CW1: Accessibility Analysis of GP Surgeries

1. *Introduction*

The pursuit of fair access to healthcare is one of the main principles of the National Health Service in England (*The NHS Constitution for England*, 2021). And as a critical component of this, the accessibility to GP surgeries, especially the ones in the suburbs, should be taken seriously. Therefore, this essay will evaluate how easily accessible GP surgeries in the studying area are and offer suggestions for improvements.

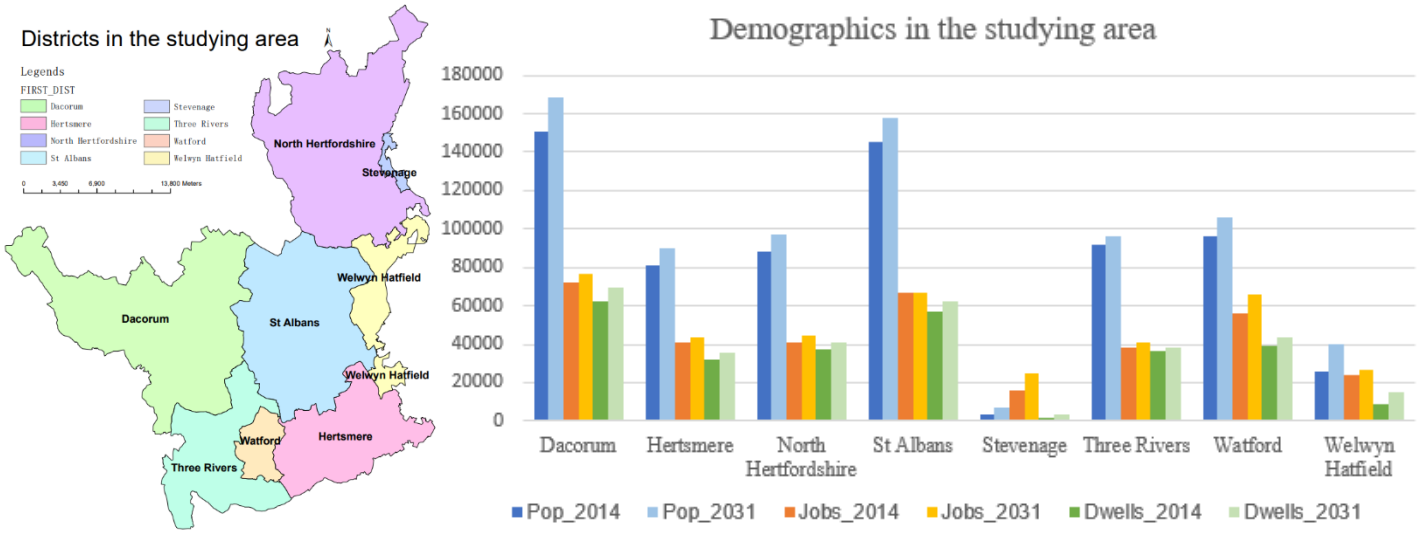

Fig.1 The districts and demographics (from file 'AECOM 2014_2031_Planning_Data') of the studying area

As shown in Fig.1, the studying area belongs to Hertfordshire, a county in southern England. It consists of 8 local government districts: Dacorum, Hertsmere, North Hertfordshire, St Albans, Stevenage, Three Rivers, Watford and Welwyn Hatfield. Also, it had a population of 681,993 in 2014. Supplementary demographics are presented in Fig.1. The graph demonstrates that in 2014, the employment rate in Welwyn Hatfield was roughly 90% with over 400% in Stevenage. However, that of the other six districts was 50%. A possible reason is that not every administrative district is completely covered. And Stevenage presents zoning, which means the areas included are working places such as industrial areas. The same goes for Welwyn Hatfield.

The report is structured as follows. Section 2 states the accessibility indicators and measures, while Section 3 shows the process and results of the GIS application. Section 4 offers evaluation and advice. Finally, section 5 reveals the limitations of data and approaches.

2. *Accessibility indicators and measure*

Components	Temporal	Land-use	Individual	Transport
Indicators	The availability of opportunities at different times	Number, quality, and spatial distribution of opportunities	Needs of individuals	Time
	The time available to participate	Demand	Abilities of individuals	Cost
		Confrontation of supply and demand	Opportunities of individuals	Effort

Table.1 Indicators of accessibility, summarized by (Geurs and van Wee, 2004, p. 128)

Geurs and van Wee (2004, p. 128) have identified 4 components of accessibility: temporal, land-use, individual and transportation. The indicators are shown in Table.1.

However, this study's dataset only offers the population, jobs and dwells as demographics, and the public transport and road data. Therefore, the final indicators include the travel time of public transport and cars, origin indicators and destination indicators.

To date, there have been different types of accessibility measure. The threshold measure is the easiest to comprehend and interpret. However, it ignores the difference in destination attractiveness (Liu and Zhu, 2004, p. 107), which is improved by opportunity measures. On this basis, potential measures further integrate the travel impedance and are believed as the most robust by Guagliardo (2004). In parallel, the space-time prism, an approach emphasizing individual differences, is not suitable for the data in this case. And utility measures do not apply to the topic due to the focus on gained benefits. In light of this, the potential measures are used in the accessibility assessment to GP surgeries. As the scale of each GP surgery is not provided, it is assumed that the attractiveness is the same. The modified formula is as follows:

$$A_i = \sum_i \frac{1}{D_j d_{ij}^{\beta}} \tag{1}$$

$$D_j = \sum_k \frac{P_k}{d_{kj}^{\beta}} \tag{2}$$

$$d_{ij}^{\beta} = \left(\frac{distance_{kj}}{travel\ time_{kj}}\right)^{\beta} \tag{3}$$

$$\beta = \begin{cases} 1, & if\ travel\ time \leq 30\ minutes \\ \infty, & else \end{cases} \tag{4}$$

Where A_i represents the accessibility of $zone_i$. D_j represents the demand of GP_j. d_{ij}^{β} (or d_{kj}^{β}) represents the distance/time between $zone_i$ (or $zone_j$) and GP_j with β represents the distance delay coefficient. The threshold of β, 30 minutes, is taken from the health indicators of GP in DfT accessibility indicators. P_k represents the population of $zone_k$. Adapted from Schuurman, Bérubé and Crooks (2010, p. 35)

To fully utilise the available data, a need index based on job and dwell data with equal weights will be established to examine the equity of GP distribution.

3. GIS's application and findings

In this study, the accessibility to GP Surgeries can be divided into two transport modes: cars and public transport. And the emphasis is on accessibility by cars because the road network dataset includes speed, length, and time while the one for public transport does not.

The data use and steps of accessibility analysis by car are shown in Fig.2. It is designed on the following assumptions: (1) each GP has the same service capability so the travel time to the nearest one could initially reflect accessibility. (2) the road network's junctions serve as the starting point of travel, disregarding the time spent getting there from home. (3) the demographics, including jobs, dwells and population, are evenly distributed at each junction.

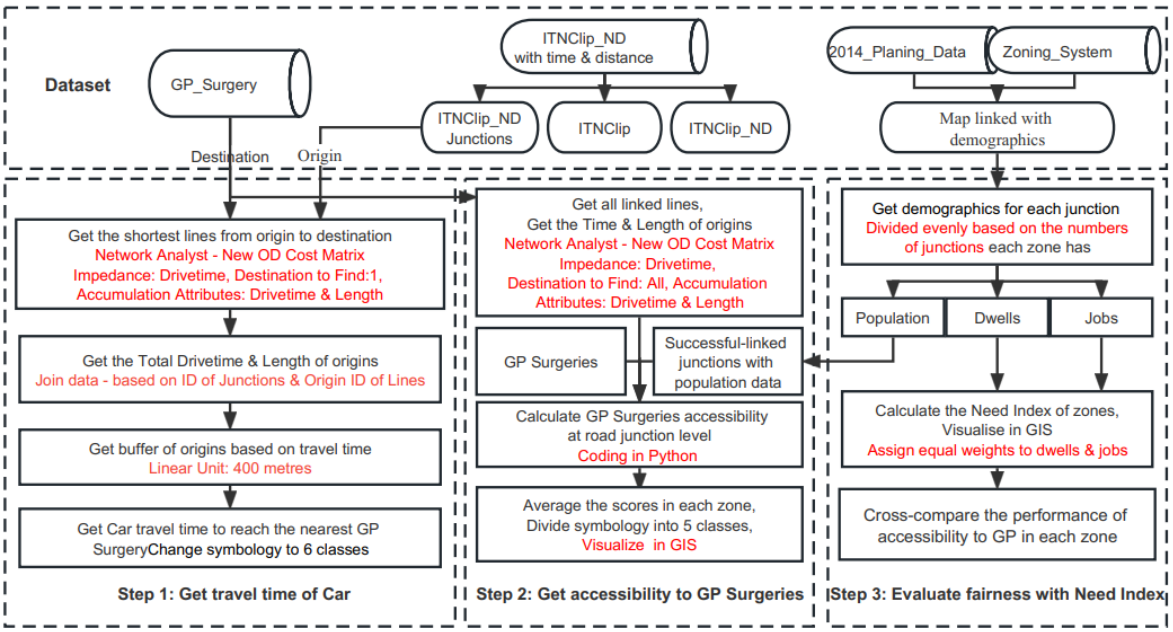

Fig.2 The steps of accessibility analysis to GP Surgeries by car using GIS

In the first step, *New OD Cost Matrix* in *Network Analyst* is used to get the travel time to the nearest GP by car. Select the junctions as origins and GP as destinations, then it created all OD routes with time and length accumulated. Transfer the results from lines to junctions and create buffer zones with 400m as a linear unit. After that, summarize the data at the zone level, dividing the journey time into three. The statistics and visualisation at junction and zone levels are shown in Fig.3.

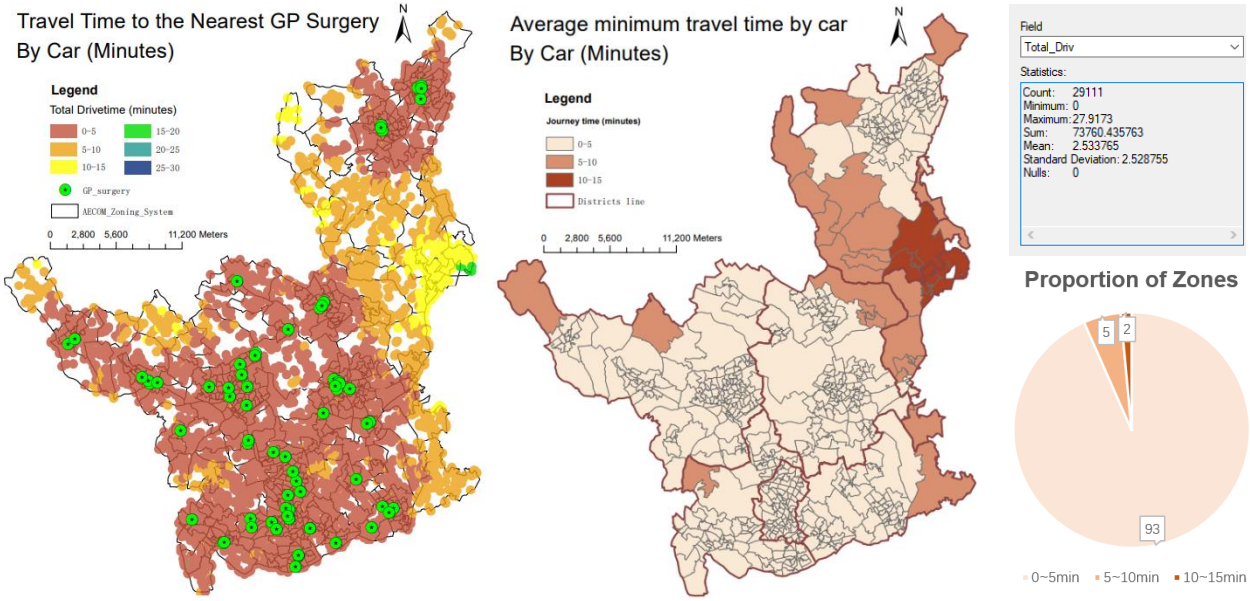

Fig.3 The statistics and visualisation of travel time indicators by car at junction and zone levels

In addition, the accessibility of public health services like GP is also affected by the population. Therefore, based on the formulas in Section 2, the accessibility score of each junction is calculated. As illustrated in Fig.4, the score of each zone is represented by the average accessibility score of all junctions in the zone. In parallel, the driving accessibility scores to GP are split into five grades (using Natural Breaks, A is the best and E is the worst), and an overview of each grade's accessibility zones is shown in Table.2.

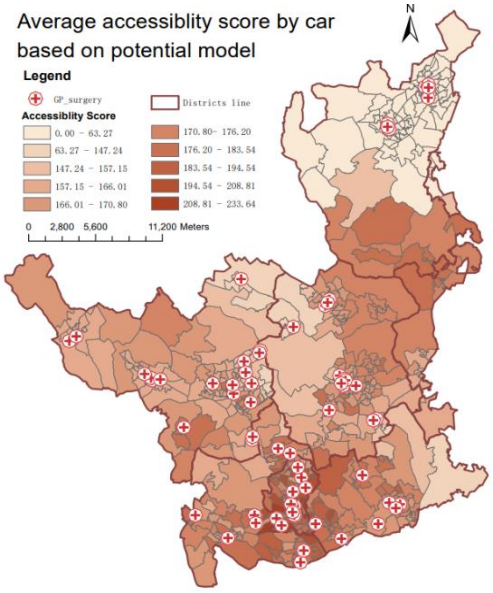

Fig.4 Average accessibility score by car

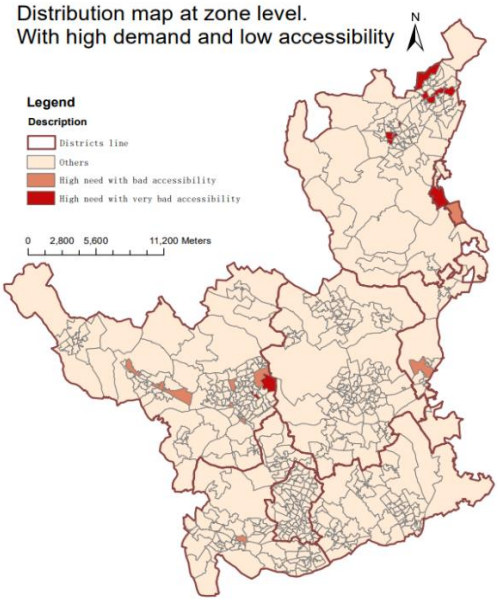

Fig.5 Distribution map on demand and accessibility

Level of Accessibility Score	Number of Zones	Total Area (km2)	Total Population	Total Jobs
Very Good	37	12.03	42017	32766
Good	115	117.94	138375	57162
Medium	216	301.38	262020	119782
Bad	127	214.91	138439	84546
Very Bad	112	179.07	101142	60197

Table.2 Overview of Accessibility to GP Surgeries by car of different Levels

Finally, to investigate the income level and rationality of GP distribution, I create a demand index based on economic parameters consisting of dwells and jobs. After computing the average housings and jobs in each zone, the range standardisation method is used to normalise the data. And then the demand index is the outcome of equal weight summarization. Divide the community into high, medium, and low demand, and perform overlay statistics with accessibility. The results are represented in Fig.5.

Accessibility Level	Need Index		
	Low need	Medium need	High need
Very Good	20	12	5
Good	61	48	6
Medium	127	80	9
Bad	59	57	11
Very Bad	47	52	13

Table.3 Statistics of accessibility and need at zone level

In addition to the cars, the given dataset also includes the network of public transport, involving rail, bus and underground. However, the rail and underground may have multiple stops with no field indicating the information, which makes accessibility analysis difficult. As Fig.6 shows, there are few lines for them in the research area so this part will focus on the accessibility to GP by bus. It is noteworthy that the bus speed is not provided. So, the speed limit set by the UK government is used to calculate the travel time before creating the bus network dataset. Nevertheless, there are relatively fewer junctions (1648 in the bus network and 30022 in the road network), so it's probably not accurate to assume that the bus stops

are the starting point of travel by bus. And the method in Fig.2 is not suitable. But from another perspective, the destination of each journey is GP, which means that *Service Area* in *Network Analyst* can be used to show its accessibility by travel time. Fig.7 illustrates the results.

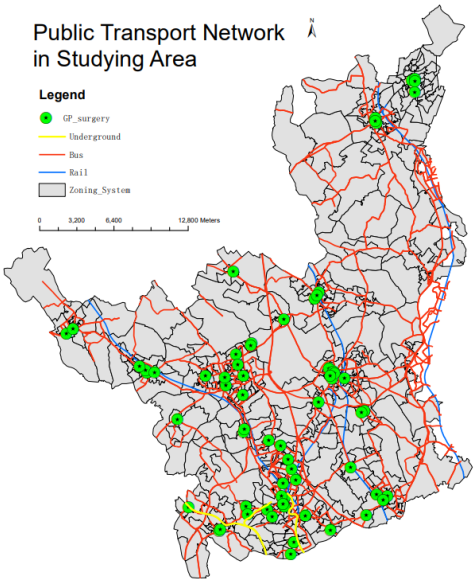

Fig.6 Public transport network in studying

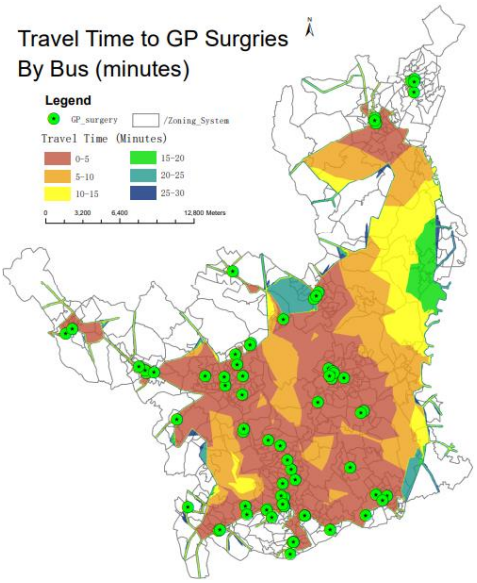

Fig.7 Travel time to GP Surgeries by bus

4. Evaluation and suggestions for accessibility improvement

Fig.3 shows the travel time by car. At the zone level, nearly 93% of zones can travel to GP within 5 minutes, with only 2% spending more than 10 minutes. In light of this, the performance is satisfactory. However, from a more micro perspective, the maximum driving time is about 28 minutes and the accessibility is spatially unequal. The region with the poorest performance was north of Welwyn Hatfield, followed by south of North Hertfordshire.

Table.2 and Fig.4 illustrate the average accessibility score by car using the potential model. According to it, almost 60% of the zones have accessibility performance that is at or above the average level. And the corresponding total jobs account for the same percentage while the living area only occupies half. Furthermore, it is noteworthy that the population has a critical impact on accessibility. Compared with Fig.3, the central and northern part of North Hertfordshire has a quite low accessibility index due to its large population, despite having a shorter average minimum travel time. Meanwhile, the eastern part of Hertsmere, the northeast Dacorum and the western part of St Albans also performed relatively poorly. On the contrary, the junction of NH and WH with a relatively long average travel time performed well

Fig.5 illustrates that the research area is generally fair, indicating a reasonable GP distribution for accessibility by car. The few selected sub-districts are mostly at the border or the heart of Dacorum and North Hertfordshire.

Fig.7, which has the same time interval as Fig.3, shows that both the central and southern parts of the study area performed well, with Welwyn Hatfield showing potential for improvement. The biggest difference is located in the northeast corner. There are 3 GP Surgeries but the lack of bus stops and lines may have contributed to its poor performance of accessibility to GP Surgeries by bus.

Overall, there are three areas in need of improvement for the accessibility to GP Surgeries. The northern part of North Hertfordshire is the first one. Although its average minimum travel time by car is less than 5 minutes, the accessibility score is relatively low due to the large population. In other words, there is a higher demand, so the first proposal is to open a new GP Surgery in a high-need low-accessibility zone. Besides, there is a lack of bus network in this area, leading to its poor performance of accessibility by public transport. Therefore, the second suggestion is to try to build more bus stops and set up new bus routes. Another area to be improved is the zones near the boundary between North Hertfordshire and Welwyn Hatfield, and the boundary of North Hertfordshire and Stevenage. It lacks a local GP, resulting in a longer travel time no matter by bus or by car. However, the population there is smaller and the economic characteristics indicate a low demand, thus the overall performance of accessibility is not bad. My suggestion is to move one or two nearby GPs closer to the area. In this way, the residents' travel experience would be improved without wasting medical resources. The last piece of advice is based on the results of the bus. In areas such as the east of Hertsmere and the north of Dacorum, the bus network is inadequate, and accessibility scores by car are relatively low. Although it is not as urgent as in the previous area, the government can still consider expanding the existing bus network.

5. Limitations of data and methods

There are lots of limitations of data. Firstly, cycling, as an important transport mode, is not involved. And the underground and rail lack key data like Junction IDs to perform network analysis. Therefore, the advice given for the area may be one-sided as it is only based on buses and cars. Secondly, because of the lack of data on money, the travel cost only considers time. Thirdly, the nearest GP outside the studying area, which may also influence residents' choice of transport mode and accessibility to GP, are not given. Fourthly, the mode share is not provided so I cannot link bus and car accessibility together to generate a composite score. Lastly, there are no details of bus speeds on different routes, so the previous results will be better than reality because I chose the bus speed limit as bus speed to calculate time.

As for the methods, the biggest problem is that multimodal transport is not considered. But in reality, people may choose mode like 'Park and Ride' to go to GP. Secondly, I overlooked some things such as the time people go from home to road junctions and bus stops.

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