Araştırma Makalesi – Original Article

Costs of Intensive Care Units and Effective Cost Containment Approaches: A Systematic Review*

Yoğun Bakım Maliyetleri ve Efektif Maliyet Kontrol Yöntemleri: Bir Sistematik Literatür Çalışması

Doğancan Çavmak[i]

[i]Asst. Prof., Tarsus University, Faculty of Applied Sciences, Department of Health Administration
https://orcid.org/0000-0002-3329-4573

ABSTRACT

Objective: Intensive care units are one of the most complex and critical service production areas that incur high levels of resource consumption in hospitals. This study aims to analyze the cost structures of intensive care units, and to examine cost containment strategies that can be implemented in this area.

Methods: The study is a systematic literature review, employing the PRISMA flow diagram. The review was carried out in two stages using the Web of Science database, focusing on the cost structures of units and cost reduction strategies.

Results: The study synthesized finding from 14 papers to examine the topic. The results of the 10 studies on the cost structure indicated that the cost structures of intensive care units are mostly composed of labor, medical consumables, and equipment expenses. Among the cost control methods, quality improvement, lean management, and value streams were detected to be frequently used approaches.

Conclusion: Given that intensive care units are high-cost service areas, it will be beneficial to examine them considering cost management approaches.

Keywords: Intensive care units, Hospitals, Cost and cost analysis, Cost control

ÖZ

Amaç: Yoğun bakımlar yüksek kaynak tüketimleri ile birlikte hastanelerin en karmaşık ve kritik hizmet üretim alanlarından biridir. Bu çalışmada yoğun bakımların, maliyet yapıları bakımından analiz edilmesi ve bu alanda yapılabilecek maliyet düşürme çalışmalarının irdelenmesi amaçlanmıştır.

Yöntem: Sistematik literatür taraması yöntemi ile yürütülen çalışmada PRISMA akış diyagramı kullanılmıştır. Tarama yoğun bakımların maliyet yapıları ve maliyet azaltma çalışmaları şeklinde iki aşamada Web of Science veri tabanında gerçekleştirilmiştir.

Bulgular: Çalışma kapsamında 14 makalenin bulguları bir araya getirilerek konu irdelenmiştir. Maliye yapısı üzerine odaklanan 10 adet çalışmanın bulguları yoğun bakımların maliyet yapılarının yoğun olarak işçilik, tıbbi malzeme ve ekipman giderlerinden oluştuğunu göstermiştir. Maliyet kontrol yöntemleri arasında ise kalite iyileştirme, yalın, değer akışları gibi yöntemlerin yer aldığı görülmüştür.

Sonuç: Yoğun bakımların yüksek maliyetli üretim alanları olması sebebiyle, maliyet yönetimi yaklaşımları ile incelenmesinin faydalı olacağı görülmektedir.

Anahtar Kelimeler: Yoğun bakım üniteleri, Hastaneler, Giderler ve Maliyet Analizi, Maliyet Kontrolü

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Introduction

Intensive care refers to a multidisciplinary care with a highly skilled interprofessional team and using an array of technologies for patients in critical conditions.[1] Critical care is also widely used to define intensive care.[2] According to the definition of The Intensive Care Society, "intensive care units (ICUs) are specialist hospital wards that provide treatment and monitoring for people who are very ill.[3] Marshall et al (2017) defined 5 domains to express the difference between ICUs and other medical care services as; a large physical space, support, and monitoring technologies, a qualified, interdisciplinary, and interprofessional human resources team, critical care services provided, and continuous improvement.[1] All these factors make the ICUs complex medical departments to manage.

Intensive care units' beds represent a small portion of total hospital beds all around the world. In United States of America (USA), according to data of the OECD, in 2020, the number of hospital beds per 1.000 population was 2.8, while the number of intensive care unit beds per 1.000 population was 0,258.[4] The number of intensive care units has been raised due to the Covid-19 pandemic. For instance, the number of intensive care units increased by 36% in the USA during the pandemic.[5] Despite the relatively lower number of beds, the costs of intensive care units account for more than %20 of hospital costs in the USA.[6] The cost of intensive care is also highly varied by cases. For instance, Lefrant et al., (2015) calculated the cost difference of an ICU patient from €684 to €3173 in France.[10] There are also many current studies from different countries which verify the high cost of intensive care units.[7-11] There are multiple factors encompassing intrinsic and extrinsic elements that influence rising cost of ICUs. The cost of ICUs is rising mainly because of the expensive treatments and both the intensive labor and equipment structure of healthcare services.[8,12] The requirement for advanced medical technologies makes it essential to invest continuously in technology. Also the necessity for highly skilled healthcare human resources cause a continuous rising in staff expenses. Additionally, pharmaceutical expenses hold an important place as a determinant of cost in ICUs.[13] Another intrinsic influencing factor is the complexity of cases. High length of stay, utilization of mechanical ventilation, hemofiltration, readmission etc. can significantly increase costs in ICUs.[14] The rising cost of ICUs is also influenced by general economic conditions of the country such as inflation, economic downturns etc. Because cost of medical supplies, equipment, staff salaries are significantly affected by these indicators[15].

As ICUs provide medical care with high costs, it is necessary to conduct cost analysis and seek cost reduction opportunities. Analyzing cost structure is crucial for logical resource allocation, cost effectiveness analysis, and also quality of care.[16,17] Therefore, the need for empirical cost data and cost containment approaches in ICUs has been growing. Although there are separate studies on cost analysis of ICUs and cost containment policies for ICUs, a holistic approach that will integrate these topics and provide wider inferences will be beneficial for both health planners and managers. Therefore, this study aims to shed light onto the cost structure of ICUs and effective cost containment policies that can be used in ICUs by conducting a systematic review.

Material and Methods

Study Design and Sample

Analyses (PRISMA)[18] was performed to identify existing evidence on the following questions:

1. What is the cost structure of ICUs?
2. What is the burden and importance of the costs of ICUs for hospitals?
3. Which cost-containment strategies and tools can be used in ICUs?

A search protocol with search terms was developed to obtain evidence on (1) the cost structure of intensive care units and (2) cost-containment strategies that can be effective for intensive care units. Web of Science database was searched for 2012-2023. WoS is considered to be the most appropriate platform to search for scientific paper thanks to its extensive coverage, systematic, standardized and reliable structure. It is also user-friendly as it allows researchers to apply their searching methodology by providing filters, categories, abstracts and more.[19,20] That is why WoS was chosen to be the most reliable platform to discuss costs of ICUs.

Searching was based on Web of Science SSCI, SCI-Expanded, and ESCI indexes. The search was restricted by the Web of Science Categories of "Health Policy Services", "Healthcare Sciences Services", "Business", "Economics", "Management" and "Social Sciences in Interdisciplinary". A twofold searching strategy was carried out: a search for empirical data on cost-of-service production in ICUs and a search for ways and tools of controlling and reducing costs in ICUs. The search strategy of the study is shown in Box 1.

Box 1. Inclusion criteria

First fold search

"intensive care" or "intensive care units" or "intensive care unit" or "ICU" or "critical care"

and

"cost" or "cost analysis" or "cost measure" or "cost measures" or "cost allocation" or "cost allocations" or "cost apportionment"

Second fold search

"intensive care" or "intensive care units" or "intensive care unit" or "ICU" or "critical care"

and

"cost containment" or "cost containments" or "cost control" or "cost reduction"

Inclusion criteria

Inclusion criteria is defined as "open access studies which analyzed empirical primary data and provide evidence on cost structure of and tools/strategies for cost containment in ICUs". Studies were eligible if they; 1) calculated the total costs of ICUs, 2) analyzed cost structure of ICUs using quantitative methodology and 3) evaluated containment strategies empirically 4) were in English and were published between 2012-2023. Any studies which conducted empirical cost analysis in any type of intensive care units (general, pediatric, cardiac or coronary) were included (***Table 1***). Studies which did not use first data obtained from hospitals, reviews, conference papers, or abstracts were excluded from the review.

Table 1. Study inclusion criteria

Study characteristics	Inclusion criteria: studies focusing on the costs of intensive care units
Study type	Research articles
Study area	General intensive, pediatric intensive care, cardiac intensive, or coronary intensive units
Study purpose	Cost calculation and/or cost analysis and/or cost containment and reduction
Study design	Empirical studies using quantitative data

Data extraction and analysis

Studies firstly were categorized into two groups according to their study purpose: cost calculation and cost containment. From all studies, the following initial data was extracted and reported on an Microsoft Excel spreadsheet: country, year, authors, study area, study purpose, study design, and main results. To extract further and more useful information, how the studies discussed the topic or issue was examined in a qualitative approach and the results were synthesized. As fundamental information, cost analysis method, cost elements as percentage of total cost, implemented cost containment method and improvements in numbers or as percentage were extracted from papers.

Limitations

The study has a few important limitations. The studies are generally from the USA and European region. This implies a geographical bias to the study and limits its generalizability. Another limitation is that the study neglects the knowledge and perception of managers and healthcare providers on the ICU's costs. Some qualitative studies which were conducted using interviews or quantitative studies based on surveys were excluded. These studies provided useful information about the intensive care units and their costs, however, the results they provided were based on healthcare providers' or managers' opinions. Therefore, the current study does not include healthcare providers' perceptions and opinions about the cost of ICUs.

Findings and Discussion

Study selection process and characteristics

From the initial search, 7779 records were listed in WOS. Of these records, 4345 were identified in the first fold and 3434 were in the second fold. 7752 were excluded after title/abstract screening and 27 papers were included in full text assessment. 14 more papers were excluded after examination of the abstracts and their methodology and data. The process resulted in 14 papers included in the final analysis (***Figure 1***).

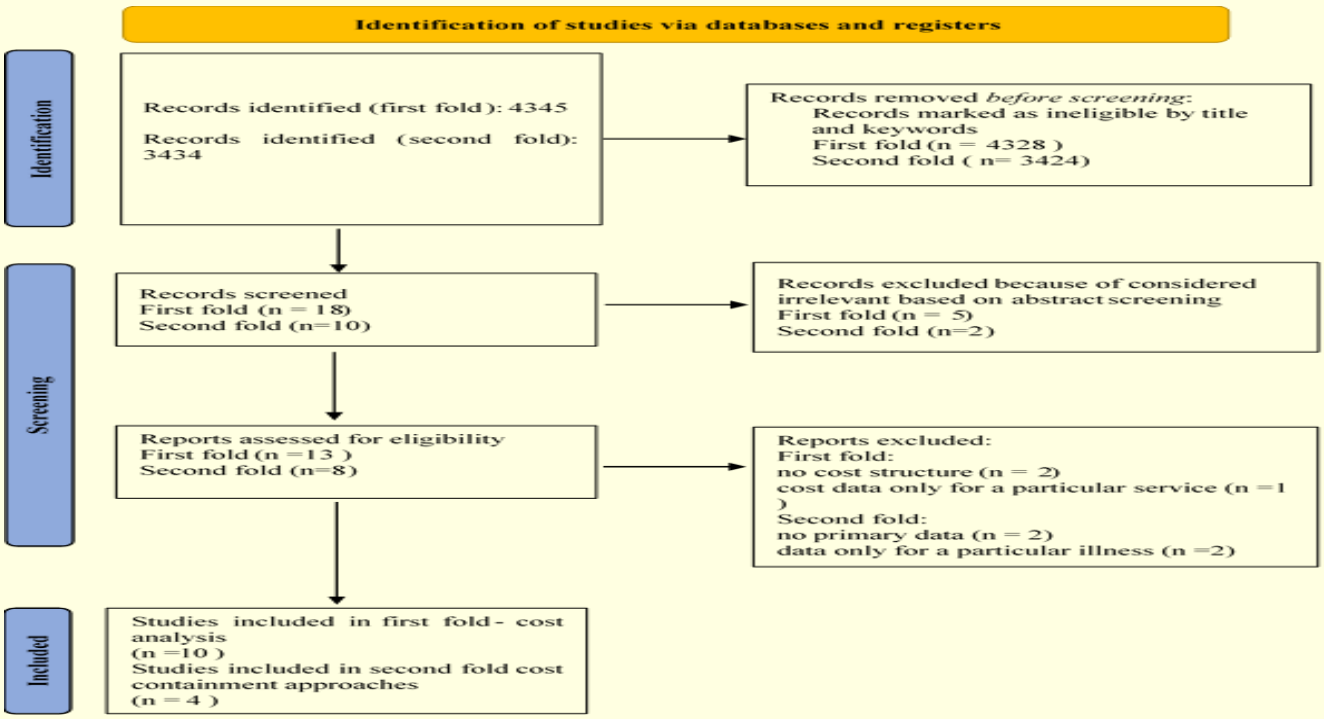

Figure 1. Prisma diagram of the study

The general characteristics and findings of the studies included in the systematic review are summarized in ***Table2.***

Table 2. Characteristics and findings of included papers

Cost calculation and analysis studies					
Authors, year	Country	Study design	Population/ Sample	Type of ICU	Fundamental findings
Tan et al., 2012[21]	Germany, Italy, the Netherlands, and the United Kingdom (UK)	Retrospective data, both bottom-up, and top-down costing for different cost items	Seven ICU departments with a total of 109 beds	Medical-surgical adult ICU	On average, the cost structure of the ICU's consisted of 14% diagnostic procedures, 22 %medical consumables, 4% hotel, 60% labor costs. Labor cost was found to be the most important cost driver at all departments
Haque et al.., 2015[22]	Pakistan	Retrospective cohort study, top-down approach, cost block method.	Record of all admissions from January 1 to June 30, 2013	Pediatric ICU	The major costs distributions of the ICU were 18% bed charges, 14% physician charges, 18% medical-surgical supplies, 19% laboratory charges and 13 % pharmacy charges
Lefrant et al., 2015[10]	France	Prospective, observational data, micro-costing of patients.	22 ICUs from 11 university hospitals, 10 general hospitals, one private hospital.	General adult ICU	The components of daily costs were %25 of working time dedicated to patient care, %23 administrative expenses, %18 other caregivers time, %19 consumables and medication, %10 laboratory tests and %6 investigation tests.
Kılıç et al., 2019[11]	Türkiye	Retrospective data, micro costing of patients	458 patients' data from a university hospital	General ICU	The cost structure for patients with more than 5 days length of stay was %45 drugs, %25 medical equipment, %18 laboratory and radiographic tests,%4 for surgical procedures, and %8 others.
Van Diepen et al., 2019[23]	Canada	National population-based data were used. Retrospective cohort. Cost data of hospitals according to classification of quartiles based on intensive care utilization.	Data of national population health dataset with 349.693 heart failure ICU admission	Cardiac and general ICUs	Intensive care units account for 7.8% of hospital costs in low ICU utilization hospitals, 19.8% in medium and 28.2% in high.

Aung et al., 2020[24]	Malaysia	Retrospective data, top-down costing, regression analysis	A teaching hospitals' four ICUs	General, cardiac, coronary, and pediatric ICUs	General ICU had the highest cost among others. Generally, nearly 50% of total costs were from overheads while pharmacy and investigation had lower than 5% in ICUs.
Singh et al., 2021[25]	India	Prospective observational data, activity-based costing.	38 patients' data from a public hospital	Surgical ICU	The components of costs were %42 human resources, %13 drugs and consumables, %5 laboratory tests, %2 laundry and diets, %38 overheads.
Kaur et al., 2021[26]	India	Prospective, bottom-up micro costing.	299 patients' data from teaching and referral hospital	Pediatric ICU	The annual cost of the ICU consisted of %58.6 human resources, %2.2 drugs and consumables, %16 physical space, %15,6 equipment.
Reddy et al., 2021[27]	India	Retrospective data, micro-costing	Data of 347 patients from a tertiary care trust hospital	COVID-19 ICU	The total direct medical cost of patients consisted of %20 drugs and consumables, %19 bed charges, %17 equipment, %14 biosafety protective gear, %15 pathology and radiology tests, %9 clinical management and % 2 biomedical waste management. Clinical management cost includes the physician and nursing consultation, and procedures; biosafety protective gear includes PPE and other protective equipment; and equipment charges include oxygen therapy
Bruynell et al., 2023[28]	Belgium	Retrospective cohort, full costing	17 hospitals, 18.235 stays in ICU	General ICU	The proportion of direct ICU costs in total hospital costs was found to be 17.4%. The proportion of indirect costs in the total cost of ICUs was 12.1%. Nursing costs had the large part of direct costs.
Trzeciak et al., 2018[29]	USA	Before and after cohort study. Clinical redesign approach. Six Sigma methodology. Define-measure-analyze-improve-control approach. Comparing cost data after Six Sigma intervention. Cost data obtained by cost accounting methodology of cost-to-charge ratio.	259 patients with prolonged mechanical ventilation (131 pre-intervention and 128 pro-intervention)	Multidisciplinary intensive care unit (ICU	Patient flow was improved by eliminating wastes in processes, length of stay decreased by 24%, and cost per case decreased by 27%.
Ersson et al., 2018[30]	Sweden	Quality improvement approach using lean methodology and especially value stream mapping, flow-oriented working process. Costs were estimated using the number of personnel working	12-bed ICU and patients between 18-89 age in 2008-2014.	Mixed ICU of a 600-bed tertiary teaching hospital	By eliminating non-value-adding activities, wastes, and redundant tasks, costs were kept highly stable with a down-ward trend while LYG and QALY improved. The cost-effectiveness ratio was improved.

		hours. Cost effectiveness was calculated by comparing the cost to incremental gain in QALY and LYG.			
Serrano-Eanelli et al., 2019[31]	USA	Retrospective chart review using data from Electronic Medical Orders for Life-Sustaining Treatment (eMOLST) system, activity-based costing.	331 patients aged over 65 admitted to ICU	General ICU in a community hospital	No statistically significant difference in costs between patients who completed the eMOLST form and those who did not. eMOLST did not reduce the direct cost of ICU per patient.
Chung et al., 2022[32]	USA	Observational comparison and cost analysis approach	739 patients received palliative care and 8252 patients received usual care with life threatening conditions in ICUs	Surgical, trauma, oncology, cardiovascular, neuro, transplant and others	Patients received palliative care were associated with length of stay and usage of invasive life-sustaining interventions has decreased. Palliative care consultations significantly reduced costs by 21% and up to 5.000 dollars per patient. Palliative care provided cost savings in pharmacy and laboratory services.

The majority of the studies were conducted in Europe and America region. Most of the cost analysis studies were retrospective and used a conventional costing methodology. Few were prospective and used contemporary approaches such as activity-based and time driven activity-based costing. There were relatively limited studies which focused on cost containment with empirical data.

Cost structure of ICUs

The studies examining the cost structure of ICUs have mostly reported human resources, drugs, medical consumables, laboratory tests, equipment, and overheads as components of costs.

Human resource costs: All studies have revealed that human resource costs had the highest share in the total cost of ICUs. Tan et al., in their study which included data from Germany, Italy, the Netherlands, and the United Kingdom revealed that 60% of total ICU costs are attributed to labor costs.[21] Similarly, Singh et al.'s study in India reported that labor cost consisted of 42.52% of total surgical ICU costs.[25] In another study by Kaur et al. focusing on pediatric ICUs, labor costs were identified as the highest cost component, accounting for 58.6% of the total cost.[26] Lefrant et al., in their study of university, private, and general hospitals in France, found that 25% of human resource costs were directly related to patient care, while 18% were associated with other operational areas.[10]

Medical consumables and medicines: Most of the studies also emphasized the significant share of medicines and medical consumables costs as components. Kılıç et al. reported that medications accounted for 45% of total cost of ICU.[11] A study conducted by Reddy et al. indicated that during the Covid-19 in India, medical consumables accounted for nearly 20% of the cost.[27] Contrarily, Aung et al., in their study of four different ICUs in Malaysia, noted that medications only had a share of 5% in total cost.[24]

Equipment and technological infrastructure costs: Equipment and especially bed costs also have a significant share in the cost structure of ICUs. Reddy et al. reported that 17% of the ICU costs for COVID-19 patients were rooted from equipment usage and bed cost accounted for 19% of the total cost.[27] Similarly, Kaur et al. have also highlighted that physical space accounted for 16% of annual ICU costs, and 15.6% were due to equipment.[26] Haque et al., found the share of medical surgical supplies as 18%.[22]

Diagnostic procedures: Studies also reported diagnostic procedures as a component of cost in ICUs. Tan et al., Lefrant et al., Kılıç et al., and Reddy et al., reported that more than 10% of the costs were related to laboratory or radiological tests. [21, 10, 11, 20]

Overheads: Overheads hold also an important role in ICU service production. Studies by Tan et al. and Aung et al. showed that overheads accounted for nearly 50% of total cost in ICUs. In other studies, the share of overheads is quite below when compared to these studies. [21, 24]

ICUs are considered among the costliest departments in hospitals. Studies in the literature have clarified that ICUs hold a significant share of total hospital production costs and have a considerable burden on hospital budgets. However, this paper which includes post-2018 studies achieved limited research that examine the share of ICUs' cost in the total production cost of hospitals. Bruynell et al. conducted a retrospective cohort study which included 18,235 ICU admissions in 17 hospitals in Belgium and revealed that ICUs accounted for 17.4% of total hospital costs.[28] They also indicated that indirect ICU costs accounted for 12.1% of total costs, including items such as management, logistics, and support services. These findings clarify that ICUs provide high-cost services and pose a significant cost burden on hospitals' production processes. van Diepen et al., also provided evidence on the cost burden of ICUs for hospitals. They classified hospitals into low, medium, and high groups considering intensive care utilization. According

to the results, the cost of ICUs had a share of nearly 8% in the low, 20% in the medium, and 28.2% in the high groups.[23]

To sum up, the cost structure of ICUs highly consists of labor, medical consumables, overheads, and diagnostic tests. However, considering different backgrounds influencing cost structures between countries (e.g., healthcare system, ICU type, patient density or length of stay), it can be observed that studies in Europe mostly emphasized laboratory and equipment costs, while studies in Asia place more focused on human resources and overheads. Especially during the COVID-19 pandemic, study of Reddy et al. showed that biosafety equipment and ICU beds became significant components.[27]

Cost containment approaches in ICUs

The studies reviewed in this research show that well-implemented quality improvement programs, such as, six sigma, lean practices, value stream mapping, process management can significantly reduce ICU costs while improving patient outcomes. Elimination of non-value-adding activities, and also palliative care interventions can be effective cost containment approaches.

Trzeciak et al., and Ersson et al. both conducted structured process improvement approaches to enhance efficiency and reduce costs. By implementing lean methodologies, Erson et al., targeted redundant tasks and waste and reduced non-value adding activities in ICUs. They achieved reduced cost while improving Quality-Adjusted Life Years (QALY) and Life Years Gained (LYG) which improves effectiveness by focusing on activities that did not contribute to patient outcomes. Similarly, Trzeciak et al. focused on prolonged mechanical ventilation in ICUs to reduce cost using the six sigma methodology. They created the value stream map for patient flow and their improvements resulted in a 27% reduction in the cost per case and a 24% decrease in ICU length of stay. [29-30]

Focusing on length of stay and unnecessary procedures are key factor to optimize clinical processes in ICUs. Erson et al., and Trzeciak et al. also clarified that processes could be improved by synchronizing shifts and aligning staffing with actual patient needs and ultimately can serve to reduce costs. Both studies show that redesigning of operational workflows for improved patient care delivery can lead to significant cost containments without jeopardizing care quality.[29-30]

Another approach that mostly examined in improving ICUs' processes is palliative care consultations. Chung et al. showed that palliative care significantly reduced the length of stay and the use of unnecessary interventions, leading to a 21% reduction in overall ICU costs.[32] Many studies which were not included in this research due to not meeting inclusion criteria found that palliative care consultations for especially patients with heavy critical conditions can be a way to reduce length of stay in ICUs[33-34], and also for cost containment.[35]

Conclusions

The aim of this study was to discuss the cost structures and burdens of intensive care units in total production cost of hospitals and provide information about the potential cost control and containment methods suitable for ICUs. Considering the complexity of treatments in intensive care units and their multidisciplinary nature, it is understandable that the literature mostly focuses on cost-effectiveness analyses at a high level.[36]

However, this research primarily considers ICUs an organizational unit and aims to examine them as a whole and to include cost studies that provides data/information on the cost structure of ICUs. It has been seen that high proportion of the studies conduct bottom-up and retrospective cost analysis approach.

Some studies also conducted contemporary approach such as activity-based and time-driven-activity based costing methods. And there are also comparative studies in the literature has been given in Table 2.

The results of the review focusing on cost structure of ICUs indicated that the cost of ICUs are mostly consisted of labor, medication, and medical supply cost components. This suggests that variable costs in ICUs are significant components. When equipment costs which is another major cost item are also taken into account[11], it becomes evident that fixed and variable costs are relatively balanced, due to requirement of high capital investments for high-quality services. This clarifies that ICUs are critical areas of healthcare service production that requires careful and professional management perspective. Additionally, it has been found that ICUs are highly benefiting from, other departments, such as imaging and laboratory services, which are significant cost drivers.

A common inference of studies is that ICUs incur the highest cost of hospitals despite having relatively low bed capacity and patient volume.[28] There are insights into the factors driving these costs. Factors such as length of stay, case mix, and the intensity of specialized services like ventilation are identified as key drivers to higher costs. Therefore, the studies' primary suggestion was to seek for ways to reduce length of stay.[24,26] Additionally, several studies suggest that ICU costs are closely associated to labor hours, indicating that there is need for further research.[10]

Examining cost containments and control implementations in ICUs were another objective of the study. Despite existing of a wide literature on cost-effectiveness studies in ICUs, there have been limited studies on the focus of this study which is improvements in workflows and cost-control methods in ICUs. Most of the existing studies on this objective are conducted holding a quality improvement perspective. Lean, six sigma, workflows, value streams, and process management approaches are common elements in studies with different perspectives.

Lean six sigma approaches, compared pre- and post-implementation situations and strong teams with defined tasks could reduce costs by improving processes, reducing errors, and minimizing waste.[29-30]Additionally, improvements in general treatment methods could lead to cost savings.[32] The study by Serrano-Eanelli et al., which explored the effects of electronic order systems, provided a basis for comparison with other studies in this field, despite its statistically insignificant results.[31]

The study also reveals some differences in cost structure of ICUs between countries that can be taken into account to choose the most appropriate cost containment method. It seems that European countries have relatively higher share of labor cost when compared to Asian countries. This mean that the time spent on by medical staff on direct patient care is dominant in these counties. Therefore, workforce optimization and efficiency improvements by conducting lean principles may be beneficial to control costs. The studies conducted in Asia region showed that these countries spend more on pharmaceuticals and medical consumables when compared to European region. Therefore, a focus drugs management, procurement efficiency may be a starting point for cost control. However, in all countries, ICUs are complicated and consuming a quite diverse of resources. Hence, an holistic quality improvement program aimed at optimizing workforce, material and process flow is recommended as the most effective method for ensuring cost control in ICUs .[37, 38] As a general significant way in this approach to control and reduce cost in ICUs, implementing advance care planning and palliative care consultations can be stated. However, it is crucial to have information about the cost pattern and distribution of patients in ICUs to be able to model potential cost savings using these approaches.[39] Therefore, addition to cost structure of ICUs, studies focuses on patient-based cost data will be contributing to the practice and literature.

Examining intensive care units in terms of cost management techniques and implementing improvements through practical applications in this field have the potential to create positive impacts on health policies. These analyses can guide resource allocation decisions for intensive care units[40], organizational structure changes[41], and managerial processes[42], thereby contributing to the enhancement of health system policies. Therefore, future studies may address the issue of cost in intensive care units within the framework of health policy components.

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