

## SPATIAL ACCESSIBILITY OF PRIMARY CARE SERVICES AMONG RURAL POPULATION IN SELANGOR, MALAYSIA



By

JABRULLAH BIN AB HAMID

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

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Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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June 2022

Chair Faculty : Lim Poh Ying, PhD : Medicine and Health Sciences

Disparities of access to health services in rural areas is a global health issue, especially in middle-income countries. Lack of access or delay in getting adequate treatment leads to poorer health outcomes. Recent method called enhanced two-step floating catchment area (E2SFCA) exhibits promising results in quantifying spatial accessibility. Comprehensive understanding of current extent of disparities of accessibility to primary healthcare in local context is essential. This study is to determine the spatial accessibility score to primary care services (clinics) across rural population in Selangor and its associated ecological factors, as well as to propose solutions for primary care service capacity upgrade.

This cross-sectional ecological study employed a geographical information system (GIS) based approach to calculate the spatial accessibility, adapted from E2SFCA method considering both public and private clinics. Public clinic refers to health clinics (*Klinik Kesihatan*) and 1Malaysia mobile clinics govern by the MOH that operated by at least one doctor. Private clinic refers to general practitioner (GP) or private medical clinic. Other types of clinics, dental clinic or primary care services that are provided at hospital is not included for the calculation of spatial accessibility score. Population data was from Housing and Population Census 2010. The spatial pattern of the E2SFCA scores was based on geostatistical tests (Global Moran's I and Getis-Ord Gi\*) and the degree of equality was based on Gini index. Associated ecological factors determined using multiple linear regression. The location-allocation modelling performed to identify optimal locations for public clinic service capacity upgrade, to improve accessibility in low E2SFCA scores areas.

High E2SFCA scores areas mainly concentrated surrounding the urban agglomeration at the centre of Selangor, largely contributed by the private sector. Low E2SFCA scores areas predominantly at the northern and coastal regions. Distribution of E2SFCA scores were equal but lower degree of equality observed at the northern region. Rural areas, closer to urban area, higher road density and higher proportion of vulnerable population were positively associated with higher E2SFCA scores (p<0.05). In the location-allocation modelling, coastal areas were prioritised for service capacity upgrade in order to optimise the increment of E2SFCA scores.

The level and distribution of E2SFCA scores reflect the performance of primary healthcare. This study provide insight for identifying disparities and areas that need attention as well as potential solutions to resolve the issue. Identification of the influencing factors elucidates the characteristics of the accessibility pertinent to local context. This approach of utilising existing data combined with GIS-based technology delivers great contribution for evidence-based in formulating policy and healthcare planning related to accessibility and resource distribution, such as projecting the health workforce distribution according to the population need. In addition, using existing data routinely collected by the government ease replication for continuous monitoring, as well as can be applied in other health care services.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

### AKSES SPATIAL BAGI PERKHIDMATAN KESIHATAN PRIMER DI KALANGAN POPULASI LUAR BANDAR SELANGOR, MALAYSIA

Oleh

## JABRULLAH BIN AB HAMID

Jun 2022

### Pengerusi : Lim Poh Ying, PhD Fakulti : Perubatan dan Sains Kesihatan

Ketidaksamaan dalam kebolehcapaian (akses) kepada perkhidmatan kesihatan di kawasan luar bandar merupakan isu kesihatan global, terutamanya bagi negara berpendapatan sederhana. Kekurangan tahap kebolehcapaian atau pengangguhan dalam mendapatkan rawatan boleh mendatangkan kesan yang buruk terhadap kesihatan amnya. Kebolehcapaian spatial boleh diukur dengan menggunakan keadah terkini yang dipanggil *Enhanced Two-Step Floating Catchment Area* (E2SFCA). Pemahaman menyeluruh mengenai tahap ketidaksaksamaan dalam kebolehcapaian kepada perkhidmatan penjagaan kesihatan primer dalam konteks tempatan adalah penting. Kajian ini dilakukan untuk menentukan tahap kebolehcapaian spatial kepada perkhidmatan pengjaan kesihatan primer (klinik) bagi seluruh penduduk luar bandar di negeri Selangor, serta mengenalpasti faktor ekologi yang mempengaruhi tahap kebolehcapaian spatial, dan juga memcadangkan solusi bagi meningkatkan kapasiti perkhidmatan dan tahap kebolehcapaian.

Kajian ekologi keratan rentas ini menggunapakai kaedah berasaskan Sistem Maklumat Geografi (*Geographical Information System*, GIS) untuk mengukur tahap kebolehcapaian spatial, yang diadaptasi daripada kaedah E2SFCA dan dengan sedikit modifikasi bagi mengambil kira klinik dari sektor kerajaan dan swasta. Klinik kerajaan merujuk kepada Klinik Kesihatan dan Klinik Bergerak 1Malaysia yang ditadbir urus oleh Kementerian Kesihatan Malaysia (KKM), beroperasi dengan sekurang-kurangnya satu pegawai perubatan (doktor). Klinik swasta merujuk kepada klinik perubatan swasta. Selain daripada jenis klinik yang dinyatakan, klinik pergigian atau perkhidmatan kesihatan primer yang ditawaran di hospital tidak termasuk bagi pengiraan skor kebolehcapaian spatial. Data berkenaan penduduk diperolehi daripada data Banci Perumahan dan Penduduk (Census) 2010. Corak spatial bagi tahap kebolehcapaian (skor E2SFCA) ditentu ukur berdasarkan ujian geostatistik (Global Moran's I dan Getis-Ord Gi\*), manakala tahap kesamaan (*degree of equality*) adalah berdasarkan pekali Gini. Faktor ekologi yang mempengaruhi tahap kebolehcapaian spatial dikenalpasti menggunakan analisa regresi linear berganda. Analisa permodelan spatial, location-allocation modelling dilakukan untuk mengenalpasi lokasi yang optimum bagi peningkatan kapasiti perkhidmatan di klinik kerajaan, untuk menambahbaik kebolehcapaian di kawasan-kawasan yang mempunyai skor E2SFCA (tahap kebolehcapaian spatial) yang rendah.

Kawasan yang berskor tinggi bertumpu di sekitar pusat bandar di bahagian tengah negeri Selangor dan didapati sebahagian besarnya adalah disumbangkan oleh sektor swasta. Manakala kawasan berskor rendah kebanyakannya dikenalpasti di bahagian wilayah utara negeri dan kawasan sepanjang persisir pantai. Berdasarkan pekali Gini, taburan skor adalah sama tetapi tahap kesamaan yang lebih rendah dikenalpasti di bahagian wilayah utara. Bagi factor-faktor yang mempengaruhi skor atau tahap kebolehcapaian, Kawasan luar bandar, lokasi berdekatan kawasan bandar, kepadatan jalan raya yang tinggi serta kawasan yang mempunyai peratusan populasi rentan yang tinggi mempunyai hubungkait positif dengan skor yang lebih tinggi (p<0.05). Dalam analisa location-allocation modelling, kawasan persisir pantai dikenalpasti sebagai kawasan yang perlu diutamakan untuk peningkatan kapasiti perkhidmatan bagi mengoptimakan peningkatan skor E2SFCA keseluruhan.

Prestasi perkhidmatan penjagaan kesihatan primer dipamerkan oleh tahap dan taburan skor E2SFCA. Kajian ini telah menunjukkan dan mengenalpasti tahap ketidaksamaan dan kawasan yang memerlukan perhatian utama serta mencadangkan solusi yang berpotensi bagi menyelesaikan permasalahan dan isu tersebut. Faktor-faktor yang dikenalpasti dapat memperjelaskan lagi ciri-ciri kebolehcapaian spatial dalam konteks tempatan. Pendekatan menggunapakai data sedia ada dan menggunakan teknologi analisa berasaskan GIS ini dapat menyumbang bagi menghasilkan bukti empirik yang boleh digunapakai dalam penggubalan dasar dan perancangan berkaitan perkhidmatan penjagaan kesihatan secara amnya dan berkaitan tahap kebolehcapaian dan pengagihan sumber, seperti membuat unjuran pengagihan tenaga kerja mengikut keperluan semasa penduduk. Di samping itu, pengunaan data sedia ada yang dikumpulkan oleh pihak kerajaan secara rutin memudahan pengulangan kaedah bagi pemantauan berterusan, serta boleh diaplikasikan bagi perkhidmatan kesihatan yang lain.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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# LIST OF ABBREVIATIONS

UPM	Universiti Putra Malaysia
FCA	Floating Catchment Area
2SFCA	2 Step Floating Catchment Area
E2SFCA	Enhanced 2 Step Floating Catchment Area
DOSM	Department of Statistics Malaysia
МОН	Ministry of Health
MaCGDI	Malaysian Centre of Geospatial Data Infrastructure
JUPEM	Jabatan Ukur dan Pemetaan (Department of Survey & Mapping)
WHO	World Health Organisation
EPU	Economic Planning Unit
11MP	11th Malaysia Plan
GIS	Geographical Information System
EB	Enumeration Block
CD	Census District
MCLP	Maximum Covering Location Problem
MaxAttend	Maximum Attendance
HN	Health need
SES	Socio-economic status
LQ	Living Quarters
нн	Household
CKAPS	Cawangan Kawalan Amalan Perubatan Swasta (Medical Practice Control Section)
FA	Factor Analysis
SLR	Simple linear regression

- MLR Multiple linear regression
- SA score Spatial accessibility score
- Q1 Q5 Quintile 1 Quintle 5 (Quintiles)
- SE Standard Error
- 95% Cl 95% Confidence Interval
- MREC Malaysia Research Ethic Committees
- NMRR National Medical Research Registry
- Aspub Accessibility score to public clinics
- Aspri Accessibility score to private clinics
- Astot Total Accessibility score
- LASEB Low accessibility score enumeration block
- L-A Location-allocation

### **CHAPTER 1**

#### INTRODUCTION

### 1.1 Background

Primary care is the first point of contact between patients and the health system, focusing on delivering basic or general health care services to the population as well as responsible for the continuity of care and coordination of specialised care and referral (Starfield & Reader, 1993; World Health Organization, 2011). Malaysia has a unique public-private mix of health care provider and the primary care partially fulfils a gatekeeper function as the population can bypass a referral from primary care clinics and go directly to public hospital outpatient care, due to 'open door' policy by the government (World Health Organization, 2012). Public clinics principally funded by the government and managed by the Ministry of Health (MOH), with nominal user fees. Private clinics are largely funded through out-of-pocket payments (fee-for-service basis) from patients or private health insurance, registered under the MOH.

Public clinic is the main primary care service provider catering for about 60% of total outpatient attendance as compared to private (Institute for Health Systems Research, 2020; MOH, 2020b), public primary care services mainly focus on serving rural population and poorer population due to its nominal fee-for-service nature.

In 2019, there were 1,027 MOH health clinics (*Klinik Kesihatan*) with health clinic to population ratio is about 1:31,000, while there were 7,988 registered private clinics (MOH, 2020b). In term of number of clinics, both public and private sector has been growing steadily. Though, the private sector has grown rapidly over the last decade (Rannan-Eliya et al., 2016). In term of number of doctors, there are 52,129 and 15,457 doctors in public and private sector respectively, with a total doctor-to-population ratio of 1:482 (MOH, 2020b). The growth in doctor-to-population ratio for the sector population in the 11th Malaysia Plan (Economic Planning Unit, 2015b) which are comparable to "developed" and high-income countries (WHO, 2013).

Despite that, accessibility to health care was a concern in the performance of the health care delivery systems (MOH, 2011) where disparities of access existed and 'less-developed' region generally had lower doctor-to-population ratio (WHO, 2013). Nonetheless continuous improvement and several strategies has been reinforced to increase accessibility by improving system delivery, developing new facilities, and upgrading existing facilities (Economic Planning Unit, 2015b), to ensure optimal performance, sustainability and to cope with

increasing expectation and demands of the population towards universal health coverage.

### 1.2 Accessibility to health care

In general, accessibility to health care can be defined as relative ease of health services can be reach and utilised by the population (Peters et al., 2008; Starfield, 2001; World Health Organization, 2011). In fact, accessibility to health care is a complex concept and several theoretical frameworks of health care accessibility existed over the few decades (Andersen, 1995; Derose et al., 2011; Khan & Bhardwaj, 1994; Penchansky & Thomas, 1981; Peters et al., 2008).



Figure 1.1 : Conceptual framework for accessibility to health care services (Adapted from Peters et al., 2008)

Accessibility to health care can be divided into four main dimensions: geographic accessibility (physical distance), availability (adequacy of services at specified location), affordability (financial capability), and acceptability (behaviour) (Mahmud & Aljunid, 2018; Peters et al., 2008) as illustrated in Figure 1.1. Geographic accessibility refers to the physical distance between location of supply (health care services or provider) and demand (population). Availability refers to the adequacy of service-to-provider supply in relation to the demand which are the population who potentially utilise the service. Acceptability generally describes the users' satisfaction towards with the quality of the services provided. While affordability describes the relationship between service cost and the ability of clients to pay (Derose et al., 2011; Khan, 1992; Penchansky & Thomas, 1981; Peters et al., 2008). Those four distinct dimensions were inter-

connected and associated between each other and affected by the population characteristics and macro environments.

The four dimensions also can be classified as spatial and non-spatial component, where spatial component encompasses of geographic accessibility and availability. Non-spatial component includes affordability, and acceptability (behaviour). From another point of view, access to health care also can be divided of either potential or realised, based on stages of use (Guagliardo, 2004; Khan, 1992; Luo & Wang, 2003). Potential access refers to existing service capacity and potential population who will be able to enter the health care system, considering the barriers and facilitator of entry into the system. Whereas realised access describes the actual use of care. This study only focuses on the potential accessibility, particularly on the spatial component of accessibility, referred as spatial accessibility.

There are several methods commonly used to measure spatial accessibility. The availability ratios (provider-to-population ratios) is widely used (Guagliardo, 2004) and most popular among policy maker due to its easy to interpreted and commonly used for international comparison in statistics report. It refers to the amount of supply and capacity of healthcare services, reflecting the availability of the healthcare services in a region (or a defined boundary) (Khan, 1992). Other than that, spatial accessibility to health services also can be measured based on: (1) travel time or distance to nearest health care facility or service; (2) number of services within certain threshold distance from population, (3) population coverage within certain threshold distance from service; (4) gravity models, which assumes accessibility decreases with increasing distance separation between health service or facility and population, and; (5) two-step floating catchment area - 2SFCA method, which is currently emerging as a popular method (Apparicio et al., 2017; Song et al., 2018). The details of the methods of measuring accessibility to health care will be elaborated in section 2.2.

### 1.3 **Problem statement**

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 (Peters et al., 2008; Van Doorslaer et al., 2006). Globally, rural population often have the issue of the lack of access to health care services as compared to urban counterpart (Apparicio et al., 2017; Bauer et al., 2017; Gulliford et al., 2002) and often had lower level of health service utilisation (Awoyemi et al., 2011; Kiwanuka et al., 2008; Rice & Smith, 2001). The lack of access and utilisation largely constrained by the travel impedance and availability of the services (Habicht & Kunst, 2005; Luo et al., 2009; Marmot, 2005), which can potentially lead to poorer health outcomes (Lawson et al., 2013; Rice & Smith, 2001) and subsequently lead to even higher health care cost (e.g., unnecessary or avoidable hospitalisation) if not being treated well earlier (Kraft et al., 2009; Wee

et al., 2007). Nonetheless, health care services and population demand are hardly to be equally distributed (Luo et al., 2009; Luo, 2014). Similar situation also occurred in primary health care setting in Malaysia where less developed areas in Malaysia generally had lower access in term of provider-to-population ratios (WHO, 2013), due the private sector which were usually concentrated in developed urban areas (Hazrin et al., 2013; World Health Organization, 2012).

In general, rural area in Malaysia defined as non-gazetted area (with a predefined imaginary geographical boundary called enumeration block) with a population of less than 10,000 (DOSM, 2011b). Therefore, rural areas in Selangor state was chosen as the study location based on the following reasons, including low health facility-to-population ratio, particularly for public health facility, and relatively low percentage of population resides within 5km to nearest health facility; as compared to other states in Malaysia. These was the strong justification to indicate the existence of pockets of areas with poor accessibility in Selangor. Therefore, rural area was suggested to investigate further. Based on available population census 2010 data, although Selangor state is one of highest urbanisation rate of 91.4% (DOSM, 2011a) and generally had better off socio-economic indicators compared to other states (Department of Statistics Malaysia, 2015), disparities of accessibility to health care could also eventually occurs in Selangor.

According to the National Health Indicator Report for year 2019 (MOH, 2020b), Selangor also has a relatively low public health facility-to-population ratio of 1:33,308 which is about three times lower than national average (1:11,293), as Selangor is the most populated state. In term of doctor-to-population ratio, the ratios for Selangor is 1:517 which is similar to national's average of 1:482 (MOH, 2020b). Although Selangor could boast in having highest number of doctors compared to any other states, the ratios may an overestimation as it includes doctors from academia as well as in managerial posts. It has been estimated that only 9% of total doctors in public sector, and 62% of total doctors in private sector works in primary care setting (Sivasampu et al., 2016).

From the perspective of distance to nearest health facility, disparities of access also been observed where rural population generally population generally live further from the nearest health facility, compared to the urban counterpart (Shariff et al., 2012; World Health Organization, 2012). Similar findings also has been reported by the National Health Morbidity Survey 2015 where higher percentage of population in rural area (27.4%; 95% CI: 23.6-31.5) had to travel more than 10km to seek outpatient care, compared to those in urban area (18.8%; 95% CI: 16.8-20.9) (Institute for Public Health, 2015b). In the Household Income and Basic Amenities Survey 2016, although rural population in Selangor had 81.9% of them living less than 5km to nearest public health facility, the figure is actually the lowest in Peninsular Malaysia (Department of Statistics Malaysia, 2017).

With that facts, rural Selangor served as a good location for case study to assess the spatial accessibility. Knowing that rural population is more likely to utilise public health facilities (Institute for Public Health, 2015b) coupled with a limited number of primary care facilities throughout Selangor to cater such high number of populations, there is possibility of overburden of public facilities and disparities of access could eventually exist. Rural population are also more frequently associated with accessibility issues, and within rural areas itself disparities could occurs where lower accessibility often associated with deep rural areas located further from the nearest urban area (Apparicio et al., 2017; Delamater, 2013; Donohoe et al., 2016a; Grimes et al., 2011; Shah et al., 2016) Large variation and difference in term of spatial accessibility to primary care could potentially be observed across the spectrum of suburban areas near the urban agglomerations of Kuala Lumpur to the deep rural areas.

The disparity of access to health care in Selangor (particularly areas with lack of access) may consequently lead to poorer health outcome in Selangor. The prevalence of burden of non-communicable disease (NCD) such as undiagnosed hypertension, undiagnosed diabetes mellitus, and undiagnosed hypertension (Institute for Health Systems Research, 2020; Institute for Public Health, 2015a) as well as mortality rates (maternal mortality, crude death rate) and stillbirth rate (MOH, 2020b) in Selangor relatively comparable to the national average. However, Selangor state had higher incidence of several communicable diseases (such as Dengue, Chikungunya, Syphilis) and mortality rate due to the communicable diseases (MOH, 2020b), as well as high number of recent outbreaks of Covid-19 cases (MOH, 2022). Although the are no reported specifically on rural Selangor had higher prevalence of communicable diseases as compare to urban Selangor, however national level analysis on prevalence of communicable diseases found that the communicable diseases were more prevalent at rural areas as compared to the urban areas(Institute for Public Health, 2021), which could occur in Selangor as well.

Therefore, it is important to address issues related to accessibility to primary care services in order to prevent the poorer health outcome due to such diseases that requires higher level of care and incurs higher cost for health care. In regard of the persisting issue on disparities of accessibility to health care services, it is vital to have an accurate and reliable measure of access for future planning to ensure optimised health care resource distribution to cope with the dynamic changes of health need of the population.

The use of availability ratio and nearest distance as a proxy measure of accessibility to healthcare has been accepted globally, however it is rather a simplistic measurement and has several limitations. Availability ratios ignores cross-boundary interaction, not considering distance separation and proximity and unable to show spatial variations within a large or high level of spatial aggregation (e.g., state, province, district) (Hu et al., 2013). The nearest distance ignores the behaviour of bypassing because it always assume population will utilise nearest services, and also did not consider the amount of availability and population demand (Dewulf et al., 2013; McGrail & Humphreys, 2014). To overcome those limitation, with the aid of technology advancement in Geographical Information System (GIS), a better approach has been developed

which is called enhanced two-step floating catchment area (E2SFCA) where it covers all the limitations mentioned (Luo & Qi, 2009). It was called "two-step" because it considers the: (1) service catchment area, and; (2) population catchment area. The E2SFCA method was revised version of the original 2SFCA method 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 (Radke & Mu, 2000; Wang & Luo, 2005). Currently, E2SFCA is considered the standard 2SFCA method (Dewulf et al., 2013).

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, (Apparicio et al., 2017; Bauer et al., 2018; Donohoe et al., 2016b; Jamtsho et al., 2015; Luo & Qi, 2009; McGrail & Humphreys, 2014; Rekha et al., 2017; Wang & Luo, 2005) as well as for among specific target population and services (e.g., elderly, ethnic minority, maternal health services) (Luo et al., 2018; Vadrevu & Kanjilal, 2016; Wang & Pan, 2016). 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 utilising the E2SFCA method. Current works and research related to the FCA-based also focusing on fine tuning the method, fitting to specific health care settings.

Therefore, it is important to study the accessibility to primary health care services, particularly using the more recent and accurate method, the E2SFCA in Malaysia local context which has not been done before. Other than that, it is also important have a comprehensive understanding of how the spatial accessibility score to primary care services distributed, including the factors that associated to the spatial accessibility. By observing the disparities of accessibility, areas that need attention could be identified by the health authorities for remedial efforts and optimisation of the resource distribution. This could contribute to the evidence-based for developing future framework in formulating policy related to health care accessibility.

### 1.4 Significance of study

Findings of this study will enrich the body of knowledge on health care accessibility, specifically for spatial accessibility to primary care in rural areas of Selangor. Main outcomes in this study were the comprehensive situation of spatial accessibility scores across rural areas in Selangor including the how the spatial accessibility score distributed across the rural areas, identify areas with high and low spatial accessibility scores, as well as the degree of equality of the spatial accessibility scores, factors that associated to the spatial accessibility

scores and finally the spatial optimisation models which was about finding optimal sites for further improvement on primary care service capacity.

The novelty of this study is the adoption and modification of the E2SFCA method by incorporating the facility availability (based on operating hour and working days) and considers the Malaysia's context of dual public-private providers in the health care delivery systems to determine the level of spatial accessibility to primary care services. The modification is expected to further improve the method specifically for our national local context. The E2SFCA method has proved to provide more comprehensive approach and accurate quantification of accessibility to healthcare and identifying both under-served and over-served area, by incorporating two main dimensions of access (service availability and geographic accessibility). This method also able to determine the accessibility of a finer spatial resolution analysis, rather than aggregating the accessibility at larger scale such as district or state level which may unable to pin point location with low accessibility due to high level of spatial aggregation. Later in this study, the spatial optimisation models will seek best location for service capacity upgrade in order to alleviate the areas with low spatial accessibility score for primary care across rural areas of Selangor.

Health is an integral part of development. Ensuring good access to primary care services (especially for the rural population) has been the national goal. That requires continuous monitoring, prompt and accurate measure of population access to health care. Therefore, it is a necessity to advance current understanding of accessibility to primary care services and findings of this research could be the bridge for implementation in future public health policies and programmes. Moreover, access to quality health care services is vital to achieving the universal health coverage as stated in the Sustainable Development Goals (SDG) in Malaysia, under the SDG outcome target 3.8 (DOSM, 2019). Achieving towards universal health coverage is one of the highlights for public health as adequate access to quality health services will safeguard the population from worsening health risks and potential risk of impoverishment due to illness (Kutzin, 2000; World Bank, 2022). In addition, research in the field of access to health services also one of the key health research priority areas under 12th Malaysia Plan (NIH, 2021), indicating that such pertinent information is deemed important by various stakeholders in Malaysia. Research uptake and application based on findings of this study by relevant authority such as Ministry of Heath, would be extremely beneficial for service planning and health resource allocation in order to improve accessibility to healthcare to the population. This study could serve as the basis for evidencebased for a context of rural Selangor.

## 1.5 Research question

Followings are the research questions for the study;

- 1. What are the spatial accessibility scores to primary care services distributed across rural areas in Selangor?
- 2. What are the factors that associated with the spatial accessibility to primary care?
- 3. Can a spatial optimisation model using GIS applied to possibly improve spatial accessibility to primary care among rural population in Selangor?

## 1.6 Objective of the study

### 1.6.1 General objective

The aim of this study is to determine and comprehensively describe spatial accessibility of primary care services, identify factors associated to the spatial accessibility score and to develop spatial optimisation model for rural population of Selangor Malaysia.

### 1.6.2 Specific objectives

Specific objectives of this study are as follows:

- 1. To determine and comprehensively describe the spatial accessibility score to primary care services across rural population in Selangor, determined using GIS-based enhanced two-step floating catchment area (E2SFCA) method.
  - a. To determine the spatial accessibility (E2SFCA) scores (public, private, total).
  - b. To map and describe spatial pattern/variation of the E2SFCA scores.
  - c. To determine both high and low E2SFCA score areas with using hotspot analysis (based on Getis-Ord-Gi\* statistics).
  - d. To determine spatial outliers using cluster and outlier analysis (based on Anselin Local Moran's I statistics).
  - e. To describe the degree of equality of the E2SFCA scores.

- f. To compare calculated E2SFCA scores with several other accessibility measures.
- 2. To determine the association between the ecological factors (geographical and demographic) with the E2SFCA scores to primary care services (public clinic, private clinics and total E2SFCA score) among rural population in Selangor.
- 3. To identify optimal sites for service capacity upgrade using the GISbased spatial optimisation technique using Location-Allocation Modelling among areas with low E2SFCA scores, and to assess how the optimisation can improve the E2SFCA scores.
  - a. To identify optimal site or location of existing public clinics for service capacity upgrade.
  - b. To evaluate the impact and outcome of the Location-allocation modelling in term of improvement of the E2SFCA scores.

### 1.7 Research hypotheses

There are several hypotheses in this study, based on each three main objectives:

- 1. For the first objectives, this study hypothesised that:
  - a. There is significant difference between the E2SFCA scores for public, private and total score.
  - b. The distribution of the spatial pattern observed across the study area is not due to random spatial processes.
  - c. There is significant difference (high or low) of the E2SFCA scores across study area, based on the Getis-Ord-Gi\* statistics.
  - d. There are areas with significantly different from its neighbouring or adjacent area (identified as outlier) based on the Anselin Local Moran's I statistics.
  - e. There is not significant unequal distribution of the E2SFCA scores across the study area.
  - f. There are differences between the E2SFCA scores and other accessibility measures across the study area.
- 2. There are association of geographical and demographic factors with spatial accessibility scores.
- 3. The Location-Allocation modelling significantly increase the E2SFCA score.

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