Website: http: jebhpme.ssu.ac.ir
EBHPME 2020; 4(1): 1-9 pISSN: 2538-5070

EBHPME

ORIGINAL ARTICLE

Evidence Based Health Policy, Management & Economics
Health Policy Research Center, ShahidSadoughi University of Medical Sciences

Variable Costs of the Intensive Care Units and its Determinants in Iranian Hospitals

Mohammad Fathi[1], Nader Markazi Moghaddam[2], Zahra Meshkani[3*], Ali Kazemi Karyani[4]

[1]Critical Care Quality Improvement Research Center at Shahid Modarres Hospital, Department of Anesthesiology, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2] Department of Health Management and Economics, School of Medicine, AJA University of Medical Sciences, Tehran, Iran
[3]Department of Health Economics, School of Health Management and Information Science, health management and economics research center, Iran University of medical Sciences, Tehran, Iran
[4] Research Center for Environmental Determinants of Health, Health Institute, Kermanshah University of Medical Sciences, Kermanshah, Iran

ARTICLEINFO

Article History:
Received: 23 Nov 2019
Revised: 21 Jan2020
Accepted: 28 Feb 2020

***Corresponding Author:**
Zahra Meshkani
Health management and economics research center, Iran University of Medical Sciences, Rashid Yasemi St. Vali –e Asr Ave, Tehran, Iran

Email:
Z_moshkani@yahoo.com

Tel:
+98-2188671614

ABSTRACT

Background: Managers can avoid waste in resources and provide valuable insight by studying the variables associated with the costs in the intensive care units (ICU). The aim of this study was to evaluate the variable costs of ICUs and factors that contribute to cost structure in Iran.

Methods: A retrospective micro-costing method was performed on 468 admissions with a length of stay ≥ 24 hours in ICUs in a university hospital in 2017. The variable costs were consumables, laboratory tests, and medicines. The IBM $SPSS_{24}$software was used to analyze the data.

Results: The variable costs per ICU day and patient were $94.14 and $1,309, respectively, and the total variable cost was $612,641. The costs for consumables, laboratory tests, and medicine were responsible for 19 %, 27 %, and 54 % of the variable costs, respectively. The average variable costs for non-survivors were 2.5 times higher than the other variables. Medicine was the key driver of costs in all ICUs. Overall, antibiotics, blood derivatives, blood biochemistry, blood group & Rh, cutter, and tracheal intubation had the highest costs.

Conclusion: To reduce the costs, national standard treatment guidelines and essential medicine lists based on treatments of the choice should be revised. Patients who are in the final stages of a terminal illness can continue their treatment at home-based care or alternative cares such as palliative to reduce the hospital costs.

Key words: Hospitals, ICU, Cost analysis, Hospital costs

Citation

This paper should be cited as: Fathi M, Markazi Moghaddam N, Meshkani Z, Kazemi Karyani A. **Variable Costs of the Intensive Care Units and its Determinants in Iranian Hospitals.** Evidence Based Health Policy, Management & Economics. 2020; 4(1): 1-9.

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[DOI: 10.18502/jebhpme.v4i1.2552]

Introduction

Hospitals are faced with limited resources, increased costs, and great demand for services. Studies also has shown evidences of a rise in the healthcare costs in recent decades (1). The intensive care unit (ICU) is one of the most important and costly wards of the hospital, which consumes about 20 % of the hospital's budget. So,all policymakers try to reduce its costs (2-4). Factors such as aging, technological advances, length of stay (LOS), the severity of illness, use of blood products, and diagnostic tests increase the costs of ICUs (5-8). Medicine is another factor that increases the costs of ICUs. Weber et al. noted that ICU medicine costs accounted for 38.4 % of the total medical costs of the hospital (9), which is caused by the risk of infection. Considering that the risk of infection is 4-5 times higher in patients hospitalized in ICUs, they need antibiotics (10).

Based on the epidemic-logical studies, most hospital deaths occur in the ICU and only a small proportion (4 %) of the patients admitted in this wardexperience an advance in their health. In the light of this, research should be conducted to evaluate the cost and sustainability of the ICUs (5). The advantages of knowing about the ICU costs include efficiently organized ICUs, streamline patient's flow, measuring the ICU performance, and evaluating cost- effectiveness of the new medical therapies (11).

The cost estimation analysis is necessary for health care practices. Despite the high costs associated with ICU, a relative dearth of information is available relating to the daily cost of ICU care. Intensive care patients require therapy that varies considerably in type, duration, and cost, which make it difficult to predict patient resource use and actual costs in the aggregate. Many studies analyzed hospital care costs by different methodologies (12-15).

The ICU costs vary across the world. In the United State, even though ICU beds are about 10 % of the total beds, 22 % of the hospital budget is related to ICU. The daily cost of ICU per patient was estimated at $ 3,221 in 2008. In the Netherlands, about 20 % of the hospital costs isforICUs that is 3 to 5 times higher than other units (8, 11, 16). Based on a study by Moerer et al., the cost of ICU in Germany is high too and there is a growing trend in this regard. The cost per patient was estimated at € 855 per day (4). In a study by Coopersmith et al., in 2008, $121 to $263 were spent for patients in ICU that were 17.4–39.0 % and 5.2–11.2 % of the total hospital costs and of total USA health care spending, respectively (17).

Cost containment is one of the major challenges in the health sector. Costs are divided into fixed and variable categories. Fixed costs occur even if services or products are not provided to organizations/hospitals and the existence of fixed costs in organizations/hospitals is inevitable. However, variable costs depend on the offered services or products, which increase by increase of the services.So, one way to reduce the organization costs is to reduce the variable costs (18-21). Considering the importance of variable costs in cost- saving, we analyzed the variable costs in this study.

In spite of the current shortages and challenges, the Iranian health care system got some valuable benefits from recent health care reforms; the decrease in out of pocket payment from 37 % to 8.5 %, decrease in out-of-hospital medicine purchase from 100 % to 3.2 %, insurance coverage of 10.2 million people and health insurance coverage of 95 % of the population, and increased medicine access from 329 to 962 types. Furthermore, the rate of cesarean operations decreased by 5.5 %; in other words, 548,000 children were born naturally during the implementation, 366 childbirth settings were developed and optimized, 30,000 hospital beds were substituted, and 1,400,000 m^2 of the physical spaces were modernized to improve the hoteling quality of these settings (22). These changes occurred by the public sector support for hospitals and certainly no

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[DOI: 10.18502/jebhpme.v4i1.2552]

optimistic management can be expected without considering the financial and economic issues.As a result, managers need to know about the costs. The aim of this study was to evaluate the variable costs of ICU patients in Iran. We analyzed the variable costs because they provide useful information for managers to reduce the costs, redistribute limited resources, and enable them to identify the cost drivers too. However, the fixed costsdo not have the potential to reduce the costs. It also can get a clear understanding of the variations' drivers in health care costs that are instrumental in developing and implementing the policies aimed at improving the efficiency of public expenditure.

Materials and Methods

Study setting

This retrospective study was conducted using a micro-costing method.The studied hospital had 270 beds with theoccupancy rate of 85 %. The hospital was mainly funded by health insurance, which indicated a lower rate of payment. It was a referral hospital for the congenital malformation disease, deformations and chromosomal abnormalities congenital malformation, and deformations. It covered three wards of ICU (OH), ICU congenital, and ICU general.We considered all inpatients with LOS ≥ 24hours in ICUs of the hospital, thus, sampling was not required.

Patient population

All inpatients admitted to one of the ICUs during 2017,who stayed for at least 24 hours were included in the study. Patients readmitted into the hospital were considered as separate permits. The patients who stayed less than 24 hours were not considered because according to hospital indicators, patients who stay less than 24 hours in the hospital are classified as outpatient (23).

Study design

To carry out the study, the following information was collected: demographics, admission diagnosis according to ICD-10, LOSinICU, ICU mortality, and all resources used by the patients during their stay in ICUs. All patients' information was recorded in the hospital auto database. Hospital training considered a control variable.

The variable costs for patients included: consumables, laboratory tests, medicine, and imaging services, but they were not performed for ICU patients of the hospital.

- For medicine, the acute type and dosage of the drugs given to patients in ICUs during their stay were evaluated.
- For consumables, all used materials were identified for patients, such as disposable clothing and gloves, sterile gloves, syringes, all kinds of kits, etc.
- For laboratory tests, all diagnostic tests, including hematology, biochemistry, arterial blood gas, microbiological analysis, and etc. were considered(19).

Finally, for all categories of the variable costs, the number of all resources used by patients was multiplied by the unit costs.

All types of costs were converted into US dollars ($ US) using the 2018year exchange rate (one
$ US = Rial 42,000) reported by the central bank of Iran (24).

Data analysis

Data were expressed in numbers, percentage, and cost per patients. Regarding the fact that the sample size in the present study was less than 3000, Shapiro-Wilk test was used to evaluate the normality assumption. Distribution of all costs was skewed; therefore, nonparametric tests were used. Mann–Whitney and Kruskal-Wallis tests were run to investigate relationshipof the independent variables (gender, age, diagnosis, LOS, laboratory test costs, medicines costs, and consuming costs) with dependent ones (total of the costs heading). For statistical analysis, IBM $SPSS_{24}$ Software was performed.

This project was funded by theResearch Center for Intensive Care of Modarres Hospital affiliated to Shahid Beheshti University of

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[DOI: 10.18502/jebhpme.v4i1.2552]

Medical Science (No: IR.SBMU.RETECH.REC.1397.535).

Results

A total of 468 patients with a LOS ≥ 24 hours were included in the study. Regarding the patients' gender, 53 % of the admissions were male and the mean age of all patients was 49 years. The mean LOS in ICU was 12.79 days and 31 % of the admissions had undergone at least one type of surgery. The descriptive characteristics of the patients hospitalized in ICUs and the cost per patient are shown in Table 1. The admissions are related to 6507 ICU days. A proportion of patients with blood circulation diseases at ICU OH was 65 %, with congenital disorder at ICU congenital was 74 %, and with metabolic diseases at ICU general was 64 %.

An overview of the variable costs in ICUs is shown in Table 2. Total variable cost was $ 612,641. The variable costs per ICU day and patient were $94.14 and $ 1,309, respectively.

The costs for consumables, laboratory tests, and medicine were responsible for about 19 %, 27 %, and 54 % of the variable costs, respectively. Overall, 56 % of the variable costs were related to ICU general.

Medicine was the key driver of costs in all ICUs. Among the medicines, antibiotics and blood derivatives accounted for 29 % and 23 % of the medicines costs, respectively. The mean dosage of antibiotics was 19. Medicine accounted for the largest share for patients with a LOS of more than 29 days. This was also true for people who died.

Blood biochemistry (55 %) as well as blood group & Rh (21 %) had the highest costs among the laboratory tests (Table 3). The highest part of the consumable cost was determined by the cutter and tracheal intubation (31 %).

Male patients had a significantly greater laboratory, consumables and variable costs in comparison with females. In contrast, females had more medical costs (P-value < 0.05).

Variable costs for elderlies were significantly greater than others (P-value < 0.05). Even though the number of patients in ICU general was higher than other wards, the maximum proportion of variable costs was related to ICU OH (P-value < 0.05).

The mean cost per day was significantly higher in the first week than two weeks later. In other words, the costs decreased slightly during the second and third weeks. Furthermore, this had an increasing trend in more than one month (P-value < 0.05).

The most common ICU admission diagnosis included circulatory system diseases, congenital malformation, and metabolic diseases with a frequency of 24 %, 16 %, and 15 %, respectively.

Circulatory system diseases, any type of neoplasm, infectious diseases, respiratory, and congenital disorders were responsible for approximately 29 %, 20 %, 17 %, 13 %, and 11 % of total variable costs, respectively. The highest variable cost was related to leukemia. The highest cost of consumables, laboratory tests, and also medicine were related to infection, circulatory system, and neurological diseases, respectively (P-value < 0.05).

The mortality rate was 49 %. The mean LOS was 9.65 and 18.37 days for the survivors and non-survivors, respectively. Non-survivor patients tended to be more expensive than survivors on consumables, laboratory tests, and variable costs. The average variable costs for non-survivors were 2.5 times higher than others (P-value < 0.05).

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Table 1. Patients' characteristics and cost per patient

Parameters		N (%)	Cost per patient $	P
Gender*	Overall	468 (100)	1,309	< 0.05
	Female	221 (47)	1,122	
	Male	247 (53)	14,205	
Age*	Less than 1	69 (15)	888	< 0.05
	1-14	17 (14)	777	
	15-24	16 (3)	384	
	25-44	81 (17)	714	
	45-64	113 (24)	1,305	
	65 and older	172 (37)	1,912	
Outcome*	Death	228 (49)	1,896	< 0.05
	Recovery	240 (51)	761	
Surgery services*	Had surgery	145 (31)	1,737	< 0.05
	Did not have surgery	323 (69)	1,127	
Ward*	ICU (OH)	96 (21)	1,812	< 0.05
	ICU congenital	101 (22)	944	
	ICU, general	271 (58)	1,275	
LOS*	Less than a week	6 (1)	61	< 0.05
	A week	223 (48)	320	
	Two weeks	90 (19)	938	
	Three weeks	65 (14)	1,540	
	One month	28 (6)	2,709	
	More than a month	56 (12)	5,048	
Diagnosis*	Musculoskeletal system and connective tissue	1 (0.2)	106	< 0.05
	Certain infectious and parasitic disease	39 (8)	2,632	
	Skin and subcutaneous tissue	2 (0.4)	2,503	
	Genitourinary system	10 (2)	926	
	Respiratory system	40 (9)	1,963	
	Digestive system	29 (6)	269	
	Endocrine, nutritional and metabolic diseases	68 (15)	255	
	Nervous system	4 (1)	2,463	
	Circulatory system	110 (24)	1,454	
	Blood and blood forming organs	6 (1)	4,061	
	Injury, poisoning and certain other consequences of an external cause	11 (2)	1,000	
	Factors influencing health status and contact with health services	3 (1)	173	
	Neoplasms	67 (14)	1,830	
	Congenital malformation, deformations and chromosomal abnormalities	75 (16)	862	

**P-value for all of the variabels: 0.01*

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[DOI: 10.18502/jebhpme.v4i1.2552]

Table 2. variable costs of the ICU ($) in 2017

Category	Total cost	Mean cost	% Of cost	% Of variable cost
Medication				
Antibiotics	97,806	55	29	16
Adrenergic	6,999	38	2	1
Proton pump hibitor (PPI)	17,861	40	5	3
Anti-Coagulant	9,376	17	3	2
Electrolyte	30,948	14	9	5
Antifungal	17,841	145	5	3
Immunodeficiency	20,761	2,076	6	3
Blood derivatives	76,440	347	23	12
Others	55,167	8	17	9
Total	333,199		100	54
Laboratory tests				
Bacteriology	4,517	18	3	1
Blood Biochemistry	90,942	197	55	15
Hematology	15,432	33	9	3
Hormone Analysis	5,755	16	3	1
Immunology	5,806	19	4	1
Blood Group & Rh	34,826	74	21	6
Others	7,932	37	5	1
Total	165,210		100	27
Consuming	114,232	249	100	19
Variable cost	612,641	1,314		100

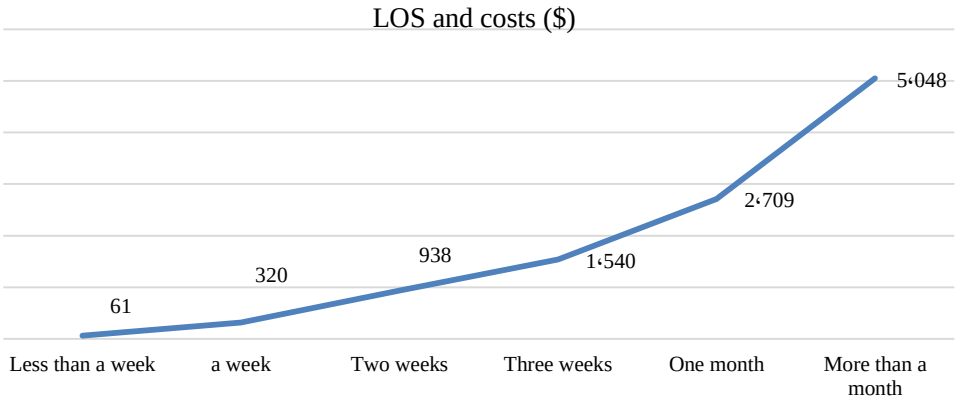

Figure 1. Patient hospitalization cost per day in the ICU of the studied hospital separated for the different time duration

Discussion

The demand for ICU has increased rapidly. The ICUs are managed for life-threatening illnesses affected by modern technologies and need highly specialized professions (5, 25). They are the most important units in hospitals, patients hospitalized in these sections are dealing with severe diseases, and the managers should allocate large contributions of budget to them. On the other hand, cost contaminated is the major goal of managers and they should pay attention to the costs. Fixed costs are like the cost of salary and equipment, while variable costs are like medicine, consumable, and ones that increase in the number of patients. Although fixed costs account for more than 50 % of the costs, they cannot be saved;managers can greatly reduce hospital costs by saving and optimal using of the variable costs (21).

A hospital manager is not capable of reducing fixed costs such as manpower, space, and equipment depreciation. Fixed costs do not change for one or more patients; in other words, the

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increased number of patientsdecreases the average fixed cost. Although most hospital costs are fixed costs, managers can reduce costs by managing variable costs such as medication, laboratory costs, and other interventions for patients.

To the best of our knowledge, it was the first study on the variable costs in ICU in Iran. Furthermore, policymakers are faced with paucity of data on the informed cost of ICUs since in spite of the importance of cost management, only a few studies have been conducted in this unit in Iran (5, 19, 26, 27).In this study, medicine, laboratorytests, and consumables were considered as variable costs in ICUs. The median cost per patient was$1,309 and medicine, especially antibiotics, had the largest share among the variable costs. Diagnosis, age, gender, surgery services, LOS, and approaching the time of death were among the effective factors on the variable cost. The average daily cost of the present study was $ 94.14 that is significantly lower than other studies. The daily costs of ICUs by use of bottom-up approaches in Greece (19) and Italy (27)were 422.40 € and 2765.67 €, respectively.

A study involving a number of ICUs conducted at a London Teaching Hospital in 2011found that mean cost of the medicine of 58 patients and related to 150 drugs of 26 € (16), significantly higher than reported in our study ($71). In a study conducted by Karabatsou et al. in Greek during 2011, authors evaluated the variable costs of an ICU general consisting of medicine, lab tests, and consumables. Based on their results, medicines, especially antibiotics were responsible for a large portion of the costs. Age, LOS, and APACHE II were among the effective factors on ICU costs. Based on our findings, medicine plays an important role in variable costs. The patients'LOSin ICUs and the high rate of infection in these wards lead to increased patients' medication needs and medication costs.Moreover,the main costs of hospitalization for those with a LOS of more than 29 days were medicine-related. As a result, it can be said that most patients, especially end-stage ones, can continue home treatment with the help of their family, which reduces the waiting costs for other patients and hospitals too.

In our study, a correlation was found between LOS and cost. Which is consistent with the studies by Cox et al. and Rossi et al. (27, 28). However, this finding is in contrast with the findings of McLaughlin et al. They found that the requirement for expensive interventions was the main driver for ICU (7).

Løes O et al. examined a total of 961 patients in the ICU general from 1978 to 1981. Their results showed that the need for care after surgery was the main reason for patients' referral to the ICUs; 78 % of the patients had cardiovascular and respiratory disorders (29). In a study by Dahl et al., the variable costs of patients in ICUswere evaluated in Phoenix in 2012. The average variable costs of the study ranged from $ 1,436 to $ 1,559, which depended on LOS, severity of illness, and surgical procedure. The median length of stay in the study was about 6 days and 57 % of the total cost of ICU was related to LOS.A correlation was found between LOS and cost in our study (30).

The hospital needto adopt several strategies, such as adherence to national standard treatment guidelines and essential medicine lists based on the treatment choices. Similar to the health sector, where demand for health care is met by physicians, so supply-side policies to reduce sector costs, especially pharmaceutical costs, can be largely effective.

Managers are recommended to consider the following policies for reducing the costs: promoting use of generic drugs, prescribing insurance deductions' prescriptions, using cost-effective and lower-priced drugs, and monitoring the physicians' performance to prevent induce demand.Furthermore, authors strongly emphasize transfer ofpatients from hospital to home so that they can continue their process of treatment at home.

Conclusion

In conclusion, variable costs of ICUs depend on the diagnosis, age, gender, surgery services, LOS, and approaching death. The most important cost-drivers were medicines and antibiotics in the studied ICUs. It may well be argued that end-stage patients

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[DOI: 10.18502/jebhpme.v4i1.2552]

can continue their treatment at home-based care such as palliative care.

There may be some possible limitations in this study. First, the study population was large and since data collection from such a population may not be recorded on time, we used the retrospective study design. Second, we studied just one hospital and the study results may not be generalizable to all Iranian hospitals and admitted patients. Third, we did not address the indirect costs and adopted a hospital perspective, not a social one, which was recommended by the experts.

Acknowledgements

The authors would like to thank all Modarres Hospital staff for their kind contributions in this research.

Conflict of interests

The authors declared that they have no conflict of interests.

Authors' contributions

Fathi M and Markazi Moghaddam N designed research; Meshkani Z and Kazemi Karyani A collected and analyzed and also wrote manuscript. All authors read and approved the final manuscript.

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[DOI: 10.18502/jebhpme.v4i1.2552]