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Cost of Blood Products in Iran: A Case Study of the Shiraz Blood Transfusion Organization Using Activity-based Costing

Sulmaz Ghahramani[1], Leila Zarei[2], Leila Kasraian[3], Maryam Mollaie[4], Hengameh Kasraei[5,*] and Kamran Bagheri Lankarani[6]

[1]M.D, Assistant Professor, Health Policy Research Center, Institute of Health, Shiraz University of Medical Sciences, Shiraz, Iran
[2]Ph.D, Assistant Professor, Health Policy Research Center, Institute of Health, Shiraz University of Medical Sciences, Shiraz, Iran
[3]M.D, Associate Professor, Blood Transfusion Research Center, High Institute for Research and Education in Transfusion Medicine and Shiraz Regional Educational Blood Transfusion Center, Shiraz, Iran
[4]Medical Student, Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran
[5]M.D. MPH, Health Policy Research Center, Institute of Health, Shiraz University of Medical Sciences, Shiraz, Iran
[6]M.D, Distinguished Professor, Health Policy Research Center, Institute of Health, Shiraz University of Medical Sciences, Shiraz, Iran

*** *Corresponding author:*** Hengameh Kasraei, Health Policy Research Center, Institute of Health, Shiraz University of Medical Sciences, Shiraz, Iran. Tel: +982166558811; Email: kasraeeh@yahoo.com

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Abstract

Background: Although blood is donated rather than purchased, collecting, storing, and testing it for viral markers is expensive. During the Cost of Blood Consensus Conference (COBCON), activity-based costing (ABC) was proposed as a standard way to figure out the cost of preparing a unit of blood.

Objectives: The ABC can be used by any organization that pays for blood or blood products. It was used to determine how much each unit of allogeneic blood costs in Iran, considering the limited blood sources and the importance of cost evaluation studies.

Methods: This cross-sectional, descriptive-analytical study was conducted at Shiraz Blood Transfusion Organization in 2020-2021 (Shiraz, Iran). We used the ABC method to determine how much each unit of allogeneic blood costs in Iran. In this study, activity centers were divided into high-level, intermediate, and final activity centers. The resources of each activity center were made up of human resources, consumables, buildings, equipment, and energy.

Results: Direct and indirect costs of producing blood were separately investigated in the studied sub-units. The final estimated cost of preparing one blood unit was almost 13 million IRR (≈308 USD). According to our findings, indirect costs comprised a significant portion (86.45%) of the cost of producing a unit of blood, while direct costs accounted for only 13.55%.

Conclusion: As evidenced by the obtained results, the cost of one blood unit was far more than the national average estimated by the Iran Blood Transfusion Organization. There is a need for additional research on the cost of other blood products and indirect cost reduction strategies.

Keywords: Activity-based costing, Allogeneic blood, Blood products, Blood transfusion, Costs

1. Background

Blood products are vital healthcare resources. Although the blood used is donated and not purchased, the process of collecting, storing, and assaying it in terms of viral markers is expensive (1). Due to limited blood donations and population aging, stricter criteria for blood transfusions are necessary (2). Accordingly, cost-benefit studies are essential for facilitating the safe and adequate management of various diseases using blood products (3). The cost of a unit of transfused blood in the early studies conducted in different countries varied from $155 in 1991 to $151.20 in 1991-1992 for patients before or during surgery and $107.26 in 1994 for the first blood bag and $100.89 for the second, which was less expensive due to unnecessity of some tests (4-6). The estimated cost varies depending on the method used for cost estimation (7). There is a lack of a uniform and accepted method to calculate the cost of collecting donated blood, preparing and storing it for injection, administering it to the person who needs it, and following up on complications. Without such a uniform method, the estimated cost will likely be lower than the actual value since some expenses are not included in the calculations.

In light of the aforementioned limitations, during the Cost of Blood Consensus Conference (COBCON), a group of experts who had valuable information in the field of blood transfusion proposed a standard method for calculating blood costs via activity-based costing (ABC). This method can be generalized to all organizations that pay the expenses of blood and blood products. (8). Cost allocation for healthcare professionals can be ambiguous in the healthcare system. The ABC is an accounting tool that allocates costs resulting from the actions performed by a company to provide goods and services to consumers. The ABC can open up insights into supply chain inefficiencies and create additional capacities. This, in turn, can direct the services provided to generate more value for the hospital system. The ABC can be designed to focus on the unit of measurement that expresses the value associated with production (9). Cost modeling using

the ABC approach optimizes blood consumption and reduces variability and resource wastage since the costs are correctly estimated and can be compared globally (10).

In Iran, multiple studies have been conducted on the cost of each unit of blood. One of these studies was conducted in the Gilan province, where the cost of each unit of packed red blood cells was estimated at 594,203 IRR (≈62 USD) in 2009 [1 USD = 9,600 IRR at that time]. Although the ABC method was used, the method employed varied from that proposed at the COBCON (11). In another study, the cost of each unit of blood was calculated in 28 Iranian provinces in 2002, and it varied between 61,000 and 118,000 IRR. The method of calculating the cost of each unit of blood was the credits allocated to blood transfusion units (12).

Blood Transfusion Organization calculates the total cost of each blood unit based on the annual budget allocated to centers divided by the number of blood units produced. Nonetheless, it fails to account for such costs as time consumption, equipment depreciation, and initial property acquisition.

2. Objectives

Considering the importance of estimating the costs of blood products and the limited availability of blood sources, we decided to use the approved ABC method to attain an estimate that is more consistent with the cost of a unit of allogenic blood at Shiraz Blood Transfusion Organization. This was achieved through an applied, cross-sectional study conducted at the Shiraz Blood Transfusion Organization (Shiraz, Iran).

3. Methods

3.1. Study framework

The current study was an applied, cross-sectional study conducted at the Shiraz Blood Transfusion Organization (Shiraz, Iran) from 2020-2021. The present study aimed to determine the cost of a single unit of allogeneic blood in Iran. Within the context of this study, the term "unit of allogeneic blood" primarily refers to packed red blood cells, with a smaller proportion comprising whole blood.

To implement this study using the ABC method, we first held briefing meetings with the Shiraz Blood Transfusion Organization officials and personnel concerning the study purpose, process, and type of information required. The related documents were reviewed, and ideas were expressed for improving the study design until reaching a consensus. A significant output of these meetings was finding the flowchart of processes involved in transfusing a single unit of allogeneic blood. Furthermore, with the help of the organization, the following information was collected: the characteristics of the involved units and departments, the cost pools (administrative, personnel, and services), personnel statistics (by cost pools), profiles of active personnel in different cost pools (history), personnel costs (by cost pools), list of available equipment in each of the cost pools (including the year of purchase, useful life, and depreciation), the cost of urban services of the organization (water, electricity, and gas); the list of consumables for each cost unit (kits and bags), details of the activities performed to collect and prepare blood for injection, and the number of blood bags produced.

In the present study, the cost of one allogeneic blood unit of the Shiraz Blood Transfusion Organization was determined in the following six steps:

3.1.1. Step 1. Defining the study perspective

One of the most important steps is determining the cost target and the perspective used in the ABC system. According to the cost target and perspective, we performed the activity center classification, activity analysis, cost identification, cost allocation, and cost calculation. Although the preferred perspective, according to the COBCON proposal, is the societal perspective, due to the lack of access to information and problems related to the time-consuming production of the required information, this perspective is generally disregarded. In the present study, the perspective used, like most studies performed in estimating the cost of a blood unit, was the perspective of the service provider (Blood Transfusion Organization and the Ministry of Health). For this reason, the investigated costs included the costs related to collecting, screening, processing, storing, and transporting blood, as well as advertising and attracting healthy donors. These costs were classified into two categories: fixed and variable .

3.1.2. Step 2. Defining the activity centers and grouping their activities

Defining and identifying activity centers is the main basis for analyzing activities and costs. Activity centers are a set of activities that are organized together to regulate and improve activities. Based on the investigations in Step 1 and using the flowchart described earlier, the list of activity centers of the Blood Transfusion Organization was identified. Thereafter, these centers were divided into high-level, intermediate, and final activity centers. High-level activity centers are units that are not directly involved in collecting and processing blood and are not in direct contact with the recipient. The costs of these centers are the overhead of other units, such as services, facilities, and security.

Intermediate activity centers are units that may be in contact with the service recipient or provide services as an intermediary to units in direct contact with the service recipient, such as the offices of the directors, deputies, and financial and administrative managers. Together with the higher activity centers, these centers provide general services and support to the final activity centers. The final activity centers encompass the units directly involved in providing services to recipients, such as collection units and laboratories. These activity centers receive overhead costs from higher-level and intermediate activity centers. The final activity centers include Routine, Product, Release, Blood Sampling, Registration, and Blood Distribution.

3.1.3. Step 3. Determining the output of each activity center

At this stage, we determined the output of each activity center. Since the output of each center is different, each activity center was separated based on its output. Thereafter, costs were determined according to the outputs.

3.1.4. Step 4. Identifying the resources needed to perform each of the activities and the characteristics of each of the resources

In this stage, according to the defined cost target or system output, the resources of each activity center (human resources, consumables, building and equipment, and energy) were determined.

3.1.5. Step 5. Activity center-based costing

The volume or number of activities determines the causal relationship between the resources used and can be used to attribute the volume of resources used to the cost. Costs were identified based on the resources required to perform each activity in Step 4. Following that, by studying and reviewing the available documents, we determined the costs related to human resources, materials, consumables, equipment depreciation, warehouses, and laboratories of each activity center.

3.1.6. Step 6. Defining and identifying cost drivers according to activity centers

Cost drivers perform exactly the same operations as resource drivers, with the difference that the cost driver is the connecting factor between the costs created in the cost pools and the cost target.

3.1.7. Step 7. Allocating direct and indirect costs to the cost target

In the current research, costs were divided into two groups according to the generation source:

1. Costs generated within each activity center
2. Costs allocated to each activity center from other activity centers

Since the costs related to each cost target are not only direct costs, the indirect costs were assigned to the cost target according to the cost drivers. Accordingly, the total costs related to each cost target were determined. The "simultaneous equations" method was used to determine the share of the 'high-level centers and final centers in the costs.

3.1.8. Step 8. Calculation of the overall cost of the cost target

In this step, the cost of preparing one unit of blood was calculated according to the cost target, its volume and amount during the investigated period, and the costs allocated to each of the cost targets. Calculations were made based on current costs plus the annual capital consumption cost to estimate the total cost. Calculations related to the purchase price, useful life of asset, current depreciation, and accumulated depreciation of capital goods were performed in consultation with the accounting department. We also considered the consumption rate of tangible and fixed assets, such as buildings, facilities, vehicles, furniture, and equipment. All calculations were carried out using Excel software .

During the study, certain commonly used consumables, which were previously subsidized by the government at a rate of 1 USD = 42,000 IRR, experienced a substantial reduction in subsidy. Consequently, these consumable materials were obtained at a partially subsidized currency rate of 140,000 IRR. The varying rates were considered when converting Rial to dollars. Except for these materials, other costs were converted at the rate of 1 USD = 42,000 IRR

4. Results

This study examined the direct and indirect costs of preparing a unit of allogeneic blood. The direct costs related to personnel (after deductions), equipment, and consumables per donor were calculated in general and separately by the performance percentage of each activity unit. The direct costs are summarized in Table 1. The direct costs section obtained a total cost of almost 248.6 billion IR Rials/ 5.9 million USD. The highest cost was related to consumables, which was almost 215.3 billion IR Rials / 5.1 million USD. In the activities section, due to the 47% share of routine activities, almost 116.7 billion IR Rials / 2.8 million USD of the total cost was for the routine part after reducing the annual depreciations .

In the investigation of indirect costs, the costs of personnel (after deductions), equipment, properties, utilities, and urban services were calculated in general and separately by the performance percentage of each activity center. The values

Table 1. Total direct costs related to producing units of allogeneic blood in 2020-2021 in Shiraz, Iran

		Cost pool									
		Personnel costs (after deductions)		Equipment		Consumables per donor*		Total cost of consumables per 141,837 blood units produced		Total direct costs	
		IRR	USD	IRR	USD	IRR	USD	IRR	USD	IRR	USD
Total costs before deducting annual depreciation		27,309,360,000	650,222.86	6,038,700,000	143,778.57	1,517,885	36.14	215,292,254,750	5,126,006.06	248,640,314,750	5,920,007.49
Annual depreciation		-	-	415,753,501.4	9,898.89	-	-	-	-	415,753,501.4	9,898.89
costs according to the share of each activity after deducting annual depreciation	Routine (0.47%)	12,835,399,200	305,604.74	2,642,784,854	629,234.49	713,407	16.98	101,187,359,732	2,409,222.85	116,665,543,786.84	2,777,751.04
	Product (0.2%)	5,461,872,000	130,044.57	1,124,589,300	267,759.36	303,5777.23		43,058,450,950	1,025,201.21	49,644,912,249.72	1,182,021.72
	Release (0.15%)	4,096,404,000	97,533.43	843,441,974.8	20,081.95	227,684	5.42	32,293,838,212.5	768,900.90	37,233,684,187.29	886,516.29
	Blood sampling (0.07%)	1,911,655,200	455,156	393,606,254.9	9,371.58	106,253	2.53	15,070,457,832.5	358,820.42	17,375,719,287.4	413,707.60
	Registration (0.05%)	1,365,468,000	32,511.14	281,147,324.9	6,693.98	75,896	1.8	10,764,612,737.5	256,300.30	12,411,228,062.43	295,505.43
	Blood distribution (0.06%)	1,638,561,600	39,013.37	337,376,789.9	8,032.78	91,073	2.17	12,917,535,285	307,560.36	14,893,473,674.9	354,606.52

*This is excluded from the total; the total includes the total cost detailed so that all expenses are annual
IRR: Iranian Rial; USD: United States dollar

Table 2. Total indirect costs related to producing units of blood in 2020-2021 in Shiraz, Iran

		Cost pool									
		Personnel costs (after deductions)		Equipment		Real estate & properties		City services		Total indirect costs	
		IRR	USD	IRR	USD	IRR	USD	IRR	USD	IRR	USD
Total costs before deducting annual depreciation		15,184,320,000	361,531.43	6,038,700,000	143,778.57	1,567,000,000,000	37,309,523.80	12,000,000,000	285,714.28	1,600,223,020,000	38,100,548.09
Annual depreciation		-	-	415,753,501.40	9,898.89	15,760,000,000	375,238.09	-	-	16,175,753,501.40	385,136.99
Costs according to the share of each activity after deducting annual depreciation	Routine (0.47%)	7,136,630,400	169,919.77	2,642,784,854.34	62,923.45	729,082,800,000	17,359,114.28	5,640,000,000	134,285.71	744,502,215,254.34	17,726,243.22
	Product (0.2%)	3,036,864,000	72,306.28	1,124,589,299.72	26,775.93	310,248,000,000	7,386,857.14	2,400,000,000	57,142.86	316,809,453,299.72	7,543,082.22
	Release (0.15%)	2,277,648,000	54,229.71	843,441,974.79	20,081.95	232,686,000,000	5,540,142.86	1,800,000,000	42,857.14	237,607,089,974.79	5,657,311.67
	Blood sampling (0.07%)	1,062,902,400	25,307.20	393,606,254.90	9,371.57	108,586,800,000	2,585,400	840,000,000	20,000	110,883,308,654.90	2,640,078.78
	Registration (0.05%)	759,216,000	18,076.57	281,147,324.93	6,693.98	77,562,000,000	1,846,714.28	600,000,000	14,285.71	79,202,363,324.93	1,885,775.55
	Blood distribution (0.06%)	911,059,200	21,691.88	337,376,789.92	8,032.78	93,074,400,000	2,216,057.14	720,000,000	17,142.86	95,042,835,989.92	2,262,924.67

IRR: Iranian Rial; USD: United States dollar

obtained are reported in Table 2. The indirect costs section obtained a total cost of almost 1,600 billion IR Rials / 38.1 million USD. The highest cost was related to the cost of real estate and properties which was almost 1,567 billion IR Rials / 37.3 million USD. In the activities section, due to the 47% share of routine activities, almost 744.5 billion IR Rials / 17.7 million USD of the total cost was for the routine part after the

Table 3. Total and each unit of blood, direct and indirect costs in 2020-2021 in Shiraz, Iran

		Total cost		cost per unit of blood*	
		IRR	USD	IRR	USD
Direct and indirect costs before deducting depreciation		1,848,863,334,750	44,020,555.59	13,035,127.19	310.36
Costs of direct and indirect depreciation		16,591,507,000	395,035.88	116,975.87	2.78
Direct and indirect costs after deducting depreciation		1,832,271,827,750	43,625,519.71	12,918,151.31	307.57
Costs according to the share of each activity after deducting annual depreciation	Routine (0.47%)	861,167,907,970	20,503,997.81	6,071,532.17	144.56
	Product (0.2%)	366,454,365,550	8,725,103.94	2,583,630.26	61.51
	Release (0.15%)	274,840,951,460	6,543,832.18	1,937,723.95	46.14
	Blood sampling (0.07%)	128,259,176,870	3,053,789.92	904,271.64	21.53
	Registration (0.05%)	91,613,839,600	2,181,281.89	645,909.31	15.38
	Blood distribution (0.06%)	109,936,295,480	2,617,530.84	775,088.98	18.45

IRR: Iranian Rial; USD: United States dollar

* A total of 141837 units of blood were produced in 2020-2021 in Shiraz, Iran

reduction of annual depreciations. Some costs are presented in Tables 1 and 2 since they are involved directly and indirectly in supplying blood

The total costs of producing each unit of blood in 2020- 2021 in Shiraz, Iran, are displayed in Table 3.

The total cost to produce 141738 units of allogenic blood before and after deducting depreciation was almost 1,849 billion IR Rials / 44 million USD and 1,832 billion IR Rials / 43.7 million USD, respectively. The final cost per unit of blood in 2020- 2021 was determined to be almost 13 million IRR [12,918,151 IRR) ≈ 308 USD)]. The final cost per unit of blood declared by the Blood Transfusion Organization in 2019- 2020 was 1.5 million IRR [1,613,093 IRR) ≈ 38.5 USD]

5. Discussion

The present study was conducted to determine the total cost of a unit of blood in Shiraz in 2020-2021 using activity-based costing (ABC). Our results highlighted an eight-fold difference between the estimated cost and the cost last declared by the Blood Transfusion Organization in 2019-2020. This considerable difference underlines the need to review the method of calculating the cost of each unit of blood so that the determined amount is closer to the actual amount. The estimated cost of producing one unit of blood in the Shiraz Blood Transfusion Center was more than the national average. This indicates the serious need to review resource management in the country's blood transfusion centers.

Considering the differences in Iran's cultural, economic, and political structure concerning developed countries that have conducted more extensive research, comparing costs between nations is challenging. Nonetheless, the economic matters related to blood transfusion are of special importance and should be examined more closely. Other studies conducted in Iran on the cost of each unit of blood are from several years ago. One of these studies was conducted in the Gilan province, where the cost of each unit of packed red blood cells was estimated at 594,203 IRR (≈$62) in 2009 [1 USD = 9,600 IRR at that time]. Although the ABC method was used, the method employed varied from that proposed at the COBCON (11). This result is very different from that obtained in our study (almost 13 million IRR or 308 USD), which was conducted on two years' worth of severe inflation apart from the mentioned research. Therefore, this discrepancy can be explained by changes in tariffs, market conditions, and exchange rates. In another study, the cost of each unit of blood was calculated in 28 Iranian provinces in 2002, ranging from 61,000-118,000 IRR. The method of calculating the cost of each unit of blood was the credits allocated to blood transfusion units (12).

In the current research, the total cost based on government currency at the time the study was conducted (1 USD = 42,000 IRR) was 308 dollars, which is comparable to what has been reported in studies performed in other nations. The cost calculated in this study is the total cost of producing a unit of blood before it is made available to the patient, explaining why it is a little lower compared with some other studies (13, 14). Several studies have estimated blood transfusion costs in the United States with methodologies similar to those observed in Western European studies (4, 15, 16). Adjusted for the value of the US dollar in 2011, the cost of a two-unit red blood cell transfusion estimated by Cantor et al. ($841.61 to $845.83) was higher than that estimated by Forbes et al. ($515.63) (4, 15) but lower than Crémieux et al.'s estimate ($1,303.68 for adults) (16).

Recognizing these limitations, a group of experts from blood collection centers, government agencies, universities, and hospitals (including transfusion medicine specialists) gathered at the Cost of Blood Consensus Conference (COBCON) to discuss the various elements involved in collecting and transfusing blood. Activity-based costing (ABC) was proposed as a standard method to provide comprehensive and generalizable estimates of blood transfusion costs (8). Shander et al. developed an ABC model to examine the cost of blood transfusions in a population from a health system perspective. They found that costs varied widely among hospitals. (17). For every two units of red blood cells transfused, the New Jersey center had the highest cost ($2458.77), followed by Rhode Island Hospital ($1508.63), Swiss hospitals ($1270.49), and Austrian hospitals ($1085.58) (17, 18). Despite the high accuracy of the ABC method, variations in estimated costs are evident.

According to our findings, indirect costs comprised a significant portion (86.45%) of the cost of producing a unit of blood, while direct costs accounted for only 13.55% of costs. This finding demonstrates the necessity of analyzing the indirect cost generators and devising strategies to reduce indirect costs. Only one-seventh of the total cost is allocated to direct expenditures; nonetheless, they receive the majority of government funding when providing government currency.

Inflation-induced fluctuations in the Rial-to-Dollar exchange rate may cause the cost estimate in this study to fluctuate over time. In addition, government-assigned multiple exchange rates for the currency of used items contribute to the variation of costs over time. It is extremely challenging to inspect changes over time in expenses due to the variability of the conditions in different time frames. In recent years, Iran has also seen a rise in the expenses of energy carriers, such as water, electricity, and gas, all augmenting the cost of producing a unit of blood.

Due to the lack of the valuation of the organizational resources in recent years and a written list, the study faced many implementation problems and proceeded slowly. Another limitation was the conversion of costs from IRR to USD for the calculated values; due to the multi-rate nature of currency prices in Iran, the interpretation and comparison of the results were challenging. Nonetheless, our study approach yielded more realistic and accurate estimates for the price of each unit of blood in Shiraz, forming the basis for other more detailed studies.

This study has outlined the steps involved in transforming an allogenic blood unit into transfusable red blood cell bags. It is essential to allocate additional time to obtain blood products besides red blood cell bags. Within this study, some of the calculated time, resources, and tools (including cost) are associated with acquiring other blood products. Nonetheless, we were unable to separate these costs in our analysis; therefore, our focus was solely on the cost up until the production and distribution of the blood cells to the centers. As a result, the price of the blood pack alone may be a little bit lower than what this study estimated.

6. Conclusion

As evidenced by the results of this study, the cost of one blood unit was far more than the national average estimated by the Iran Blood Transfusion Organization. There is a need for additional research on the cost of other blood products and indirect cost reduction strategies.

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Footnotes

Conflicts of Interest: The authors declare no conflict of interest**.**

References

1. Hofmann A, Ozawa S, Farrugia A, Farmer SL, Shander A. Economic considerations on transfusion medicine and patient blood management. *Best Pract Res Clin Anaesthesiol.* 2013;**27**(1):59-68. doi: 10.1016/j.bpa.2013.02.001. [PubMed: 23590916].
2. Tinegate H, Chattree S, Iqbal A, Plews D, Whitehead J, Wallis JP, et al. Ten-year pattern of red blood cell use in the North of England. *Transfusion.* 2013;**53**(3):483-9. doi: 10.1111/j.1537-2995.2012.03782.x. [PubMed: 22803573]
3. Ferraris VA, Ferraris SP, Saha SP, Hessel EA, Haan CK, Royston BD, et al. Perioperative blood transfusion and blood conservation in cardiac surgery: the Society of Thoracic Surgeons and The Society of Cardiovascular Anesthesiologists clinical practice guideline. *Ann Thorac Surg.*2007;**83**(5):27-86. doi:10.1016/j.athoracsur.2007.02.099. [PubMed: 17462454].
4. Forbes JM, Anderson MD, Anderson GF, Bleecker GC, Rossi EC, Moss GS. Blood transfusion costs: a multicenter study. *Transfusion.* 1991;**31**(4):318-23. doi: 10.1046/j.1537-2995.1991.31491213295.x. [PubMed: 2020994].
5. Lubarsky DA, Hahn C, Bennett DH, Smith LR, Bredehoeft SJ, Klein HG, et al. The hospital cost (fiscal year 1991/1992) of a simple perioperative allogeneic red blood cell transfusion during elective surgery at Duke University. *Anesth Analg.* 1994;**79**(4):629-37. doi: 10.1213/00000539-199410000-00003. [PubMed: 7943767].
6. Roberts WA, Kirkley SA, Newby M. A cost comparison of allogeneic and preoperatively or intraoperatively donated autologous blood. *Anesth Analg.* 1996;**83**(1):129-33. doi: 10.1097/00000539-199607000-00023. [PubMed: 8659723].
7. Abraham I, Sun D. The cost of blood transfusion in Western Europe as estimated from six studies. *Transfusion.* 2012;**52**(9):1983-8. doi: 10.1111/j.1537-2995.2011.03532.x. [PubMed: 22313531].
8. Aledort L, Broder M, Busch M, Custer B, Fergusson D, Goodnough L, et al. The cost of blood: multidisciplinary consensus conference for a standard methodology. *Transfus Med Rev.* 2005;**19**(1):66-78. doi: 10.1016/j.tmrv.2004.09.005. [PubMed: 15830329].
9. Ruiz J, Dugan A, Davenport DL, Gedaly R. Blood transfusion is a

critical determinant of resource utilization and total hospital cost in liver transplantation. *Clin Transplant.* 2018;**32**(2). doi: 10.1111/ctr.13164. [PubMed: 29193383].
10. Sun D, Abraham I. The cost of allogeneic blood transfusion. *World J Hematol.* 2012;**1**(3):8-13. doi: 10.5315/wjh.v1.i3.8.
11. Davoudi-Kiakalayeh A, Paridar M, Toogeh G. Cost unit analysis of blood transfusion centers in Guilan province. *Sci J Iran Blood Transfus Organ.* 2012;**9**(3):346-52.
12. Gharehbaghian A, Jalilzadeh Khoei M, Honarkaran N, Davoodi F. Estimsation and comparison of the production cost of blood and blood products in 28 IBTO centers in 2002. *Sci J Iran Blood Transfus Organ.* 2005;**1**(2):61-70.
13. İndelen C, Uygun Kızmaz Y, Kar A, Shander A, Kırali K. The cost of one unit blood transfusion components and cost-effectiveness analysis results of transfusion improvement program. *Turk Gogus Kalp Damar Cerrahisi Derg*. 2021;**29**(2):150-7. doi: 10.5606/tgkdc.dergisi.2021.20886. [PubMed: 34104508].
14. Wang D, Ye Y, Zheng Q. Cost of blood and body fluid occupational exposure management in Beijing, China. *Int J Environ Res Public Health*. 2020;**17**(12):4192. doi: 10.3390/ijerph17124192. [PubMed: 32545465].
15. Cantor SB, Hudson Jr DV, Lichtiger B, Rubenstein EB. Costs of blood transfusion: a process-flow analysis. *J Clin Oncol*. 1998;**16**(7):2364-70. doi: 10.1200/JCO.1998.16.7.2364. [PubMed: 9667252].
16. Crémieux P-Y, Barrett B, Anderson K, Slavin MB. Cost of outpatient blood transfusion in cancer patients. *J Clin Oncol*. 2000;**18**(14):2755-61. doi: 10.1200/JCO.2000.18.14.2755. [PubMed: 10894876].
17. Shander A, Hofmann A, Ozawa S, Theusinger OM, Gombotz H, Spahn DR. Activity-based costs of blood transfusions in surgical patients at four hospitals. Transfusion. 2010;**50**(4):753-65. doi: 10.1111/j.1537-2995.2009.02518.x. [PubMed: 20003061].
18. Shander A, Hofmann A, Gombotz H, Theusinger OM, Spahn DR. Estimating the cost of blood: past, present, and future directions. *Best Pract Res Clin Anaesthesiol.* 2007;**21**(2):271-89. doi: 10.1016/j.bpa.2007.01.002. [PubMed: 17650777].