-domain of WIMD-2014 (WIMD-income), and the Townsend Index of the LSOA in which the surgery is located. As neither data pertaining to core hours nor number of registered patients were normally distributed, Spearman's rank-order correlations were preferred. A similar analysis was also undertaken to examine the geographical distribution of the subset of surgeries with appointment hours after 6.30pm in relation to area deprivation. In this instance, surgeries not open after 6.30pm were not normally distributed in terms of WIMD-2014, therefore Mann-Whitney U tests were performed due to the ordinal nature of the data. Third, relationships were examined at LSOA level between FCA-derived accessibility scores for surgeries with different 'core' and 'extended' hours of provision and indicators of deprivation, poor health, and socio-economic status (see Table 1 for a breakdown of measures). The purpose here is to test for potential associations between accessibility scores and a subset of census variables at the LSOA level in order to identify whether GP surgeries offering extended hours provision are accessible to targeted groups such

as those in employment and to identify any inequalities in provision. All statistical analysis was undertaken using SPSS version 23.

[INSERT TABLE 1 ABOUT HERE]

4. Results

4.1 Spatial variations in GP access based on ‘core’ and ‘extended’ hours of provision

Figures 1-3 show GP surgery locations and variations in accessibility scores classified by quintiles for access to main surgeries offering appointments within core (i.e. between 5pm and 5.30pm) and extended (i.e. before 8.30am and after 6.30pm) hours of provision. In these maps the darker the shading the better the relative accessibility to surgeries offering appointments within these time slots. The areas with no shading currently have no access to main surgeries offering appointments within the modelled travel time threshold. As is evident from Figure 1, most LSOAs have some level of access to a GP surgery offering appointments during core hours. Here most GP surgeries can be found near major urban areas in both north-west and south-east Wales. However, despite greater numbers of available GPs within these areas, overall levels of access based on FCA calculations are generally lower. This is likely due to surgeries residing in or around more densely populated LSOAs where higher potential competition for services leads to lower overall levels of access. For similar reasons, some LSOAs in rural mid-Wales exhibit high FCA scores because they are in close proximity to a GP surgery and experience little competition for their services from neighbouring population centres. In comparison, Figures 2 and 3 show levels of access to surgeries offering extended hours of provision. What is striking here is the number of LSOAs estimated as having no access within the given travel time threshold. Moreover, whilst a number of GP surgeries in both north and south Wales offer appointments before 8.30am, only surgeries operating in the south offer appointments after 6.30pm.

[INSERT FIGURES 1 TO 3 ABOUT HERE]

4.2 GP surgery characteristics and ‘core’ and ‘extended’ hours of provision

Table 2 provides a summary of the key characteristics of surgeries with varying ‘core’ and ‘extended’ hours of provision, as well as the average deprivation level of the areas in which these surgeries are located. There is some evidence to suggest that, on average, surgeries offering appointment times before 8.30am and/or after 6.30pm (‘extended’ provision hours) tend to be larger, indicated by both average list size and GP numbers, than those surgeries offering appointments between 5pm and 5.30pm (representing ‘core’ provision hours). Comparisons across deprivation gradients were less distinctive however: relative to ‘core’ provision, surgeries offering extended appointment hours were situated in less deprived areas according to mean WIMD-2014 and Townsend deprivation measures. However, these mean differences in deprivation level were marginal and even less so when median Townsend scores were preferred. In addition, Spearman rank-order correlation coefficients, not included in Table 2, indicated a positive association between number of core hours and number of registered patients at individual surgery level ($Rho = 0.106$, $p=0.024$), suggesting core hours are longer when patient numbers are greater. Overall, the average number of registered patients per GP in Wales in September 2015 was 1596. However, no significant correlation was identified between number of core hours and registered patient-GP ratio ($Rho = -0.046$, $p=0.328$). Similarly, no relationship was apparent between number of core hours and either WIMD-2014 ($Rho = -0.03$, $p=0.523$), WIMD-income ($Rho = -0.017$, $p=0.724$), or Townsend ($Rho = -0.033$, $p=0.485$) deprivation measures, suggesting an even spread of surgeries offering longer core hours. The same was true regarding surgeries with appointment hours after 6.30pm ($n=37$), with no significant associations identified with either WIMD-2014 or WIMD-income; although trends according to Townsend were suggestive of a (non-significant) trend, with those surgeries in more affluent areas of Wales more likely to offer such extended hours ($U = 6397$, $p=0.093$).

No significant trends with deprivation were found for those surgeries offering appointments before 8.30am (n=71).

[INSERT TABLE 2 ABOUT HERE]

4.3 Accessibility scores for surgeries with different ‘core’ and ‘extended’ appointment hours

Table 3 presents the correlation coefficients and associated significance levels for the LSOA-level relationships between access to GP surgeries with different ‘core’ and ‘extended’ appointment hours and measures of deprivation, poor health, and socio-economic status. As evident, these results suggest that FCA scores are positively associated with higher percentages of unemployed persons (except for the 5-5.30pm subset), higher percentages without a car, and higher Townsend scores (representing more deprived LSOAs). FCA scores tended to be lower for those LSOAs with a higher ranking on WIMD-2014 and WIMD-income, which represent those LSOA areas that are least deprived (but only after 6.30pm is significant). Accessibility scores tend to be higher for those areas with greater percentages of economically active residents (although this trend is reversed, but not significantly so, for those surgeries offering appointments after 6.30pm). Finally, for those areas with the highest percentages of the population in bad or very bad health, FCA scores tend to be lower before 8.30am and between 5pm and 5.30pm and higher after 6.30pm only.

[INSERT TABLE 3 ABOUT HERE]

5. Discussion

5.1 Summary of main findings

This study has illustrated how GIS-based FCA tools can be used to examine inequalities in primary care provision through the example of spatial variations in potential accessibility to those GP surgeries across Wales providing core and extended hours of provision. In summary,

our analysis suggests that access to GP appointments outside of so-called ‘core’ hours shows considerable spatial variation within Wales. In particular, GP surgeries situated within a 15-minute drive of LSOA population-weighted demand centres and offering appointments before 8.30am were generally found in and around major urban areas in north-east and south-east Wales. This is in contrast to surgeries offering appointments after 6.30pm which were predominantly located within the south; indicating a potential north-south divide in access to evening-based extended-hours primary care provision in Wales. Perhaps unsurprisingly, number of core hours were positively associated with patient list size, although no association was identified with GP-patient ratio or surgery-area deprivation. A non-significant ($p < 0.10$) trend with deprivation (as indicated by Townsend score) was found with regards to surgeries offering appointment times after 6.30pm, with these surgeries tending to be located in slightly more affluent areas of Wales. This association was not supported by either WIMD-2014 or WIMD-income deprivation measures however, or in relation to appointments before 8.30am. Overall, levels of access to surgeries offering extended-hours appointments (both before 8.30am and after 6.30pm) were greater in more deprived LSOAs (based on Townsend) and in LSOAs with higher proportions of unemployed residents and car-less households; more deprived LSOAs measured by WIMD-2014 and WIMD-income were only associated with better access to appointments after 6.30pm. LSOAs with a higher proportion of economically active residents and LSOAs with a lower percentage of residents with bad or very bad health were associated with better access to surgeries offering appointments before 8.30am, but not after 6.30pm. The negative association between access score and percentage poor health for appointments before 8.30am was reversed for appointments after 6.30pm.

5.2 Study limitations

FCA techniques remove the reliance on reporting accessibility based on administrative boundaries but they do not consider actual demand for services or utilisation behaviour. In the

absence of such data, assumptions have been made relating to the parameters used within the FCA model (such as travel time thresholds, mode of transport and road conditions, and the form of the distance-decay function); for example, a uniform 15-minute travel time catchment area was used to compare our findings with those of previous studies, but this threshold may need to be varied between rural (where there may be less choice) and urban areas, or if such techniques are used in wider international studies (Allan, 2014). A ‘porous’ access for patients across Local Health Boards (LHBs) in Wales has also been assumed when in reality there may be limited flexibility for ‘near-the-boundary’ patients to register with GPs in neighbouring LHB areas. Further research is therefore required to examine the impacts of specific LHB policies regarding GP registration to enforce such rules within the FCA model and similarly with regard to patients accessing primary care services across the Wales-England border.

In this study, access is assumed to be via private transport; thus, incorporation of bus and rail timetable information into the analysis would likely impact on estimated FCA scores (Langford et al., 2016). Road congestion levels at certain times of the day have also not been considered and it is possible that this could have a significant impact especially on the early morning (pre-8.30am) and early evening (post-6.30pm) accessibility calculations. Additionally, some errors may be introduced by representing population demand at population-weighted centroids within LSOAs (especially for larger rural LSOAs) by assuming patients are accessing GP services from home rather than from their workplace, or by considering population totals rather than population cohorts based on potential demand or health needs. However, it is possible to further refine the model should data on surgery utilisation patterns become available at the all-Wales level. At present, Welsh Government do not publish opening hours of branch surgeries; and as these are largely based in rural areas, there is a strong possibility that accessibility is underestimated in some rural areas of Wales with a high proportion of such surgeries. Similarly, in this study we have not considered spatial variations in alternative approaches to ‘out-of-hours’

health care provision in different parts of Wales, but such services could be included in future research to provide a more complete picture of accessibility to primary care services.

Finally, limitations arise from the nature of the database – these include, for example, the sample size, the need to consider confounding variables, the lack of widespread weekend appointment times in Wales, and the need to investigate in more detail the availability of appointment times in a wider range of ‘core’ working hours. With regard to the former, fewer surgeries offer extended appointment hours (i.e. pre-8.30am: 16% and post-6.30pm: 8%) and therefore this limits the statistical analysis that has been conducted here.

5.3 Policy Implications and Future Research

Advocates of extended hours provision contend that greater access to primary care services could reduce the demand for secondary care and have clinical benefits in terms of increased contact times with patients who are familiar to their GPs and may be presenting with complex health conditions. This may especially be targeted at patients whose needs are not currently being met by existing GP operating hours or for employed people who require appointments outside their working hours. Others have questioned the effectiveness of extending such provision for those groups likely to be in greatest need of health services or have cast doubt on whether such extended hours provision is associated with large improvements in overall patients’ experience of general practice (Cowling et al., forthcoming). This has led to concerns in some quarters that increasingly scarce resources are being diverted from areas in need of greater attention (Ford, 2015). A recent NAO report recommended, with regard to variations in core hour openings of GP surgeries, that “NHS England needs to assess and monitor what effect these variations have on patients and other health and care services” (NAO, 2017; p. 10).

Previous studies have highlighted the importance of the geographical location of health services, demonstrating, for example, the impact of closer proximity of GP surgeries on

reductions in the number of patients seeking unscheduled secondary care (Huntley et al. 2015). At the same time, research in England has shown that patients living in more deprived areas have lower GP/nurse to patient ratios than patients in less deprived areas and that, while 37% of patients living in rural areas do not have access to a GP service within a 2km radius, only 1% of patients living in urban areas have similar constraints (NAO, 2015). Similarly, 80% of patients had at least two GP surgeries within a 2km distance of where they live, suggesting at least some degree of choice. Whilst the use of such distance metrics can be of use to policy makers in highlighting the spatial distribution of GP surgeries, they do not take into account factors such as the potential demand placed upon these services from different patient groups, supply-side (surgery) characteristics (such as opening times and appointment availability), or potential distance decay effects.

In England, GP Access Fund areas have piloted the use of Primary Care Access Hubs to enable patients to have increased access to primary care settings with extended hours provision that include, at least in some pilot areas, those with appointments available beyond 9pm in the evenings (Monday to Friday) and between 8am and 10pm at weekends for patients living in close proximity to hubs. In a similar vein, the Welsh Government in their *Programme for Government* are committed to improving access to GP surgeries in order to make it easier to get an appointment (Welsh Government, 2016b). The national primary care services plan for Wales highlights the importance of both improving and securing equitable access to services by planning care locally and increasing the number of hours for which appointments are available (Welsh Government, 2015). However, the responsibility for provision of 24-hour care of patients can be transferred to LHBs if GP surgeries decide to opt out of such provision (BBC, 2018b). Such surgeries are grouped to form GP or Primary Care Clusters within LHBs (as of August 2018, 64 cluster networks across Wales which serve between 30 and 50 thousand patients) which are part of a more community owned- and led- approach aimed at more locally

planned care. The accessibility maps produced as part of this study highlight the current state of extended hours provision in Wales and should inform future policy concerning the collaborative delivery of services and the exact choice of surgeries or hubs selected for extended access provision in relation to local demand. At present, the availability of such evening and weekend appointments has been shown in this study to be spatially, if not socially, uneven across Wales. These techniques can be used to compare provision for those groups who could typically avail themselves of such provision in evenings and at weekends (such as those employed during a 'typical' working day).

Building on such concerns, further research could examine how these potential accessibility scores for extended hour's provision impact on the ease in which patients can get an appointment; which was seen to be more difficult for those patients living in more deprived areas of England (Torjesen, 2014). In addition, the increasing use of online and web-based consultation technologies to enable patients to consult electronically out-of-routine hours, may also need to be factored into an analysis of the role of geography on utilising different types of GP services. Such findings could inform wider debates regarding the influence of geographical variations in the supply of primary care physicians in relation to potential demand on a wide range of health outcomes as well as the potential impacts of access to primary care services on attendance at A&E departments or on the demand for wider out-of-hours services (Gulliford, 2002; Kelly et al. 2016; Turnbull et al., 2008).

6. Conclusions

Previous research using a national patient survey in England found that those in full-time employment and those unable to get time off work were most likely to benefit from weekend opening and extended opening hours (Ford et al., 2015; Cowling et al., 2017). Given the presumption that appointment availability prior to 8.30am and after 6.30pm were partly aimed

at employed people of working age unable to attend during 'core' hours, then the findings presented here that accessibility to surgeries offering the latter appointment availability (but not the former) were associated with lower levels of those economically active may suggest a spatial mismatch that is worthy of further investigation. More generally, the types of network-based accessibility models used in this study demonstrate how these tools can be used to plan the provision of extended access to appointment times for patients at evenings and/or weekends that account for local demand for services within the areas covered by Primary Care Clusters.

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Table 1: Variable descriptions

Variable	Description
Unemployment (%)	Percentage of 16-74 year olds unemployed at the time of the 2011 UK census
No car (%)	Percentage of households with no access to a car or van at the time of the 2011 UK census
Economically active (%)	Percentage of 16-74 year olds classed as economically active at the time of the 2011 UK census
Bad or very bad health (%)	Percentage of residents who self-assessed their general health as bad or very bad at the time of the 2011 UK census
Townsend score	A composite measure of deprivation based on four UK census variables, namely percentage unemployed, lack of car access, non-home ownership, and household overcrowding. Scores are calculated by transforming all variables to a normal distribution, standardizing using z-scores, and aggregating using equal weights.
WIMD 2014 (rank)	A measure of relative deprivation for small areas made up of individual constituent indicators to thematic areas such as education, housing, and crime. These 'domains' are differentially weighted to create an overall deprivation index where small areas are ranked from most to least deprived.
Income domain of WIMD 2014 (rank)	The income sub-domain of the overall WIMD 2014.

Table 2: Characteristics of practices that have varying ‘core’ and ‘extended’ hours provision in Wales (as of November 2015)

‘Core’ and ‘Extended’ hours provision	Number of practices	Minimum List size	Maximum List Size	Average List size	Average GP size	Average Number of Patients to GP	Mean Total WIMD (2014) Rank (1=deprived; 1909=least deprived)	Average Townsend Score (higher scores present greater deprivation)
Before 8.30 am	71	1926	24740	8998	5.61	1733.70	925	0.76
Between 5pm and 5.30 pm	439	1220	24740	7018	4.42	1765.71	844	1.05
Between 5.30 and 6pm	350	1260	24740	7199	4.54	1775.25	844	1.04
Between 6pm and 6.30pm	112	1538	18725	7682	4.92	1774.09	791	1.12
After 6.30 pm	37	2886	14853	7799	5.41	1606.56	863	0.63

Source: Welsh Government statistics on opening hours and appointment times of GP practices as of November 2015. (<http://gov.wales/statistics-and-research/gp-access-wales/?lang=en>) Last accessed January 17th 2017.

Table 3: Correlation of census variables with FCA Accessibility scores (Spearman coefficients all LSOAs within Wales)

Socio-economic variables		Before 8.30	Between 17.00 and 17.30	After 18.30
Percentage Unemployment	Correlation Coefficient	.120**	.031	.157**
	Sig. (2-tailed)	.000	.169	.000
Percentage No Car Ownership	Correlation Coefficient	.162**	.215**	.129**
	Sig. (2-tailed)	.000	.000	.000
Townsend Score	Correlation Coefficient	.152**	.171**	.125**
	Sig. (2-tailed)	.000	.000	.000
Rank of the LSOA on Total WIMD (2014) score	Correlation Coefficient	-.003	.023	-.084**
	Sig. (2-tailed)	.892	.324	.000
Rank of the LSOA on the Income Domain of WIMD 2014	Correlation Coefficient	-.037	-.007	-.085**
	Sig. (2-tailed)	.110	.760	.000
Percentage Economically Active (16-74)	Correlation Coefficient	.101**	.074**	-.033
	Sig. (2-tailed)	.000	.001	.152
Percentage in Bad or Very Bad Health	Correlation Coefficient	-.052*	-.089**	.156**
	Sig. (2-tailed)	.024	.000	.000

* Significant at 5% level

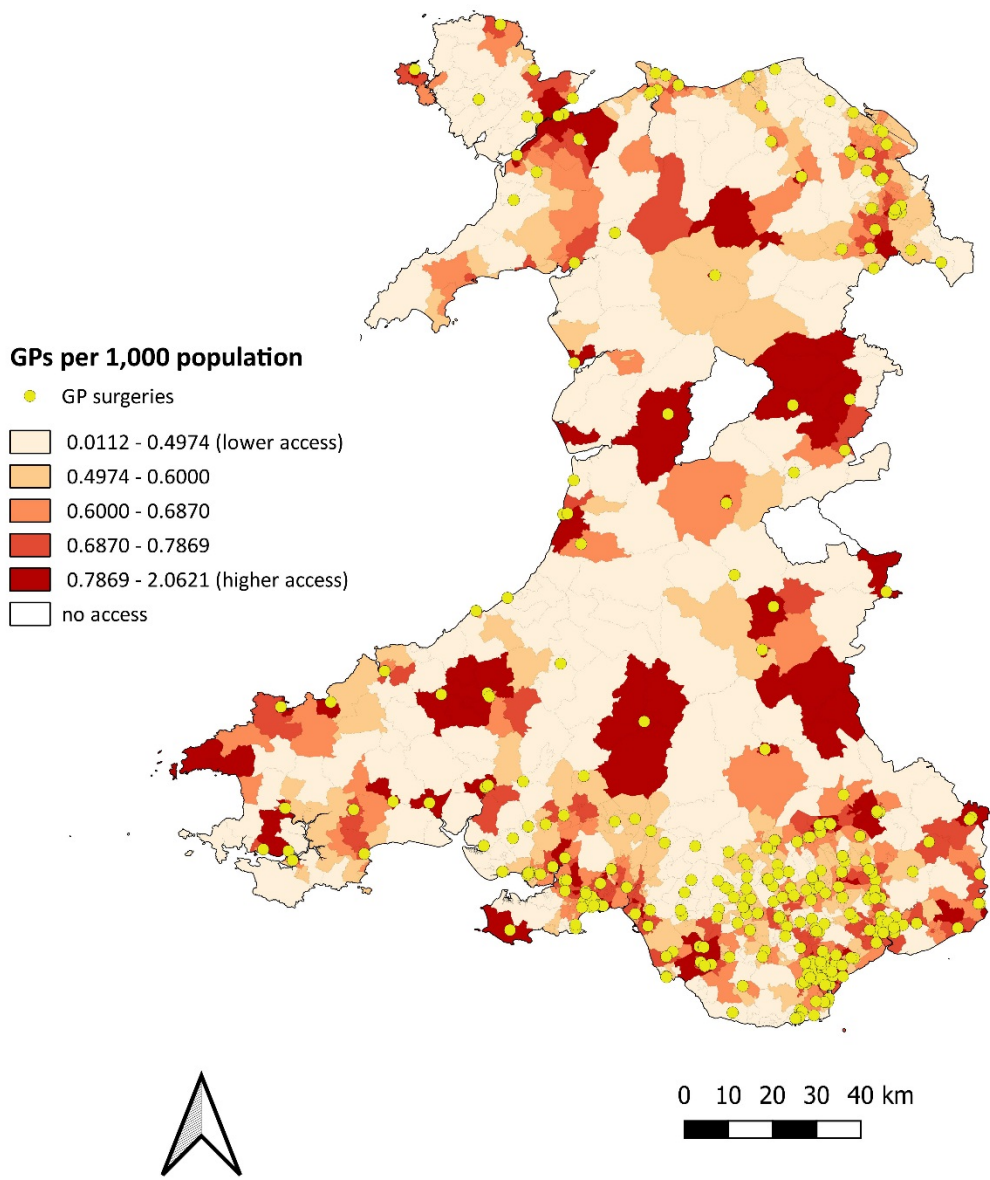
** Significant at 1% level

Figure captions:

Figure 1: GP surgery locations and variations in accessibility scores for access to GPs based at surgeries offering appointments between 5pm and 5.30pm (threshold travel time 15 minutes). All areas not shaded have no access within this time threshold.

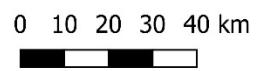
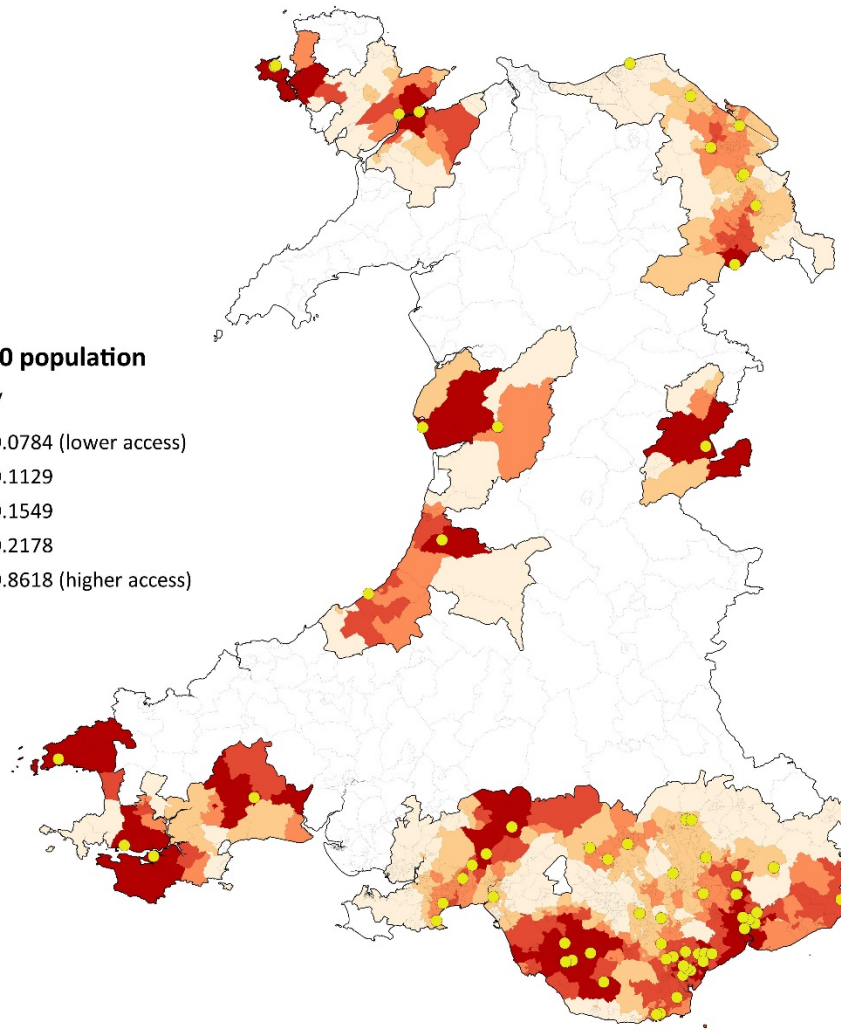
Figure 2: GP surgery locations and variations in accessibility scores for access to GPs based at surgeries offering appointments before 8.30am at least two week mornings (threshold travel time 15 minutes). All areas not shaded have no access within this time threshold.

Figure 3: GP surgery locations and variations in accessibility scores for access to GPs based at surgeries offering appointments after 6.30pm at least one day a week (threshold travel time 15 minutes). All areas not shaded have no access within this time threshold.



GPs per 1,000 population

- GP surgery
- 0.0003 - 0.0784 (lower access)
- 0.0785 - 0.1129
- 0.1130 - 0.1549
- 0.1550 - 0.2178
- 0.2179 - 0.8618 (higher access)
- no access



GPs per 1,000 population

- GP surgery
- 0.0001 - 0.0151 (lower access)
- 0.0152 - 0.0516
- 0.0517 - 0.0924
- 0.0925 - 0.2127
- 0.2128 - 1.7233 (higher access)
- no access

