Analysis of Distribution and Public Accessibility of Dental Clinics in Johor, Malaysia using Geographic Information System (GIS) Methods

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Author's contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

Original Research Article

ABSTRACT

Aims: To evaluate the distribution and accessibility of dental clinics in Johor, Malaysia using GIS methods.
Study Design: Retrospective GIS-based study utilizing existing open-access secondary data.
Place and Duration of Study: Qualiteeth Dental Clinic**,** between January 2021 and May 2021.
Methodology: The location of each dental clinic in Johor was obtained from the Official Portal of the Ministry of Health Malaysia. The population data of each district in Johor were retrieved from the Department of Statistics Malaysia, Pocket Stats Quarter 1 2021. The map of Johor and its district boundaries were extracted from DIVA-GIS and mapped. All data for analysis were extracted from the integrated database in Quantum GIS (QGIS) into Microsoft Excel.
Results: Johor had a total population of 3.78 million up to the 1st quarter of 2021. There were a total of 395 dental clinics, consisting of 330 private and 65 public dental clinics within the state. It exhibited an overall dental clinic to population (DCtP) ratio of 1 dental clinic per 9,264 residents. The ratio of public dental clinics to population (PuCtP) was 1: 56,298 while the ratio of private dental clinics to population was (PrCtP) was 1: 11,089. The district which has the least number of dental clinics available to serve the population was Mersing. Disparities were found in primary dental clinics, with clinics more sparsely distributed in peripheral districts than in central districts.

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Conclusion: The spatial analysis shows a trend of urban clustering of private and public dental clinics. Besides, the relationship between DCtP ratio and population density was directly proportional, and dental clinics were distributed relative to the relative wealth. More private dental clinics could be found in districts with higher mean monthly household incomes.

1. INTRODUCTION

Spatial analysis is a technique used to examine the locations, attributes, and relationships of features in spatial data through overlay and other analytical techniques to address a question or gain useful knowledge. These skills have been used in emergency management, city services, business location, retail analysis, transportation modeling, crime and disease mapping, and natural resource management [1]. These tools help to solve health research questions from a geographical perspective such as: "What is the spatial distribution of the disease under consideration?", "Can we detect patterns?" and "What are the possible coincidences with disease-causing factors?" [2].

Information on the distribution of dental clinics in Malaysia is required to enhance the optimization of effectiveness and resource utilization among service providers. Geographic Information System (GIS) has the potential to access the patterns of dental clinics to identify geographic regions most in need of dental clinic access. GIS is currently recognized as a set of strategic and analytic tools for public health, so the design and implementation of an information system for dental clinic distribution with GIS capacity should be considered [3].

Malaysia is a country of Southeast Asia, lying just north of the Equator, between latitudes 1^0 to 7^0 North and longitudes 100^0 to 119^0 East. It composes of two noncontiguous regions: West Malaysia and East Malaysia. Malaysia comprises 13 states and 3 Federal Territories. The total land area of Malaysia is 329,758 km^2 with West Malaysia occupying 131,598 km^2 [4]. The total population of Malaysia in the 1st quarter of 2020 was estimated at 32.75 million and the population density stood at 99 persons per square kilometre [5].

The state under study is Johor, located at the southern part of West Malaysia. The state covers a total area of over 19,166 km^2 [6]. Besides, Johor has a projected population of 3.7 million by the 1st quarter of 2021 with a population density of 197 persons per square kilometre [7]. All 10 districts in Johor state are included in this study, namely Batu Pahat, Johor Bahru, Kluang, Kota Tinggi, Mersing, Muar, Pontian, Segamat, Kulai and Tangkak.

Healthcare in Malaysia is mainly under the Ministry of Health (MOH). Malaysia generally has an efficient and widespread system of healthcare, operating a two-tier health care system consisting of both a government base universal healthcare system and a co-existing private healthcare system [8]. The government aspires to achieve a developed nation status by 2020. It is from Vision 2020 that the Oral Health Division has taken the lead to formulate a National Oral Health Plan (NOHP) for the year 2010. The NOHP documents oral health goals and strategies. Goals are defined for four key oral conditions; dental caries, periodontal conditions, oral malignancies, and dental injuries. The Plan also outlines strategies to ensure that all stakeholders will play their respective roles towards improving oral health and the quality of life of Malaysians [9].

The shortage of dentists is one of the most common health workforce problems around the globe [10]. However, the total number of dentists in Malaysia has been increasing year by year. Malaysia Health Minister Datuk Seri Dr. Adham Baba reported that there were 11,059 dentists in public and private sectors as of June 2020, with the dentist-population ratio at 1:2,963. There were 6,530 dentists registered and served under the ministry [11]. Also, there were 1088 new dental registrants in 2019 while there were only 231 registrants in 2009 [12]. Moreover, the most serious problems are the maldistribution of dentists among regions and between rural and urban areas [10].

The distribution and accessibility of dental clinics have been addressed in many studies worldwide. However, published study on this using the GIS methods in Malaysia is very scarce. Given the current organization and maldistribution of oral health care in Malaysia and the widespread nature of oral diseases, it is crucial to analyze the extent to which the population can potentially access dental healthcare. Analysis using the GIS

methods can assist current and future practicing dentists, dental school administrators, and policymakers to make an informed decision to determine suitable practice locations and target areas for public health initiatives. This would help to deliver dental health service efficiently.

Hence, this study sought to examine the distribution and public accessibility of dental clinics in Johor, Malaysia using GIS methods. This study aims to present the number, location, and density of the dental clinics, and their accessibility to the population of Johor.

2. MATERIALS AND METHODS

All data were collected from open-access secondary data. The locations of each private dental clinic in Johor, Malaysia were obtained from the website http://medicalprac.moh.gov.my/v2/modules/mast op_publish/?tac=SENARAI_KLINIK_PERGIGIAN _SWASTA which lists all the private dental clinics registered with the Ministry of Health (MOH) [13].

The list of public dental clinics in Johor was obtained from the MOH website https://www.moh.gov.my/index.php/database_sto res/store_view/7 [14]. All private and public primary and specialist dental clinics in Johor were included in this study. Duplicate addresses were identified and excluded from this study. Primary dental clinics include dental clinics that perform general dental treatments. Hospital-based specialist dental clinics are excluded because patients are required to visit a primary dental clinic to get referred to the hospital.

The population data in each district were retrieved from the Department of Statistics Malaysia, Pocket Stats Quarter 1 2021, Johor. https://www.dosm.gov.my/v1/index.php?r=colum n/cone&menu_id=TGtoVU9YRFdsMkovQmM0S nV1a0pWdz09 [7].

2.1 Inclusion Criteria

1. All public and private general and specialist dental clinics in Johor, Malaysia
2. Population residing in Johor, Malaysia

2.2 Exclusion Criteria

1. Hospital-based specialist dental clinics
2. School dental services
3. Mobile dental clinics

The map of Johor and its district boundaries, together with the population were extracted and mapped from DIVA-GIS. http://www.diva-gis.org/datadown [15].

Randomly selected samples of 1-2% of the geocoded dental clinic addresses were web-searched to test the integrity of the data. The addresses were converted into latitudes and longitudes using Google Maps. They were analyzed in Microsoft Excel 365 and later exported into the mapping software to map out the specific location of each clinic.

"Accessibility" in this paper refers to physical accessibility determined by driving distance between the residential area and the location of dental clinics. According to the survey conducted by "Rakuten Insight", about 61 percent of the Malaysian respondents stated that they owned a car. In the past years, the car ownership rate in Malaysia has been higher than in its neighboring countries [16]. Most of the residents commute by private vehicle or rely on their friends or family members with cars. Hence, to assess geographic accessibility, buffers with radii of 5km, 10km, 15km and 20km from each dental clinic were placed to rule out area which is not within a 20km radius from a dental clinic and which area has easy access to a few dental clinics.

A database was set up, including the locations and density of dental clinics within city districts, population within districts, and dental clinic to population ratio. Statistical data were processed in the GIS environment (using QGIS software functions) to analyze the distribution, population, dental clinic to population ratio, and geographic accessibility of dental clinics. The number and location of all existing dental clinics were correlated with the number and density of the population in the districts of Johor to investigate which residential areas are facing either low access to or a lack of dental clinics.

2.3 Data Analysis

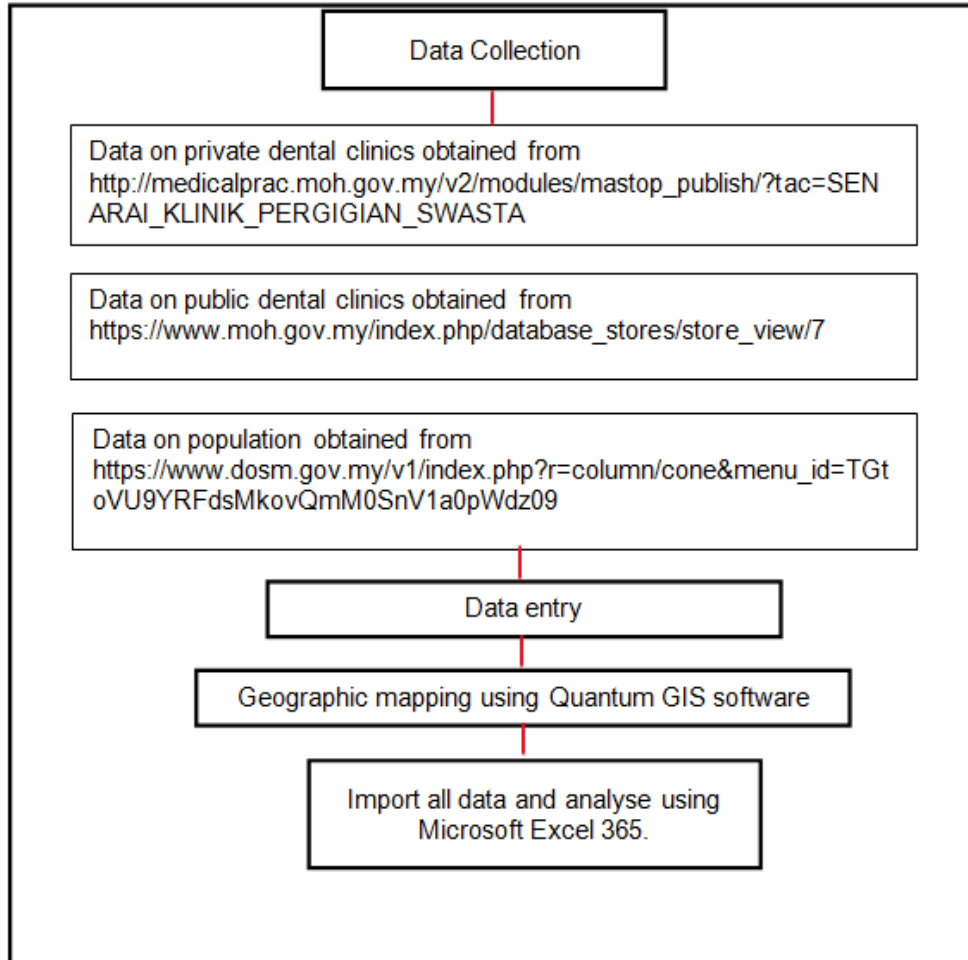**2.3.1 Conduct of study**

Fig. 1. Flow chart

3. RESULTS

A total of 10 districts in Johor were analyzed in this study, with a total population of close to 3.7 million. Overall, there were a total of 395 dental clinics, out of these clinics, 330 were private dental clinics and 65 of them were public dental clinics. Johor Bahru district had the highest number of dental clinics, with 197 private dental clinics and 16 public dental clinics. Batu Pahat district had the second-highest number of dental clinics in Johor, with 34 private dental clinics and 11 public dental clinics. Muar was the district with the third-highest number of dental clinics in Johor. There were 23 private and 7 public dental clinics in Muar.

Johor Bahru was the most populated area with 1.62 million population and had the second-lowest dental clinic to population (DCtP) ratio (1:7,612). The highest DCtP ratio was found in Mersing since there were only 5 dental clinics available in the district. The highest private dental clinic to population (PrCtP) ratio was in Mersing which had only 2 private dental clinics, while the lowest ratio was found in Batu Pahat (1:6,521).

Batu Pahat had the lowest public dental clinic to population (PuCtP) ratio – 1:20,155 – with the average PuCtP ratio for Johor state being 1:56,298. Kulai had the highest public dental clinic to population (PuCtP) ratio of 1:147,400.

Fig. 2. A map showing districts in Johor

Mersing was the only district with less than 10 dental clinics available. More than 30 dental clinics were found in Batu Pahat and Johor Bahru districts. The other districts had a range of 11 to 30 dental clinics.

The majority of the population in Johor was within a 20km catchment area from a public dental clinic. The public dental clinics were more sparsely distributed in the northeast area of Johor, specifically the Mersing district.

Private dental clinics were more densely located in the south, west-south, west, and north-west region of Johor state. The areas which were not under 5km to 20km coverage by public dental clinics were not covered by private dental clinics as well.

4. DISCUSSION

According to the latest National Health and Morbidity Survey (NHMS 2019), involving 17,000 people, showed that only 25% visited the dentist over the last 12 months. Although more dental services were being offered in Malaysia, as well as improved annual dentist-to-population ratios, many Malaysians still did not regularly seek oral healthcare check-ups and treatment. Access to dental services is also a challenge, mainly in rural areas with geographical factors contributing to the difficulty in the continuous access for general and dental healthcare [17].

Dimensions of accessibility not only restrict to geographical accessibility, other dimensions such as availability of services, affordability of services, acceptability of services, and how accommodative the services are to the population should be taken into account [18]. However, in this study, accessibility refers to accessibility by driving since most of the residents in Malaysia commute by private vehicle [19]. Generally, the physical facilities of the public transports offered in Malaysia, are insufficient since the public buses do not provide convenience facilities such as ramps for disabled people with wheelchairs [20]. Hence, the utilization of public transport in Malaysia is not popular and most of the residents own a private vehicle.

Table 1. Dental clinics, population and their ratios in Johor, Malaysia

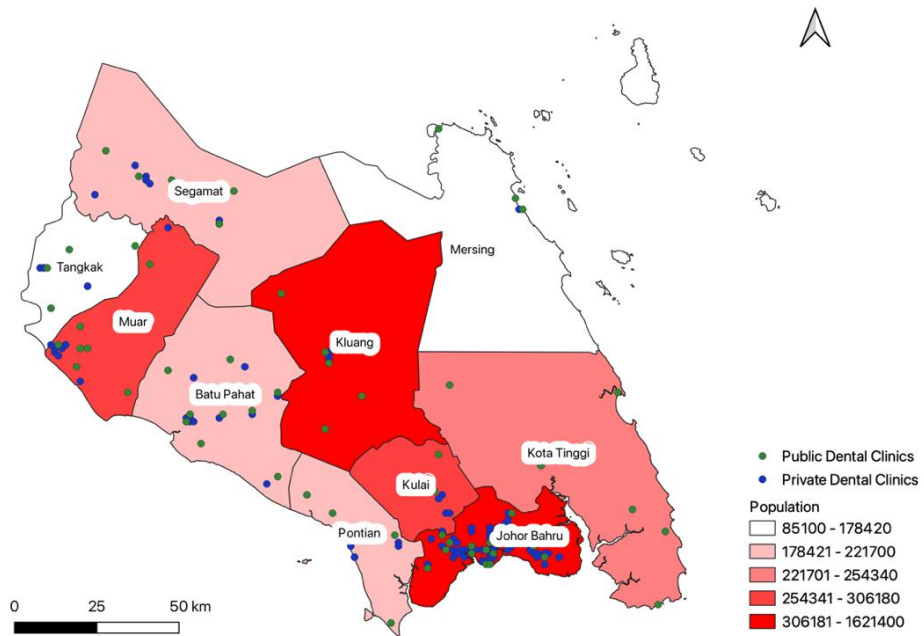| Districts	Private Dental Clinics (n)	Public Dental Clinics (n)	Total Dental Clinics (n)	Population	Mean House-hold Income	DCtP ratio	PrCtP ratio	PuCtP ratio
Batu Pahat	34	11	45	221,700	7,392	1:4,927	1:6,521	1:20,155
Johor Bahru	197	16	213	1,621,400	9,315	1:7,612	1:8,230	1:101,338
Kluang	16	5	21	351,700	5,953	1:16,748	1:21,981	1:70,340
Kota Tinggi	8	7	15	231,300	6,982	1:15,420	1:28,913	1:33,043
Mersing	2	3	5	85,100	4,937	1:17,020	1:42,550	1:28,367
Muar	23	7	30	288,900	7,540	1:9,630	1:12,561	1:41,271
Pontian	11	5	16	183,100	6,776	1:11,444	1:16,645	1:36,620
Segamat	12	5	17	221,700	6,431	1:13,041	1:18,475	1:44,340
Kulai	16	2	18	294,800	8,602	1:16,378	1:18,425	1:147,400
Tangkak	11	4	15	159,700	6,659	1:10,647	1:14,518	1:39,925
Total	330	65	395	3,659,400				

*Population data is projected population in 1st quarter of 2021 based on Housing and Population Census Malaysia 2010; Source: Ministry of Health (MOH), Department of Statistics Malaysia (DOSM)

Table 2. Number of dental clinics stratified according to districts in Johor, Malaysia
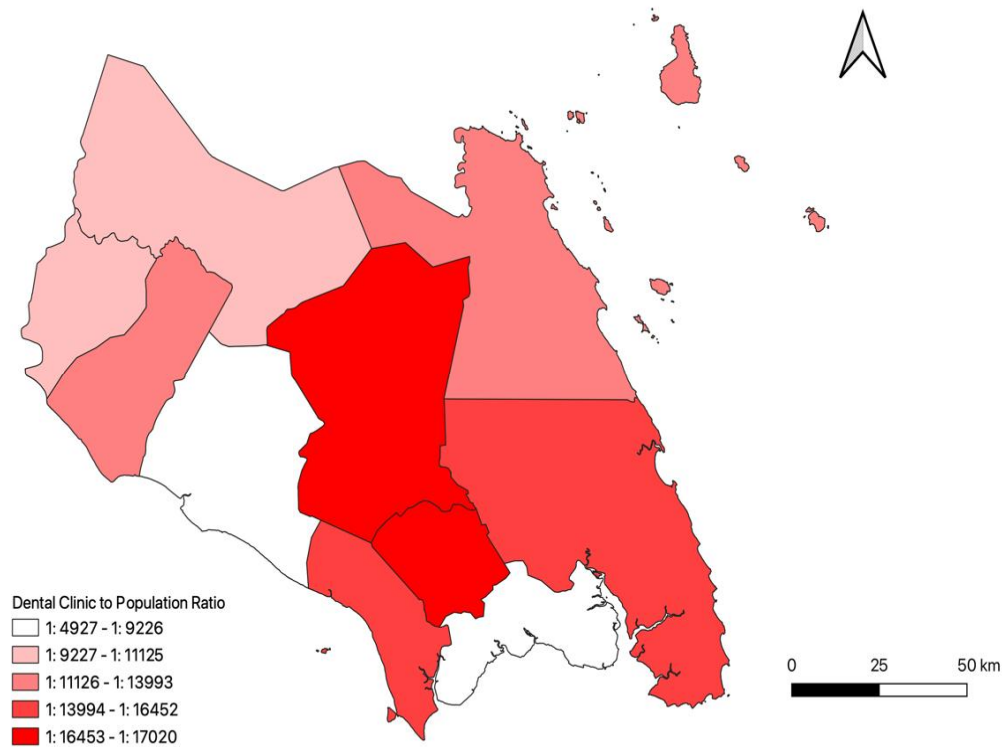
| Districts	Number of dental clinics			
	Less than 10	11 - 20	21 - 30	More than 30
Batu Pahat				/
Johor Bahru				/
Kluang			/	
Kota Tinggi		/		
Mersing	/			
Muar			/	
Pontian		/		
Segamat		/		
Kulai		/		
Tangkak		/		
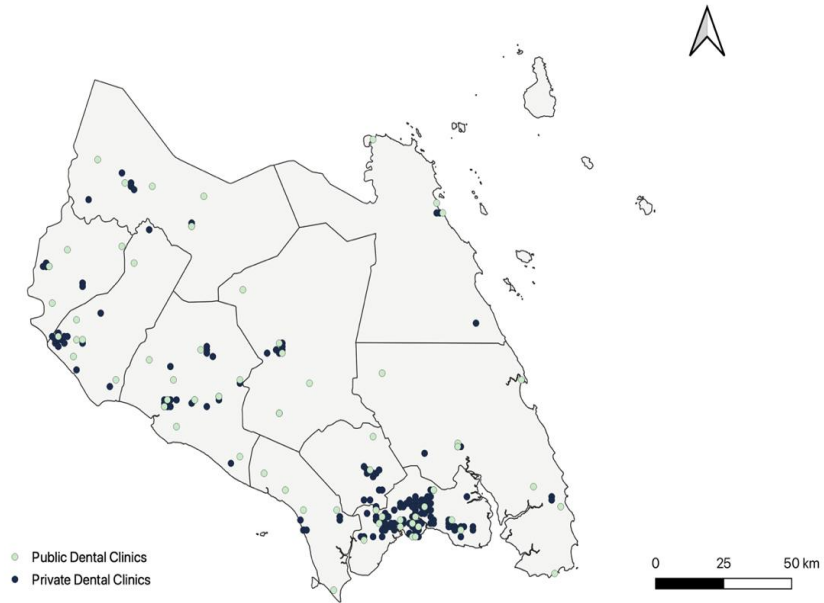
Fig. 3. Distribution of dental clinics in different districts in Johor Mapped using Geographic Information System (GIS)

Fig. 4. Population and distribution of dental clinics in each District in Johor
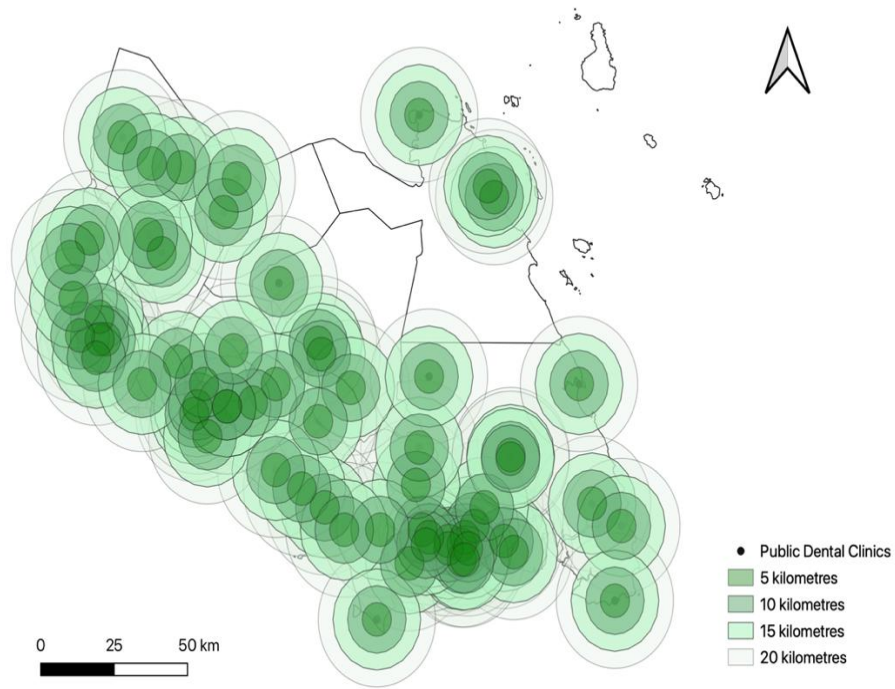
Fig. 5. Dental clinic to population ratio of different Districts in Johor
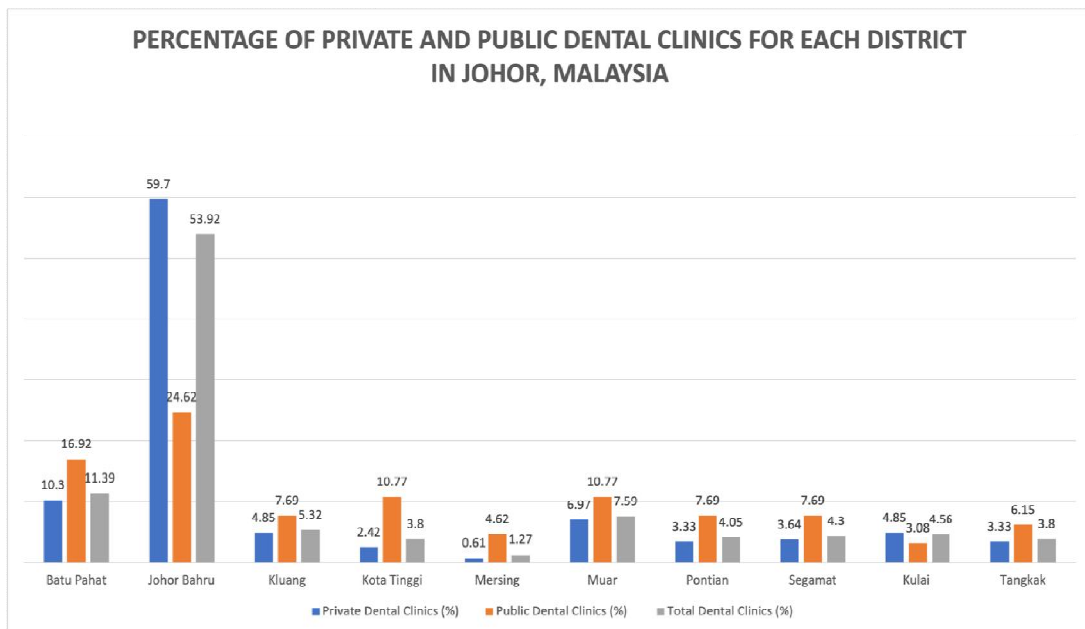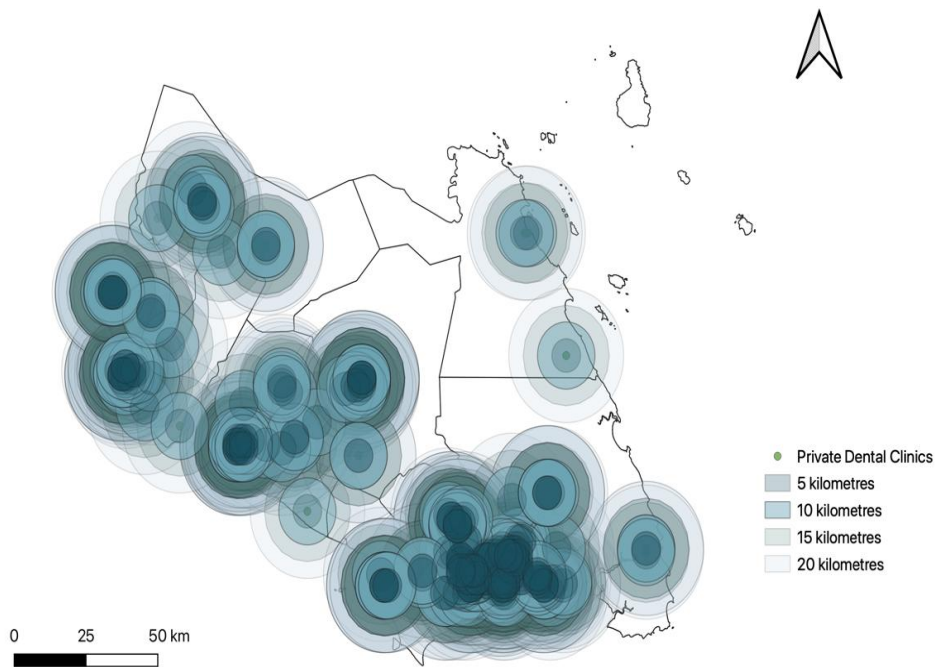

Fig. 6. Percentage of private and public dental clinics for each district in Johor, Malaysia

Fig. 7. 5km, 10km, 15km and 20km buffer coverage from each public dental clinics in Johor

Fig. 8. 5km, 10km, 15km and 20km buffer coverage from each Private Dental Clinics in Johor

The number of dental clinics is directly proportional to the population. More dental clinics are needed to cater the oral healthcare demand of the residents in the districts with large population. Johor Bharu is the capital of Johor. It had the most number of dental clinics (213) and the highest population (1,621,400) among Johor districts, making it the district with the second-lowest dental clinic to population (DCtP) ratio – 1:7,612. The district with the lowest population (85,100), which is Mersing had the highest DCtP ratio of 1:17,020. The result is in agreement with the study done by Alsharif et al. where more than half (55%) of clinics were located within 3km of the city center, and more than 80% were within 6km [21]. The relationship between DCtP ratio and population is directly proportional.

The capital of Johor, Johor Bahru had the highest number of private dental clinics (197). This is in line with the hypothesis that the distribution of private clinics is patterned by population. (As shown in Fig. 4 and Fig. 5). The population of Johor Bahru was the highest among all districts in Johor, which is about 44.31% (1,621,400) of the total population in Johor. The city has a very close economic relationship with Singapore. Around 3,000 logistic lorries are crossing between Johor Bahru and Singapore every day for delivering goods between the two sides for trading activities. Many residents in Singapore frequently visit the city during the weekends; some of them have also chosen to live in the city. Many of the city's residents work in Singapore [22]. This could explain the higher mean household income of the residents in Johor Bahru. Singaporeans would visit the dental clinics in Johor Bahru during the weekends due to cheaper dental treatments.

Interestingly, this study identified more private dental clinics than public dental clinics in Johor, which indicates that private dental practice plays a major role in meeting oral healthcare demands. The districts with a lesser number of private dental clinics also noted to have lower mean monthly household income than other districts, with the mean household income of the entire Johor state to be RM 7,068.70. Mersing, for instance had the least number of private dental clinic and the lowest monthly household income. This result is in line with a study done by Bohari et. al which suggested that dental clinics are distributed relative to the relative wealth [23].

In France, the link between oral health and socio-economic characteristics has been previously shown in studies carried out in children. In these works, the level of oral health in children, as reflected by the decayed, missing, filled teeth (DMFT) index or the presence of periodontal disease or dental trauma [24,25]. Another study done in Paris suggested that the income level was strongly associated with the need for dental care. Indeed, the prevalence of self-reported dental problems was twice higher when the income was lower than 1,115 Euros per month, compared to the prevalence among participants with an income of 2,605 Euros or higher [26].

Since the charges for dental treatments are much higher in private dental clinics than in public dental clinics, most of the residents with lower socioeconomic status would prefer to seek dental treatments in public dental clinics. An example that can be provided here is the scaling treatment fee which is over 45 times more expensive in private than public dental clinics for Malaysians in Malaysia [27,28]. Hence, more private dental clinics can be found in districts with higher mean household income since they are could not sustain in rural areas as a result of lack of dentists, high costs, and low population density [29,30].

Disparities were found in primary dental clinics, with clinics more sparsely distributed in peripheral districts than in central districts. This result is similar to Auckland, New Zealand, where the most peripheral tracts demonstrated a 2-fold sparsity relative to the most central tracts [19]. This uneven distribution of dental clinics in Malaysia is similar to the situation in other countries, with dental services being more saturated in the major cities and along the coastlines [31-35].

Ministry of Health (MOH) Malaysia ensured that there is at least 1 public dental clinic available to serve the population in each district. It is also evident that public dental clinics are more evenly distributed throughout Johor than private clinics.

A larger area of the districts Segamat, Kluang, and Mersing (as shown in Fig. 8) was not under 20km coverage from private and public dental clinics. Two private dental clinics located in the east region of Mersing have the advantage of being a monopoly because there is no other option for the residents nearby, especially the population in Mersing and north-east of Kota Tinggi seek for an alternative private dental clinic. The areas at the east side of Segamat, the north side of Kluang and the east side of Mersing

are housed by Endau-Rompin National Park, the second-largest park in Malaysia. This explains the absence of dental clinics in these areas.

Although the present study has yielded some preliminary findings on the distribution and accessibility of dental clinics in Malaysia, this study did not consider where patients from a particular district seek treatment or whether any public transport is available to improve the accessibility. Accessibility has to be studied deeper by taking into account the time and distance from home to the bus station and other public transportations available. The use of straight-line distance (Euclidean distance) and the buffers might not be accurate as they simplify the route that patients take to visit a dental clinic but it is the easiest method to understand the analysis of proximity or distance.

Other social determinants may affect the utilization of dental services in Johor, so future studies can consider taking into account the analysis of the socioeconomic status, income, job security, and education level.

Besides, the list of private and public dental clinics was last updated in December 2020 as the list for 2021 has not been released. The district population data was projected from the Housing and Population Census of Malaysia 2010 and was last updated in the 1st quarter of 2021.

4. CONCLUSION

The spatial analysis shows a trend of urban clustering of private and public dental clinics. This can be explained by the most attractive and convenient locations, in terms of accessibility, and a concentration of services that can generate large flows of people most of the time. Access to dental clinics is not difficult except in rural areas, where the population is also lesser.

Besides, the relationship between DCtP ratio and population is directly proportional and dental clinics are distributed relative to the relative wealth. More private dental clinics can be found in districts with higher mean monthly household incomes.

The number of dental clinics in Johor might increase in the coming years. Hence, this study helps to visualize the irregular distribution of dental clinics and facilitates understanding, planning, monitoring, and allocation of resources to the disadvantaged or underserved areas.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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