Hospital Selection Problem: An Integrated Analytic Hierarchy Process (AHP) and Fuzzy-TOPSIS Approach

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Abstract

This research provides a step by step procedure for hospital selection problem. Although the concept of hospital location selection, site selection and other related tools and techniques have been investigated in previous literature, hospital selection problem is less investigated. In addition, the problem is not adequately linked with Multiple-Criteria Decision Making (MCDM) approaches. To address the gap of previous literature, this research has been completed in three linked steps to achieve as follows. The first phase of this research aims to investigate potential criteria to be applied in hospital selection problem. To do so, it applies a literature review to find potential criteria of hospital selection. Following, as developed criteria should be fit with the problem, an Analytic Hierarchy Process (AHP) is applied to rank and finalize the developed criteria of previous phase. Finally, the obtained criteria of the second phase are applied to compare and select three potential hospitals by a Fuzzy-TOPSIS approach. According to the obtained results of the first phase, cost, knowledge and expertise, quality, communication, environment, reliability and fast service are potential criteria of hospital selection. In addition, the second phase shows that cost, quality, knowledge and expertise, environment and communication are the main decision making criteria of this research. Finally, the third phase provided final ranking of hospitals as A1>A2>A3.

Keywords
Hospital selection, MCDM, Fuzzy MCDM, AHP and Fuzzy-TOPSIS.

1. Introduction
A proper decision making plays a significant role in final output of an idea (Miller and Lee, 2001). In other words, short, medium and long term decisions can significantly affect the performance (Galankashi and Helmi, 2017). As an important example of decision making, many people are involved in hospital selection problem. To be more specific, hospital selection problem is involved with a proper investigation of different potential hospitals to choose from.

Similar to any decision making process, there are many decision making criteria which are available to assess the hospitals. In addition, there are numerous qualitative and quantitative decision making tools to be applied in hospital performance assessment (Zehir et al., 2016).

With the progress of healthcare systems, people have a chance to be selective in their hospital selection process. In other words, there are different hospitals with different quality, service, knowledge, expertise and technology levels to serve people. In this regard, people can choose among different available alternatives for their medical treatment process. Therefore, hospital selection problem has been changed during recent years. According to recent studies on hospital selection problem (Ghosh, 2015), it is critical for all patients to choose their hospital based on different quantitative and qualitative criteria. In other words, hospital selection criteria should be less but fit to cover all aspects of this decision. To be more specific, hospital selection problem should see different financial and non-financial aspects of choosing a hospital (Watkins, 2000). In addition, similar to other decision making problems, a decision maker should make a trade-off between numerous quantitative and qualitative issues when he/she is going to choose a hospital among different potential alternatives. Therefore, a proper hospital selection problem should handle three simultaneous problems of applicable criteria, appropriate assessment process and beneficial decision making tools to choose best alternatives among different potential alternatives.

Although hospital selection problem has been widely investigated in previous studies (Ghosh, 2015), its integration with MCDM approaches is less examined. Furthermore, many decision makers, managers, practitioners and patients makes their decisions by linguistic terms rather than exact scales (Galankashi et al., 2016). In other words, the majority of daily expressions happen in fuzzy environments rather than exact judgments (Rezaei el al., 2020; Galankashi et al., 2020). Therefore, fuzzy environments are highly recommended as they can reflect diverse suspicions which are available in exact pairwise comparison process of hospitals. By the way, developing the specific measures and metrics of hospital selection problem, ranking them using an MCDM technique, applying an appropriate data collection tool and lastly using an appropriate Fuzzy MCDM (FMCDM) methodology to rank different hospitals are challenges of decision makers. Although there are numerous criteria to be applied in hospital selection problem (Ghosh, 2015), they are less investigated in previous literature. In other words, by ignoring the availability of numerous decision making criteria and their definite differences, many studies still suggest cost and quality as the main criteria of hospital selection problem. However, it is useful to know which hospital selection criteria is more suitable to be applied in hospital performance assessment and selection process. Though, developing a stage by stage methodology to be applied in hospital selection process is important as:

1. The developed approach of this study can be applied in real hospital selection process
2. The applied research methodology can be applied in other healthcare sections such as labs, clinics, etc.

The scope of this study is limited to healthcare industry with a focus on hospital selection problem. More specifically, this research suggests a framework to be applied in hospital selection problem. However, although the concept of this study is limited to hospital selection problem, its procedure, method, criteria and arrangement are appropriate to be applied by managers, practitioners and researchers who are interested in quantitative managerial decisions in healthcare industry. This research contributes to apply specific criteria to assess and compare different hospitals using a fuzzy approach. Consequently, this research suggests an incorporated methodology for hospital selection problem. Therefore, this research aims to analyze previous research on hospital selection, finalize specific criteria of hospital selection problem and finally apply Fuzzy-TOPSIS in hospital selection problem. The remainder of this research is organized as follows. Section 2 provides the investigated literature review. Next, different phases to achieve the objectives of study are discussed in Section 3. In conclusion, the results and discussions are discussed in Sections 4 and 5, respectively.

2. Literature Review

This section provides different definitions, concepts and related issues including healthcare industry, hospital selection, hospital selection criteria and a review on previous literature. Finally, a summary and identification of research gaps are explained at the end of this section.

2.1 Healthcare Industry

There are different terms applied to call this industry including health economy and medical industry. According to previous research (Menon et al., 2000), healthcare industry includes different sections, hospitals, organizations,

companies and many other components that are trying to deliver products and services to treat people who are suffering from numerous diseases and require a wide range of treatments such as preventive, curative, palliative and rehabilitative care. In other words, this industry aims to maintain and re-establish the health related issues by manufacturing, commercializing and providing both goods and services to society. There are numerous issues linked with this industry. However, finance, product and service are three major components of this industry. As an important section of this industry, according to previous literature, a healthcare supply chain includes suppliers, manufacturers, distributors, retailers and customers to provide goods and services to different customers of this industry including patients and hospitals (McKone-Sweet et al., 2005). Similar to manufacturing supply chains, the presence of all these components is not compulsory in healthcare supply chains.

2.2 Hospital selection

According to Ghosh (2015), the majority of previous literature on hospital selection have been completed in Europe and USA. In other words, the problem is less investigated in other areas including developing countries. As discussed, healthcare industry includes numerous sections which aim to deliver final goods and service to patient in a desired time, quality and price. As many patients receive these goods and services at healthcare departments, hospital selection problems become critical since there are many factors involved in this decision. In other words, a patients cannot complete his/her medical treatment without the assistance of hospitals or other healthcare departments. The necessities of patients might be in the form of prevention, curative, surgery and many other types of treatments. In this regard, hospital selection problem aims to investigate and analyze different hospitals to choose from. Consequently, final prioritization of hospitals using different criteria is the main output of this research.

2.3 Hospital selection criteria

According to explanations presented in previous sections, there are different hospital selection criteria to be applied. In other words, there are different patients with different levels of income, education, acceptable risk and many other characteristics which cause them to choose different criteria in their hospital selection process. However, the quantity of these criteria might be increased as a decision maker might be forced to make a sudden and fast decision. Therefore, a literature review is applied to find the most frequently applied criteria of hospital selection as tabulated in Table 1. In other words, the majir criteria of hospital selection are tabulated in this table.

Table 1. Hospital Selection Criteria

Criteria	Sample Reference
Cost	Goeree et al., (1999)
Knowledge and expertise	Jannat et al., (2017)
Quality	Hull (2018)
Communication	O'Halloran et al., (2013)
Environment	Abdulkareem et al., (2021)
Reliability	Delfino et al., (1993)
Fast Service	Psirides et al., (2013)

2.4 Identification of research gap

As a summary of this section, a step by step methodology for hospital selection problem is not properly investigated, particularly in developing countries. Furthermore, as there are several measures, metrics and criteria to assess and compare the performance of hospitals, it is critical to use fit, measurable and understandable criteria. Finally, it is very common for managers, practitioners, decision makers and people to make their expressions, judgments and comparisons in fuzzy environment instead of exact scales (Hashemzahi et al., 2020). Therefore, to address this gap, this study develops a methodology to investigate hospital selection criteria, prioritize them using an AHP and finally compares and ranks three hospitals using Fuzzy-TOPSIS methodology.

3. Research Methodology

The developed research methodology is explained in this section. As shown in Figure 1, this research has been accomplished in three linked phases as follows. Firstly, a literature review is completed to develop potential criteria of hospital selection. Next, the second phase applies an AHP to finalize hospital selection criteria. Finally, the third

phase applies a fuzzy-TOPSIS to rank three hospitals using the developed criteria of second phase. Different phases of this research have been explained as follows. The first phase of this research aims to review different studies on hospital selection problem. In other words, the first phase of this research initiates from an initial idea. Next, a literature review is completed to support the initial idea. In this regard, different studies on hospital selection problem are reviewed and potential hospital selection criteria are extracted. Therefore, the main output of the first phase of this research is potential hospital selection criteria to be applied in the second phase. Following, the second phase of this research aims to finalize hospital selection criteria with regard to numerous concerns of healthcare industry. In other words, the second phase of this research aims to investigate the outputs of the previous phase with regard to different specifications which are necessary in healthcare industry. To do so, an AHP is applied as a proper decision making tool to finalize hospital selection criteria. In other words, an AHP is applied to make a pairwise comparison between decision making criteria and final alternatives. In this regard, the main outputs of this phase are final hospital selection criteria to be applied in the next phase. Finally, the third phase of this research applies a Fuzzy-TOPSIS approach for the aim of hospital selection. In other words, once hospital selection criteria were finalized in previous phases, they are applied in a Fuzzy-TOPSIS decision making model to investigate and rank different hospitals. Therefore, final phase of this research applies a fuzzy MCDM technique to rank different hospitals with regard to their performance. Different phases of this research are depicted in Figure 1. In other words, this figure shows a summary of discussed research methodology.

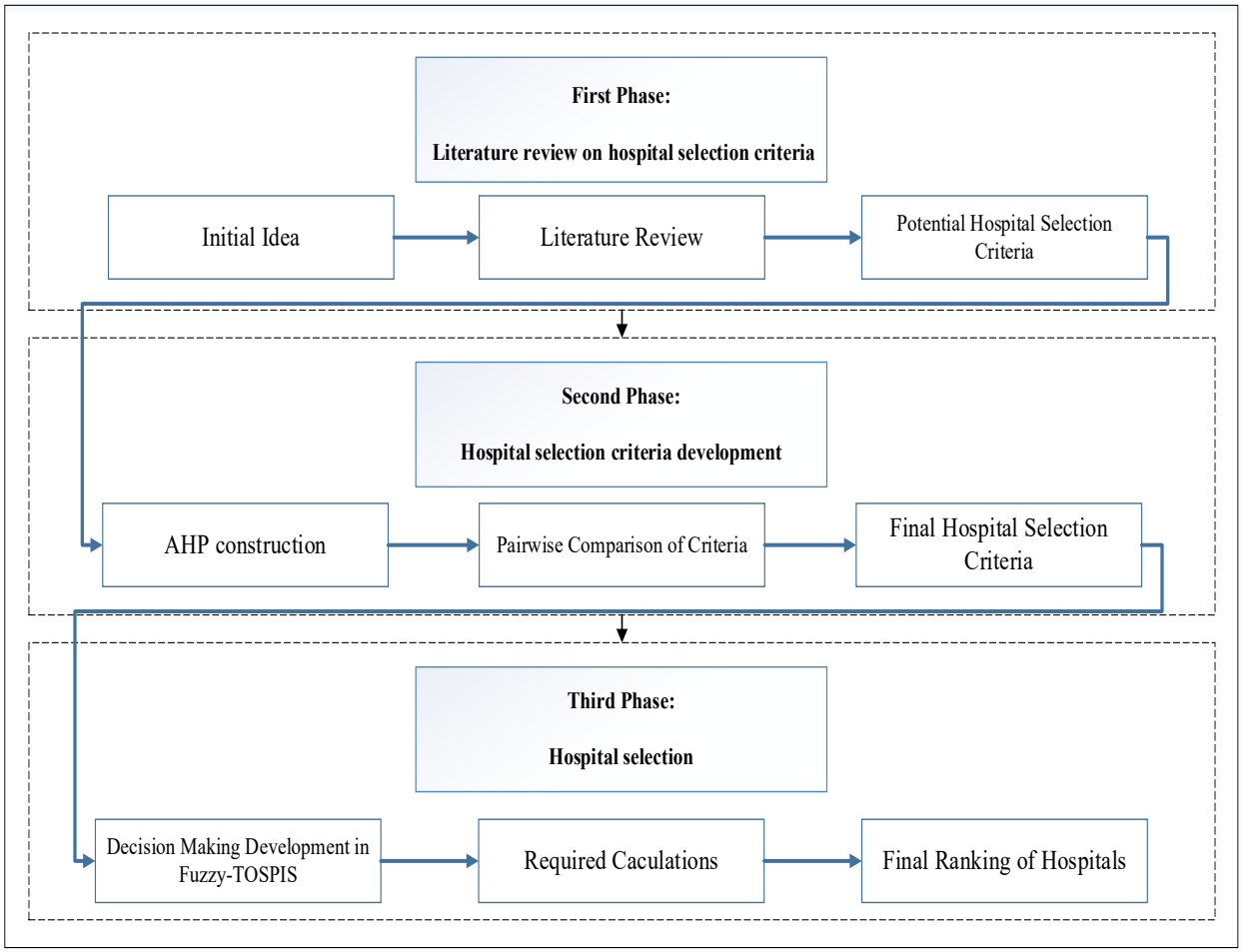

Figure 1. Research Steps

4. Results

The obtained results of this study are illuminated in this section. According to research methodology section, there are three linked phases to achieve the objectives of this study. Therefore, this section has been arranged based on these

phases to ease the tracking process of obtained results. Regarding the data collection, there were three issues linked with data collection process. Firstly, it was necessary to rely on fit and applicable hospital selection criteria. In this regard, a literature review was conducted to find reliable hospital selection criteria. Secondly, the AHP questionnaire has been designed based on different steps of completing this approach. In addition, as different experts have contributed to fill this questionnaire, the obtained outputs are completely reliable. Finally, similar to AHP questionnaire, Fuzzy-TOPSIS questionnaire is also designed based on its standard steps and have been filled by different patients to be more reliable. As discussed, the initial phase of this study investigates previous literature to develop potential hospital selection criteria. As a reminder, the main output of this phase is tabulated in Table 2. According to this table, cost, knowledge and expertise, quality, communication, environment, reliability and fast service are initial criteria of hospital selection. Following, an AHP is applied to determine fit hospital selection criteria to be applied in this research.

Table 2. Initial list of hospital selection criteria

A	B	C	D	E	F	G
Cost	Knowledge and expertise	Quality	Communication	Environment	Reliability	Fast service

As discussed in the second phase of research methodology, an AHP is applied to finalize hospital selection criteria. To do so, an interview was conducted with five researchers of this area to collect required data of AHP calculations. The final weights are calculated according to the judgments of each expert and are tabulated in Table 3. The second column of this table applies some parameters (C1, C2,..,C7) as the representative of each criteria. In addition, the obtained weight of each criteria is displayed in the last column. The simple average is applied to calculate final weight of each criteria as tabulated in the last column of this table.

Table 3. Final weights of hospital selection criteria

Criteria	**Applied Parameter**	**Obtained Weight**
Cost	C1	0.423
Knowledge and expertise	C2	0.194
Quality	C3	0.145
Communication	C4	0.083
Environment	C5	0.069
Reliability	C6	0.056
Fast service	C7	0.030

Therefore, the second phase showed that cost, knowledge and expertise, quality, communication and environment are the main hospital selection criteria, respectively. These criteria are applied to compare and rank the performance of three hospitals. The applied decision making hierarchy of the third phase of this research is depicted in Figure 2. The first level of this hierarchy shows the goal, the second level shows the decision making criteria and finally the third level shows different alternatives to be prioritized. A fuzzy-TOPSIS approach is applied to compare the performance of these three hospitals.

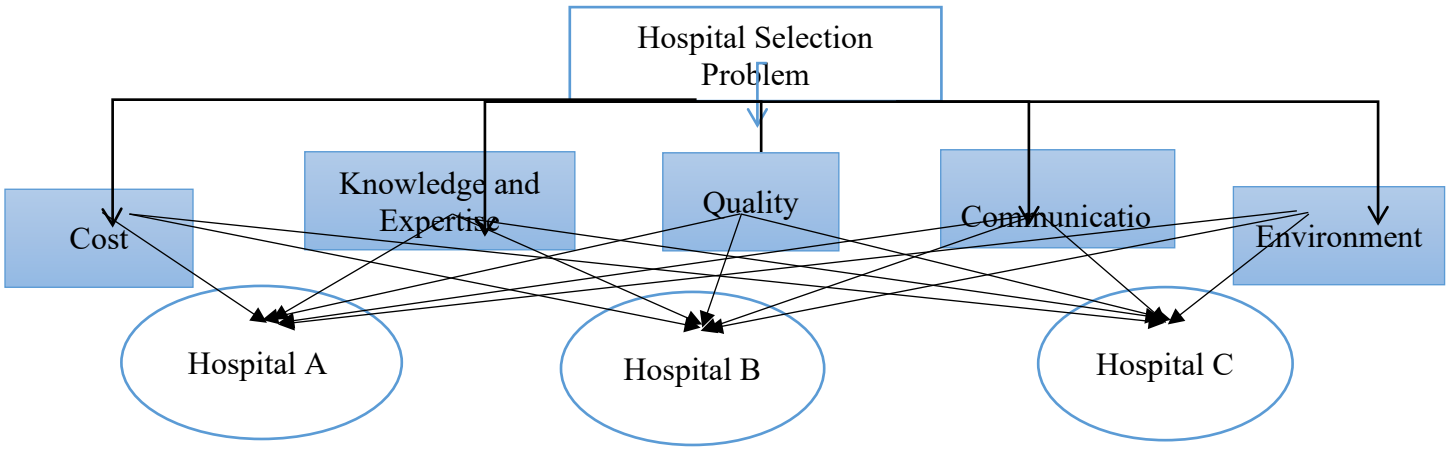

Figure 2. Hospital selection decision making hierarchy

Next, a questionnaire was designed and an interview was conducted with five patients to collect required data of Fuzzy-TOPSIS. Following, the weight of each hospital were calculated. Table 4 tabulates the obtained distance of each alternative from positive and negative ideal solutions. In other words, this table shows how each alternative is far from positive and negative ideal solutions. According to Table 5, the first alternative (hospital A) has the highest score which is followed by hospitals B and C, respectively. Therefore, the results of this research suggests hospital A as the best alternative to be chosen by patients.

Table 4. Distance from positive and negative ideal solutions

Hospital	D+	D-
Hospital A	3.62	4.29
Hospital B	3.83	3.72
Hospital C	3.83	3.77

Table 5. Final ranking of hospitals

Hospital	Ci	Ranking
Hospital A	0.54	1
Hospital B	0.49	3
Hospital C	0.50	2

5. Conclusion

This study developed a step by step approach to be applied in hospital selection problem. In this regard, this study was completed in three linked phases to achieve its objectives. The first phase of this research investigated potential criteria to be applied in hospital selection problem. A literature review was conducted to find numerous potential criteria of hospital selection. Next, to decrease the quantity of the developed criteria and improve their applicability, an AHP was applied to rank and finalize the developed criteria of the second phase. Finally, the obtained criteria of the second phase were applied to compare the performance of three potential hospitals using a Fuzzy-TOPSIS approach. The obtained results of the first phase showed that cost, knowledge and expertise, quality, communication, environment, reliability and fast service are potential criteria of hospital selection. Next, according to the obtained results of the AHP, cost, quality, knowledge and expertise, environment and communication are the most important decision making criteria of this research to be applied in the next phase. Finally, the third phase provided the final ranking of hospitals as A1>A2>A3. Although the developed framework and methodology have been applied in healthcare industry, other

scholars can apply the similar research in other industries including automotive, electrical appliances, etc. In addition, different MCDM approaches can be integrated instead of AHP-Fuzzy TOPSIS.

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