The Service Range of Hospitals and the Syntactic Values of Their Positions in Erbil

No'man M.H. Bayaty[1]

[1]Architectural Department, Faculty of Engineering, Tishk International University, Erbil, Iraq
Correspondence: No'man M.H. Bayaty, Tishk International University, Erbil, Iraq.
Email: noman.bayaty@tiu.edu.iq

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Abstract: The growing nature of the city of Erbil under a relatively prosperous economy has led to the establishment of many private and public institutions, including hospitals and clinical facilities. The locations of these establishments and their relations with the city's network have not been studied enough. This research is trying to check the positions of these hospitals and compare their effect on the city through space syntax. Hospitals of Erbil are counted and classified into local and global. Then an axial analysis is run to identify the local and global cores of the city. The third step is to compare the locations of these hospitals with the syntactic values of their positions. The research found that large hospitals are more compatible with their positions than the local ones, and there are neighborhoods in the city that still lack their local hospitals.

Keywords: Hospitals' Locations, Site Analysis, Space Syntax, Erbil

1. Introduction

Hospitals are some of the most important buildings in the category of healthcare facilities. Other building types might include rehabilitation centers and clinics. The service range of a hospital can be determined, other than the geographical aspects, by two main features: its size and its specialization. According to studies, hospitals, in term of size can be classified into very small hospitals with up to 50 beds, small hospitals with up to 150 beds, standard hospitals with 600 beds and large hospitals with more than that number (Neufert, 2002). The second feature is the specialization of hospitals. General hospitals can serve most purposes but cannot treat the very advance cases, and this is why specialized hospitals, even if smaller, can have a wider service area.

Some studies even mention, that the procedure of planning hospitals using the typical techniques of "catchment populations" and geographically defined, cross-boundary flows, do not seem very effective. Instead, they propose a more entangled economic analysis of the users, providers, and market services for a better outcome (Adler, 1999). This suggests exploring other options in searching for a better methodology for hospitals' planning and this study is searching for an alternative.

The study aims to analyze the relationship between the locations of hospitals, and their sizes and specialization, and use Space Syntax as a tool to check the compatibility between the location of hospitals and their serving ability within the city's structure.

2. Literature Review

2.1 Similar Studies

Several studies tried to investigate the problems of planning hospitals' locations and their service basins. Different techniques have been used through the process to reach a better framework for choosing appropriate locations and more integrated facilities.

In a study published by (Varnakovida and Messina) in 2008, a detailed analysis was conducted to pick up clues for good sites for hospitals in Michigan state area. They studied the relation between the building and the historical and geographical aspects of the site. The study analyzed the locations of 139 hospitals within the different regions of the state and tried to view the setting of the hospital in its region and the amount of its suitability.

The study's tools and processes to analyze the sites' locations included calculating the time travel from any point to the hospital, the accessibility from any point to the hospitals, the relationship between hospitals and the roads' networks, and the population density served by each hospital. The study created a model for analyzing these sites and found gaps in certain places. These places lacked healthcare units according to population density and needed longer travel times to reach a hospital (Varnakovida & Messina, 2008)

Another study presented by Soltani and Marandi, analyzed the locations of hospitals. However, this study used different techniques. The study investigated the process of choosing a site for a hospital in Shiraz – Iran with the use of different analytical techniques. The authors depended heavily on the Geographical Information Systems (GIS) as a main source of information. Then they applied multi-level fuzzy analytical hierarchy of analyses for a more efficient decision-making.

What the study concluded is that the techniques mentioned as, Analytical Hierarchy Process (AHP) and Analytical Network Process (ANP) can be used as both qualitative and quantitative attributes. These techniques prove to be compatible with the planning process and well integrated with the site selection (Soltani & Marandi, 2011).

A third study produced by several authors in 2016 attempted to generate a comprehensive framework for hospitals' site analysis. The study calls it a multidimensional evaluation approach. Researchers analyzed hospitals in 10 European cities and their macro environments combining various techniques, such as functional quality, location quality, environmental quality, and economical aspects. Each one of the previous categories include mini categories where different attributes are studies, such as, flexibility, accessibility, pollution, suitability, connection to green areas and several others. The study then applies the hierarchical framework on a project and concludes it to be useful and comprehensive (Oppio et al., 2016). Accessibility to hospitals has also been under research. One study tried to focus on the aged and their accessibility to health care centers in Illinois, U.S. The study again uses the geographical information (GIS) to find out the range service of each hospital. It found out that 80 % of the aged people live within 7.7 km of a hospital (Love & Lindquist, 1995).

Another study tried to focus on the different attributes of hospitals' locations and accessibility, which are defined by the study as method of aggregation, type of distance, and measure of accessibility. The study focuses on residential quarters and uses the census as a main source of information, since most of its analysis depends on the population density and the census tracts (Apparicio et al., 2008). The previous studies represent a humble field of literature where the techniques used to study the hospitals' locations within their environment are mostly geographical, showing a gap in this field and encouraging a more diverse research.

2.2 The Application of Space Syntax

Just as in the previous few paragraphs, many studies tried to apply the Space Syntax methodology on several aspects of architecture and urban environment. The methodology has been developing for

several decades now, and has proved to be a good tool to measure several social aspects of the urban and architectural environment.

In terms of measuring different social and functional aspects in hospitals using Space Syntax, the amount of literature is very rich. One study tried to study the hospitals as spatial activity zones. It analyzed the hospital's spatial configuration and the workflow between different spaces. The study analyzed the movement between spaces while conducting different medical procedures. The study applied syntactic measurements during the analysis and tested these spaces using the Visibility Graph Analysis, to test the visual control between spaces (especially the nurses' stations and patients' rooms (Koch & Steen, 2012).

Another study applied the same techniques on the design of ICU of a large hospital in Atlanta. The study observed the movement of people within these units and then performed the Visibility Graph Analysis. The study can explain the differences between different people in the way they behave, move and position themselves within the space. Nurses for example tend to stay in zones where they can have high visual access to multiple patients, while doctors tend to position themselves where they can maximize their awareness of the surrounding environment. The syntactic measurements prove to be a good indicator of human behavior and activity within spaces (Lu et al., 2009).

A third study analyzed the medical-surgical units in hospitals using Space Syntax analysis. The study used the methodology to analyze medical-surgical nursing units, and was able to find the efficiency gap in the performance of the buildings. The study finds that the perception of nurses did not match the anticipated benefits of the floor plan designs (Trzpuc & Martin, 2010).

The amount of studies in this field is extensive. Researchers try to analyze every aspect of hospitals' design and planning using different methodologies, especially applying syntactic measurements to predict human behavior, and this is what the current study will also attempt.

3. Research Problem and Methods

Through the brief survey of the previous studies, a few points can be noticed. The positions of the hospitals depend on various factors. The surrounding neighborhood, population served, the hospital's type, relation to transportation network and many other factors can be mentioned. The second point presents the ability of Space Syntax methodology to predict various social and behavioral attributes. The main problem the research found, is that despite the extensive research in both fields separately (studying hospitals' locations and applying Space Syntax on predicting social attributes), very limited studies have followed both methodologies and applying them on the case study (the city of Erbil).

In this study, a simple process will be followed. First all the hospitals in the metropolitan area of Erbil will be counted. Then they are classified into two categories: local or global. For the sake of the current research, local hospitals are considered small hospitals or with no clear specialization, and are expected to serve a neighborhood smaller than the city. The global ones are either large hospitals, or specialized ones, and are expected to receive patients from all over the city.

The second step is to run a space syntax analysis. With the help of this analysis, the local and global cores of the urban structure can be found. Then a comparison is executed to view the amount of correspondence between positions of these hospitals on ground and the extent of optimization, since local hospitals tend to be situated in local cores, and the global ones in their corresponding global cores.

4. Space Syntax Methodology

Space Syntax has been one of the leading analysis method in architectural and urban studies for a few decades. The methodology is proving useful in terms of predicting different attributes: spatial, formal, social, functional, and others. The current study will focus on a few aspects of the analysis. First, the analysis method used is the axial analysis. There are a few other methods, such as, the segment analysis, visual graph analysis and agent analysis. In the axial analysis, the urban environment is reduced to a map where each space is represented by a line. The resulting map (axial map) undergoes the step-depth method analysis to find out the connectivity attributes as well as attributes related to the depth of spaces and their integration within the system. Details of these analyses can be found in several studies (Hillier & Hanson, 1989).

The main attributes the study focuses on are the integration and choice. Integration represents the depth and segregation of spaces. Spaces with higher integration are less segregated and have stronger connection with the system. They also represent the human occupation in these spaces; in other words, spaces with higher integration have more people in them, or move towards them (Al-Sayed, 2018). Choice is the attribute that measures the control on the adjacent spaces and the flow between them. It measures the movement through spaces, vehicular or pedestrian, so higher choice values mean higher movement through spaces.

One final point is the radius of analysis (radii). When the radius is 2 for example, it means the program (DepthmapX is used here) will study the relationship between the space and the two spaces after it, 5 means it will measure five steps away and so on. The final radii is (n) which measures the relationship between the space and the whole system. This means that integration cores at radii, 2 or 5 represent local cores within the system, while high radii, or radii of (n) represent the global core of the whole system (Al-Sayed, 2018).

5. Results

Table 1: The names of the hospitals in Erbil and their codes

Hospital's code	Hospital's name	Hospital's code	Hospital's name
L1	Swedish Specialist Hospital	L2	Newroz Hospital
L3	Balsam Hospital	L4	Rozhawa Hospital
L5	Soran Hospital	L6	Kurdistan Salamati Hospital
L7	Hawler Hospital	L8	Zheen Hospital
L9	Rasul Hospital	L10	CMC Hospital
L11	Life Support Team Hospital	L12	Sardam Hospital
L13	Surgical Specialty Hospital	L14	Westeye Hospital
L15	Howar Hospital	L16	Daik Hospital
L17	Tehran Hospital	L18	Sima Hospital
G1	Maternity Hospital	G2	EMC Hospital
G3	Rizgary Hospital	G4	PAR Hospital
G5	Paky hospital	G6	West Erbil Emergency
G7	Nanakali Hospital		

In figure (1), we can see the axial plan of the city of Erbil, and the locations of all the hospitals are viewed on it. Local hospitals have been given a blue (L) symbol, and the global ones are given a red (G). The total number of hospitals counted in the research is 25, with 18 as local and 7 global.

The next few figures will show the results of the axial analysis. Fig (2), (3), (4) and (5) show the map of the city with radii values of (2), (5), (10) and (n) respectively. The colors represent the strength of the choice value. Red represents increase in choice while the blue represents low choice values. For shorter radiuses, we notice the cores are multiple and spread almost equally on all parts of the city, but once the radius is enlarged towards higher values and towards the global radius (Rn), the effect changes to a more linear fashion. The effects of the ring road on the city is clear from the images. Erbil consists of multiple ring roads (30m, 40m, 60m, 100m, 120m) and these roads are taking high values for choice, especially clear from (figure 5) which represents the Global Choice diagram. It means that hospitals situated on these roads will receive more movement and will probably have a wider service range.

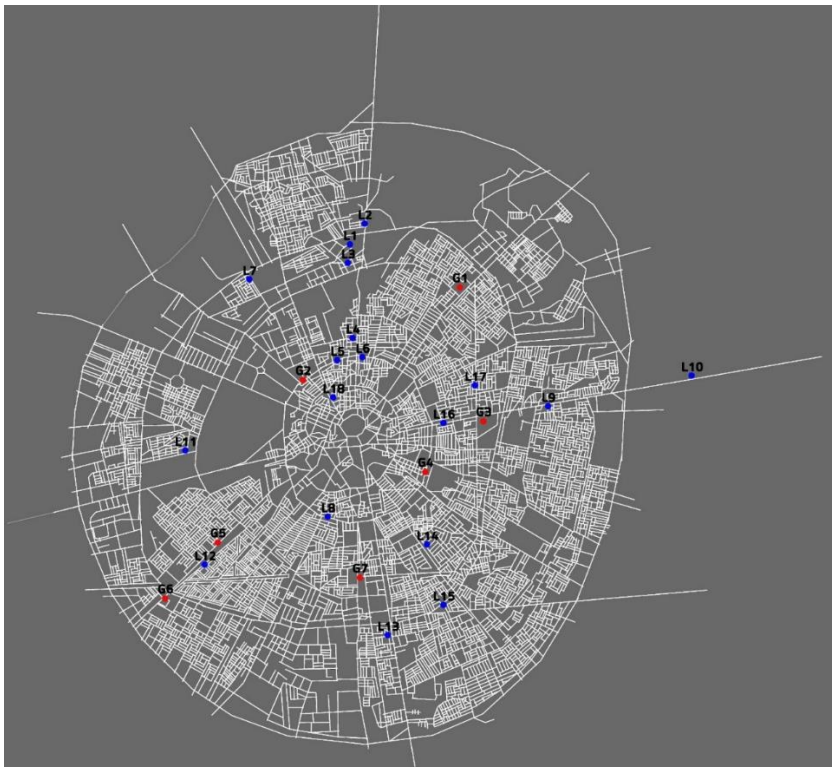

Figure 1: Erbil city axial map with the location of hospitals

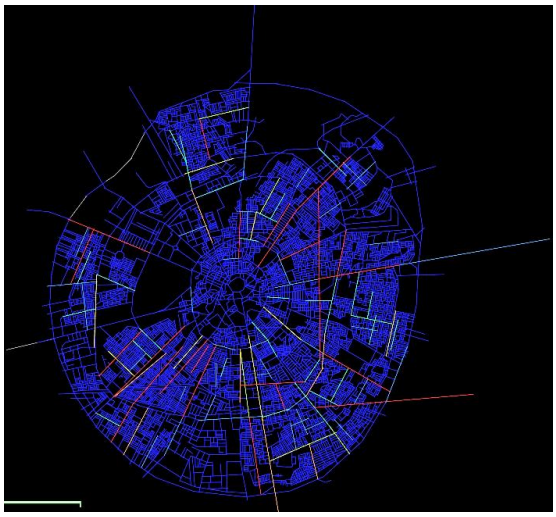

Figure 2: R2 Choice values

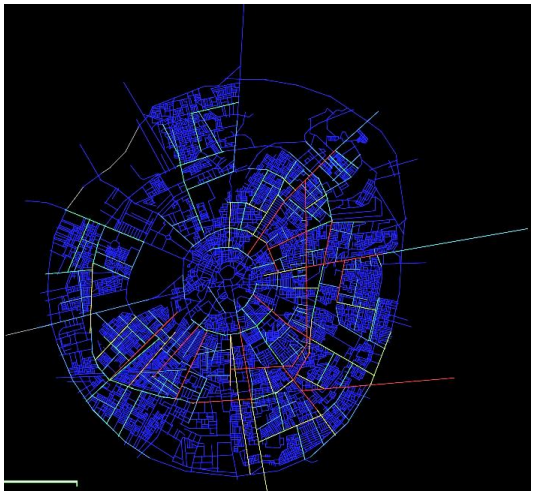

Figure 3: R5 Choice values

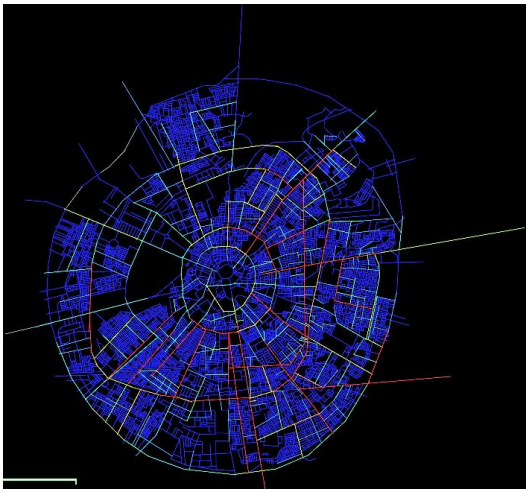

Figure 4: R10 Choice values

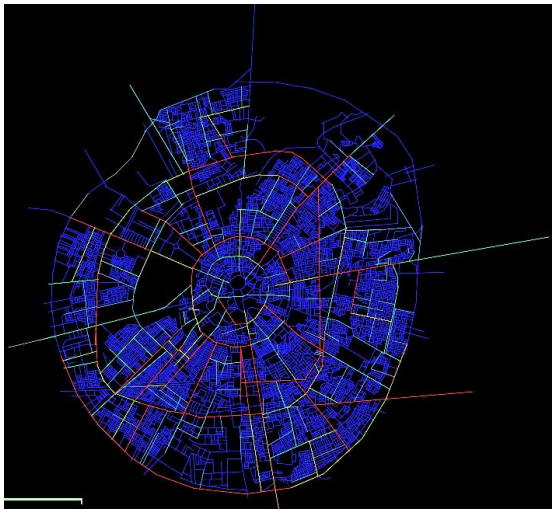

Figure 5: Rn Choice values

The integration values are presented in the same way in figures (6), (7), (8) and (9), and within the same radii, (2), (5), (10) and (n). Again the color spectrum representing the strength of this attribute is ranged from blue (low integration) to red (high integration). For the shorter radii, again it is noticed that integrations cores are spread on different parts of the city. As the radius increases the integration core starts to concentrate at specific locations. The final diagram, which represents the global integration core (Rn), shows that the core of the city is not in the center. The city has a radial urban pattern, with all the streets leading to its center, and all the ring roads circling the center. Despite the center being a formal core of the city, syntactically, it is not, and the integration core is shifted to the east (40m road). There might be multiple reasons for this, but currently the best explanation would be the difference in building density of the western and eastern part. The density of streets and buildings in the western part is less, due to large empty lots, and the presence of airport and largest park in the city.

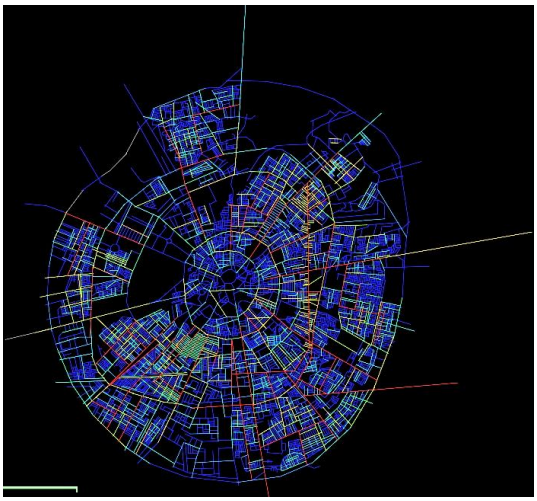

Figure 6: R2 Integration values

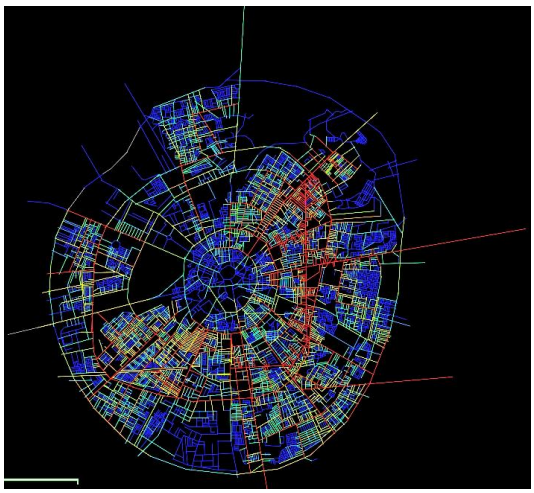

Figure 7: R5 Integration values

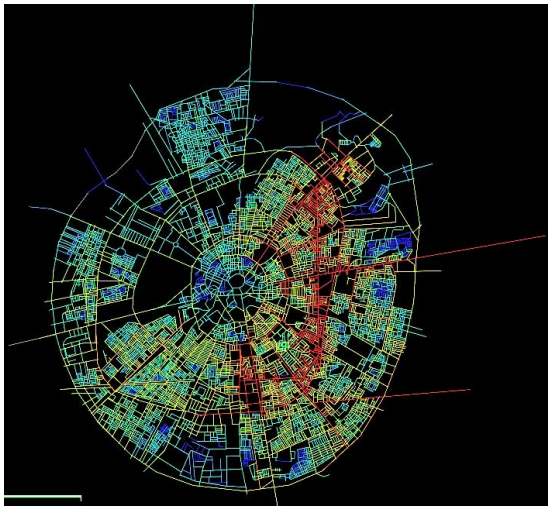

Figure 8: R10 Integration values

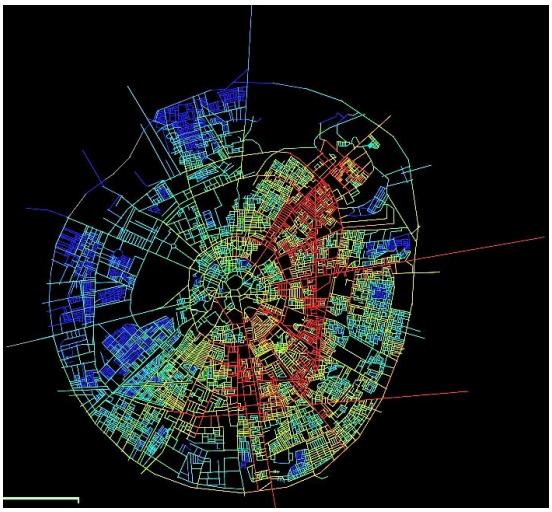

Figure 9: Rn Integration values

In terms of numbers and figures, the highest 10% of each attribute refers to its strongest core. In the R2 Choice diagram, and by comparing the positions of the local hospitals with the local cores, it was found that out of 18 local hospitals 11 were situated within the highest 10% of choice values. This means that 61.1% of the local hospitals are situated within the local choice cores. As for integration (R2 radii) which refers to the local integration core of the system, and by taking the highest 10% of values, it was found that 9 local hospitals were located within the highest 10% integration values. In other words, 50% of the local hospitals are located within the local integration cores of the city.

Checking the global cases; by taking the global choice values (Rn radii), and comparing them to the locations of the global hospitals, the research found that 5 out of 7 hospitals were situated within the highest 10% choice values, leading us to the result that a strong majority (71.4%) of the global hospitals are within the global choice cores. As for integration, it was found that 4 out of 7 hospitals were within the highest 10% integration values of the (Rn radii) integration map, keeping the percentage of global hospitals within the global integration core at 57.1%.

6. Conclusion

From the results above, we can conclude a few points. First, the correlation between the positions of the hospitals and their syntactic values is considered high. This relatively positive relationship can represent a good location and site selection. The study also found that the global hospitals had a stronger relationship with their cores than the local ones. There can be many reasons for this result and the previous one can be one of them.

There are also the differences in percentages of the hospitals' distributions between the choice and the integration maps (71.4% and 57.1% for the global choice and integration respectively). The reasons can be traced back to the nature of the analysis and its attributes. Choice values are usually more spread around the system, while integration cores tend to focus in smaller geographical area, which gives less chance to the scattered points to locate themselves within the integration core. The relationship between the choice and integration and their relationship with the urban morphology of the city of Erbil can become a topic of another study.

The study would suggest a further research by checking the level of service range performance and the accessibility values of these hospitals by other means. Comparing the results with the current study can speculate on the validity of space syntax as an efficient tool for measuring the performance of these hospitals within their neighborhoods and the quality of their locations.

References

Adler, D. (ed.) (1999). *Metric handbook: Planning and design data* (2nd Edition), United Kingdom, Architectural Press.

Al-Sayed K. (2018). *Space syntax methodology* (5th Version) A teaching guide for MSc courses, Bartlett School of Architecture, UCL.

Apparicio, P., Abdelmajid, M., Riva, M., & Shearmur, R. (2008). Comparing alternative approaches to measuring the geographical accessibility of urban health services: Distance types and aggregation-error issues. *International Journal of Health Geographics*, 7(1), 7. DOI: 10.1186/1476-072x-7-7.

Hillier B., & Hanson J. (1989). *The social logic of space* (1st Edition), United Kingdom, Cambridge University Press.

Koch D., & Steen J. (2012). Analysis of strongly programmed workplace environments: Architectural configuration and time-space properties of hospital work. *Proceedings of the 8th Space Syntax Symposium*, Ref. No. 8146. Santiago.

Love D., & Lindquist P. (1995). The geographical accessibility of hospitals to the aged: A geographic information systems analysis within Illinois. *Health Services Research*. 29:6, pp. 629-651.

Lu Y., Peponis J., & Zimring C. (2009). Targeted visibility analysis in buildings correlating targeted visibility analysis with distribution of people and their interactions within an intensive care unit. *Proceedings of the 7th Space Syntax Symposium*, Ref. No. 068. Stockholm.

Neufert, E., & Neufert, P. (2002). *The architect's data* (3rd Edition), United Kingdom, Wiley-Blackwell.

Oppia, A., Buffoli M., Dell'Ovo M., & Capolongo S. (2016). Addressing decisions about new hospitals' siting: a multidimensional evaluation approach. *NCBI*, 52(1), 75-87. DOI: 10.4415/ANN_16_01_14.

Soltani A., & Marandi E. Z. (2011). Hospital site selection using two-stage fuzzy multi-criteria decision making process. *Journal of Urban and Environmental Engineering*, 5(1), 32-43. DOI: 0.4090/juee.2011.v5n1.032043.

Trzpuc, S. J., & Martin, C. S. (2010). Application of Space Syntax Theory in the Study of Medical-Surgical Nursing Units in Urban Hospitals. *HERD: Health Environments Research & Design Journal*, 4(1), 34–55. DOI:10.1177/193758671000400104.

Varnakovida P., & Messina J. P. (2008). Hospital Site Selection Analysis. Retrieved from *https://www.researchgate.net/publication/268298914_Hospital_Site_Selection_Analysis*.