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Case Report

Simulating Service System and Estimating the Hospital Beds for ICU Patients of Behbahan Shahidzade Hospital in 2015

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ABSTRACT

Introduction: Hospital bed is one of the most important resources of a hospital. The optimal estimation of the future number of beds needed is one of the important and interesting subjects for the policy makers. The aim of the present study was to simulate the service system and estimate the hospital beds for the ICU patients.

Method: This is a simulation and modeling study. Stochastic simulation method was used to model the services system of ICU. The initial research population was consisted of 560 patients hospitalized in the ICU of Shahidzadeh general hospital in Behbahan, Khuzestan. The beds needed in the future was estimated based on key and significant parameters and variables including length of stay, admissions rate, and discharges rate for 10000 days and 5000 patients simulated (admission rate, λ=2). Data were analyzed using SPSS 18.0 and EXCEL 2010 software's.

Findings: the results showed that mean and median of the patients' length of stay were 5.4±9.3 and 3 days, respectively. Among the different variables, the patients' age, having diabetes, having dyslipidemia , the number of diagnostic tests, and the number of radiography services were the most important predictors of the patients' length of stay .The findings of simulation model showed that if the bed estimation is performed based on 10 and 20 initial beds , ICU will approximately encounter the shortage of bed up to the future 13 years (5000 days) . If only the ICU works with 40 initial beds, it will need some additional hospital beds for 42.7 % of days (2135 days). Therefore, the ICU in the study can provide service for 57.3% of days (2865 days) with the same existing 40 beds.

Conclusion: we concluded that according to the existing beds and resources, the studied hospital will strongly face a shortage of ICU beds in most of the future days.

Key words:ICU bed, Length of stay, Simulation, Stochastic model

INTRODUCTION

Increasing the patients' waiting time in the different wards of the hospital due to the shortage of beds or their inappropriate resources distribution led to increase the patients' transfer to the other hospitals and their unsatisfactory (1).Therefore, the optimal resources allocation

and estimation of the hospital beds for every ward is one of the most important strategies for the hospital resources management. Optimizing the use of the hospital beds results in promoting the service quality to the patients and preventing the loss of financial resources (2). Intensive care unit is the most sensitive wards of a hospital in which shortage or lack of beds putting the patients' life at risk (3). On the one hand, the ICUS' beds are the most expensive hospital beds (4). Therefore, predicting correctly and rightly the number of the beds needed in this unit results in optimizing the resources and also the patients and society's satisfaction (5). The various studies showed that the different factors and variables such as patient's characteristics, the hospital length of stay (LOS), bed occupation rate, timely discharge, and medical counseling impact on the hospital bed size in the different wards(6). Hospital length of stay indicator is widely used for the various targets such as planning the hospital bed, hospital resources management and quality control. LOS is an indirect representative indicator of the resources use and the efficiency of the hospital beds (7, 8). In the different studies, it has been as a key variable to estimate the hospital beds (9, 10). In Iran, LOS in ICU is higher than the other countries. Rafiee (11) and Bahrami reported 9 and 15 day for stay of the patients in ICU. Strand et al. showed that ICU' length of stay in Finland, Norway and Denmark were 3.3, 4, and 3.1 days, respectively (13). One of the common methods to evaluate the current situation and predict the future is to use a simulation model. Use of simulation models results in reducing costs and improving efficiency. Simulation is the process of making a model from the real data (14, 15) .the mathematical stochastic simulation is a method to estimate and allocate the hospital resources especially hospital beds (16). Simulation provides a real picture from the dynamic of a health system and results in increasing analyzer's understanding and their better recognition of future. The wide capability of simulation methods in modeling the complex and uncertain system results in increasing its application in the healthcare systems (17).

METHODOLOGY

This is a simulation and modeling study. Stochastic simulation method was used to model the services system of ICU. The initial research population was consisted of 560 patients hospitalized in the ICU of Shahidzadeh general hospital in Behbahan, Khuzestan. Studied ICU had 10 available beds. Initial data and variables of patients were extracted from medical record and hospital information system. These variables were included clinical and demographic characteristic of patients, hospital services delivered in ICU, and admission–discharge system of ICU. In this census study, data of all hospitalized patients in ICU were gathered. This study was included two phase: first, statistical analysis that in this phase we determined significant predictors of patients' length of stay as key parameters of simulation model using backward multivariate regression analysis. According to Kolmogorov-Smirnov, data of length of stay were right skewed. Therefore, we used non parametric test including Spearman coefficient, Kruskal Wallis, and Mann-whitny for data analyzing. According to paired t-test, goodness of fit was confirmed for regression model. Then, according to fitted los model and appropriate distribution of parameters and variables, we generated random data for 5000 patients and 10000 admission days (admission rate, λ=2). The statistical distributions of the models' variables were included the number of hospital service, the patient's admission rate, and length of stay (Poisson distribution), nominal and categorized variables (uniform distribution), and numerical variables including age (normal distribution). Finally, based on admitted and discharged patients in same days, we calculated occupied and vacant beds for 5000 simulated days (13 years) based on following formula:

Vacant beds= available beds (10 beds) + the same day discharged patients-total discharged patientsIn this study, sensitivity analysis was performed based on increase of 10, 20, 30, and 40 initial hospital beds. Data were analyzed using SPSS 18.0 and EXCEL 2010 soft wares.

FINDINGS

Out of 560 patients studied, most of the patients (60.4%) were male. Most of the patients (52.9%) lived in Behbahan and other lived in villages and the other towns. Mean age of the patients was 51.3±9.2years. Also, most of the patients (42.2%) were above 61 years old. The results showed that most of the patients were covered by social security insurance funds (29.1%) and Iranian health insurance (25.7%). 40.9% of patients were with high blood pressure, 29.6% with hyperlipidemia and 11.8% with diabetes. The patients' distribution in the different days of a week and in the different seasons was almost the same. Also, the patients with trauma (24.1%) and stroke (10%) diagnoses had the highest hospitalization rate. In the present study, the mean and median length of stay was5.4±9.3 and 3 days, respectively. The results of correlation coefficient test showed that there is statistically a positive significance relationship between the patients' length of stay with patients' age (P=0.003) , the number of laboratory, CT Scan, sonography, and radiography services per patients (p=0.001) . The mean LOS of patients with diabetes, high blood pressure, and hyperlipidemia was significantly higher than the others (Table 1,2).

Table 1. Descriptive characteristic of patients (N=560)

Variable		Frequency	Percent	Mean (SD)	Sig
Gender	Male	338	60.4	5.09(± 6.370)	0.112
	Female	222	39.6	6.08(±12.62)	
Season of admission	Autumn	142	25.4	6.66(±13.21)	0.043
	Winter	142	21.8	6.25(±9.86)	
	Spring	147	26.3	4.45(±5.117)	
	Summer	149	26.6	4.76(±7.47)	
Living place	Behbahan	296	52.9	5.85(± 10.772)	0.990
	Others	264	47.1	5.08(±7.472)	
Risk factors	Hypertension	229	40.9	7.46(±11.50)	0.001
	Hyperlipidemia	166	29.6	9.13(±13.106)	
	Diabetes	66	11.8	11.39(±15.98)	
Type of diagnosis	Trauma	135	24.1	5.00(±9.075)	0.001
	Post cardio pulmonary resuscitation	57	9.6	8.00(±14.00)	
	Drug poisoning	47	8.4	3.09(±4.00)	
	Stroke	56	10	9.00(±14.00)	
	Sepsis	39	7	5.00(±3.00)	
	Others	193	34.5	4.00(±7.00)	
	Post-operative care	36	6.4	2.00(±2.000)	
Type of medical insurance fund	Social security insurance	163	29.1	6.50(±12.40)	0.564
	Iranian health insurance	144	25.7	5.35(±7.64)	
	Military insurance	76	13.6	4.76(±8.67)	
	Rural health insurance	57	10.4	4.58(±6.907)	
	Others	120	21.4	5.15(±7.73)	

Table 2.Correlation coefficient of the quantitative variables with the LOS

Variables	Correlation coefficient	Sig
Age of patients	0.124	0.003
The number of radiography	0.104	0.014
The number of CT Scan	0.104	0.001
The number of sonography	0.251	0.001
The number of diagnostic tests	0.732	0.001

All significant variables (p<0.05) including the patients' age, risk factors(diabetes, hyperlipidemia, and hypertension history), the number of radiography service, the number of sonography service, the number of diagnostic laboratory and CT scan were entered into the

linear regression model. Linear regression analysis showed that the patients' age , diabetes and hyperlipidemia history , the number of diagnostic tests and the number of radiography service were the most important predictor of the patients' LOS in ICU (Table 3) .

Table 3. Multivariate regression analysis of factors affecting LOS in ICU patients

Predictors	Unstandardized Coefficients		Standard Coefficients	t	Sig	CI 95%	
	B	Std. Error	Beta			Lower Bound	Upper Bound
(Constant)	10.457	2.618	-	3.995	0.001	5.315	15.599
Age	-0.083	0.018	-0.266	-4.689	0.001	-0.118	-0.048
Diabetes	2.794	1.133	0.096	2.465	0.014	-5.021	-0.548
hyperlipidemia	2.814	1.031	0.137	2.728	0.007	-4.837	-0.787
The number of diagnostic tests	0.45	0.047	0.402	9.304	0.001	0.355	0.546
The number of radiology service	0.0352	0.163	0.092	2.157	0.031	0.031	0.673

According to statistical distribution, Simulation process was performed for 10000 days and 5000 patients. The daily number of admission and discharge rate, the number of the beds needed for every day, months and the future year (since beginning this study up to about next 13 years) was estimated .

Table 4 shows the admission and discharge rate per days and the number of beds needed for the first 60 days.

Empty bed	Discharged patients	Admitted patients	Day	Empty bed	Discharged patients	Admitted patients	Day
-26	1	1	31	9	0	1	1
-26	1	1	32	8	0	1	2
-25	3	2	33	6	0	2	3
-22	4	1	34	4	0	2	4
-24	2	4	35	2	0	2	5
-24	2	2	36	-1	0	3	6
-27	1	4	37	-5	0	4	7
-29	0	2	38	-6	0	1	8
-31	1	3	39	-9	0	3	9
-30	3	2	40	-13	0	4	10
-30	1	1	41	-14	0	1	11
-29	3	2	42	-15	0	1	12
-30	0	1	43	-16	0	1	13
-32	2	4	44	-20	0	4	14
-32	1	1	45	-24	0	4	15
-32	2	2	46	-24	0	0	16
-33	3	4	47	-26	1	3	17
-30	3	0	48	-26	0	0	18
-33	1	4	49	-26	1	1	19
-34	2	3	50	-24	2	0	20
-36	1	3	51	-25	0	1	21
-38	0	2	52	-27	2	4	22
-38	3	3	53	-29	1	3	23
-37	3	2	54	-27	4	2	24
-38	0	1	55	-27	1	1	25
-32	7	1	56	-26	2	1	26
-32	2	2	57	-28	1	3	27
-34	2	4	58	-26	3	1	28

-32	2	0	59	-27	1	2	29
-32	2	2	60	-26	3	2	30

Table4. The status of the admission rate, discharge rate, and the number of required beds for the first 60 days (from 5000 days)

*Negative numbers shows shortage of beds

Table5 shows the different scenarios related to the number of needed beds based on different initial beds (40, 30, 20, 10 beds). According to table5, if the estimation is performed based on the initial 10 and 20 beds, almost ICU will strongly encounter the shortage of beds. If only the ICU works with 40 initial beds, it will need some additional hospital beds in 42.7 % of days (2135 days). Therefore, studied ICU can provide service in 57.3% of days (2865 days) by the same existing 40 beds.

Table 5.Estimating the required beds based on the various scenarios of the existing beds

Years	Percentage of the days in which ICU encounter the shortage of bed			
	Scenario1: 10existing beds	Scenario2: 20 existing beds	Scenario3: 30 existing beds	Scenario4: 40existing beds
1th year(2015)	%98.6	%97.5	%86.3	%37
2th year (2016)	%100	%100	%98.6	%47.7
3th year(2017)	%100	%100	%98.4	%41.9
4th year (2018)	%100	%100	%48.9	%35.3
5th year (2019)	%100	%100	%94.3	%53.3
Total 5000 years 2015-2027	%99.8	%66.5	%94.1	%42.7

*This study was started in 2015.

DISCUSSION

The aim of this study was to estimate the required hospital beds of intensive care units (ICU) using the stochastic simulation method. The hospital bed management is one of the main duties of the hospital managers and the health system planners (18). The hospital bed management means to use optimally the existing beds and plan for the capacity of the needed bed in the future. A right hospital bed management led to reduce waiting list and appropriate patient flow between a surgical units and inpatients wards (19). The optimal estimation of the number of bed needed is one of the interesting and important issues for policymakers (20). In Iran the other countries, many different studies have been performed on the hospital bed estimation (21-24). Negoyan et al. have provided an integrated model to estimate the beds needed in General ICU (22). In most of the methods related to the hospital bed estimation, the variable of patients' length of stayis a key variable. The various studies have also emphasized use the index of occupancy rate to estimate the bed hospital (25-27). The results of the present study showed that the mean and median of the patients' LOS were 5/4±9/3 and 3 days, respectively. Among the various variables, the patients' age, diabetes, cholesterol, the number of diagnostic tests and radiology service were the most important predictors of the patients' hospital stay .The results of the present study were highly consistent with Torabi and colleagues' results on postoperative determinants of the CABG patients (28). Many different studies have reported the positive influences of age, risk factors and hospital service on hospital length of stay (25, 26). Also, using the random simulation method, it was obvious that with the existing 10 beds, ICU almost will encounter the bed shortage in all days of year up to the future 5000 days. Only if ICU works with the initial 40 beds, it will need the additional beds on average in 42.7% of days for the future 5000 days. It will provide service for all patients' admitted in most of the days (57.3%) by the same 40 beds. Prevalence of diseases requiring can be one reason of increasing the hospital beds in ICU. For example our study showed that the

traumatic patients are a considerable part of the patients hospitalized in ICU. Increasing trend of these events and traumas can increase need to the hospital beds and resources. More than 99/100000 people die every year due to trauma and accidents in worldwide. This statistic is 58/100000 in Iran. A study reported that more than 70% beds of the emergency centers in the hospitals have been occupied by traumatic patients; hence predicting the required beds for these patients is important (30). Goldwaser et al. reported that increasing occupancy rate results in increasing need to the hospital beds in ICU and increasing the patients' waiting time for receiving service (31). Therefore , the hospital managers can take major steps to use optimally the hospital beds through optimizing the patients' length of stay based on the controllable factors such as the number of hospital service and estimate bed needed based on simulation models.

CONCLUSION

The results of the current study showed that some different factors including the patient's age, the number of laboratory service, the number of radiology service, diabetes and hyperlipidemia history impact significantly on the hospital length of stay. The results also suggested that under the existing conditions, the studied hospital will strongly face a shortage of ICU bed at present and in the future in most of the days.

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