Patterns of the Spatial Distribution of Hospitals Around Ramkhamhaeng University

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Abstract

This Study aims to 1) analyse the centre and spatial distribution of hospital in the area around Ramkamhaeng university (RU) and 2) investigate the hospital demand in the area around RU. The area in the distance of 0 to 20 km. from RU was determined as the study area. The number of hospitals in the distance of 0 to 20 km. around RU was displayed. The buffers of distance from 0 to 5 km., 0 to 10 km. 0 to 15 km. and 0 to 20 km. were examined. The centre of spatial distribution and standard distance of the data were studied. The trend and the spatial of directional distribution were calculated and then the density of hospital around RU was evaluated. Secondly, the questionnaires about the hospital demand in the area around RU were conducted. The questions were proved by 3 specialists for the precision of questions. The proved questionnaires were then tested by 30 non-subject populations with 0.782 confidential interval. Next, the complete questionnaires were subjected to the study area by 100 samples per buffer distance. The total of 400 samples were collected. The result showed that the total number of hospitals was 157 places. For the pattern of hospital distribution, in the distance of 0 to 5 km. had uniform distribution pattern. The pattern in the distance of 0 to 10 km. was random. As regards the distance of 0 to 15 km. and 0 to 20 km., the patterns were clustered biased distribution. Comparison of the demand for hospitals services in Ramkhamhaeng University, separated by 4 groups of the distance from Ramkhamhaeng University, indicated that the sample who lived in 0-15 km. from the university are mind about the nearest hospital while the sample in faraway area are interested in medical expenses factors. The results would be information for a new hospital building decision to serve economic and social growing around the university in the future.

Keywords: *Spatial patterns distribution, Hospitals, Ramkamhaeng university, Location*

1. Introduction

Bangkok Metropolis and Vicinity are Primate city, which are economic prosperity centre of Association of Southeast Asian Nations or ASEAN. The growing rate of economic activity of this area tend to be higher in every year with the highest population, compared with other area. the record from Department of Provincial Administration (2022) [1] reported the number of populations, which was updated in June 2022, the population was about 5,510,469 people for Bangkok and 5,353,629 people for 5 provinces in Primate city. Moreover, Commuter Population and Non-registered Population in 2021 are the highest in Bangkok Metropolis about 49%, 49.5%, and 32.7% for Commuter Population (Workers), Commuter Population (Students) and Non-registered Population, respectively [2]. All type of population in Bangkok Metropolis and Vicinity which are expanding every year lead an increasing all resources demand including health services in all types of hospitals. Uamkhram, S. and Srisatidnaraku, B. (2012) [3] reported that there were 2 variables that the people who lived in Bangkok Metropolis decided to use the public hospital, which were medical expenses reimbursement and the recommendation of a close person. In contrast, there were 6 variables for choosing the private hospital, which were quality of medical treatment, good service systems, service behaviour of hospital staffs, advertisement through various media, appropriate medical fees, and good hospital designing.

The most hospital which located surrounding Ramkhamhaeng University were private hospital. However, there were 141,925 people in Bangkapi district of Bangkok Metropolis [2] who had a demanding of hospital service. The most people still travel to use the hospital services in many large hospitals which located in the inner city, reported by National Statistical Office. (2017) [4], lead so many problems such as high-density people in the large hospitals, travelling cost, and losing time to wait for health service. However, the leader of Ramkhamhaeng University had a demand to study feasibility of building a hospital in the university to serve all university staffs, students, and people who lived near the university. From this reason brought the authors to explore the number of hospitals surrounding Ramkhamhaeng University and create hospital database, separated by the distance from the university which were 0-5, 0-10, 0-15, and 0-20 km. Moreover, analysis of pattern of hospital distribution, variables of hospital choosing and a new hospital service within the university demand were needed, gathered the data from sample groups who lived in 4 distance groups (20 km) surrounding the university. The results would be information for a new hospital building decision to serve economic and social growing around the university in the future.

2. Objectives

This Study aims to

1) to analyze the center and spatial distribution of hospital in the area around Ramkamhaeng university and

2) to investigate the hospital demand in the area around Ramkamhaeng university.

3. Population and Samples

Ramkhamhaeng University's chancellor has a determination to explore a feasibility to establish a hospital in the university. Therefore, research and important data for all decision are necessary then brought the authors to this work. This project defined Population to all people who lived in 4 groups: 5, 10, 15, and 20 km. from Ramkhamhaeng University, which is in the central regions of Thailand around Hua Mak Sub-District, Bangkapi District, Bangkok. However, 400 sample were choose by accidental sampling, about 100 people per each buffer distance. The study area illustrated in (Figure 1), separated by the distance from the university. Yellow point refers to the central of Ramkhamhaeng University. Yellow zone, pink zone, orange zone, and blue zone refers to 0-5 km, 6-10 km, 11-15, and 16-20 km. from the central point.

4. Data Collection and Methods

This work separated a working step into 2 parts: Hospital spatial distribution database creation process was the first step. High resolution satellite photo which illustrated all study area and geographic coordinates collection data of all hospital in the area by field survey, were gathered to develop the database of road line and hospital point which located around Ramkhamhaeng University in 5, 10, 15, and 20 km with Buffer tool in GIS programme. Then, the hospital points from Google earth and Google maps were used to compare the accuracy of points. All hospital's geographic coordinates were converted and presented in Universal Transverse Mercator style (UTM). Center analysis of spatial distribution and standard deviation of hospital data surrounding Ramkhamhaeng University were examined by Mean center method as eq. 1 and 2, Median center method with the shortest distance of each hospital point to all point in the study area, Central feature with all shortest distances to all hospitals. Moreover, Standard Distance (SDEx and SDEy) was also calculated by eq. 3, 4 and 5 to present standard deviational ellipse.

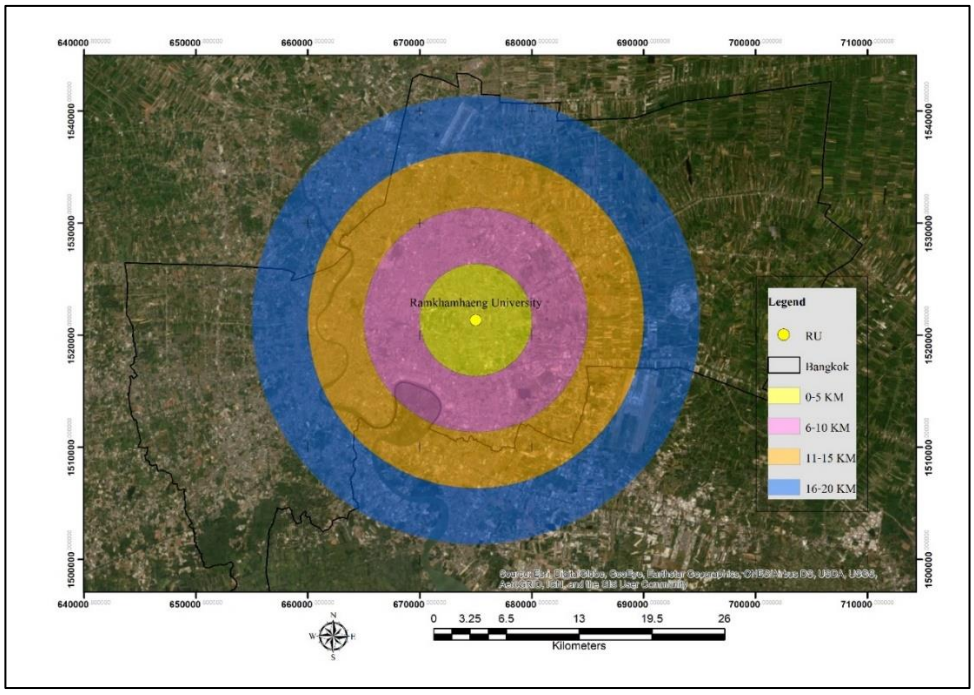

Figure 1. The Study Area Surrounds Ramkhamhaeng University With 4 Buffer Zones.

$$\bar{X}_{Coord} = \frac{\sum_{i=1}^{n} X_i}{n} \quad (1)$$

$$\bar{Y}_{Coord} = \frac{\sum_{i=1}^{n} Y_i}{n} \quad (2)$$

$$SDE_x = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n}} \quad (3)$$

$$SDE_y = \sqrt{\frac{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}{n}} \quad (4)$$

$$SD = \sqrt{\frac{\sum_{i=1}^{n}(X_i - \bar{X})^2}{n} + \frac{\sum_{i=1}^{n}(Y_i - \bar{Y})^2}{n}} \quad (5)$$

Where X_i and Y_i refers to each hospital geographic coordinates in Latitude (X) and Longitude (Y) while $\bar{X}$ and $\bar{Y}$ are mean center. n is the number of hospital points which appeared in the study area.

Furthermore, Nearest Neighbor Analysis: NNA and Nearest Neighbor Index: NNI (values between 0 – 2.4) were used to analyze the pattern of hospital spatial distribution in the buffer zones of 5, 10, 15, and 20 km around Ramkhamhaeng University under conditions which was illustrated below,

If NNI is close or equal to 0, the hospital spatial distribution pattern is Cluster pattern.

If NNI is close or equal to 1, the hospital spatial distribution pattern is Random pattern.

If NNI is close or equal to 2.14, the hospital spatial distribution pattern is Dispersed pattern.

Moreover, Kernel Density Estimation was used to analyze hospital density in the distance about 20 km surrounding Ramkhamhaeng University.

Secondary step, the need of hospital of patient who lived around the study area in 0-20 km, was examined by Questionnaire in Open-ended and Close-ended Forms. Content validity and Index of items objective congruence of Questionnaire form needed to be checked by at least 3 specialists. Moreover, reliability checking by Cronbach alpha coefficient was operated by 30 informants (excluded sample groups). The Cronbach alpha coefficient was about 0.823 then, this form was lunched to 400 people in 4 sample groups who lived in 0-5, 5-10, 10-15, and 15-20 km around the university area. (100 people per group). Respondent Basics was exhibited in form of frequency and percentage, the need of hospital and factors in deciding to use the service were investigated by rating scale at 1-5 (lowest to highest). Moreover, Analysis of Variance: ANOVA and the Scheffe method was used to display the different of people demand and factors in deciding to use the service in 4 groups.

5. Results and Discussion

The results were illustrated that there were 16 hospitals which located in the distance of 0 – 5 km from the university. Average Nearest Neighbor method gave Nearest Neighbor

Raito (NNI) value of 1.215 at a significant of 95% refers to Dispersed pattern due to not many hospitals surrounding in 0 – 5 km and these hospitals distributed in regularly form. However, there were 43 hospitals in the distance of 0 – 10 km from the university, distribution in a form of Random pattern with NNI of 1.075 at a significant of 95% due to an increasing of population led an increasing of hospitals. Moreover, distribution in a form of Cluster pattern with NNI of 0.855 and 0.834 at a significant of 99%, found in the distance of 0 – 15 km and 0 – 20 km with 82 and 113 hospitals as illustrated in Figure 2 (a) – (d) and Figure 3 (a) – (d). The most hospitals in both of last 2 groups located in the inner city such as in Huai Khwang District, Phaya Thai District, and Pathum wan District which is an important economic center and has high density population. [1, 5]

The center of all hospital presented in a form of Mean center, Central feature, and Median center method as illustrated in Figure 2 (a) – (d) and Table 1, indicated that the center of hospitals (which located in 0 – 20 km) set up around western direction from the university in all distance groups. The mean centers were in area which called inner city. The standard distance measurement with 1st Standard deviation of mean center form were at 3.06, 5.58, 8.49, and 10.58 km for 0-5 km, 0-10 km, 0-15 km, and 0-20 km group respectively.

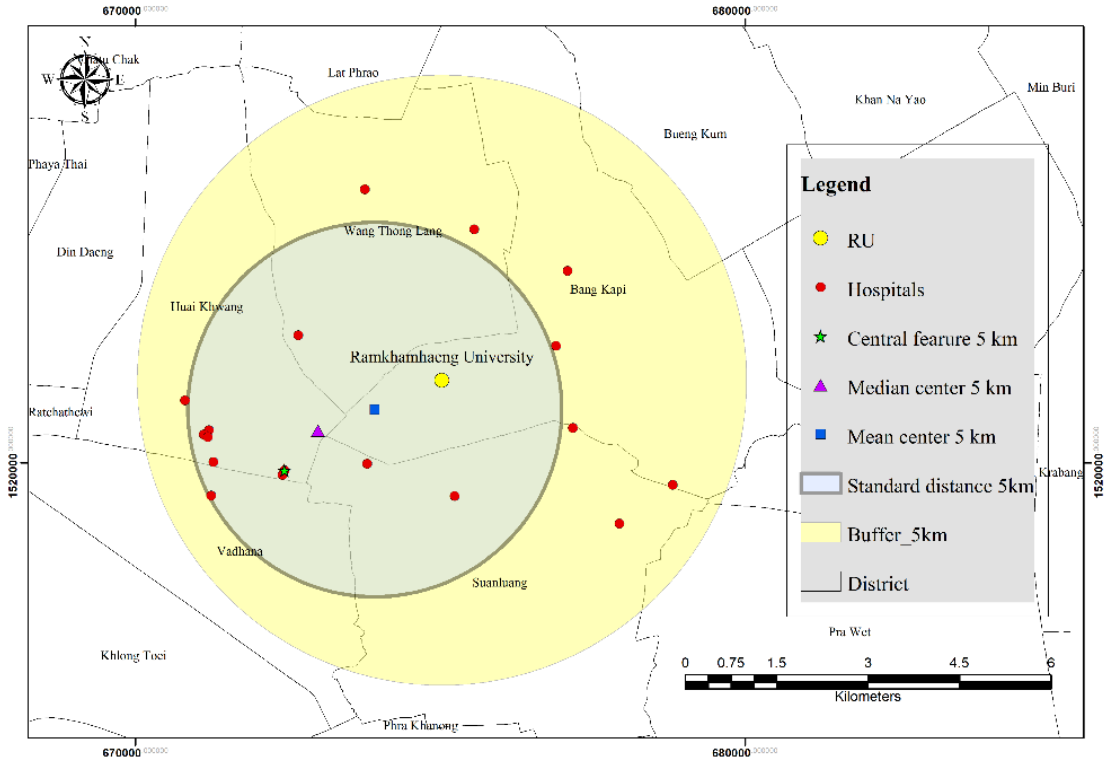

Figure 2. (a) Mean center, Central feature, Median center, and Standard distance of hospitals in 0 – 5 km

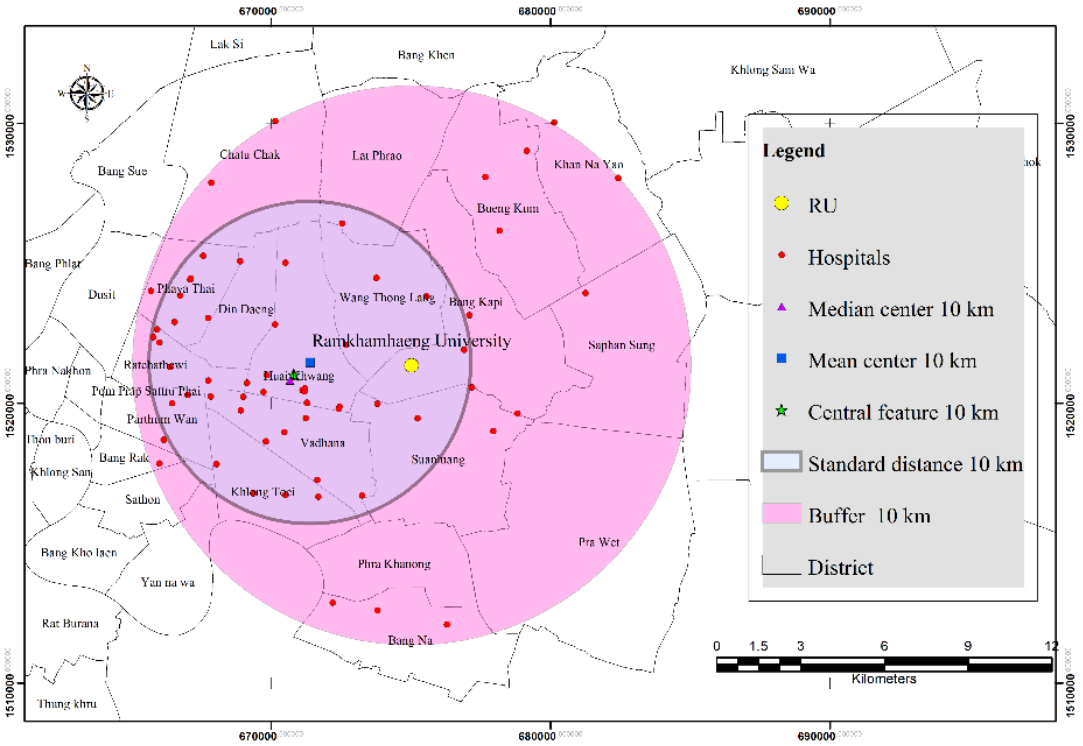

Figure 2. (b) Mean center, Central feature, Median center, and Standard distance of hospitals in 0 – 10 km

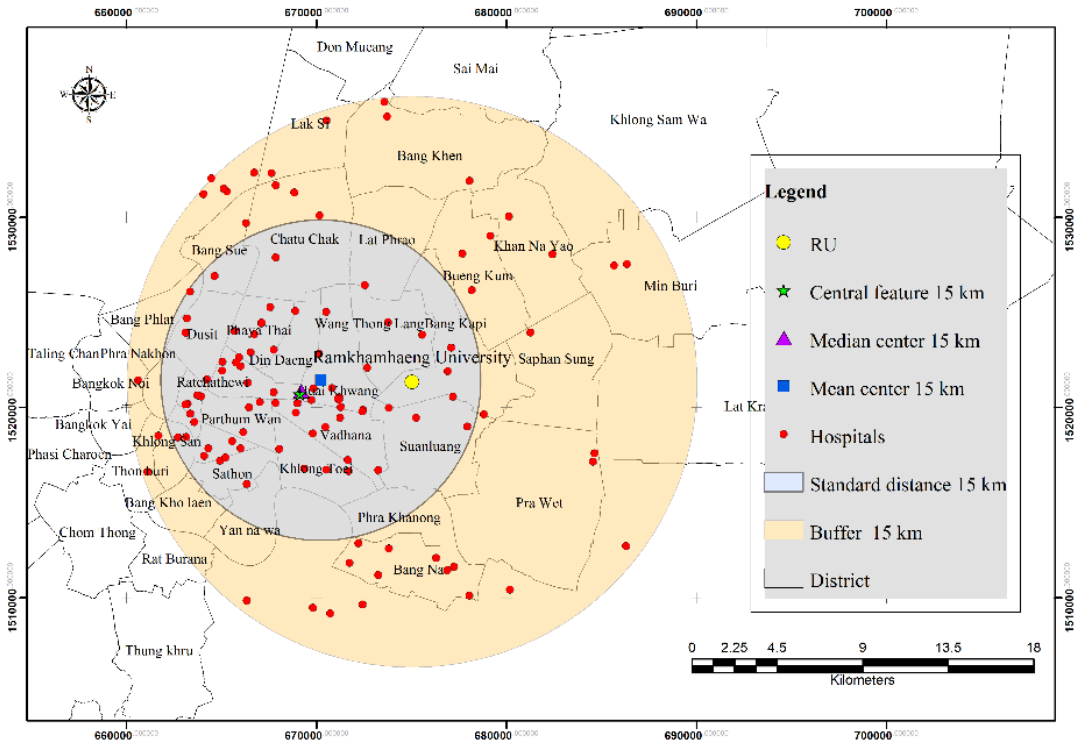

Figure 2. (c) Mean center, Central feature, Median center, and Standard distance of hospitals in 0 – 15 km

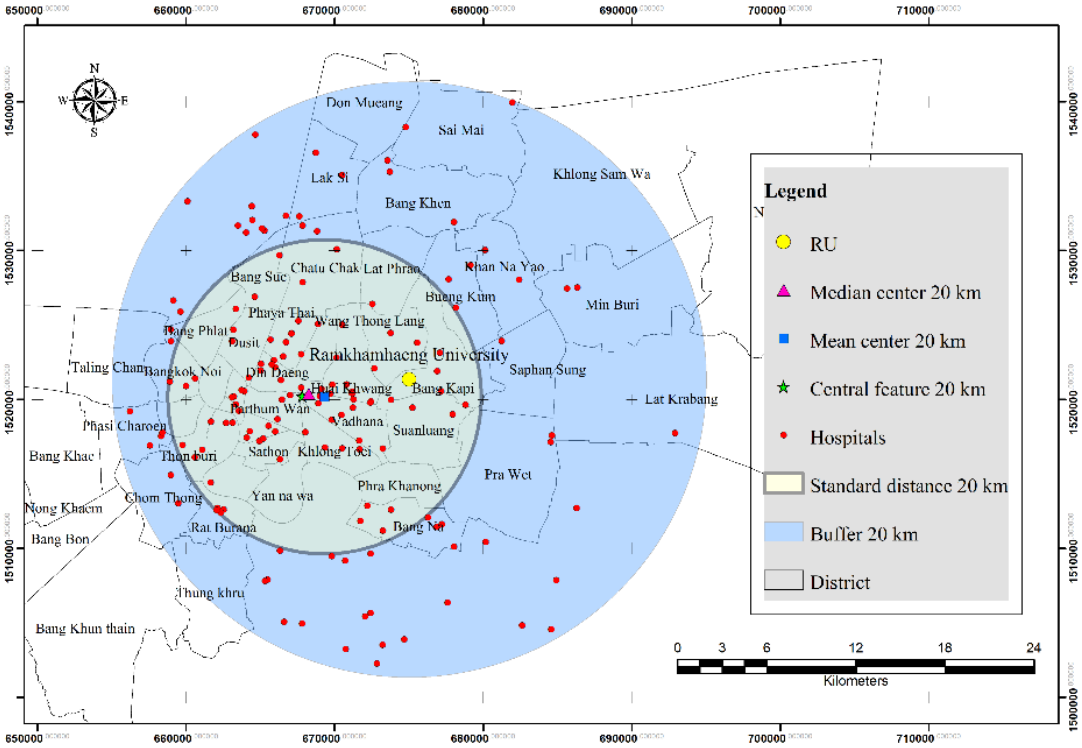

Figure 2. (d) Mean center, Central feature, Median center, and Standard distance of hospitals in 0 – 20 km

Table 1. Central feature, Median center, and Mean center of hospitals in each distance group.

0 – 5 km		
Center type	**Longitude (UTM)**	**Latitude (UTM)**
Central feature	X: 672413	Y: 1519834
Median center	X: 672963	Y: 1520505
Mean center	X: 673942	Y: 1520867
0 – 10 km		
Center type	**Longitude (UTM)**	**Latitude (UTM)**
Central feature	X: 670808	Y: 1521025
Median center	X: 673048	Y: 1520471
Mean center	X: 673958	Y: 1520873
0 – 15 km		
Center type	**Longitude (UTM)**	**Latitude (UTM)**
Central feature	X: 669129	Y: 1520731
Median center	X: 669188	Y: 1520863
Mean center	X: 670223	Y: 1521443
0 – 20 km		
Center type	**Longitude (UTM)**	**Latitude (UTM)**
Central feature	X: 667823	Y: 1520233
Median center	X: 668270	Y: 1520374
Mean center	X: 669318	Y: 1520187

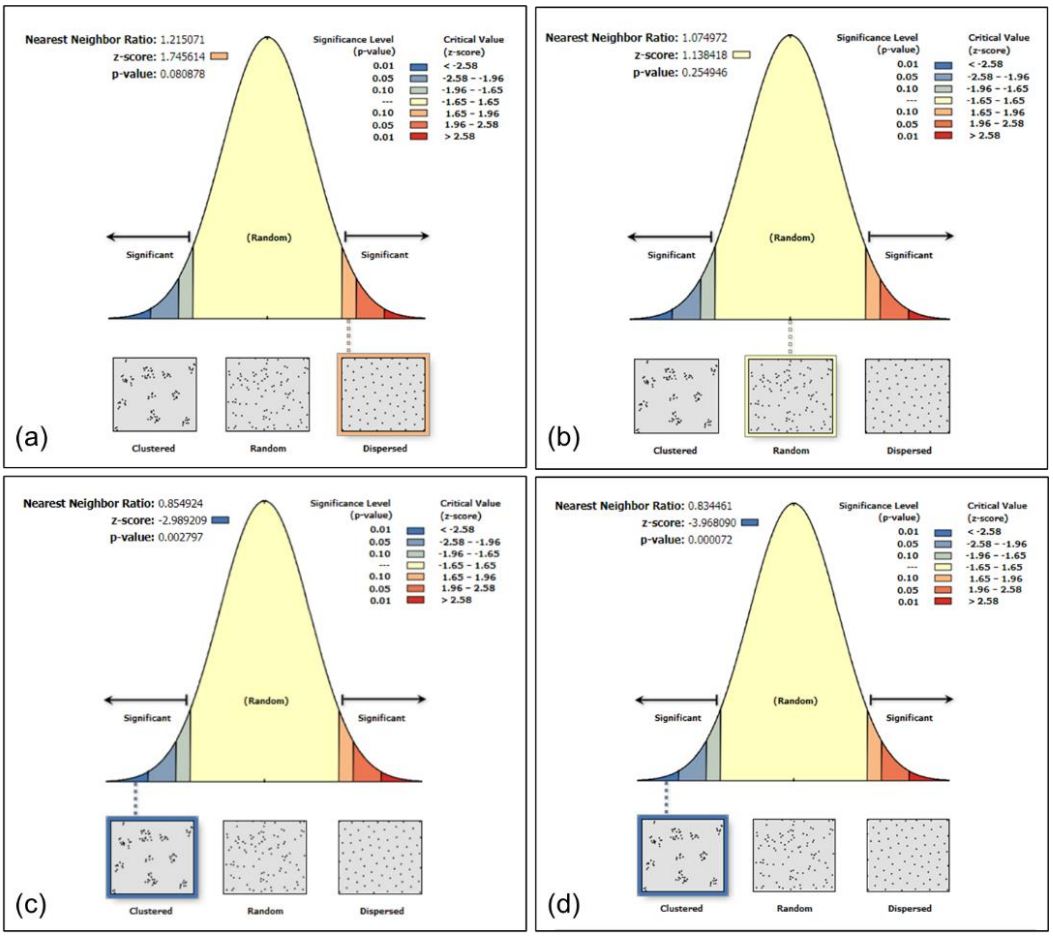

Figure 3 Nearest Neighbor Raito and distribution pattern of hospitals in (a) 0 – 5 km, (b) 0 – 10 km, (c) 0 – 15 km, and (d) 0 – 20 km

The trend of hospitals in 0-5 km and 0-10 km from the university tended to expand to the center of the city, follow along main streets such as Ramkhamhaeng road and Rama 9 road with the expanded direction of north to south of the university in Dispersed and Random pattern for 0-5 km and 0-10 km respectively. However, the expanded direction of hospitals spread to the north (Phaya Thai District) and south (Wattana District) of Bangkok in Cluster pattern for both of last groups as illustrated in Figure 4 (a) to (d)

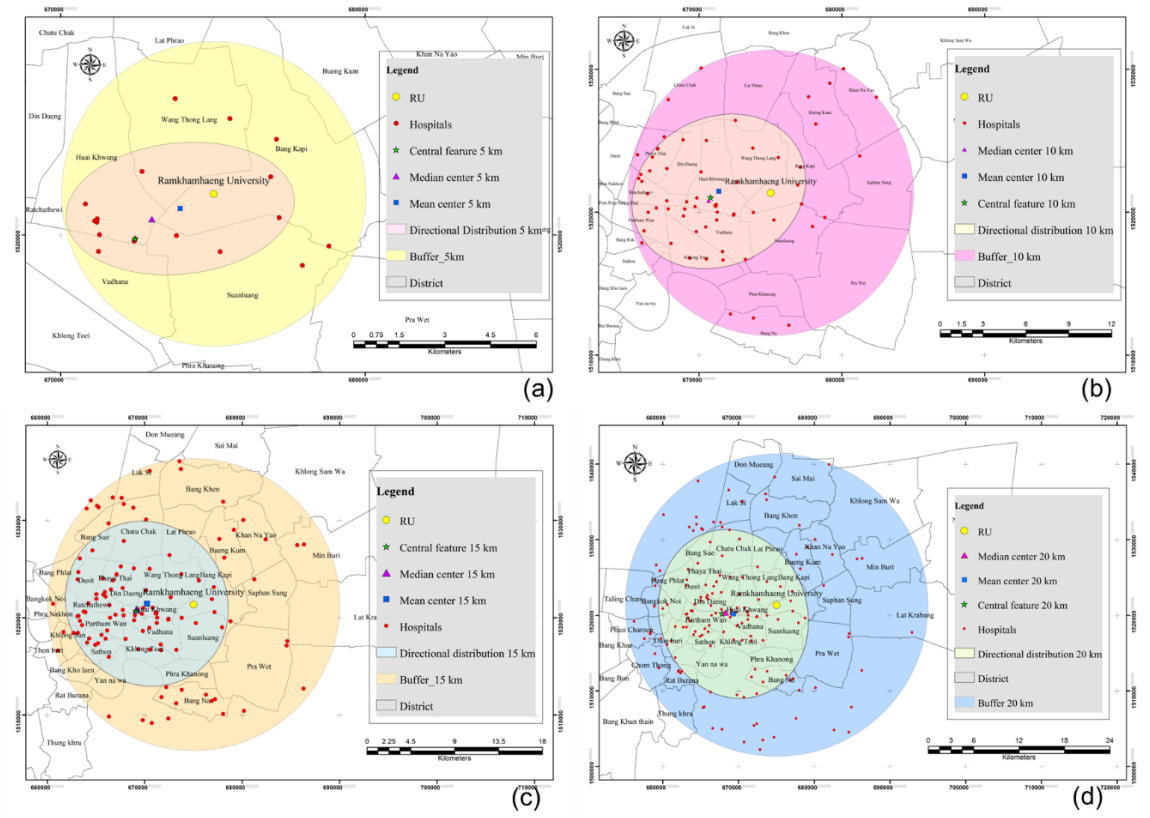

Figure 4. Trend and direction of hospital distribution in (a) 0-5 km, (b) 0-10 km, (c) 0-15 km, and (d) 0-20 km.

Kernel Density Estimation was used to analyze density of hospitals in 0 – 20 km from Ramkhamhaeng University. The results as Figure 5 indicated that the most of density type from the center was medium density such as Wattana, Phayathai, Samphanthawong, Khlong San, Bang Rak, Phasi Charoen, Bangna District. Moreover, there was high density in the west direction of the university which was connected to inner of Bangkok such as in Huai Khwang, Ratchathewi, Ratchaburana, and Pom Prai Sattru Phai District. However, there was low density in the eastern direction of the university especially in Wang Thonglang, Bangkapi, Suan Luang, Saphan Sung, Bueng Kum, Khanna Yao, Phra Khanong, and Lat Krabang District. The density and distribution pattern of hospital surrounding Ramkhamhaeng University results were conform to Central - place theory which has different size of area depending on the rank of order. The area which has high rank of order means there were so many populations, many type of products, and services, then lead a lot of customers there. [6, 7] Therefore, the density of hospital was higher in the inner of city then, dropped down in the next area. The results were also in accordance with Yang et al. (2016) [8] that the spatial distribution of hospitals indicated a core in the central urban areas and also agreed with Burgel and Burgel, (2018) [9], Li et al., (2019) [10], and Lobo et al. (2020) [11] that the important factor for human settlement dependent on the size of populations with the high density of settlement activities always located in the inner city then fading in the next area.

Moreover, these results were also conformed to a study about Spatial Distribution of Housing Estates in the Area of Bangkok: Nong Chok District, studied by Taeshapotiwarakun (2018) [12], that the distribution pattern of Housing Estates in the area was cluster pattern with concentrated the near of road which had high urban activities, following the central-place theory.

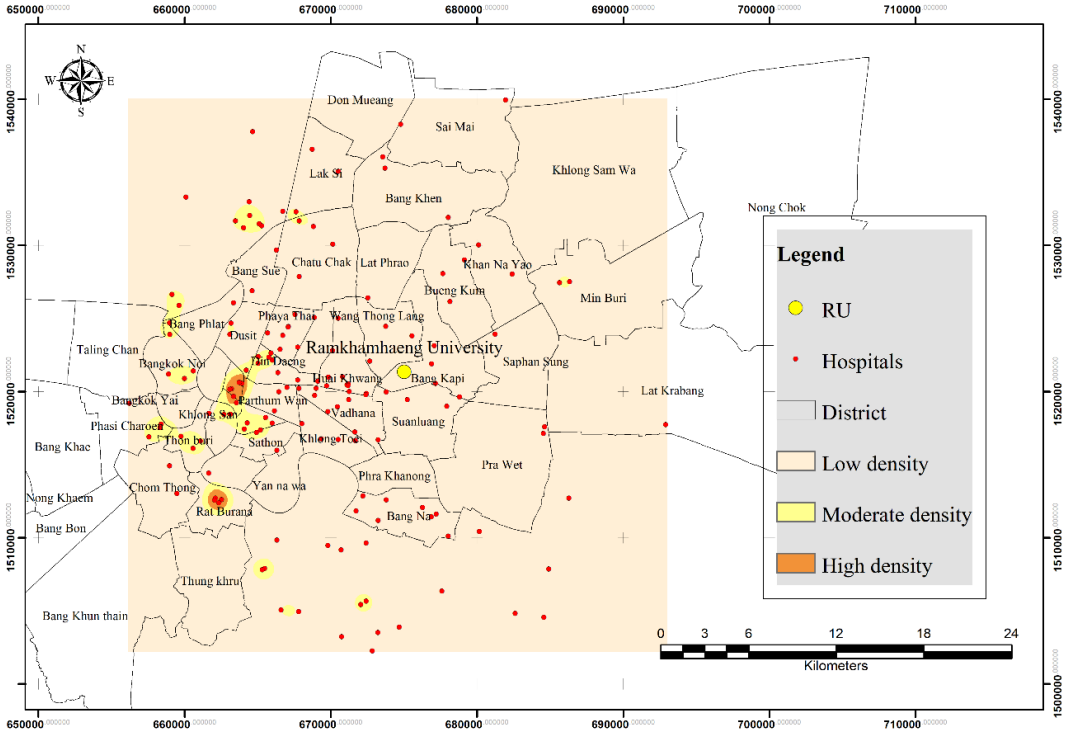

Figure 5. Hospital density analysis in 0-20 km from the university by Kernel Density Estimation.

As the purpose of leaders of Ramkhamhaeng University, the new hospital which will be located within the university, is committed to build up there to serve people inside and outside. However, an analysis of the needs of a new hospital service in Ramkhamhaeng University in the future and its needing factors were required. The results indicated that the sample from 4 groups who lived in the different distance from the university had different needed to use a new hospital in the university at a significant of 95% (F = 56.753, P Value = 0.000) as illustrated in Table 2. a pair comparison of the difference of a new hospital needs in the university area of samples in each group were tested. The results as presented in Table 3 indicated that distance from a new hospital to location of sample impacted samples decision at a significantly of 95%. The people group who lived near the university (in 0-5 km) want to use a new hospital service than other groups at 4.47, 3.35, 2.17, and 2.04 for a group of 0-5 km, 6-10 km, 11-15 km, and 16-20 km far from the university, respectively (1.00 – 5.00 refers to the lowest to the highest of a need of new hospital).

Table 2. The results of analysis of variance of 400 samples separated by distance

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	389.367	3	129.789	56.753	.000
Within Groups	905.610	396	2.287		
Total	1294.978	399			

Table 3. An average of demand for services of new hospitals in Ramkhamhaeng University, separated by distance group

Sample group (separated by a distance from the university)	**an average of demand**	**0 – 5 km**	**6-10 km**	**11- 15 km**	**16 – 20 km**
		4.47	**3.35**	**2.17**	**2.04**
0 – 5 km	4.47	-	1.120*	2.300*	2.430*
6 – 10 km	3.35	-	-	1.180*	1.310*
11 – 15 km	2.17	-	-	-	-
16 – 20 km	2.04	-	-	-	-

The most factors which affected the selection of a new hospital in Ramkhamhaeng University analysis, separated by distance, indicated that 74% of the people who lived in 0 – 5 km from the university interested in the nearest hospital, however; 63%, 48%, and 38% respectively of the people groups who lived in farther distance (6-10 km, 11-15 km, and 16-20 km) minded about medical expenses fees at as presented in Table 4. The results were conformed to Sahachaisaeree and Pimonsathean (2002) [13] that low-income people and government staffs had no choice, they must get just the health service from public hospital due to low medical expenses fees and medical expense reimbursement thus they needed to take a long time to travel to public hospital due to long distances and traffic congestion problem. However, high-income people had more choice to select many private hospitals which could gave convenient to them with a short distance. Moreover, the results also similar to a study of Wei and Xiao (2014) [14] and Yu et al. (2017) [15] that age, education, occupation, and income of patients affected to hospital choosing. Therefore, short distance from the hospital to home, low medical expenses fees, promotion, and short waiting time were the most factors which people concerned.

Table 4: The most factors which affected the selection of a new hospital of each sample group

Sample group	Factor	Percentage
0 - 5 km	Nearest hospital	74
6 – 10 km	medical expenses fees	63
11 – 15 km	medical expenses fees	48
16 – 20 km	medical expenses fees	38

6. Summary and Conclusions

Patterns of the Spatial Distribution of Hospitals around Ramkhamhaeng University focused on the different distance groups (0-5 km, 0-10 km, 0-15 km, and 0-20 km from the university). The results illustrated that the distribution of the hospitals within 0-5 km presented in a form of Dispersed pattern while in a group of 6-10 km had a random pattern. However, there were cluster pattern for 11-15 and 16-20 km group. Moreover, high density of hospitals illustrated around the west side of Ramkhamhaeng University in the distance of 0-10 km with the high populations, however; there was lower density at the east side of the university with the lower population. The hospital distribution pattern concerned to Central-Place theory that was the central of economic prosperity which many products and good service were served to the most people with good transportation.

An analysis of hospital demand of the people who lived in 4 groups, separated by the distance from Ramkhamhaeng University indicated that hospital demand varied in the distance with a significantly of 95%. The people who lived in near the university demands to use the new hospital in the University if it would be built in the future while the demand was faded in the farter area due to traffic congestion problem and transportation fees. Moreover, the most 2 factors which the most people concerned to choose the hospital were the shorter distance and low or appropriate medical expenses fees. For suggestion, this work got the data from sample groups without publication of more data concerning about the new hospital in the university which could affect to people decision. Moreover, weighing of type of hospitals will be required to find the center of hospital in the next study.

Conflict of Interest

The author declares no conflict of interests

Approval of Documents Related to Study Protocol

The Human Subject Research Ethics Sub-Committee of Ramkhamhaeng University, Thailand, has approved this study. Study Code: RU-HS-RES/xd-0124/62, Approval Date: 08/07/19 and Expiry Date: 07/07/20

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References

[1] *Department of Provincial Administration, "Population Statistics", **(2022)**, [cited 2022 July 15], Available from: https://stat.bora.dopa.go.th/stat/statnew/statMONTH/statmonth/#/view*

[2] *National Statistical Office, "Summary of important results: Latent Population in Thailand of 2021", **(2022)**, [cited 2022 July 15], Available from: http://www.nso.go.th/*

[3] *S. Uamkhram and B. Srisatidnaraku, "Discriminating Factors of The Health Care Consumers in Governmental and Private Hospitals, Bangkok Metropolitan", [Master's thesis, Chulalongkorn University] Bangkok: Chulalongkorn University, **(2012)**, [cited 2022 July 15], Available from: http://cuir.car.chula.ac.th/bitstream/123456789/36335/3/sutreraporn_ua.pdf*

[4] *National Statistical Office, "The 2017 Private Hospital Service", **(2017)**, [cited 2022 July 15], Available from: http://www.nso.go.th/sites/2014/DocLib13/*

[5] *Department Of Health Service Support, "List of hospitals which accept patients overnight", **(2011)**, [cited 2022 July 15], Available from: https://hss.moph.go.th › fileupload_doc_slider*

[6] *L. J. King, "Central Place Theory", Reprint. Edited by Grant Ian Thrall: WVU Research Repository, **(1985)***

[7] *L. J. King, "Central Place Theory", Reprint. Edited by Grant Ian Thrall: WVU Research Repository, **(2020)***

[8] *C. Yang, S. Chen, W. Hu, Z. Wu. and Y. Chao, "Spatial distribution balance analysis of hospitals in Wuhan", Int. J. Environ. Res. Public Health. vol. 13, no. 10, **(2016)**, pp. 971, https://doi.org/10.3390/ijerph13100971*

[9] *G. Burgel and G. Burgel, "New Paradigms In Urban Geography", In Practical Geography and XXI Century Challenges. **(2018)**, pp. 709-710.*

[10] *M. Li, J. Van Vliet, X. Ke, and P. H. Verburg, "Mapping settlement systems in China and their change trajectories between 1990 and 2010", Habitat International, vol. 94, **(2019)**, pp. 102069.*

[11] *J. Lobo, L. Ma. Bettencourt, M. E. Smith, and S. Ortman, "Settlement scaling theory: Bridging the study of ancient and contemporary urban systems", Urban Studies, Vol. 57, no. 4, **(2022)**, pp. 731-747, Doi: 10.1177/0042098019873796*

[12] *C. Taeshapotiwarakun, "Spatial Distribution of Housing Estates in the Area of Bangkok: Nong Chok District", Built Environment Inquiry – BEI, vol. 17, no. 2, **(2018)**, pp. 115-135*

[13] *N. Sahachaisaeree and Y. Pimonsathean, "The Use of Geographic Information Systems (GIS) in health care facility planning of Bangkok". Bangkok: KMITL, **(2002).***

[14] *M. Wei and J. C. Xiao, "Study on Influencing Factors and Countermeasures Analyses of Choosing a Different Medical Institutions by Patients", Chinese Health Service Management. Vol. 4,* ***(2014)****, pp. 259-261.*
Available from: http://en.cnki.com.cn/Article_en/CJFDTotal-ZWSG201404007.htm

[15] *W. Yu, M. Li, F. Ye, C. Xue and L. Zhang, "Patient preference and choice of healthcare providers in Shanghai, China: a cross-sectional study", BMJ open. Vol. 7, no. 10,* ***(2017)****, pp. e016418.*