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Review Article

Urgent need for standardised guidelines for reporting healthcare costs in ICUs – Results of an integrative review of costing methodologies

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ABSTRACT

Objectives: Diverse costing methodologies in critical care have produced discrepant results. We aimed to critically review studies addressing critical care patients' costs, to estimate total costs and cost categories and to delineate methodologies used and relevant limitations.
Methods: Integrative review based on key-word searches of electronic databases targeting primary studies that report estimates of patient cost, in the last 21 years. We assessed the level transparency of reporting and the quality of the studies, by the SIGN tool.
Results: Overall, 12 research articles were included, of which eight studies mentioned the specific approach used to identify the elements of cost. Most studies employed a micro-costing and one study a macro-costing approach. With regard to approaches to valuation of cost components, only one study identified the bottom-up approach. The total patient cost ranged from US$ 487 to US$ 39,300 and human resources was identified as the cost category mostly driving total costs.
Conclusions: Although valid methodologies to evaluate critical care patients' costs, such as micro-costing, are employed more frequently, a variety of non-standardized methods are still used. There is a pressing need to develop standardised guidelines for reporting of observational studies of cost in healthcare, with particular considerations for critical care.

Implications for clinical practice

- Comprehensive approaches to critical care costs are important in realistic allocation of budget and resources.
- This study synthesises data on variables important for the delineation of reliable costing methods in critical care.
- Understanding the elements that comprise critical care patient costs and the strategies that aid identification and valuation of these costs allows for comparisons and cost management.
- The results of this study may inform projections of cost for procedures and the varied activities developed in the intensive care unit.

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Background

In most countries, professionals dealing with costs in the area of healthcare have taken an interest for more accurate cost methodologies (Hrifach et al., 2016). Despite considerable advances in this field, implementation of cost methodologies in the complex context of critical care is still far from adequate (Pines et al., 2002).

Intensive care units (ICUs) constitute a substantial financial burden to healthcare institutions. In Netherlands, Europe the costs of ICUs were almost five times higher than the unit costs of wards (Oostenbrink et al., 2003). In Ontario, Canada critical care accounted for only 8.1% of inpatient days, but for 15.9% of inpatient direct expenses of hospitals between 1999 and 2004 (Leeb et al., 2006). In the United States, costs in 2005 corresponded to 13.4% of hospital costs, 4.1% of national health expenditure and 0.66% of the Gross Domestic Product (Halpern and Pastores, 2010).

In this context, application of a standardised cost methodology should allow for meaningful and realistic comparisons and predictions, which is essential for cost management. The degree of reliability and accuracy of cost prediction will depend on cost methodology and can impact critical care outcomes and decision-making (Costa et al., 2008; Tan et al., 2012). To contextualise the problem, the current guidelines on the conduct of economic evaluations do not make specific recommendations as to which costing method should be used (Clement et al., 2009). An earlier review of ICU costs (Elliott, 1997) had concluded that comparison and evaluation of costs was problematic, because of the variance in costing methodologies.

Given the difficulty to compare different published analyses of patients costs, this review aims to critically review published studies on cost methodologies to estimate the costs of critical care patients, to delineate the methodologies used and relevant limitations.

Specific aims included to identify and evaluate: a) cost estimation techniques (e.g., micro- vs., macro-costing), b) approaches to valuation of cost components, c) cost categories contributing to cost, d) total costs per patient and cost per day and e) cost categories driving total costs. The present integrative review is relevant because it helps to understand the elements that comprise critical care patient costs and the strategies that aid identification of these costs.

The selection of an appropriate costing methodology depends largely on the intended use of cost information, being that several costing guidelines focus on identification, measurement and valuation of resources steps (Mogyorosy and Smith, 2005). For the identification and measurement of cost two conventional methods can be used; micro-costing and macro-costing. Micro-costing is a methodology that allows for the identification of costs per individual patient; whereas, in macro-costing, cost components are defined at a highly aggregated level (Tan et al., 2008).

Regardless of the method employed, two techniques are used for valuation of cost components: a) the top-down approach requires data at the department level and values each cost component by computing averages per patient; b) the bottom-up approach demands data at the patient level and values each cost component for individual patients (Tan et al., 2012). Thus, the level of accuracy is determined by the identification of cost components and cost component evaluation (Tan et al., 2009).

Method

We employed an integrative literature review. To ensure methodological rigor and to be able to synthesize results from different studies, we adopted the stages described by Whittemore and Knafl (2005): problem identification; literature search; data evaluation; data analysis and synthesis.

Problem identification

We applied the methodology proposed by Whittemore and Knafl (2005) to formulate a searchable research question. *Concept*: costing; *Target population*: critically ill patients hospitalized in an ICU; *Health care problem*: accurate costing methodology, *Type of studies*: Primary quantitative research studies. Therefore, the guiding question we used to conduct this review was: Which cost methodologies have been used to estimate the costs of critical care patients admitted to the ICU? Additionally, we explored how do these cost methodologies compare with regard to accuracy of cost assessment.

Literature search

In May 2018, we conducted an electronic search of the databases Latin American and Caribbean Literature in Health Sciences (LILACS), PubMed of the *National Center for Biotechnology Information* (NCBI), Embase and CINAHL to identify articles published from January/1997 to May/2018. The time frame was intentional, due to the latest review performed in the environment of critical care (Elliott, 1997).

To construct the search strategy, we used the search terms Intensive Care or critical care, or ICU combined by the Boolean operator "and" with the following terms: Cost* or Econom*. We decided to use more comprehensive keywords to make the search more sensitive to review articles. The search strategy for PubMed is included in Appendix 1.

The eligibility criteria included articles: a) published in the English, Spanish, or Portuguese language; b) dealing with critical care patient costs regardless of type of ICU, and regardless of patient demographic (adult, pediatric, and neonatal) and c) having adequate transparency of reporting by including in the minimum their methodology of cost estimation and cost per patient. We excluded review papers, editorials and articles exploring the cost of a specific condition in isolation.

To assess article eligibility for this integrative review, the article title and abstract were read and if the title and abstract were not available, the entire article was read. Two independent reviewers conducted this process. When the two reviewers disagreed, they discussed the data with a third reviewer with expertise in the area until they reached a consensus on including or excluding the article from the present review.

Studies that fulfilled the eligibility criteria were read in full. Before the decision to include them in the final sample, the articles were subjected to evaluation of transparency level. We used the method proposed by Fukuda et al. (2011); which establishes a hierarchy of four levels (level A, B, C and D) of transparency based on the description of components of costs, data for both quantity and unit price of resources for each component.

Although the authors mentioned that estimates meeting at least level B standards are acceptable, for this review we have also included studies with estimates that only meet the C standard, to assure comprehensiveness of the review.

Results from all databases were combined in Mendeley® and duplicates were deleted. The PRISMA (Moher et al., 2009) flowchart in Fig. 1 describes the article selection process in detail.

Appraisal of quality

Due to the lack of appraisal tools specifically for observational studies of cost (Ruger and Reiff, 2016), to appraise methodological rigor we used the Scottish Intercollegiate Guidelines Network (SIGN) checklist, based on guidelines for economic studies by Drummond and Jefferson (1996). This tool has two sections: Section one includes nine items addressing the internal validity of the study under review. However, as this review does not include

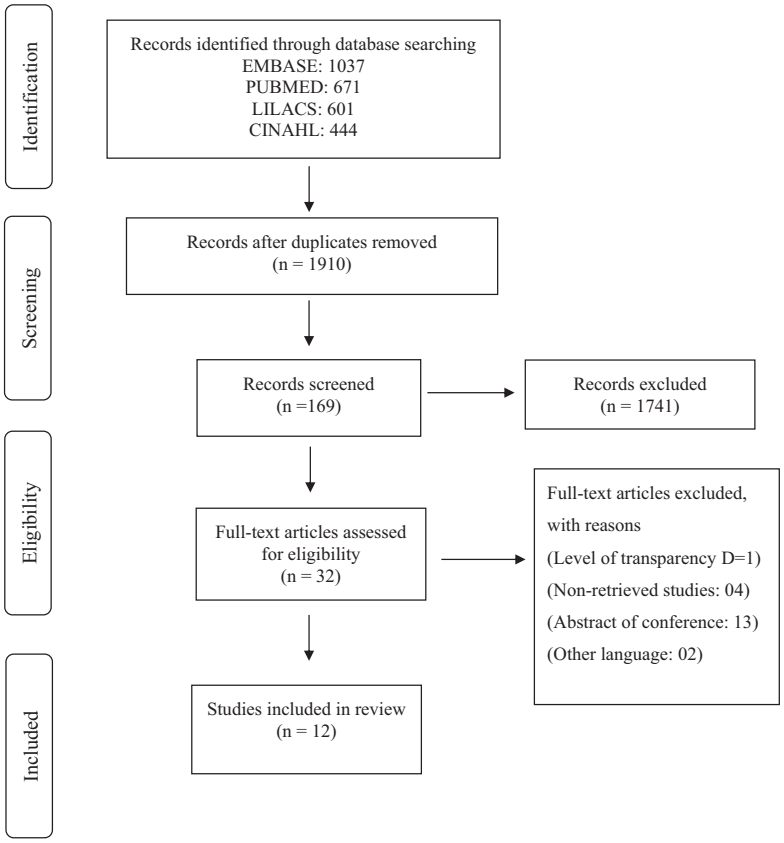

Fig. 1. Flowchart (Moher et al., 2009) describing the process of study selection.

economic evaluation studies, items 1.5, 1.6 and 1.8 were not considered as applicable. Section two regards the overall assessment of the paper. Studies are classified as:

- High quality (++): Majority of criteria met. Little or no risk of bias. Results unlikely to be changed by further research.
- Acceptable (+): Most criteria met. Some flaws in the study with an associated risk of bias, Conclusions may change in the light of further studies.
- Low quality (0): Either most criteria not met, or significant flaws relating to key aspects of study design. Conclusions likely to change in the light of further studies.

Data synthesis

Data synthesis was performed by the Constant Comparison Method according to Whittemore and Knafl (2005). The data from primary sources were extracted using a validated instrument as described by Ursi and Galvão (2006) which addressed the variables of interest: characteristics of studies (year, country, type of setting, type of ICU, type of patient population, study design and sample), costing methodology (level of accuracy, cost block, level of transparency), results (total cost per patient, non-patient and patient-related costs, category driving total cost) and limitations reported by the authors.

Subsequently, data were ordered chronologically and compiled into a Microsoft® Excel 2010 spreadsheet. The variables were categorised and compared to identify patterns of similarity and differences that allowed generalizations.

Due to variations in cost classification, we have chosen to group more broadly by the block method (Seidel et al., 2006). This method analyses cost items as non-patient-related (block 1, block 2, block 3) and patient-related costs (block 4, block 5, block 6).

Results

This review included 12 studies, which are summarised in Table 1. One article was excluded due to low level of transparency (D). No articles were excluded based on their methodological quality. The identified articles involved a total of 3906 patients, among which 2.953 were adults, 459 neonates, and 495 children. Quality appraisal is summarized in Table 2.

Table 3 includes the level of accuracy for cost estimation, type of cost, level of transparency and main limitations of reviewed studies.

Regarding cost estimation, 50% of the studies (Lefrant et al., 2015, Shweta et al., 2013, Prinja et al., 2013, Mclaughlin et al., 2009, Geitona et al., 2007, Moerer et al., 2007) mentioned use of the micro-costing approach. In one study a macro-costing approach was used (Geitona et al., 2010). In some studies, there was a confusion regarding use of the terms micro-costing and bottom-up approach.

Regarding the approach to valuation of cost components, only one study (Jacobs et al., 2001) identified the type of approach as bottom-up. Although the rest of studies did not mention the type of approach, six studies (50%) (Lefrant et al., 2015, Prinja et al., 2013, Geitona et al., 2010, Geitona et al., 2007, Moerer et al., 2007, Garcıa et al., 1997) provided sufficient details of how cost categories were assessed. Total cost, cost per day, non-patient-related, patient-related costs (block costs), and category driving total costs are summarized in Table 4.

Based on those studies that reported total patient costs, total costs ranged from US$ 487 to US$ 39,300 (median US$ 1958 – US $ 24,100) and the average cost per day from US$ 20.2 to US$ 7700 (median £578 – US$ 6100). We observed that all studies included cost categories that were patient-related and only two (Garcıa et al., 1997, Prinja et al., 2013) studies included categories

Table 1
Characteristics of reviewed studies (n = 12).

Article	Year	Country	Type of setting	Type of ICU	Type of patient	Study design	Sample
Peter et al.	2016	India	Private teaching[a]	Medical	Adult	Prospective cohort	499
Khandelwal et al.	2016	United States	Trauma center[a]	Mixed: 5 ICUs	Adult	Secondary analysis	572
Lefrant et al.	2015	France	Multicentre[b]	Mixed: 21 ICUs	Adult	Prospective, observational	104
Shweta et al.	2013	India	Tertiare care teaching	Respiratory	Adult	Prospective analysis	74
Prinja et al.	2013	India	Public hospitals[c]	General	Neonatal	Cost analysis study	360
Geitona et al.	2010	Greece	Teaching University Hospital	General	not stated	not stated	312
McLaughlin et al.	2009	England	University Teaching Hospital	Medical/surgical	Adult	Prospective analysis	64
Geitona et al.	2007	Greece	Public obstetric and maternity hospitals	Medical	Neonatal	Prospective analysis	99
Moerer et al.	2007	Germany	Multicentre[d]	Mixed: 51 ICUs	Adult	Cross-sectional survey	453
Jacobs et al.	2001	England	Teaching hospital	General	Adult	not stated	193
Parikh et al.	1999	India	Tertiary care teaching hospital	Neurology-neurosurgery	Adult	Prospective, observational	993
García et al.	1997	Spain	Tertiary university Hospital	General	Pediatric	Prospective, observational	495

Notes:
[a] Affiliated university.
[b] 10 university hospitals, 10 general hospitals and 1 private.
[c] Four hospital publics.
[d] 15 primary care hospitals and 14 general care hospitals, 10 maximal care hospitals and 12 focused care hospitals.

Table 2
Evaluation of the quality of the studies regarding methodological rigor.

Article	SECTION 1: INTERNAL VALIDITY									SECTION 2
	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.1
Peter et al., 2016	yes	yes	can't say	no	NA	NA	no	NA	yes	+
Khandelwal et al., 2016	yes	yes	can't say	yes	NA	NA	no	NA	yes	+
Lefrant et al., 2015	yes	yes	yes	yes	NA	NA	no	NA	yes	++
Shweta et al., 2013	yes	yes	can't say	no	NA	NA	no	NA	yes	+
Prinja et al., 2013	yes	yes	can't say	yes	NA	NA	yes	NA	yes	++
Geitona et al., 2010	yes	yes	no	yes	NA	NA	yes	NA	yes	++
McLaughlin et al., 2009	yes	yes	can't say	yes	NA	NA	no	NA	yes	+
Geitona et al., 2007	yes	yes	yes	yes	NA	NA	yes	NA	yes	++
Moerer et al., 2007	yes	yes	can't say	yes	NA	NA	no	NA	yes	+
Jacobs et al., 2001	yes	yes	no	yes	NA	NA	no	NA	yes	+
Parikh et al., 1999	yes	yes	can't say	no	NA	NA	no	NA	yes	+
Garcıa et al., 1997	yes	yes	can't say	yes	NA	NA	no	NA	yes	+

Abbreviations: NA-not applicable.
Notes: 1.1 The study addresses an appropriate and clearly focused question; 1.2 The economic importance of the question is clear 1.3 The choice of study design is justified; 1.4 All costs that are relevant from the viewpoint of the study are included and are measured and valued appropriately; 1.5 The outcome measures used to answer the study question are relevant to that purpose and are measured and valued appropriately; 1.6 If discounting of future costs and outcomes is necessary, it been performed correctly; 1.7 Assumptions are made explicit and a sensitivity analysis performed; 1.8 The decision rule is made explicit and comparisons are made on the basis of incremental costs and outcomes; 1.9 The results provide information of relevance to policy makers; 2.1 How well was the study conducted (High quality (++), Acceptable (+), Unacceptable – reject 0).

not directly related to patients. Patient-related costs ranged from 59% to 99% of total costs and non-patient related costs from 1% to 34.4%. By analyzing the categories with the greatest impact on total costs, we identified that human resources influenced total costs the most and represented between 28% (Geitona et al., 2010) and 62.7% (Prinja et al., 2013) of total costs.

There was no homogeneity regarding the approach to evaluation and categorisation of costs, which limits the comparability among studies and the robustness of any inferences about which costing method is preferable.

Discussion

Based on the identified studies, the micro-costing methodology is the one used most commonly to evaluate ICU costs. Micro-costing is sensitive enough to translate patient variability in terms of disease severity and multiple interventions, as well as intensive care service variability (Tan et al., 2008).

The steps of identification and valuation of costs determines the level of accuracy. For example, a bottom-up micro-costing can overestimate costs, whereas a top-down macro-costing calculation tends to underestimate costs. Even though bottom-up micro-costing is considered the gold standard to estimate hospital costs, its application is laborious and has prevented its use in economic evaluations (Tan et al., 2009). One strategy that has been used to overcome this difficulty is the use of the mixed approach, which appears to be a trade-off between the accuracy of the bottom-up approach and the simplicity of the top-down approach (Hrifach et al., 2016). Thus, when a cost component is known as the most predominant in the composition of total cost may restricted the use the bottom-up micro-costing for these components once it provides viability to the method and reliable estimations (Tan et al., 2009).

In the only study that the approach for evaluating cost components was mentioned, activity-based costing was used, which is one of the most widely used forms of bottom-up costing. This approach breaks down the patient care process into discrete activities (Negrini et al., 2004).

As mentioned by Negrini et al. (2004), the attribution of costs is the main obstacle to developing a universal cost model. It appears there is no standardized method to apportion these costs. While Negrini et al. (2004) found that the most common approach has been to divide the total running cost by the number of bed-days, calculating the average cost per patient-day, in our analysis we

Table 3
Level of accuracy for cost estimation, classification of cost, level of transparency and main limitations of reviewed studies.

Article	Level of accuracy		Classification of cost	Level of Transparency	Main limitations
	Identification	*Valuation			
Peter et al., 2016	NS	NS (ID)	Medical and non-medical direct, indirect costs	C	Indirect costs underestimated, results may not be generalized
Khandelwal et al., 2016	NS	NS (ID)	Direct variable, fixed direct, indirect costs	B	Variation in defining costs, single hospital
Lefrant et al., 2015	Micro Costing	NS (SD)	Human resource, administrative and patient dependent expenses	B	Patient samples may not be representative
Shweta et al., 2013	Micro Costing	NS (ID)	Fixed and variables	B	Single hospital, small sample, limited period of evaluation
Prinja et al., 2013	Micro Costing	NS (SD)	Capital and recurrent resources	B	Not analyze incremental cost and indirect as productivity losses, transportation costs
Geitona et al., 2010	Macro Costing	NS (SD)	Direct costs	B	Single hospital, results may not be generalized
McLaughlin et al., 2009	Micro Costing	NS (ID)	Capital costs (fixed costs), semi-fixed and marginal	B	Support services apportionment, sample.
Geitona et al., 2007	Micro Costing	NS (SD)	Variable costs	A	Mean cost was underestimated, not was include costs for depreciation
Moerer et al., 2007	Micro Costing	NS (SD)	Variable fixed costs	B	Total patient cost not identification. Cost catalogue based on average ICU values
Jacobs et al., 2001	NS	ABC	NS	C	not available
Parikh et al., 1999	NS	NS (ID)	NS	C	not available
Garcıa et al., 1997	NS	NS (SD)	Fixed and variable costs	B	Results are not extrapolated to other units

Abbreviations: NS-not stated, ID-Insufficient details, SD-Sufficient details.
* It is identified whether the authors have indicated the type of approach as top-down/bottom-up and whether they present sufficient details of how each cost component was calculated.

Table 4
Results according total cost, cost per day, non-patients and patients related costs (block costs) category driving total costs.

Article	Mean total cost (median)	Cost per day (median)	Non-patient related costs			Patient-related costs			Category driving total costs
			Block 1	Block 2	Block 3*	Block 4	Block 5	Block 6*	
Peter et al., 2016	US$2,818 (1,958)	US$255 (n.a.)	[a]23% (not delineated)			77% (not delineated)			n.a.
Khandelwal et al., 2016	US$39,300 (24,100)	US$7,700 (6,100)	38% (not delineated)		1,9%	NI	20,4%	39,3%	Staff (39,8%)
Lefrant et al., 2015	n.a.	€1,425 (1,263)	22% (not delineated)		19%	16%	19%	24%	Staff (42,5%)
Shweta et al., 2013	US$2,081.10 (n.a.)	US$222 (n.a.)	[b]24,1% (not delineated)		n.a.	8,9%	36%	31%	Staff (37%)
Prinja et al., 2013	US$113,1 (n.a.)	US$ 20,2 (n.a.)	11,9%	10,6%	5,7%	[c] Included	9%	62,7%	Staff 62,7%
Geitona et al., 2010	€16,516 (n.a.)	n.a.	NI	25,2% (not delineated)		10,2%	35,7%	28,9%	Staff (28,9%)
McLaughlin et al., 2009	n.a. (€10,916)	n.a. (€2205)	NI	NI	1,4%	20%	32,3%	46,4%	Staff (46,4%)
Geitona et al., 2007	€5.845 (n.a.)	n.a.	NI	3,1%	[d]Included	22,7%	14,2%	59,9%	Staff (59,9%)
Moerer et al., 2007	n.a.	€791 (n.a.)	NI	NI	NI	21%	22%	56%	Staff (56%)
Jacobs et al., 2001	n.a.	£703 (578)	NI	NI	NI	Included (not delineated)			n.a.
Parikh et al., 1999	US$ 487 (n.a.)	US$ 57 (n.a.)	Included (not delineated)			Included (not delineated)			n.a.
Garcıa et al., 1997	US$825	n.a.	3,2%	6,8%	1,1%	9,5%	17%	62,5%	Staff (62,4%)

Abbreviations: n.a. = not available, NI – Not included. Notes: Block 1 – Capital equipment, Block 2 – States, Block 3 – non-clinical support services, Block 4 – clinical support services, Block 5 – Consumables, Block 6 – Staff, * block 3 and 6 include staff.
[a] Considered as indirect costs and direct nonmedical (travel, food, accommodation, communication, lost wages).
[b] Approximate, missing details of some variables for the calculate.
[c] Included in block 6.
[d] Included in block 2.

found that several studies used a mixed approach. In this way the costs can be defined as patient-specific costs and non-patient-specific. We used a cost-block method to describe categories of cost, and although this method made grouping of cost categories across studies feasible, we still encountered difficulties since each study included different cost categories. This obstacle is in accordance with observations by Negrini et al. (2004), who highlight the differences in inclusion/exclusion criteria of some costs categories across studies as a significant limitation, as the costs do not represent the same cost components.

The identified studies exhibited a moderate to low level of transparency. Fukuda et al. (2011) mention that without clarifying the scope of costing, the readers would be unable to judge the potential applicability to their own analyses. Wheeler (2015) stresses that the lack of quality and transparency is a widespread problem. Thus, increasing cost transparency, as well as transparency of costing methods, will alleviate the information asymmetries that exist in health care today. To address this gap, initiatives are being developed, as, for example, the systematic review still in development by Xu et al. (2014) with the objective of reporting micro-costing studies with specific guidelines and checklists. Xu et al. (2014) state that standardizing the methods and techniques for conducting and reporting a micro-costing analysis is important. The quality and transparency of individual studies will be enhanced, and comparability across studies and interpretation of findings will improve to help inform clinical and health policy decision-making about resource allocation in the long run.

There is a wide variation of cost of ICU patients in different countries, which can be in part attributed to the costing methodology (Tan et al., 2012), staff-to-patient ratio (Csomós et al., 2005), type of patient (Hsu and Brazelton, 2015), length of stay, the admission diagnosis, the need for mechanical ventilation, the need for continuous hemodialysis and severity score (Karabatsou et al., 2016).

Cost experts have proposed several approaches to reduce the cost discrepancies attributed to costing methodologies including: a) use of standardized costing methodologies on the basis of the availability of direct cost data, either with a bottom-up or top down approach (Tan et al., 2012), and b) approaching costs in blocks with the top-down costing method (Negrini et al., 2006).

In line with the findings of this review, others studies have identified the category of human resources as the most predominant in the composition of total cost per patient, with percentages ranging from 32% (Tan et al., 2008) to 67 to 77% (Alvear, Canteros and Rodríguez, 2010) and 73 to 85% (Alvear et al., 2013). Although in this review, it was not possible to identify the professional category with the greatest impact, some studies have broken down the costs of human resources, identifying the nursing staff category as having the greatest impact, ranging from 56% (McLaughlin et al., 2009) to 68% (Tan et al., 2008) of human resources costs. This is in part a consequence of official regulations prescribing minimum number of nurses per ICU bed (Moerer et al., 2007).

It is important to note that none of the included studies used specific instruments to analyze costs of nursing services. Towards this goal, Miranda and Jegers (2012) suggest the use of workload instruments, such the Nursing Activities Score (Miranda et al., 2003), as a tool to support bottom-up micro-costing methodologies.

Limitations

This integrative review of published reports on ICU costs has several limitations, mostly stemming from shortcomings of the studies included. Moreover, we only included healthcare and biomedical databases containing indexed journals, which excluded articles in economic/financial databases and grey literature. Although we conducted a systematic search, there were issues with article identification. Some of the retrieved articles did not use the keywords according to the database nomenclature, which may have limited the completeness of search outcomes.

Conclusion

Although valid methodologies to evaluate critical care patients' costs, such as micro-costing, are employed more frequently, a variety of non-standardized methods are still used for the analysis of cost components as well as for the evaluation of total costs. There is a pressing need to develop standardized guidelines for reporting of observational studies of cost in healthcare, with particular considerations for critical care. Future research needs to address the strategy used for the identification and evaluation of cost components. Standardized methods need to be developed in order to maximize transparency.

Appendix 1. Search strategy

Datebase		Result
CINAHL	Intensive Care OR critical care OR icu) AND (Cost* OR Econom*) Title – 1997–2018	444
PUBMED	(Intensive Care[ti] OR critical care [ti] OR icu [ti]) AND (Cost* [ti] OR econom*[ti]) Titulo, 1997-abril de 2018	671
EMBASE	(Intensive Care OR critical care OR icu) AND (Cost* OR Econom*) Title – 1997–2018	1037
LILACS	(Intensive Care OR critical care OR icu) AND (Cost* OR Econom*) Title, abstract, assunt – 1997–2018	601
	Total	2753
	After duplicates removed	1917

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.iccn.2019.07.005.

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