Identification and Prioritization of Local Indicators of Hospital Bed Allocation in Iran

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Research

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Identification and Prioritization of Local Indicators of Hospital Bed Allocation in Iran

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Abstract

Background: The distribution of hospital beds can be used as an indicator for evaluating the distribution of health services. This study aimed to determine and prioritize indicators of bed allocation in Iran.

Methods: In the first phase of the study we determined factors affecting bed distribution using a scoping review. In the second and third phases we applied expert panel and Delphi method to localize indicators of bed allocation. Finally, we carried out Analytic Network Process (ANP) approach based on Decision Making Trial and Evaluation Laboratory (DEMATEL) technique (DANP) to determine the weight and importance of indicators and to evaluate the causal relationship between them.

Results: We identified 75 criteria affecting the distribution of beds through scoping review. In two rounds of Delphi, 28 criteria were agreed upon and entered into the DANP phase. Population, existence of a reference hospital in the area, the type of hospital (general/specialized), common diseases in the area, existence of home care services have had the most interaction with other variables. The variable of home care services was at the highest level of the causal chain.

Conclusions: Bed occupancy rate, the average length of stay, waiting list, as well as type and level of the hospital had the highest priority in the distribution of hospital beds. Moreover, considering the importance of home care, policies should be adopted to expand these services

nationwide. The criteria identified in this study will be helpful in developing policies aimed at equitable allocation of hospital beds considering the efficiency criteria.

Key word: hospital bed, distribution, allocation, criteria, DEMATEL, DANP

Introduction:

Today, health care reforms seek to provide access to universal and equitable health care in countries. However, inequality in the geographical distribution of health care resources has limited the sustainable development of health care, health outcomes, and economic efficiency [1-3]. Inequality in the distribution of medical facilities and equipment is mainly seen in government hospitals in many countries[4]. Meanwhile, the increase in the number of known treatable diseases and the high cost of new equipment, technologies, and treatment methods, as well as the rising level of public expectations on the one hand and the limited available resources on the other hand, underscore the need for careful decision-making in allocating resources [5].

As health care costs increase, health policymakers are focusing on hospital services as the most expensive sector of health systems. Often half of the total health sector costs are allocated to hospital services. Therefore, efforts should be made to increase efficiency, reduce costs, and use the potential capacity of inpatient centers[6].

Nowadays, researchers and policymakers increasingly pay attention to the distribution of health resources such as beds, physicians, and equipment as indicators of public health[7]. Nevertheless, the heterogeneous and inappropriate allocation of these expensive resources has led to a waste of resources in health systems [8]. Among these resources, the number of hospital beds is the primary indicator for estimating the capacity of a certain geographical region in providing medical services and consequently as a measure for allocation of other required resources, including human resources, diagnostic and treatment equipment, as well as support facilities[9]. In this regard, the distribution of hospital beds can be used as one of the indicators for evaluating the distribution of health services [10]. Therefore, considering the importance of allocation of hospital resources based on the number of beds in each ward, bed distribution is one of the most critical issues in the management of hospitals[11]. Studies suggest several factors for bed

distribution, including population size, age and gender structure of the population[9, 12], hospital bed occupancy rate, number of staff [13], demand for services, the effect of home care packages[14], the average length of stay[15], and type of diseases[16].

Inappropriate distribution of beds poses many challenges to hospitals and may result in the reduced access to health services and imbalanced distribution of nurses, physicians, and medical equipment [17]. Overcrowding of hospital wards and lack of enough beds lead to a reduction in the employee-to-patient ratio and can potentially reduce patients' safety and satisfaction and may increase the risk of job burnout due to increased workload [18]. A study in Norway revealed that patient overcrowding and bed shortages reduce both the quality of care and time spent for each patient and accordingly increase the risk of medical errors, accidents, and infections[19].

Development of hospital beds have different dimensions. Therefore, determining the factors affecting the distribution of hospitals beds is necessary to provide a comprehensive view on bed distribution, to prepare development plans based on the priorities, and to avoid wasting vital resources through more effective bed allocation policies. Considering these factors by health policymakers and managers for the allocation of impatient beds increases the efficiency of limited and expensive resources of the health sector. This study aimed to determine and prioritize indicators of bed allocation in Iran. The findings of this study can be used as a comprehensive evidence for bed allocation policy in the country.

Method:

Study setting:

This study was performed in four steps, including scoping review, expert panel, Delphi method, and Analytic Network Process (ANP) approach based on Decision Making Trial and Evaluation Laboratory (DEMATEL) technique (DANP). The main objective of this study was to determine the local indicators of bed allocation in the country and to evaluate the weight, importance, and the relationship between the indicators. This study was approved by the ethics committee of Shiraz University of Medical Sciences under the code IR.SUMS.REC.1399.340

The first phase of the study was aimed to identify factors affecting bed distribution in a region determined using scoping review. The second and third phases were carried out to localize indicators of bed allocation using expert panel and Delphi method. The fourth phase was carried

out to determine the weight and importance of indicators and to evaluate the causal relationship between them for policy objectives.

1. Scoping review

In this phase, the scoping review method was used to determine the factors affecting the distribution of hospital beds. Given that number of hospital beds depends on various factors such as economic status, social conditions, and burden of diseases, a scoping review was designed to create a comprehensive framework regarding the key determinants of inpatient bed distribution. The reason for using the scoping review method is that this method allows the review of studies with different designs. In this study, scoping review was performed using a five-step approach proposed by Arksey and O'Malley[20], as follows.

1.1. Determining research question:

The present study aimed to answer the question: what are the factors affecting the distribution of hospital beds?

1.2. Searching and extracting studies:

To search for relevant articles, we followed four steps. 1) Firstly, we searched various scientific databases to ensure that there was no similar review. Before conducting a comprehensive review. 2) The search terms were identified and the search strategy was developed. We extracted relevant keywords related to the concept using Medical Subject Heading (MeSH) database. Then, depending on each database, the appropriate search strategy was determined.3) Using the search strategy, articles related to the study question were extracted. In this regard, we searched six main databases, in clouding PubMed, Scopus, Web of Science, ProQuest, Sciencedirect, and Embase. 4) The websites of scientific societies, the World Health Organization and the World Bank were searched for other publications. We used search terms in three fields, including title, abstract, and keywords. The search terms in each group were combined with the logical operator "OR" and the groups were combined using the logical operator "AND". The search strategy of the study is shown in Table 1. We used EndNote software to manage resources.

Table1: search strategy for criteria affecting the distribution of hospital beds

Searching Databases	**PubMed, Scopus, Web of Science, ProQuest, Science direct, Embase**
Limitations	Language: Articles with language in English

	Time: unlimited
Search Strategy	#1 AND #2
#1	"hospital bed" OR bed OR "inpatient bed" OR "in-patient bed"
#2	Distribution OR allocation

1.3. Selection of related studies:

Because of translation limitations, only studies with full text in English were included. No time limit was considered for the inclusion of articles in the study.

To formulate the main question of the review and also in all stages of article appraisal and inclusion, the three main criteria of scoping review studies were applied. In this regard, inpatient beds, factors affecting the distribution of beds, and different geographical regions in all countries of the world were considered as Population, Concept, and Context (PCC) respectively.

A three-step appraisal process was performed to select the relevant studies. Using the search strategy, we retrieved 82964 reports. First, the titles were reviewed and after duplicate deletion, 2526 articles entered the evaluation stage. Then the abstracts of the selected articles were reviewed by two researchers and the items that did not meet the objective of the research were removed. Finally, 26 full text articles were selected for the final analysis. For articles whose full text was not available, the corresponding author or other authors were contacted by email. We used the The "Critical Appraisal Skills Programme" (CASP)[21] checklists and the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) [22]tools to evaluate the quality of the articles. In all stages of appraisal, disagreements were reviewed by the third researcher.

1.4. Data charting:

In the fourth stage of the scoping review, two researchers jointly extracted the codes and tabulated them. In order to become more familiar with the content of the reports, each article was read at least twice by each researcher. At this stage, the initial codes were extracted from the articles according to the research question. The extracted data was summarized in a table.

1.5. Analyzing themes and collecting and summarizing the data:

In the last step of the scoping review, two researchers jointly proceeded to extract the criteria affecting the distribution of hospital beds according to the table of meaningful units. We analyzed the extracted data using qualitative thematic analysis[23]. In the thematic analysis, we first became familiar with the data by reading the data charting form several times. Then we identified the initial codes based on the research question. In the next step, we performed an interpretive analysis of the initial code and organized them into sub-themes and main themes. Examining the themes was the next step. In this regard, we conducted an in-depth review of the identified themes in order to combine, refine, separate, or discard the original themes if necessary. The information extracted from the studies was used to develop a map of evidence related to the factors affecting distribution of hospital beds.

2. Expert panel

At this stage, an expert panel was held with six experts in the field of health services management. Because some of the criteria extracted from the scoping review phase were repetitive, overlapping, and had the same results, it was necessary for the experts to revise them. Therefore, the criteria were provided to the experts as a list and they were asked to modify the list based on the country context.

In order to conduct the panel, all relevant ethical consideration were observed. All participants informed of the objectives of the study and completed an informed consent form. Participants were also assured about the confidentiality of the information and the anonymous transfer of the study results.

3. Delphi

We used a two-round Delphi method to localize criteria for allocation of hospital beds based on the country context. In this study, Delphi method was used as a method to obtain consensus. We applied a purposeful sampling method to recruit the participants. Participants included people who to have research, educational and executive experience in the health system, managerial experience and activity in hospitals or university headquarters of the Ministry of Health. The characteristics of Delphi participants are listed in Table 2.

Table2: Demographic and job characteristics of the research participants in Delphi rounds

		Number	Percentage
gender	male	28	63.6
	female	16	36.4
Level of Education	Doctor of Philosophy	42	95.5
	Master of science	1	2.3
	Bachelor	1	2.3
Field	Health Management and Economics	21	47.7
	Health policy	3	6.8
	Specialist Physician	8	18.1
	General physician	5	11.3
	Pharmacology	3	6.8
	other	4	9.0

We used an electronic Delphi method (E-Delphi) to collect data because it facilitates access to experts from different locations and to ensure anonymity of participants. Therefore, an online questionnaire was designed and provided to experts for the survey. The questionnaire included demographic information (gender, field, and specialty) and the main questions included criteria affecting the distribution of beds. Participants answered to 40 question about criteria affecting the distribution of beds in the form of yes or no.

. Forty-four and thirty-eight in the fields of health services management, health policy, health economics, and different medical specialties were participated in the first and two round of the Delphi. For analysis, the agreement level was above 70% for each criterion. Criteria with a score below 50% of the agreement were eliminated and between 50 and 70% of agreement, was considered for the second round. To reach a consensus in Delphi method, participants were invited to participate in the second round.

4. DEMATEL-based ANP (DANP)

Resource allocation decisions are usually based on limited criteria. At the macro level, the allocation of health resources is usually based on the historical patterns and bargaining power of

different stakeholders or different regional authorities. Therefore, the use of multi-criteria decision-making methods, along with weighing and choosing the best choices, can help increase transparency in the resource allocation process and ensure its effectiveness[24].

In this phase of the study, the factors affecting bed distribution that were localized and summarized in the previous stage are examined in terms of causal relationships and their relative importance. For this purpose, DANP technique was used as one of the multi-criteria decision-making methods. The DEMATEL technique is used to make Influential Network Relations Map (INRM), but cannot determine the weight of individual criteria, where ANP is useful. In cases where the evaluation criteria are diverse and complex, the ANP can determine priority of criteria and their relationships[25]. The DANP method uses the output of DEMATEL and calculates the weights of the effective variables using the basic concept of network analysis process (ANP)[26]. DANP is a convenient tool that can determine the interrelationships between criteria and sub-criteria[27, 28].

4.1. Data collection:

We developed a 28 in 28 DEMATEL matrix using criteria obtained through the Delphi method. The matrix was completed by 15 experts in the field of health management. The experts determined the effect of row variables on column variables based on the scoring method (no effect = zero, very low effect = 1, low effect = 2, high effect = 3, very high effect = 4).

4.2. Steps of DANP method

The method steps are as follows :[29-31]

Step 1: Creating a direct relationship matrix (A): This matrix consists of a simple average of respondents' opinions. Which is called matrix A.

$$a_{ij} = \frac{1}{k}\sum_{k=1}^{k} p_{ij} \quad (1)$$

Step 2: Calculating the normalized direct relation matrix (D): Matrix D is obtained by normalizing matrix A.

$$D = \left[d_{ij}\right]_{n\times n} \ (2)$$

Matrix D is calculated as follows:

$$D = S \times A \ , \ S > 0 \ (3)$$

$$\left[d_{ij}\right]_{n\times n} = S \times \left[a_{ij}\right]_{n\times n}, S > 0, i, j \in \{1,2, \dots, n\} \ (4)$$

$$S = Min\left[\frac{1}{\max\limits_{1\le i\le n}\sum_{j=1}^{n} a_{ij}}, \frac{1}{\max\limits_{1\le j\le n}\sum_{i=1}^{n} a_{ij}}\right] \quad (5)$$

Step 3: Extracting the complete matrix of direct and indirect effect (T): This matrix is calculated from the following equation:

$$T = D(I - D)^{-1} \quad (6)$$

If the sums of rows and columns in the matrix T are represented by the vectors r and d, respectively, we have:

$$T = \left[t_{ij}\right]_{n\times n} \quad (7)$$

$$R = [r_i]_{n\times 1} = \left(\sum_{j=1}^{n} t_{ij}\right)_{n\times 1} \quad (8)$$

$$D = [d_i]_{1\times n} = \left(\sum_{i=1}^{n} t_{ij}\right)_{1\times n} \quad (9)$$

r_i represents the sum of the rows of row i of the matrix T. c_i represents the sum of the i^{th} row of the matrix T. $r + c$ represents the degree of interaction that one criterion has with other criteria and determines its degree of importance. $r - c$ represents the influence degree of one criterion. The positive value of $r - c$ indicates that the criterion have influence on others and the negative value represents that the criterion is under influence of other criteria.

Step 4: Adjusting the threshold value and draw the effect-communication map: To reduce the complexity of the effect-communication map, decision-makers must set a threshold value for the impact levels. Accordingly, only elements whose effect level in the matrix T is greater than the threshold value can be selected and shown in the graph. The threshold value was obtained from the mean score of the elements of the total effect matrix and consequently the INRM was drawn.

Step 5: Reliability: In this step, the convergence of expert opinions is examined. In this regard, the following equation is used, whose value should be compared with 0.05.

$$\frac{1}{n(n-1)}\sum_{i=1}^{n}\sum_{j=1}^{n}\frac{\left|g_c^{ij\rho} - g^{ij(\rho-1)}\right|}{g_c^{ij\rho}} \times 100\% \quad (10)$$

Step 6: The internal dependency matrix is calculated. The sum of each column in the total relation matrix with the normalization method is equal to 1.

ANP is commonly used to create a weightless super matrix to determine the weight of criteria. The ANP questionnaire is difficult to understand. Instead, the NRM and the total effect matrix (matrix T) are derived from DEMATEL to show the interrelationships between the factors. The combined method can be described in the following steps:

Step 1: Comparing the criteria throughout the system to form a super matrix. The general shape of the super matrix can be described as follows:

$$W = \begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \\ e_{11}\ldots e_{1m_1} & e_{21}\ldots e_{2m_2} & \cdots & e_{n1}\ldots e_{mm_n} \end{array} \\ \begin{bmatrix} W_{11} & W_{12} & \cdots & W_{1n} \\ W_{12} & W_{22} & \cdots & W_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ W_{n1} & W_{n2} & \cdots & W_{nn} \end{bmatrix} \end{array}$$

In such a way that *Cn* represents cluster *n*, *enm* represents the element m^{th} in cluster *n*, and Wij represents the main eigenvector of the effect of elements in cluster *j* compared to cluster i^{th}. In addition, if cluster *j* has no effect, so *Wij* = [0]

Step 2: By multiplying the normalized matrix, which is derived from the DEMATEL method, the weighted super matrix is obtained. Using the matrix T and the threshold value *p* from DEMATEL, we create a new matrix. The values of the clusters in the T matrix are set to zero if their values are less than p. The new matrix with p-cut is called the total effect matrix T alpha.

$$T_\alpha = \begin{bmatrix} t_{11}^{\alpha} & \cdots & t_{1j}^{\alpha} & \cdots & t_{1n}^{\alpha} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\alpha} & \cdots & t_{ij}^{\alpha} & \cdots & t_{in}^{\alpha} \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{\alpha} & \cdots & t_{nj}^{\alpha} & \cdots & t_{nn}^{\alpha} \end{bmatrix} \rightarrow d_1 = \sum_{j=1}^{n} t_{1j}^{\alpha}$$

The matrix T alpha should be normalized by division using the following formula.

$$d_i = \sum_{j=1}^{n} t_{1j}^{\alpha} \quad (11)$$

The normalized total effect matrix T_s can be obtained by the following equation.

$$T_s = \begin{bmatrix} t_{11}^{\alpha}/d_1 & \cdots & t_{1j}^{\alpha}/d_1 & \cdots & t_{1n}^{\alpha}/d_1 \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{\alpha}/d_2 & \cdots & t_{ij}^{\alpha}/d_2 & \cdots & t_{in}^{\alpha}/d_2 \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{\alpha}/d_3 & \cdots & t_{nj}^{\alpha}/d_3 & \cdots & t_{nn}^{\alpha}/d_3 \end{bmatrix} = \begin{bmatrix} t_{11}^{s} & \cdots & t_{1j}^{s} & \cdots & t_{1n}^{s} \\ \vdots & & \vdots & & \vdots \\ t_{i1}^{s} & \cdots & t_{ij}^{s} & \cdots & t_{in}^{s} \\ \vdots & & \vdots & & \vdots \\ t_{n1}^{s} & \cdots & t_{nj}^{s} & \cdots & t_{nn}^{s} \end{bmatrix}$$

Matrix T_s and weightless super matrix W calculate the weighted super matrix Ww. using equation 11. Equation (11) shows the effect level values as the basis of normalization for the determination of the weighted super matrix.

$$W_w = \begin{bmatrix} t_{11}^s \times W_{11} & t_{21}^s \times W_{12} & \cdots & \cdots & t_{n1}^s \times W_{1n} \\ t_{12}^s \times W_{21} & t_{22}^s \times W_{22} & \vdots & & \vdots \\ \vdots & \cdots & t_{ji}^s \times W_{ij} & \cdots & t_{ni}^s \times W_{in} \\ \vdots & & \vdots & & \vdots \\ t_{1n}^s \times W_{n1} & t_{2n}^s W_{n2} & \cdots & \cdots & t_{nn}^s \times W_{nn} \end{bmatrix}$$

Step 3: We limit the weighted super matrix by rising it to a perfectly large exponent *k*, as in Equation 12. This step continued until the super matrix converges and becomes a long-term stable super matrix to receive ANP weights.

$$\lim_{k\to\infty} W_w^k \quad (12)$$

Total weights are calculated using the above steps to obtain a stable super matrix.

Findings:

In the review phase we retrieved 82964 reports, and finally 26 articles were included in the analysis (Figure 1).

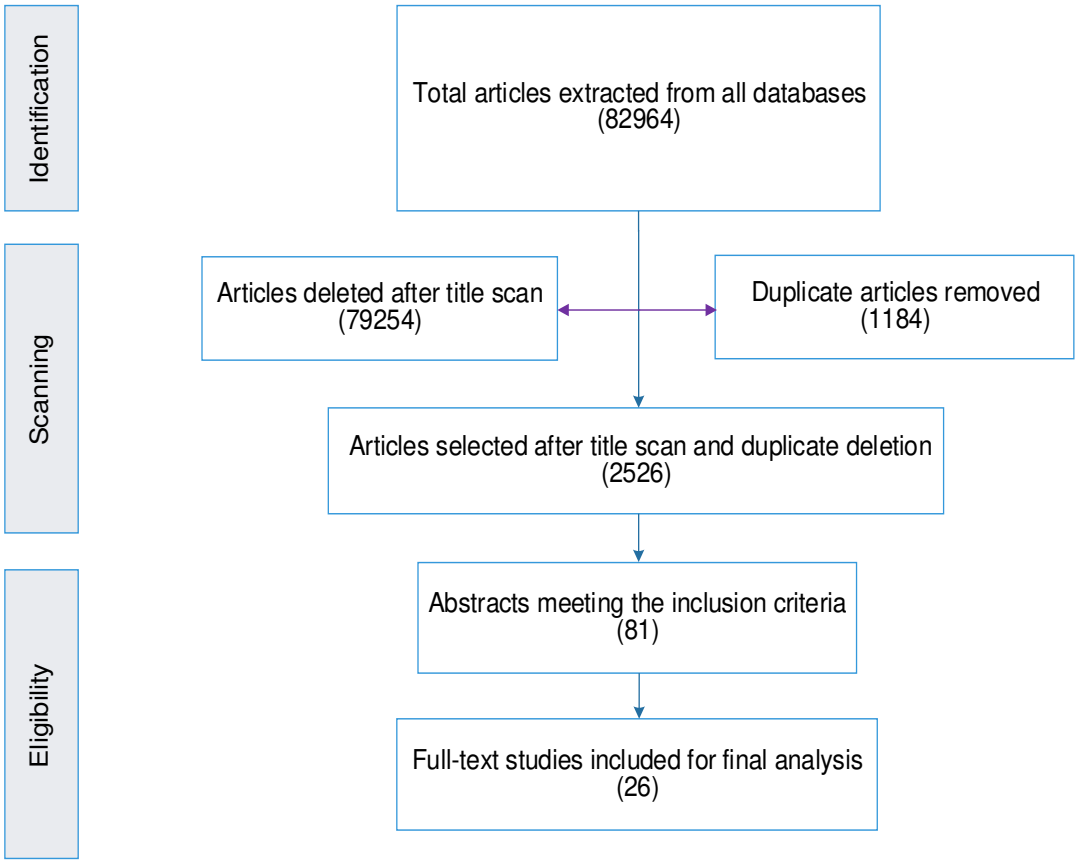

Figure1: PRISMA Flowchart of the included papers in the scope study

Most of the articles were published in the European countries before 2000. A large number of articles were done with a qualitative method. Table 3 shows the characteristics of the included studies.

Table3: Characteristics of studies included in the synthesis for criteria affecting the distribution of hospital beds

Characteristics		Number	**Percent (%)**
Publication year	Before 2000	9	**34.61**
	2000-2005	6	**23.07**
	2006-2010	3	**11.53**
	2011-2015	2	**7.69**
	2016- present	6	**23.07**

Publication type	Journal article	23	**88.46**
	Conference proceeding	3	**11.54**
Study setting	Europe	13	**50**
	America	8	**30.76**
	Asia	4	**15.38**
	Africa	1	**3.84**

We identified 75 criteria for distribution of hospital beds (Table 4). Population size (6 studies), average length of stay (5 studies), and bed occupancy rate (5 studies) were the most frequent criteria.

Table4: criteria affecting the distribution of hospital beds in region

	criteria		criteria		criteria
1	Physician distribution	2	Age and sex distribution of the population	3	availability of community care and nursing home care
4	number of general physicians	5	Morbidity	6	Length Of Stay
7	number of special physicians	8	Government revenue per capita	9	Number of patient days
10	Area size	11	Saving per capita	12	distance of people to the hospital
13	Percentage of urban population	14	Number of nearby counties	15	quality of care
16	Expected revenue of the hospital	17	local economic development	18	patterns of urbanization
19	Insurance type	20	Mortality	21	Number of bed private hospitals
22	waiting time	23	public sector investment	24	fee-for-service hospitals
25	disease incidence and disease types in regions	26	Political system	27	Number of bed industrial hospitals
28	flu season typically	29	political pressure & political constraints	30	Number of bed homeland &short stay medical care
31	lack of available medical staff	32	Treatment category or Hospital wards	33	hospital region(rural community, regional center
34	population growth	35	political decisions	36	proportion of admissions to hospital which came from a certain geographic area
37	population in the state	38	Existence of medical school in the area	39	Annual maintenance cost of a bed

40	number of beds per capita	41	flow of travelers or The net inflow of travelers	42	secondary and tertiary levels of hospitals
43	economic prosperity	44	percentage of elderly	45	Districts with university hospitals
46	Number nurses	47	health care systems (NHS / social insurance-based)	48	number and the capacity of specific medical specialties
49	size of a hospital	50	Bed occupancy rates	51	Number of admitted& discharged non-elective patients at specialty
52	Number of admitted& discharged elective patients at specialty	53	Level of Deprivation in area	54	hospital readmission
55	number of consultants	56	growing population over 80 years of age	57	marital status
58	geographical distribution of the population	59	length of stay for an elderly patient	60	Employment rate
61	The number of people with access to private services	62	percentage of beds for age related diseases	63	Level of Education
64	socio-economic status related diseases	65	equity in access	66	previous allocations
67	increasing tendency of rural and small-town residents to travel past their local or even their district hospitals into the great urban centers for medical care	68	tendency to use a given hospital	69	preferential allocation
70	metropolitan	71	Number of days beds were filled to capacity	72	types of hospitals(individual hospitals or within health centers) general hospital; or, specialized hospital
73	Number of bed long-stay care	74	Service tariff	75	Family size

The expert panel stage led to the development of 6 main topics and 39 sub-topics. These criteria were examined in the next phase using Delphi method (Table 5).

Table 5: Criteria dimensioning and Delphi stage agreement scores

dimension	criteria	First round agreement score		second round agreement score	
		yes	no	yes	no
Healthcare manpower	number of general physicians available in the area	65/9	34/1	73/7	26/3
	number of special physicians available in the area	65/9	34/1	76/3	23/7
	Number of nurses available in the area	59/1	40/9	63/2	36/8
Health facilities	Existence of long-term care center or nursing home and the number of beds	61/4	38/6	68/4	31/6
	Existence of home care services	81/8	18/2		
	current Per capita hospital beds to population	86/4	13/6		
	Existence of private centers in the desired area	93/2	6/8		
	Existence of a medical school in area or city	56/8	43/2	63/2	36/8
	Geographical distance from services	95/5	4/5		
	Number of beds in hospitals of other organs (Army, Ministry of Oil, etc.)	100	0		
	Number of beds in neighboring public or private hospitals (neighboring cities)	90/9	9/1		
	Number of short-term medical care beds	88/6	11/4		
	Existence of a reference hospital in the area	95/5	4/5		
Population	Population	100	0		
	Age distribution of the population	97/7	2/3		
	Sex distribution of the population	97/7	2/3		
	Population growth	88/6	11/4		
	flow of travelers or The net inflow of travelers	84/1	15/9		
	Mortality rate	70/5	29/5		
	Urban or rural area	72/7	27/3		
Hospitalization	Bed occupancy rates	97/7	2/3		
	Number of wards and variety of specialties in current hospitals	90/9	9/1		
	Types of common diseases in the area	90/9	9/1		
	Average length of stay	88/6	11/4		
	Re-admission rate of current hospitals	56/8	43/2	60/5	39/5
	Admission rate of elective patients in the current hospital	95/5	4/5		
	Admission rate of urgent patients in the current hospital	95/5	4/5		
	Type of hospital (general / specialized)	95/5	4/5		
	Hospital level (secondary / tertiary)	90/9	9/1		
	Number of consultants in the current hospital	47/7	52/3		
	Waiting list of current hospitals	90/9	9/1		

The economic dimension of the hospital	Expected revenue of the hospital	68/2	31/8	65/8	34/2
	Service tariff	50	50	52/6	47/4
	Annual maintenance cost of a bed	84/1	15/9		
	The public sector investment in the region	52/3	47/7	73/7	26/3
Socio-economic dimension of society	Deprivation rate	56/8	43/2	65/8	34/2
	Education status (average year of education) in the area	47/7	52/3		
	Marital status (percentage of married) in the area	27/3	72/7		
	Family size	50	50	44/7	55/3
	Insurance coverage status	61/4	38/6	57/9	42/1

In the first round of the Delphi, 24 criteria were selected. The scores of these criteria were above 70%. The second round was conducted with the participation of 38 experts who received a questionnaire containing 12 criteria. In this round, four criteria that had a score above 70% were added to the previous criteria. Finally, the result of two Delphi rounds was the extraction of 28 criteria affecting the distribution of hospital beds (Figure No. 2). At this stage, the socio-economic dimension of the society was eliminated due to disagreement in the two rounds.

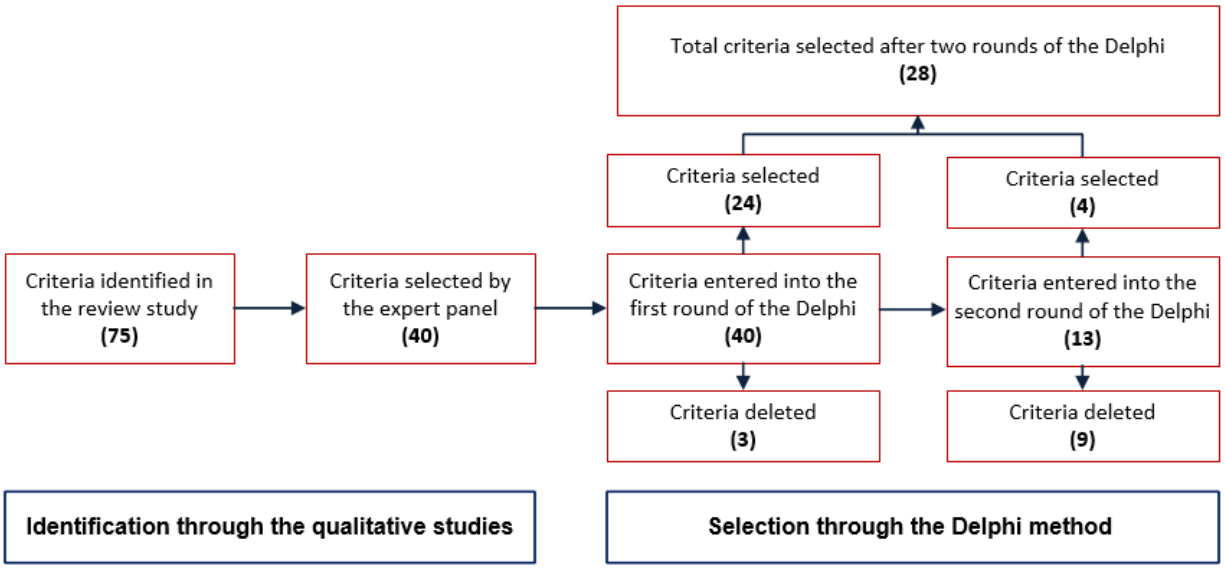

Figure 2: The process of reviewing and selecting the criteria affecting the distribution of hospital beds

In the last phase, the weight of the criteria obtained through DANP method. The results showed that, based on the $r + d$ score, population size, the presence of a reference hospital in the region, the type of hospital (general/specialized), the type of common diseases in the region, and the existence of home care services had the most interaction with other variables, respectively, so they have the most importance. The $r - d$ scores showed that the most influential variables were the presence of home care services, the annual cost of maintaining a usable bed, the gender distribution of the population, the geographical distance from the services, the number of beds in public or private hospitals in the neighboring cities. Being urban or rural, mortality rate, the age distribution of the population, bed occupancy rate, passenger flow or net entry of passengers into the region were under highest degree of influence by other variables (Table 6).

Table6: Level of importance and influence. From criteria affecting the distribution of hospital beds in region

		criteria	**R**	**D**	**R+D**	**R-D**
A	A1	number of general physicians available in the area	3.113	2.206	5.320	0.907
	A2	number of special physicians available in the area	2.468	3.061	5.529	-0.593
B	B1	Existence of home care services	3.602	2.111	5.714	1.491
	B2	current Per capita hospital beds to population	2.758	2.892	5.650	-0.135
	B3	Existence of private centers in the desired area	2.723	2.630	5.353	0.093
	B4	Geographical distance from services	3.287	2.386	5.673	0.901
	B5	Number of beds in hospitals of other organs (Army, Ministry of Oil, etc.)	2.789	2.619	5.408	0.170
	B6	Number of beds in neighboring public or private hospitals (neighboring cities)	3.217	2.439	5.656	0.778
	B7	Number of short-term medical care beds	1.721	2.200	3.921	-0.480
	B8	Existence of a reference hospital in the area	3.203	3.001	6.205	0.202
C	C1	Population	3.542	3.529	7.071	0.013
	C2	Age distribution of the population	1.201	2.582	3.783	-1.381

	C3	Sex distribution of the population	2.792	1.609	4.401	1.183
	C4	Population growth	2.408	2.898	5.306	-0.491
	C5	flow of travelers or The net inflow of travelers	1.479	2.107	3.586	-0.628
	C6	Mortality rate	0.749	2.276	3.024	-1.527
	C7	Urban or rural area	1.095	3.350	4.445	-2.255
D	D1	Bed occupancy rates	1.550	2.560	4.110	-1.010
	D2	Number of wards and variety of specialties in current hospitals	2.792	2.777	5.569	0.015
	D3	Types of common diseases in the area	2.898	2.890	5.788	0.009
	D4	Average length of stay	2.585	2.285	4.870	0.300
	D5	Admission rate of urgent patients in the current hospital	2.457	2.129	4.587	0.328
	D6	Admission rate of elective patients in the current hospital	2.223	2.352	4.575	-0.129
	D7	Type of hospital (general / specialized)	3.153	2.772	5.925	0.381
	D8	Hospital level (secondary / tertiary)	2.816	2.754	5.570	0.062
	D9	Waiting list of current hospitals	2.926	2.408	5.334	0.518
E	E1	Annual maintenance cost of a bed	3.342	1.967	5.310	1.375
	E2	The public sector investment in the region	2.730	2.829	5.559	-0.099

Moreover, results of ANP showed that among the five main dimensions, the hospitalization dimension had the highest weight. Among all 28 variables, the existence of home care services had the highest weight, followed by population and geographical distance from services, respectively. In addition, we determined the intra-dimensional weight. The number of general practitioners in the region in the dimension of workforce, the criterion of home care services in the dimension of health facilities and equipment, population size in the dimension of population, type of hospital (general / specialized) in the dimension of hospitalization, and the annual cost of maintaining a usable bed in the economic dimension were of the highest importance and weight.

Discussion:

Resource allocation in the health system is rarely focused on regions with higher level of need, rather, this is often affected by political interests[32]. In many cases, resource allocation is based mainly on previous allocations. Preferential allocation is also another resource allocation method that benefits parts of the health care system that already have many resources. This can be mainly due to better opportunities for large regions or influential patient groups to lobby for resources[33]. However, better use of resources and access to health services is possible through the management of the resource allocation process. In this regard, identifying factors and variables affecting the allocation of resources, especially hospital beds, as one of the most expensive resources of the health system, is of outmost importance.

The results of our scoping review showed that there are many criteria (75 criteria) affecting allocation of hospital beds. Studies in the United States, the United Kingdom, and Canada have focused on criteria such as population, bed occupancy, and the average length of stay. Other criteria including level of hospital, cost of a bed, number of consultants, deprivation, and type of hospital were mentioned only once. For Iran, out of 75 criteria, 28 criteria were selected in 6 dimensions of health workforce, population, hospitalization, health facilities and equipment, the economic dimension of hospital, and the socio-economic dimension of society.

The DANP classified criteria of hospital bed allocation in term of their influence status. In this regard, the hospitalization dimension had the highest weight among other dimensions. Therefore, the variables of this dimension are more important for the allocation of beds and should be considered by policymakers in this field. In this dimension, there are important variables, including the current hospital bed occupancy rate, the type of hospital, and the type of common diseases in the region.

Among the 28 variables, bed occupancy rate was highly influenced by others. In the past, to determine the capacity of hospital beds, the bed occupancy rate index of current hospitals was often considered the basic variable both at the macro policy level and at the management level of health centers. In this regard, the bed occupancy rate of 85% was considered as a target. This rate is reported to be 45% for small hospitals due to economic inefficiency and 75% for specialized units. The main reason for setting this goal was the timely supply of hospital beds and cost control[34]. In this regard, Bagust et al[35] have argued that when the occupancy rate of hospital beds is close to 85%, delay in supplying inpatient beds is inevitable. Recent studies have concluded that to determine the bed capacity of hospitals, other important factors such as hospital size[36],

waiting time[37], epidemiological status of the region[34], changes in demand and acceptance rate[38] and hospital performance criteria[34]should be considered. In support of these findings, our study showed that the variable of bed occupancy rate is actually an effect variable, so paying attention to the causes is of particular importance.

In this study, the variable of type of common diseases had a high interaction with other variables, which indicates its importance. Numerous studies[15, 39-41] have identified common diseases as an important factor in bed allocation. In the last decade, the pattern of diseases and causes of deaths in the world has changed. As predicted by the World Health Organization, by 2030 the share of non-communicable diseases such as cancer, cardiovascular disease as well as accidents will increase in the causes of death in world. In Iran, the prediction burden of diseases until 2035 shows that endocrine diseases, nutrition and metabolism with 32%, cardiovascular diseases with 25%, as well as cancers and tumors with 20% will be the three main groups of causes of death in the country[9, 42]. Therefore, changes in the pattern of diseases towards chronic diseases have a significant effect on future demands for hospital beds. It is also conceivable for a chronic patient to have a more extended stay that could result in a longer waiting list and a higher bed occupancy rate.

Also, the variable of hospital type (specialized or general) is very important due to its high weight and high interaction with other variables. Therefore, type of hospital should be considered by policymakers for allocation of inpatient beds. It is because general hospitals are often different from specialized hospitals in the number of beds, facilities and consequently hospitals indicators such as bed occupancy rates, the average length of stay, waiting list, number of general practitioners and specialists. In his study, Zwarnstein (1990) divides hospitals into several categories in terms of facilities. University affiliated hospitals connected to the university and have full specialized facilities, specialized hospitals with complete specialized services, and smaller hospitals with only one specialty. General hospitals, with minimal medical, surgical and radiographic facilities, as well as hospitals that cannot perform the basic tasks of a public hospital, such as tuberculosis and infectious diseases hospitals[43].

The next dimension that weighed the most was the health facilities. In this dimension, the variable of existence of home care services was the most important variable because it had the most weight and the most effect among all the 28 variables. Therefore, it was located at the highest level of the causal chain.

Most advanced health care systems have reduced the number of inpatient beds in recent years. Studies show that the number of hospital beds in OECD countries has decreased. In England, due to changes in the length of stay, the number of hospital beds in general and acute services has decreased by 43% and the number of maternity beds has decreased by about 51% [44]. There was also widespread closure of neurological wards in the Britain, northern and western Europe, and the United States[45].

One of the causes for the reduction of dependence of advanced health systems on hospital beds is the transfer of patients out of the hospital and the provision of care at the community level. With the improvement of home care programs, there is a possibility of saving many hospital beds. Although the evidence for cost savings varies by relocating care, strengthening outpatient care is useful because early intervention and support can prevent costly hospital care, so the patient will incur a lower opportunity cost[46, 47].

In this regard, evidence on the use of hospital beds based on appropriate criteria in Australia and Canada show that 70% of acute hospital bed days are due to inadequate access to home care services, rehabilitation services, social services, and inadequate family support[46]. Any improvement in this area depends on having the capacity to provide adequate out-of-hospital care. In this regard, Iran will need to plan to ensure the future needs of population.

Moreover, in the health facilities dimension, existence of the reference hospital and geographical distance from the health services were important variables that had a lot of interaction with other variables and should be considered in the allocating of inpatient beds. Long geographical distance from hospital services, reduces the possibility of using hospital services. This problem increases inequalities in the availability of hospital beds and access to inpatient services. This condition has the most significant effect on rural areas and vulnerable populations such as the elderly and the poor[41]. In this regard, a study in China shows that equal geographical distribution of hospital beds reduced maternal mortality rates[48]. Therefore, based on health outcomes, the needs of a geographical region should be assessed to determine whether the demand of the population, especially vulnerable and marginalized groups, is sufficiently met. Furthermore, the presence of a reference hospital in a region can reduce the flow of patients to large cities and increasingly reduces travel costs. However, to meet the demand of the population of the region, the necessary measures must be taken to provide sufficient beds for these hospitals.

The next important dimension is population. In this dimension, there were several important variables that should be considered in the allocation of hospital beds. Among which the population size had the most interaction with 28 other variables and it had the most weight after home care. Moreover, the geographical context of the region (urban or rural), mortality rate, and age distribution of the population were the variables that received the most impact from other variables.

In several studies, population has been reported as one of the determinant factors in the allocation of health facilities and beds[15, 39, 40, 49-51]. In this regard, policy and planning for distribution of hospital beds should be based on the population structure, age and gender distribution of the population, geographical context, and mortality rate. Otherwise, we would either face a shortage of beds and reduced access to services or the additional number of beds will reduce the efficiency of resources[46].

The age distribution of the population was one of the variables that was greatly influenced by other variables and should in fact be considered as an effect factor. Schofield and Earnest point out that aging will increase the demand for acute bed days between 70 to 130 percent by 2050. However, this increase may have another cause, such as an increase in the number of people with chronic diseases[52]. Therefore, along with paying attention to the aging as an effect factor, policymakers should consider the causes. The same is true for mortality, so the causes and the following needs must be addressed.

Conclusion:

The distribution of hospital beds has always been associated with fundamental challenges such as accessibility, cost modification, and equity in distribution. Therefore, it is necessary to develop a framework for equal distribution of hospital beds to improve access to inpatient services. Many factors affect distribution of inpatients bed that some of them, including the type of hospital, average length of stay, and occupancy rate of hospital beds are under the control of the health system. Meanwhile, prediction and control of some other factors such as population-relayed variables is outside the health system. The influence status of the variables affecting distribution of hospital beds and their interrelationship should be considered by policymakers to determine the desired number of beds. The data of the active hospitals, including bed occupancy rate, the average length of stay, waiting list, type and level of hospital, variety of wards and specialties in hospitals should be considered as the first evidence. Secondly, health facilities such as number beds of

neighboring cities, the capacity of private sector and other institution, type of care centers (long-term or short-term) need necessary attention. Moreover, the demographic characteristics of the region, mortality rates, the geographical context of the region, and the flow of patients to the region should not be ignored. In addition, due to the remarkable effect of home care services in the distribution of hospital beds, these services should be expanded around the country to reduce dependence on inpatient beds. Finally, it seems that the criteria identified in this study will be useful for policymakers for equitable allocation of inpatient beds considering the efficiency criteria of hospital beds.

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