Spatial Accessibility to Primary Care in Dual Public-Private Health System in Malaysia: A Case Study in Rural Selangor

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Research

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Abstract

Background:

Disparities of access to health services in rural areas is a global health issue, especially in middle income countries including Malaysia. Recent method called enhanced two-step floating catchment area (E2SFCA) exhibit promising results in quantifying the health care accessibility. This study aimed to describe and explore the pattern of spatial accessibility to primary care services based on secondary data.

Methods:

The E2SFCA method were adapted to measure the level of accessibility to primary care across rural area in Selangor state of Malaysia, with slight modification to suit our local context considering for public and private providers as well as incorporating clinic's availability factor into the original formula. For each provider, spatial pattern of accessibility scores was mapped, spatial autocorrelation local Moran's I and Getis-Ord-Gi* was performed and the degree of equality was computed based on Gini index.

Results:

Areas with high E2SFCA scores mainly concentrated encircling the periphery of the large urban areas at the centre of the state, largely contributed by the private sector whereas low E2SFCA scores areas observed predominantly at the northern region and along the coastal region. As a whole, the E2SFCA scores across rural Selangor population was fairly equal but lower degree of equality was observed at the northern region of the state.

Conclusions:

The level and distribution of E2SFCA scores reflects the performance of the primary health care. Findings from this study provides insight for the health authorities to identify disparities of access to primary care services and areas that need attention, hence would be basis for future health care planning and resource distribution.

Background

Disparities of population's access to health care services is a known global health issue and is even more challenging in low- and middle-income countries [1, 2]. Accessibility to healthcare defined as relative ease of health services to be utilized by the population [1, 3, 4]. Rural population often have the issue of the lack of access to health care services as compared to urban counterpart [5–7], largely constrained by the travel impedance and availability of the services [8–10]. Similar situation also occurred in Malaysia where less developed areas in Malaysia generally had lower access in term of provider-to-population ratios [11], especially the private sector which were mainly located in urban areas [12, 13]. Nonetheless, health care services and population demand are hardly to be equally distributed [9]. In fact, the geographic disparities in health care access existed within rural areas itself where lower accessibility often associated to rural areas that were located deep further to the nearest urban area, especially due to unmatched population and service distribution [5, 14–17].

Accessibility to health care indeed is a complex concept and several theoretical framework of health care accessibility exists [1, 18–21]. The accessibility can be divided into two main components; spatial and non-spatial [20]. For each component, there are two dimensions, with spatial access encompasses of geographic accessibility (physical distance) and availability (adequacy of services at specified location), whereas non-spatial access includes to affordability (financial capability), and acceptability (behavior) [1, 22]. Spatial accessibility can be measured using two-step floating catchment area (2SFCA), in which was proposed to consolidate the elements of cross-boundary interaction, proximity, service availability, service supply, population demand and distance decay concept into one integrated measure [23, 24]. It was called two-step because it considers the: (1) service catchment area, and; (2) population catchment area. This method is then constantly being studied, improved, and revised since the last decade, and various versions of 2SFCA exist to suit specific local context and scenario [25–28]. Notable improvement was on the decay function where step-zonal decay with gaussian function had been introduced (replacing the initial dichotomous decay)[14, 26] to improve the 2SFCA, thus named as enhanced 2SFCA (E2SFCA). Currently, E2SFCA is considered the standard FCA method [29].

Recently, the E2SFCA (or its variant) method has been widely used to measure spatial accessibility in primary care services in both urban and rural settings [5, 15, 24, 26, 30–34], as well as other health care services such as inpatient care, specialized services and among specific population (e.g., elderly, ethnic minority, etc.) [25, 28, 35–41]. Numerous of those studies using the E2SFCA method were conducted at high-income and developed countries [5, 15, 24, 26, 28, 30, 32, 35–37], but recently there are growing number of studies from low- and middle income countries as well, primarily from China [38, 39] and India [33, 40, 42], follows to benefiting from technology advancement of GIS and availability of data. The E2SFCA method has been proved to be a better measures of health care accessibility, by specifically identifies both low or high access areas which would be useful for practical health care planning and allocation purposes by the policy makers.

Despite of its growing popularity, so far there is limited health care accessibility studies in Malaysia utilizing the E2SFCA method. Therefore, it is crucial to advance current knowledge in measuring accessibility to primary health care services, particularly using E2SFCA method in Malaysia local context which has not been done before. This could elucidate on: (i) the current situation of spatial accessibility to primary care considering of Malaysia's dual public-private provider specifically for rural area; (ii) differences in term of spatial accessibility between the public and private primary care across the rural areas, and; (iii) degree of equality of the spatial accessibility distribution across rural areas. By adapting the E2SFCA method, this study is to correspond to the questions pertaining to the spatial accessibility to primary care among rural population in our local context. Thus, this cross-sectional ecological study aimed to describe and explore pattern of spatial accessibility to primary care services within Selangor state of Malaysia using the modified E2SFCA method. Findings from this study could provide baseline data for future studies and better understanding for developing framework in formulating policy related to health care accessibility.

Methods

Study area

Selangor state located at the west central region of Peninsular Malaysia, encircling two federal administrative centers (Kuala Lumpur and Putrajaya) of Malaysia (Fig. 1a). There were nine administrative districts, namely Gombak (GBK), Hulu Langat (HUL), Hulu Selangor (HUS), Klang (KLG), Kuala Langat (KUL), Kuala Selangor (KUS), Petaling (PET), Sabak Bernam (SBK) and Sepang (SPG). PET was excluded from this study as PET is a 100% urban district. Department of Statistics Malaysia (DOSM) defines a rural areas as the non-gazetted area with a population of less than 10,000 [43]. Although Selangor state is one of highest urbanization rate of 91.4% [44] and generally had better off socio-economic indicators compared to other states [45], rural Selangor served as a good location for case study to assess the E2SFCA method for several reasons: (1) rural Selangor had the lowest percentage of households within 5km of public health facilities coverage in Peninsular Malaysia [43], and (2) Selangor as being the most populated state, it has rather low public health facility ratio to population of 1:32,555, which is about three times lower than national average [46]. With that facts, there is possibility of overburden of public facilities and disparities of access could eventually exist in rural Selangor. More to that, Selangor is located encircling the urban agglomerations of Kuala Lumpur and its surrounding cities, large variation and difference in term of spatial accessibility to primary care could potentially be observed due to the broad range of geographical characteristic from deep rural to suburban areas near the core of the large urban center.

Data sources

Three secondary datasets were obtained from several government agencies including population data, primary care facilities data and road network data. All data from Selangor state (including urban and rural) and from adjacent states were obtained to cater for population demand and service distribution accounting for cross-boundary interaction.

Population data were sourced from Population and Housing Census 2010 data, aggregated at enumeration block (EB) level provided by Department of Statistics Malaysia (DOSM). The EBs are geographical contiguous areas of land which identifiable imaginary boundaries formed within gazetted boundaries, contains roughly around 100 living quarters. It can be classified to urban and rural EB based on aforementioned criteria. A total of 1,349 rural EBs in Selangor state were all included in the study, with average of 345 peoples per EB and 6 EB with zero population. Other variables extracted were sex and age group (with 5-year intervals), which were used to quantify vulnerable population in later stage of analysis.

Data on both public and private primary care facilities were obtained from the Ministry of Health Malaysia (MOH) data in, 2017. Public facilities refer to clinic that run by at least by a doctor (health clinic and mobile services called 1 Malaysia mobile clinic). Private facilities refer to private medical clinic (general practitioner) that specifically provides modern medicine on primary care. Coordinates of these facilities were geocoded based on the street address. Due to unavailability of data on number of doctors per clinic, estimated number depending on types of clinic were used. It was estimated that number of doctors (median) at public and private clinic in Selangor were six and one respectively [47], whereas number of doctors for mobile services was one [48]. Data on operating hours were used in estimating facility’s availability. All reachable clinics by population catchment within study area and from adjacent states were included.

Data on road network were from Malaysian Centre of Geospatial Data Infrastructure (MaCGDI), 2017. Due to unavailability of data on actual speed limit for each road, estimated speed limit was used based on common speed limit depending the type of the road, which were 90 km/h for expressway, 60km/h for federal and state road, and 30km/h for residential road [49]. Length and speed limit of each road were used to calculates travel time distance. Traveling time was calculated with assumption of population were travel using motorized vehicle where this is the most common mode of transport of the population to seek primary care in Malaysia [50], according to speed limit.

Enhanced two-step floating catchment area (E2SFCA)

This study adapts the E2SFCA model by Luo and Qi [26] with several consideration and modification to suit our national context of primary care setting, which will be explained in the following paragraphs. Population data was aggregated at enumeration block (EB) level, which is the smallest spatial aggregation (geographic boundary) available in the census data. Considering of the dual public-private providers for primary care, access score to public and private were calculated separately, and then a total access – which is the sum of public and private scores. For simplicity, the accessibility scores to public, private and total accessibility score will be abbreviated as *Aspub*, *Aspri*, and *Astot* score respectively. The term E2SFCA scores refers to the *Aspub* score, *Aspri* score and *Astot* score. Each clinic was weighted by number of doctor (physicians) and operating hours to indicate total supply. Distance separation between the population point (EB) and clinic was based on travel time using motorized vehicle via road network, calculated using Closest Facility function of the ArcGIS (ESRI Inc., Redlands, USA, version 10.7) Network Analyst extension.

To allow better precision in calculating distance separation, population weighted centroid was used [51]. The weighted was based on road network, although EB is the smallest geographic boundary, some rural EB can be quite large and geographic centroid can fall far from where the population concentrated at. Higher road density area often associated with higher housing density and where the population usually concentrated at [52] and rural settlements in Selangor generally could be either clustered, concentrated or scattered along the main road [53].

Although a catchment size of 60 minutes was recommended for rural areas to cater for large rural and remote areas [14, 24, 27], this study used 30 minutes. The decision was grounded by the findings on Malaysia’s National Health Morbidity Survey (NHMS) 2015 findings where mean travel time (self-reported) for seeking outpatient care for rural population was 30 minutes (median was 15 minutes) [50]. Only 100 nearest clinics within the catchment size were considered to mitigate redundancy [54]. Three-step zonal distance decay function (0–10, 11–20 and 21–30 minutes) with fast decay weight of 0.945, 0.400 and 0.010 respectively [55] was used in the calculation as it will produce sharper decay effect, with more distinguishable reduced access score as compared to slow decay [25].

This study incorporates health need and clinic availability into the E2SFCA calculation in step 1 – supply-demand ratio of each clinic. Health need (HN) was quantified as total percentage of vulnerable population (toddler aged < 5 years, elder aged > 64 and female aged 15–45) [24] in the EB. High HN was those with higher percentage of vulnerable population. HN then was transformed to a range of 0.5–2.0 to be incorporated in step 1 of E2SFCA calculation [56]. The E2SFCA formula were further modified by including the clinic availability, which was calculated based on total operating hours per week for each clinic. Similarly, the total operating hours per week were transformed, to a range of 0.25–2.0, where 24 hour clinic will be assigned weight of 2.0, extended-hour public health clinic and private clinic (which generally operates from 8am up to 10pm) as 1.5, clinics that operates at common office hour (8am – 5pm) with 5 working days per week weighted as 1.0 and those public mobile health clinic 0.5 and 0.25 (depending on its schedule at each site). With that, the modified formula of E2SFCA calculation used in this study was as below.

Step 1 – Assigning an initial supply-demand ratio (R_j) to each service location, by determining all population that are within catchment area of service

$$R_j = \frac{S_j \times CA_j}{\sum_{k \in (D_{jk} \in D_r)} P_k W_r \times HN_k} \qquad (1)$$

Step 2 – Summation of the R_j that are within each population location (EB), to get final spatial access scores

$$A_k^F = \sum_{j \in (D_{jk} \in D_r)} R_j W_r \qquad (2)$$

Where R_j is the supply-demand ratio within catchment size for clinic location *j*. S_j is the total number of doctors (supply) for clinic at at location *j*. CA_j is the clinic availability weight for clinic location *j*. P_k is the total population at EB location *k*. D_{jk} is the travel time between *j* and *k*. D_r is the *r*th zone (r = 1–3). W_r is the distance weight for the *r*th travel time zone. HN_k is the health need weight for population at EB location *k*. $A^F{}_k$ is the final accessibility E2SFCA score at EB location *k*. More details on E2SFCA calculation mentioned in previous studies [24, 26, 27].

Spatial pattern and spatial statistics

Choropleth mapping used to visualize the spatial pattern of the E2SFCA scores. The E2SFCA scores were ranked and grouped into five classes based on Jenks Natural Breaks Classification, which identifies breakpoints between classes using Jenks algorithm that based on Fischer's “Exact Optimization” method by minimizing the sum of variance within each of the classes while maximizes the variance between classes and is a standard method and commonly used in GIS applications [57, 58]. To ensure the observed spatial pattern was not due to random arrangement, spatial autocorrelation analysis using global Moran's I statistic [59] was performed. To further investigate where the EBs of high or low E2SFCA values clustered together, Hot Spot Analysis using Getis-Ord Gi* statistics was performed to indicate high/low value areas with significant confidence interval (CI) level of 90%, 95% and 99% [60]. A positive Gi value (z-score) of > 1.645 (90% CI), > 1.960 (95%CI) and > 2.576 (99%CI) indicates hot spot (EBs with high E2SFCA scores clustered together), a negative Gi value of <-1.645 (90% CI), <-1.960 (95% CI) and <-2.576 (99% CI) indicates cold spot. A Gi value within >=-1.645 and < = 1.645 indicates not statistically significant (neutral). Choropleth mapping and all spatial statistical tests were performed using ArcGIS software.

Gini coefficient

Gini coefficient [61] is commonly used to measure the degree of inequality. The value ranges from 0 to 1, with higher value indicates higher degree of inequality. Value of ≤ 0.2 considered as absolute equality, value ≤ 0.3 considered relatively equal and 0.4 is the cut-off point of being reasonably equal [62]. Gini coefficient was performed for each E2SFCA scores to examine the distribution of spatial accessibility scores for the whole rural Selangor and within each district.

Results

Descriptive

Descriptive statistics on E2SFCA scores across districts were displayed in Fig. 2. In general, GBK, KLG and SPG were the three districts with highest E2SFCA scores (*Aspub*, *Aspri* and *Astot*). On the other hand, HUS, KUS and SBK were the bottom three. It also can be observed that *Aspri* score for rural Selangor was slightly higher than *Aspub* score (1.154 vs 0.800), totaling 1.953 for *Astot* score. From perspective of public-private share, about 59% of the *Astot* score was contributed by the *Aspri* score.

Spatial pattern and Hot Spot Analysis

Spatial pattern of E2SFCA scores were illustrated in Fig. 3. At a glance, higher E2SFCA scores, were areas that surrounds the urban center of Selangor. In hotspot analysis (Fig. 4), cold spot areas for *Aspub* score appeared to be along coastal area of KUS, KUL and SPG, as well as in middle HUS. On the other hands, hot spots for *Aspub* score appeared at the south part of urban center of Selangor, and spotted at the up north of HUS. For *Aspri* score, it was clear that hot spots areas were those near to the urban center region of the state. While cold spots appeared at most of the coastal areas (except KLG) and central of HUS. North region of Selangor (SBK, KUS and HUS) appear to be where most of the cold spot areas are, and it can be summarized that low access areas tend to be located further from the urban center of Selangor.

Population affected and differences of the E2SFCA scores

Around 36.2%, 40.5% and 44.5% of total population resides in the cold spot areas in relation to *Aspub*, *Aspri* and *Astot* score respectively (Table 1). None of EBs in SBK had hot spots and more than 90% of the SBK population resides in cold spot areas, particularly for *Astot* and *Aspri* scores. On the other hand, GBK had almost of its EBs in hot spot areas. In term of mean E2SFCA scores, generally the mean score of the hot spot areas in rural Selangor were about twice higher than overall rural Selangor while cold spot areas were half of overall rural Selangor. For example, *Astot* score in hot spot areas were about 1.8 times higher than rural Selangor mean (3.648 vs 2.078) and 3.7 times higher than mean of cold spot areas (3.648 vs 0.995). This indicates that population in hot spot areas relatively have about 1.7 and 3.6 folds better in term of *Astot* score to primary care as compared to average rural population of Selangor and those population in the cold spot areas respectively. But in HUL district, population in hot spot areas had mean score of about seven folds than mean score of cold spot areas in the district (3.560 vs 0.508).

Table 1
Total population and mean E2SFCA score of the hot/cold spot areas, by district

	EB	Estimated Population	Public					Private					Total			
			% Population		Mean E2SFCA score			% Population		Mean E2SFCA score			% Population		Mean E2SFCA s	
			Hot spot	Cold spot	Mean	Hot spot	Cold spot	Hot spot	Cold spot	Mean	Hot spot	Cold spot	Hot spot	Cold spot	Mean	Hot spot
Rural Selangor	1,349	451,900	26.8	36.2	0.827	1.508	0.406	36.2	40.5	1.251	2.336	0.428	35.0	44.5	2.078	3.648
GBK	15	4,852	93.9	-	1.393	1.409	-	100.0	-	2.787	2.787	-	100.0	-	4.181	4.181
HUL	57	23,690	19.8	35.2	0.771	1.743	0.284	53.6	5.3	1.588	2.264	0.354	48.3	22.1	2.359	3.560
HUS	215	67,009	17.8	41.6	0.758	1.830	0.300	14.2	38.0	1.029	2.927	0.398	11.1	49.8	1.786	4.391
KLG	40	15,713	19.4	-	1.243	2.250	-	68.9	24.4	2.089	2.900	0.298	68.9	-	3.333	4.166
KUL	326	115,860	45.9	21.7	0.921	1.326	0.344	64.5	22.4	1.558	2.016	0.549	62.8	23.1	2.479	3.216
KUS	248	80,952	-	61.6	0.501	-	0.432	5.5	41.9	0.825	1.737	0.457	5.3	54.0	1.326	2.297
SBK	233	68,909	-	45.7	0.606	-	0.454	-	99.4	0.300	-	0.302	-	98.9	0.906	-
SPG	215	74,915	58.2	28.0	1.194	1.576	0.533	62.3	32.0	1.929	2.629	0.676	62.3	32.0	3.123	4.172

Note: Dash "-" refers to zero hot/cold spot EB in the district, therefore, respective mean E2SFCA score could not be calculated. The E2SFCA score were multipl 1000 to ease presentation.

Table 1: Total population and mean E2SFCA score of the hot/cold spot areas, by district

[Insert Table 1 about here – In separate file due to landscape format]

Equality of the E2SFCA scores distribution

Table 2 describe the degree of equality of the E2SFCA scores in rural Selangor as a whole rural Selangor and within each district. Across whole rural Selangor, the *Aspub* and *Astot* scores were equally distributed, with Gini coefficient values of 0.35 and 0.37 respectively. *Aspub* score exhibit greater degree of equality as compared to *Aspri* score (0.35 vs 0.43). Across districts, the Gini coefficient for *Aspub* score ranged between 0.18–0.47, 0.29–0.40 for *Aspri* score, and 0.17–0.33 for *Astot* score.

Table 2
Gini coefficient of accessibility scores.

	EB	*Aspub* score			*Aspri* score			*Astot* score		
		Gini	95% CI		Gini	95% CI		Gini	95% CI	
			LL	UL		LL	UL		LL	UL
Rural Selangor	1,349	0.35	0.33	0.36	0.43	0.42	0.45	0.37	0.36	0.38
GBK & HUL	72	0.37	0.31	0.43	0.29	0.23	0.36	0.32	0.26	0.39
HUS	215	0.47	0.40	0.53	0.40	0.35	0.44	0.33	0.29	0.37
KLG & KUL	366	0.29	0.27	0.31	0.31	0.28	0.33	0.29	0.26	0.31
KUS	248	0.18	0.16	0.20	0.31	0.28	0.34	0.25	0.22	0.27
SBK	233	0.20	0.18	0.22	0.34	0.30	0.38	0.17	0.15	0.19
SPG	215	0.30	0.28	0.33	0.31	0.28	0.34	0.30	0.27	0.33
Note: GBK and KLG districts were combined into its nearest adjacent district, due to small number of EB										

Discussion

Malaysia has a unique public-private mix health care delivery system, where public clinics were principally managed by the Ministry of Health (MOH) whereas private clinic largely funded through out-of-pocket payment or health insurance, registered under MOH. Although public clinic is the main primary care service provider for both urban and rural population catering for about 60% of total outpatient attendance as compared to private [46, 63], public primary care services mainly focuses on serving rural population and poorer population. On top of static or landed clinics, there are also mobile services which attend to scheduled sites to serve population at targeted remote areas [64]. For private clinics, they were mainly located in urban areas (Fig. 1b), similar as previously reported [12, 13].

The rationale of calculating the spatial accessibility score to primary care services separately based on public-private sector is to provide insight on how much the private sector and public sector contribute to the health care delivery system in our local context respectively. Public clinics should be accessible to all rural population knowing of its affordable price, but may not for private clinics due financial barrier. Total accessibility score to primary care services accounting both public and private clinics reflects the ideal accessibility level of the rural population when the financial barrier is lifted. In fact, the state authorities had introduced a health care subsidization scheme called "*Peduli Sihat*" to alleviate health care cost targeting the poorer population to utilize private clinic [65]. Assuming that no financial barrier among the rural population through benefiting from the subsidiary scheme, the total accessibility score to primary care services was approximately doubled (Fig. 2c) as compared to accessibility score that based on public clinics only (Fig. 2a). Another viable reason of understanding the accessibility score to public or private clinics separately is because of higher tendency of those rural population and poorer population to utilize or favor public clinics [50, 63], despite of having choice to opt for private clinics. Our study also found that rural population of Selangor actually had good spatial accessibility to private clinics and most districts have equal or higher *Aspri* score compared to the *Aspub* score. Nonetheless, this study found that total E2SFCA (*Astot*) score was contributed 59% by the private sector (*Aspri* score), this indicate that health policy related to public-private collaborative such as subsidization for poorer population to utilize private clinic is fairly important for improving access to primary care services.

Spatial pattern of the E2SFCA scores exhibited in Fig. 3 showed that discrepancies of access existed throughout rural areas of Selangor where higher score tends to appears near to any urban area. It can be observed that the E2SFCA scores, were higher near or surrounding the urban area in each district especially surrounding the large urban agglomeration at the center of the state. This explains why districts that had closer proximity to the large urban center of the state such as GBK and KLG tend to have higher E2SFCA scores, regardless of *Aspub*, *Aspri* or *Astot* score. These findings exhibit similar to commonly reported, where higher access primarily occurs near or surrounding the large urban areas [14–16, 66]. In our study, possible reasons were because the private clinics heavily concentrated in the large urban core at the center of the state, alongside with the presence of extensive road network, because the public clinics appears to had more disperse distribution across both urban and rural areas throughout the state (Fig. 1b) and the Gini value also proved that the public clinics were more equally distributed compared to the private clinics.

Meanwhile, areas with lower E2SFCA scores were more prominent at the northern part of Selangor and along the coastal regions (Fig. 3). Descriptive statistics (Fig. 2) also revealed that three districts at the northern part of Selangor state such as SBK, KUS and HUS have the lowest E2SFCA scores, regardless of *Aspub*, *Aspri* or *Astot* score. Based on Household Income and Expenditure Survey (HIES) 2016, those three districts also amongst the lowest median household income [67], which could possibly link the association between lower accessibility and low socio-economic status of the population that were commonly reported [24, 29, 40, 68].

Although spatial pattern of the E2SFCA scores can be observed, hotspot analysis provides better indication by distinguishing and pin-pointing specific areas that were statistically significant of high and low E2SFCA scores that clustered together. Hot spot analysis (Fig. 4) confirms that the cold spots mostly located further from the urban center region of the state, particularly on the coastal area of SBK and KUS, middle HUS, as well as at the southern coastal areas of Selangor. Low E2SFCA scores along the coastal areas (except at the center region) probably due to the imbalance between high population density and number of clinics at those areas. Furthermore, the road network also not as extensive as at road near the urban center region (which can be observed in Fig. 1b). Though, the association between population density and road network could be confirmed using appropriate statistical analysis however that is not the scope of this paper. Although hot spot areas mainly concentrated surrounding the large urban center of the state, there were some hot spot areas located up north of the HUS district, which is due to the existence of public mobile services there. This finding could suggest that mobile services were relatively effective in alleviating access to primary care at the targeted area.

Although discrepancies of access existed across rural of Selangor, but the disparities may tolerable and the distribution of the E2SFCA scores were reasonably equal with exception of the *Aspri* score. Amongst the districts, HUS appear to had the least degree of equality in term of all three E2SFCA scores, this could be the geographic distribution of the population settlements and clinics was spatially heterogenous (Fig. 1), causing the large variation in the E2SFCA scores. On the other hand, KUS and SBK were the better-off in term of equality. Though, having equal distribution of the E2SFCA scores alone may not suffice to indicate how good the accessibility in that area. For example, KUS and SBK had good Gini coefficient values but they were both at the lower end in term of E2SFCA scores. Rural areas in northern part of Selangor had bigger primary care accessibility issues as compared to other districts, due to relatively low accessibility scores (KUS and SBK), and even worst for HUS because it also had a low degree of equality as well. Nonetheless, access to public (*Aspub* score) appear to had higher degree of equality in the northern coastal part, particularly KUS and SBK, except for HUS which was the worst. Meanwhile, private had higher degree of equality near the urban center (GBK and HUL) region of the Selangor state.

During the E2SFCA scores calculation, all rural EBs in Selangor can reach public clinic within catchment size of 30 minutes, meaning that none of the EB had zero *Aspub* score. Meanwhile, most EBs can reach any private clinic within the catchment size and only small number of EBs have zero *Aspri* score (results not shown). This indicates that the use of 30 minutes catchment size is suffice and applicable for rural Selangor setting, although 30 minutes catchment size was initially recommended for urban areas [32]. But if a larger scale study to be conducted (macro or national level), using multiple catchment sizes will be crucial due to different threshold distances amongst the population. For example, urban population should have smaller catchment size due to services and population are densely located. But for rural population, they are have to travel further as the health services are more dispersed, hence requires larger catchment size to avoid zero E2SFCA scores [54]. As for our national context, it is possible to use the National Health and Morbidity Survey data to gauge optimal catchment size for each state or region for the variable catchment size approach, based on reported mean distance to seek primary care for each states or region. Similar approach in determining specific catchment sizes for specific region or states could be applied for other country given the required variables were available in their national household survey or census data.

Considering the dual public and private providers, this paper depicts a comprehensive situation of the spatial accessibility to primary care of our local context specifically in rural Selangor state which has not has been conducted before. In order to produce accurate results, this study used smallest area aggregation data (i.e., EB) to produce homogenous areal unit and also includes the data on population and health facilities from adjacent states to eliminates edge effect [36]. The conceptualization of the spatial accessibility in this study accounts for health need (*HN*) of the population and availability of each clinic. Higher *HN* population implies that higher utilization of primary care services among them, causing reduced access due to higher competition and congestion. This is also consistent with the National Health Morbidity Survey findings where vulnerable populations (i.e., toddler, elderly and women aged 15–45) had higher number of annual outpatient visit [50, 63, 69]. Khakh et al., (2019) in his study suggested that service hours and days of clinics' working can be considered to further improve the measure of access [70], in which this study had incorporated the clinics' availability factor in the E2SFCA calculation. Higher clinic availability means that the population had more opportunity window to obtain health care services, given that the clinics had longer operating hours. Future study could be conducted to explore how the accessibility differs between office hours (day), and after office hours (night), as temporal differences of accessibility could exists depending on the clinic or facility schedule [71].

In the future, data such as actual number of doctors and clinic's operating hours can be incorporated into the E2SFCA calculation to further improve precision of the accessibility scores estimation as per Malaysia's context. This study also only use fixed catchment size of 30 minutes, regardless of type of clinic although bigger clinic should theoretically have bigger catchment size or service coverage [54, 72]. Therefore the use of multiple catchment sizes depending on type of clinic or different types of rural areas also could further improve the precision of the E2SFCA measure, especially for a national-level or a larger scale study [32, 73]. This study also demonstrates the practicability of data integration, benefiting from multiple databases that routinely collected by the government agencies. Continuous monitoring on the performance of the primary health care accessibility could be conducted feasibly.

Limitations

There were some limitations of the study, number of doctors used to weight the primary care services capacity at each facility was based on assumption. This study assumed all public clinics to have six doctor per clinic (except for mobile services). In our actual context, the public clinics have seven types (type I-VII) of categorization with the former (type I) is the largest health clinic catering for higher number of patients per day, hence could have higher number of doctors per clinic, compared to the latter one. Another limitation was the data on clinic's operating hour for private clinics were only based on 24-hour statuses as the actual operating hour data was not available at the moment of this study commenced, although data on public clinic's operating hour can easily be obtained. Despite of using finest spatial aggregation of population data available, it still has a limitation as the data was for year 2010. Although it is estimated that Selangor had average population growth of 1.9% annually for the last 10 years [74], it may be difficult to consider the dynamic change of the population due to migration, constant boundary changes, opening of new settlements or city [75] as well as urban expansion [76].

Conclusions

As conclusion, this study comprehensively described the situation of the spatial accessibility to primary care specifically for rural areas in Selangor state of Malaysia in term of spatial pattern, identification of low and high accessibility areas, quantification of population affected as well as the degree of equality of the spatial accessibility. These findings could benefit the policy maker and health authorities in identifying areas that need attention. High access areas were seen concentrated near to the urban center of the state. On the other hand, northern part and coastal region of the state appears to be areas that need attention as it had relatively lower accessibility score and degree of equality. Although the disparities of access to primary care in Selangor state were not severe however there were still room for improvements. Perhaps, primary care services at low access area could be further improved either by upgrading existing facility or bring the services nearer to population through mobile services. Our findings also suggest that a good public-private partnership policy in primary care could remarkably improve the access among rural population.

Declarations

Ethics approval and consent to participate

This research was registered under National Medical Research Registry (NMRR-18-837-39750). Ethical approval was obtained from Medical Research & Ethical Committee under provision of Ministry of Health Malaysia, reference number KKM.NIHSEC. P18-1491(5). This study only involves the use of secondary databases that were routinely collected by several government agencies for research purpose, formal approvals were sought from respective custodian of the data

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the current study are not publicly available due the data sharing agreement with the respective data custodian. Processed data are however are available from the corresponding author on reasonable request and with permission of the respective data custodians (Department of Statistics Malaysia and Malaysian Centre of Geospatial Data Infrastructure).

Competing interests

The authors declare that they have no competing interests.

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Authors’ contributions

JAH, MHJ, RAM and PYL conceptualized the study. JAH, and PYL conduct general statistics and data management, while SNSI provide technical input on spatial data analyses. JAH and PYL drafted the manuscript, MJH and RAM assisted in finalizing the manuscript content. This study is under supervision of MHJ, RAM, SNSI and PYL. All authors read and approved the final manuscript.

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Figures

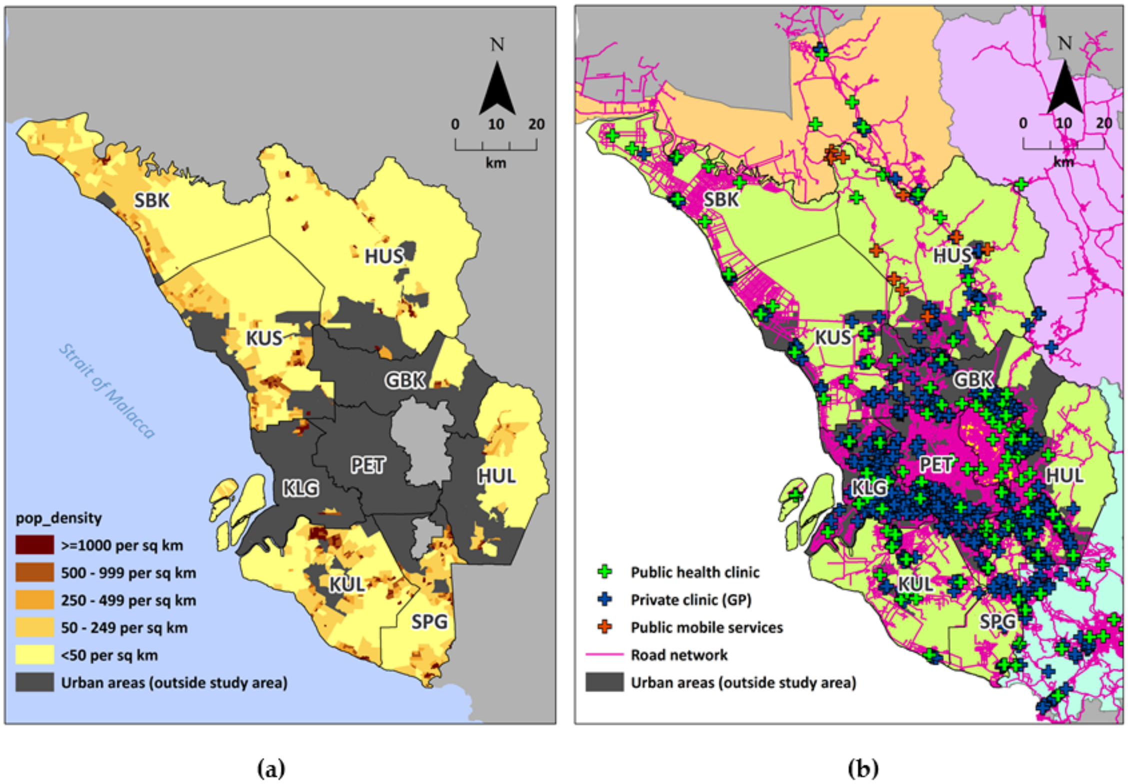


Figure 1

Study area and districts from adjacent states. (a) Population density (person per square kilometer) of rural Selangor. (b) Primary care facility distribution (by clinic type) and road network of study area and adjacent districts/states. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

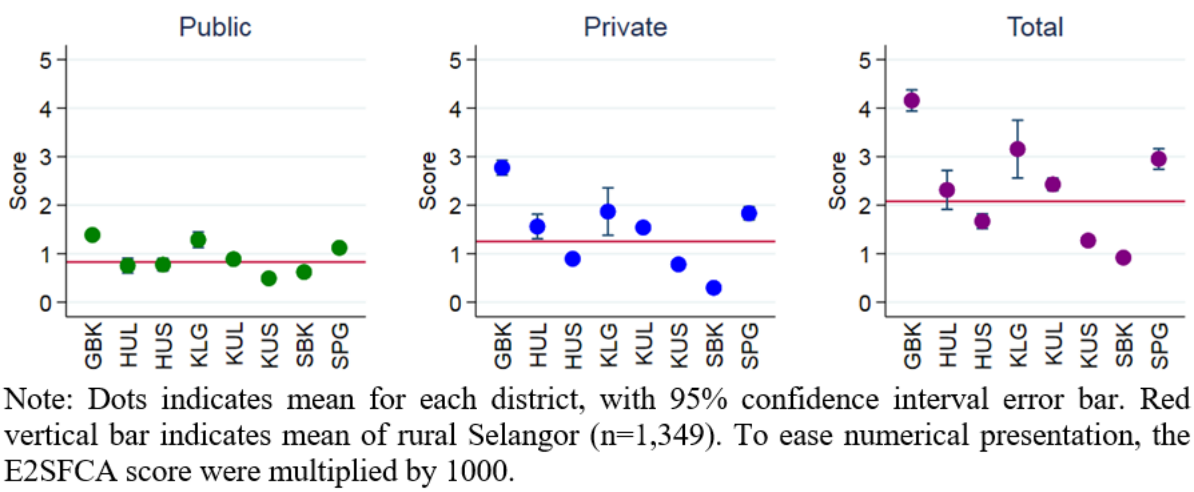
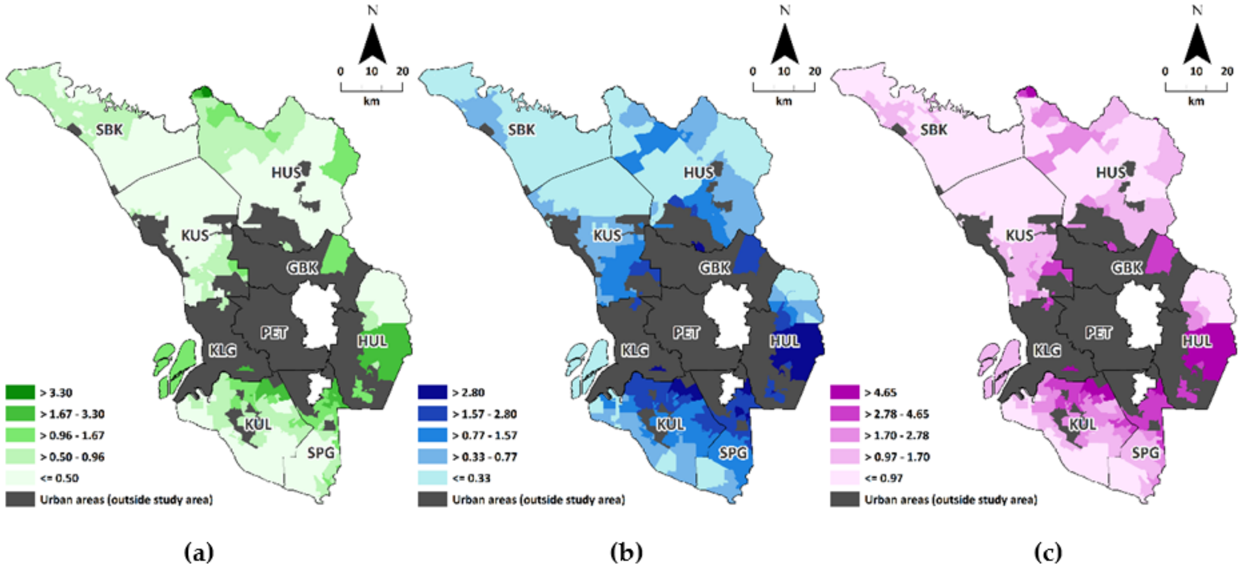


Figure 2

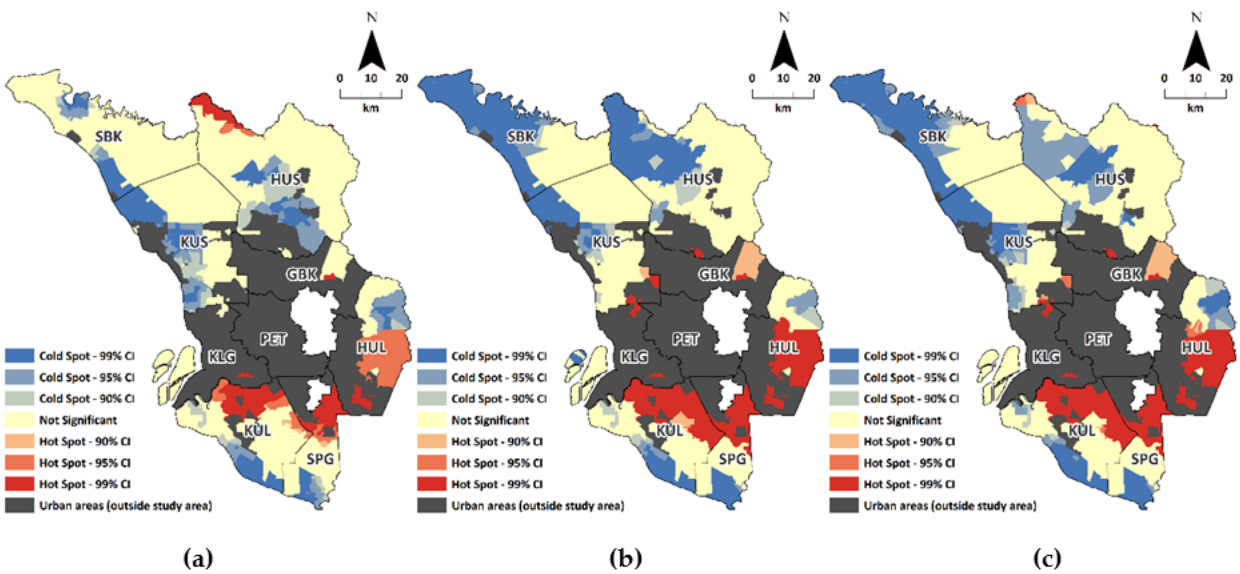
Descriptive statistics on E2SFCA scores (Public, Private and Total accessibility), across districts of Selangor.



Notes: Based on Natural breaks (Jenks) classification. The E2SFCA score were multiplied by 1000 to ease presentation.

Figure 3

Spatial pattern of E2SFCA scores distribution. (a) Aspub score, (b) Aspri score, and (c) Astot score. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.



Notes: Hot/cold spots identified based on Getis-Ord GI* statistics. All Global Moran's I test showed positive autocorrelation (ranged from 0.60 to 0.92) with statistical significance of $p<0.001$.

Figure 4

Mapping of Hot-spot analysis of the E2SFCA scores. (a) Aspub score, (b) Aspri score, and (c) Astot score. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.