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Review Article

The Costs of Burn Victim Hospital Care around the World: A Systematic Review

Pamela Alejandra Escalante Saavedra [1,2], Jessica Vick De Oliveira Leal [3], Camila Alves Areda [2,3], Dayani Galato [1,2]

1. *Health Sciences and Technology Post-Graduate Program, University of Brasilia, Brasília, Distrito Federal, Brazil*
2. *Research Group on Access to and Responsible Use of Medications, University of Brasilia, Brasília, Distrito Federal, Brazil*
3. *Pharmacy Graduate, University of Brasilia, Brasília, Distrito Federal, Brazil*

***Corresponding Author:** Email: saavedra.pamela.alejandra@gmail.com

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Abstract

Background: Burn injuries are very common and fire-related burns account for over 300,000 deaths per year globally. The costs of the treatment of these patients change around the world. The aim of the present study was to conduct a systematic literature review to identify the costs related to hospital stays of burn victims in countries with different Human Development Index (HDIs).

Methods: PubMed, CINAHL and BVIS databases were searched using the following terms: "burn," treatment" and "costs". The review included articles that presented cost studies or economic assessments of burn victims in which the costs were reported, and published between 2012 and 2019. The quality of the evidence was assessed using the Consensus on Health Economic Criteria. This review presents register in Prospero (CRD42019137580).

Results: The review included 19 economic studies conducted in 13 countries, most with a very high HDIs. Most studies estimated direct acute burn care costs through bottom-up costing and institutional data. Total hospital care costs ranged from US$ 10.58 to US$ 125,597.86 per patient, the cost of 1% of total body surface area burned ranged from US$ 2.65 to US$ 11,245.04, and the cost of hospital care per day, from US$ 24.23 to US$ 4,125.50.

Conclusion: The costs are high and show wide discrepancies among countries. Medical costs and other losses caused by fatal and non-fatal burn injuries differ considerably among demographic groups, care protocols, and country HDIs.

Keywords: Burn; Injury; Burn units; Cost and costs analysis; Health care costs

Introduction

Globally, fire-related burns account for over 300,000 deaths per year (1). There has been a downward trend in burn incidence and length of hospital stays (2). The American Burn Association (ABA) reported 486,000 burn injuries in 2016 and it recognizes these data are underestimated, because some burns may have been treated solely at hospital clinics (3).

The early use of surgical procedures and enhanced antimicrobial therapy and care options have led to improved survival rates (4). There are several burn treatment protocols provided by health services, and they differ among countries, resulting in a wide variety of costs (5).

Hop et al (5) presented the mean of cost per burn patient in high-income countries was $88,218 (range $704-$717,306; median $44,024). However, limitations of their study included a lack of harmonization among the data analyzed and lack of assessing the articles' methodological quality. Furthermore, only one study from South America was included. Cost in countries with low to intermediate resources are limited and additional studies are needed to improve insight into burn care costs and efficiency in these contexts (5).

It is necessary to create initiatives to make data in economic evaluations clearer and more uniform. One such initiative was developed by Evers et al (6) who defined the Consensus Health Economic Criteria List (CHEC).

The costs of burn care can depend on other factors, such as the Human Development Index (HDI). The HDI compares indicators from countries in the areas of wealth, literacy, education, life expectancy at birth, birth rates and others, with the goal of assessing a populations' wellbeing (7).

Therefore, there are gaps in economic knowledge relative to burns, both in emerging and developing countries. The aim of the present study was to conduct a systematic literature review to identify the costs related to hospital stays of burn victims in countries with different HDIs.

Methods

This was a systematic literature review registered in International Prospective Register of Systematic Review (Prospero) under protocol CRD42019137580.

The review was conducted in the PubMed, CINAHL and BVS databases using the following MeSH terms: "burn," "treatment" and "cost" in all fields. The search was conducted in May 2019. Additionally, a time filter was applied to find publications between 2012 and 2018. The cutoff year of 2012 was defined based on a previous systematic review (5). In the present study, the following inclusion criteria were adopted: cost studies or economic evaluations of burn patient victims in which care costs were reported; and publications in English, Spanish or Portuguese. Technology comparison studies, reviews, reports and case series and letters to the editor were excluded.

The articles were selected in the following sequence: First, titles and abstracts obtained in the databases were reviewed. Additionally, the reference lists were verified to assess the inclusion of new pertinent articles. The complete texts of the eligible articles were reviewed to see whether they fit the inclusion criteria. The articles were selected by two independent researchers. Differences were resolved by consensus, and in case of divergence, the study was taken to the next phase of analysis.

For the selected articles, the following information was extracted: design; economic study perspective; method; and source of cost data. Additionally, patient clinical data were also recorded: sex and age; mean or interval of total burn surface area; type of treatment received (only acute care: admission up to 1st hospital discharge or including complete rehabilitation: also includes readmissions for reconstructive surgeries); length of stay; and percentage of hospital mortality. Furthermore, the researchers recorded the total cost of treatment per burn patient, cost of 1% of total body surface area burned, and cost of hospital care per day, when available. In articles where this information was missing but there was data that allowed for its estimate, the mean cost of 1% of the total surface area burned and the cost of hospital care per day were calculated. The results were summarized using measures of central tendency (mean and median) and dispersion (standard deviation).

To allow for the comparison of costs among the different studies, all values were converted into US dollars using the exchange rate in the original

study's year of publication, using a conversion tool (8).

The countries were classified according to the Human Development Index (HDI), countries are classified according to four tiers: very high (0.800 or more); high (0.700-0.799); medium (0.550-0.699); and low (less than 0.550) (7) human development.

The Consensus on Health Economic Criteria (CHEC) proposed by Evers et al (6), was used to assess the quality of the economic methods used in the studies. The maximum possible score was 20, meaning that all the information requested by the CHEC is present. When the study did not present enough details regarding a specific characteristic, it was not scored. The results of the instrument were not used for elimination purposes; however, they indicated the completeness of the assessed economic criteria.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was adopted to present this study.

Results

The search yielded 553 articles within the defined period (2012-2019 May). After analyzing the titles and abstracts and then reading the articles in full, 19 articles were chosen for this review (9-27) (Fig. 1).

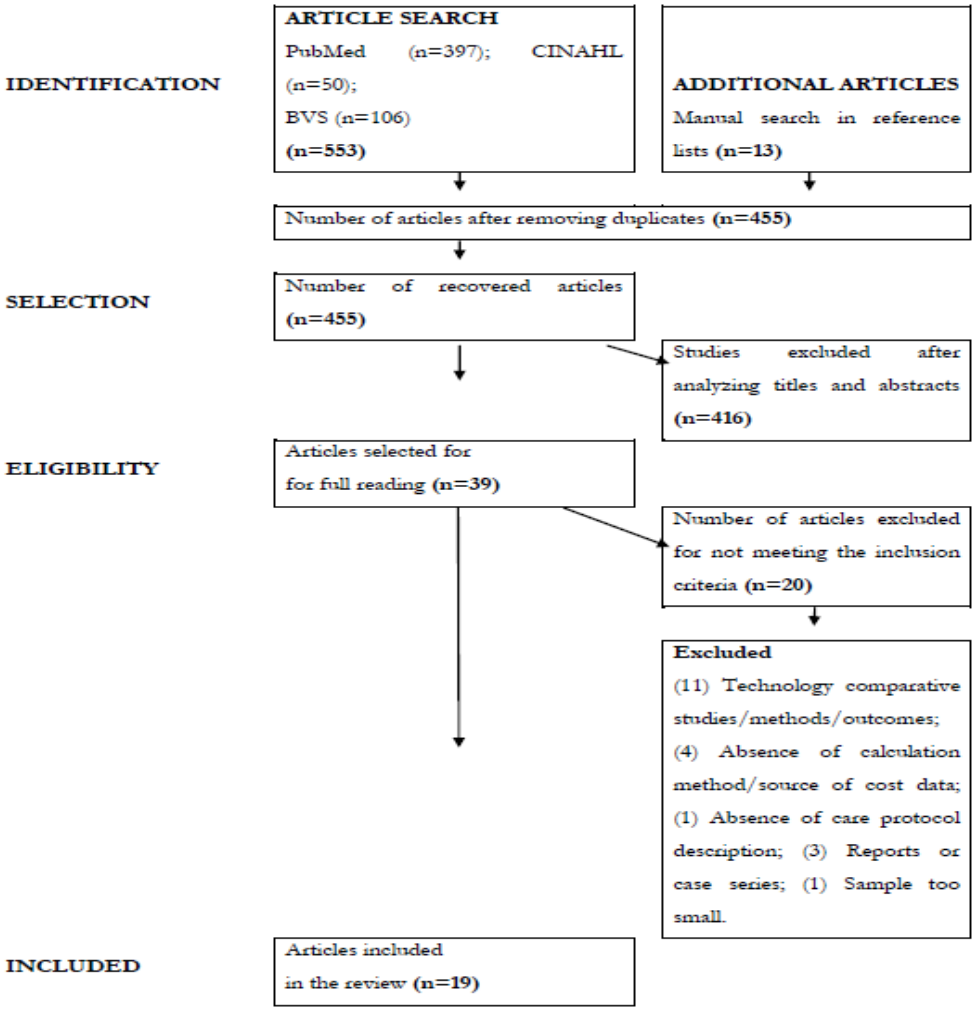

Fig. 1: Flow chart with different phases of the selection of articles to be included in the review

Most of the studies scored moderately on the CHEC checklist and analyzed costs of burn care from the perspective of the health service (hospital) within a two-year time frame is presented on Table 1 with other information about these studies.

The characteristics of patients and hospital stays are presented on Table 2.

The results of HDI from UNDP classification is presented on Table 3 with other information about costs.

Table 1: Characteristics of studies included: Objective, economic method and completeness

Author (year)	*Study period*	*Design*	*Analyzed hospital treatment*	*Economic method*	*Cost data source*	*Application of the CHEC (Max 20)*
Ahn CS et al. (2012)	2008	Retrospective	From admission to first discharge	Bottom-up	Purchasing department (public hospital system)	7
Seah et al. (2018)	Jul 2002 to Jun 2012	Retrospective	(...)	Top-down	Database	14
Hop et al. (2016)	Aug 2011 to Jul 2012	Prospective	From admission to first discharge and reconstructive surgeries*	Bottom-up (direct health-related costs + direct non-health-related costs + indirect costs)	Hospital financial department (patient records and questionnaire applied three months after the burn occurred)	16
Mushin et al. (2018)	Jul 2011 to Jun 2015	Retrospective	(...)	Bottom-up	Hospital financial department	12
George et al. (2016)	Jan 2011 to Dec 2011	Retrospective	From admission to first discharge**	Bottom-up (predetermined fees)	Hospital financial department (NHS)	11
Jeevan et al. (2014)	Jan 2006 to Dec 2010	Retrospective	From admission to first discharge	Bottom-up	Hospital financial department (NHS)	14
Haikonen et al. (2014)	Jan 1999 to Dec 2009	Retrospective	From admission to first discharge and reconstructive surgeries	Perfect costing methodology	Database and hospital financial department	11
Santos et al. (2016)	2000 to 2013	Retrospective	(...)	Top-down	Database	15
Karimi et al. (2015)	Mar 2009 to Mar 2011	Prospective	(...)	Bottom-up	Hospital financial department	11
Latifi et al. (2017)	Mar 2012 to Mar 2015	Prospective	From admission to first discharge and reconstructive surgeries	Bottom-up	Database and hospital financial department	12

Emami et al. (2016)	Mar 2009 to Mar 2011	Prospective	From admission to first discharge	Bottom-up	Database and hospital financial department	6
Arslan et al. (2013)	Aug 2008 to Oct 2011	Retrospective	From admission to first discharge	Bottom-up	List of prices of the institution (sponsored by the Social Security Ministry); treatment is paid by the insurance company	11
Eser et al. (2016)	Jan 2012 to Dec 2014	Retrospective	Emergency department	Bottom-up	Hospital financial department	10
Anami et al. (2017)	May 2011 to May 2013	Prospective	From admission to transfer to the nursing ward	Bottom-up	Public price lists (CBHPM and Brasíndice price)	12
Santos et al. (2017)	2000 to 2014	Retrospective	(...)	Top-down	Database	15
Ter Meulen et al. (2016)	Oct 2013 to Sep 2014	Retrospective	From admission to first discharge	Bottom-up	Hospital financial department	17
Ahuja et al. (2013)	2011	Retrospective (6 months) and prospective (6 months)	From admission to first discharge	Bottom-up	Financial department and 50% from salaries (public) and laboratories and blood blanks (private)	8
Gallaher et al. (2015)	Jun 2011 to Aug 2014	Retrospective	From admission to first discharge	Bottom-up (activity-based costing)	Purchasing department (public hospital system)	15
Kao et al. (2018)	2015	Retrospective	From admission to first discharge	Bottom-up	Hospital financial department	13

Note. CHEC Consensus Health Economic Criteria List (Evers et al, 2005). NHS: National Health Service in the United Kingdom. CBHPM: Hierarchical Brazilian Classification of Medical Procedures. (...) Not available

Table 2: Patients, trauma and hospitalization characteristics

Author (yr)	***Sample (n) Patients***	***Gender (percentage of men)***	***Age***	***TBSA (%)***	***Stay of length (days)***	***Hospital mortality***
Ahn CS et al. (2012)	20 Adult	65.0%	Average: 40.5 yr (range: 18 to 84)	Average: 19.5%	(...)	Deaths excluded from the study
Seah et al. (2018)	25,098 Pediatric	65.5 per 100,000 people	(...)	96.4% of the children <1 year old had <10% TBSA and 2.0% had >10% TBSA;	Average: 2.5 d (SD: ± 3.6) in patients <1 year old; 2.9 d	0.04%

				94.3% in the age group from 1 to 5 yr old had <10% TBSA and 2.6% had >10% TBSA; 95.2% in the age group from 6 to 10 yr old had <10% TBSA and 2.6% had >10% TBSA; 94.1% in the age group from 11 to 16 yr old had <10% TBSA and 3.1% >10% TBSA	(SD: ± 4.4) in patients between 1 and 5 yr old; 3.1 d (SD: ± 4.5) in patients between 6 and 10 years old; 3.4 d (SD: ± 4.9) in patients between 11 and 16 yr old	
Hop et al. (2016)	249 Adult and pediatric	64.3%	Average: 29 yr (range: 0 to 91)	Average: 8% (range: 0.2% to 95%); 54.6% of the patients had from 0% to 5% TBSA; 26.1% had from 6% to 10% TBSA; 13.3% had from 11% to 20% TBSA; 6.0% had more than 20% TBSA	Average: 12.2 d (range: 0 to 92 days)	Deaths excluded from the study
Mushin et al. (2018)	34 Adult, self-inflicted	47.0%	Average: 31.0 yr (SD: ± 15.2)	Average: 2.80% (SD: ± 14)	Average: 11 d (SD: ± 23)	0
George et al. (2016)	21 Adult, self-inflicted	47.6%	Average: 37.4 yr (SD: ± 15.7); median: 38 yr (IQR: 26.5)	Average: 13% (SD: ± 23.6%; range: from 0.25% to 80%); median: 0.5% (IQR: 18.25%) 23.8% of the patients had an average TBSA of 53.2% (SD: ± 15.3%; range: 35% to 80%; median: 48%; IQR: 13%) and 76.2% had an average TBSA of 0.5% (SD: ± 0.5%; range: 1.25% to 2%; median: 0.5%; IQR: 1.75%)	Average: 51.8 d (range: 1 to 147 d)	12.5%
Jeevan et al. (2014)	1,075 (incidence) and 262 (costs) Adult	2.6:1	Average: 44.1 yr (range: 16.1 to 94.3)	Average: 6.2% (range: 0.01% to 95%)	Average: 7.7 d (range: 0 to 342 d) for survivors; 9.8 d (range: 0 to 64 d) for those who died	4.1%
Haikonen et al. (2014)	2,723 (incidence) and 168 (costs) Adult and	74.0%	Men: average 41 yr (median: 41; range: 0 to 97);	44 patients with 0% to 5% TBSA; 31 with 5% to 10% TBSA; 41 with 10% to 20% TBSA;	(...)	6.0%

	pediatric		women: average 50 years (median: 51; range: 0 to 97)	25 with 20% to 30% TBSA; 9 with 30% to 40% TBSA; 10 with 40% to 50% TBSA; 8 with 50% TBSA or more		
Santos et al. (2016)	26,447 Adult	58.0% (1.38:1)	Average: 38.3 yr (SD: ± 27.8); median: 38 years	Average: 11% TBSA (median: 5% TBSA); in survivors, the average was 10% TBSA (median: 5%); in those who died, the average was 37% TBSA (median: 35%)	Average: 16 d; median: 9 d	4.4%
Karimi et al. (2015)	1,721 Adult and pediatric	63.0%	34.9% in the group were from 0 to 15 yr old; 60.7% were from 15 to 64 yr old; 4.5% were 65 yr old or older	Average: 17.3%	Average: 14.4 d (SD: ± 10.9) (range: 0 to 64 d)	5.9%
Author (year)	Sample (n) Patients	Gender (percentage of men)	Age	TBSA (%)	Stay of length (days)	Hospital mortality
Latifi et al. (2017)	912 Adult and pediatric	71.1%	18.6% in the group were from 0 to 15 yr old; 77.6% were from 15 to 64 yr old; 3.7% were 65 yr old or older	38.8% of the patients had less than 10% TBSA; 29.1% had from 11% to 22% TBSA; 32.1% had more than 23% TBSA	Average: 14.1 d (range: 0 to 64 d)	5.9%
Emami et al. (2016)	187 Geriatric (> 55 yr old)	69.0%	Average: 63.4 yr (SD: ± 8.1); median: 64 yr (IQR: 51 to 72)	Average: 20.3% (SD: ± 8.4%)	Average: 19.5 d (range: 3 to 59 d)	12.8%
Arslan et al. (2013)	950 Adult and pediatric	62.1%	Average: 30.5 yr (SD: ± 22.5) (range: 0 to 94)	Average: 14.0% (5 to 50); range: 1% to 85%	Average: 13 d (range: 3 to 45 d); minimum of 2 and maximum of 95 d	2.0%
Eser et	264	32.2%	81% of the	94.7% of the patients had	(...)	0.4%

al. (2016)	(...)		patients <50 years old; 19% >50 years old	less than 10% TBSA; 5.3% had more than 10% TBSA		
Anami et al. (2017)	180 Adult	72.8%	Median: 40 yr (IQR: 30.0 to 53.8)	Average: 27.9% (SE: ± 1.3%)	Median: 23.0 d (IQR: 14 to 34)	5.6% (<11% TBSA); 92.3% (>60% TBSA)
Santos et al. (2017)	27,503 Adult and pediatric	62.1% (1.64:1)	Average: 24.8 yr (SD: ± 21.2); median: 22 yr	(...)	Median: 5 d	8.1% (2009 to 2014)
Ter Meulen et al. (2016)	884 Pediatric	56%	75% of the patients <4 years old; 25% >4 yr old	Average: 8%; 77% of the patients had from 1% to 10% TBSA; 18% had from 11% to 22% TBSA; 3% had from 21% to 30% TBSA; 2% had more than 30% TBSA	Average: 5.6 d (SD: ± 10.0) (range: 0 to 137 d)	Deaths excluded from the study
Ahuja et al. (2013)	797 Adult and pediatric	54.9%	Average: 23.04 yr (range: 18 d to 83 yr)	Average: 42.2% (range: 2% to 100%)	Average: 7.86 d (range: 1 to 62 d)	32.3%
Gallaher et al. (2015)	905 Pediatric	55%	Median: 3 yr (IQR: 2 to 10) with 80% <18 yr old	Average: 17.9% (SD: ± 15.3); median: 15% (IQR: 8% to 23%)	Average: 23.1 d (SD: ± 30.3); median: 12 d (IQR: 6 to 30)	(...)
Kao et al. (2018)	52 Adult	46.2%	Average: 22.2 yr (SD: ± 4.6) (range: 15 to 38)	Average: 44.6% (SD: ± 20.3)	Average: 65.9 d (SD: ± 5.4)	3.8%

TBSA: Total burn surface area. SD: Standard deviation. IQR: Interquartile range. SE: Standard error of the mean. (...) not available

Table 3: Cost (total and by stratum) of hospital treatment of burn victims according to the Human Development Index (HDI) of the analyzed countries

Authors (year)	***Country HDI***	****Average treatment total cost (USD)***	****Average 1% TBSA cost (USD)***	****Average hospital daily rate cost (USD)***
Ahn CS et al. (2012)	0.939 (very high)	US$ 125,597.86	[a]US$ 6,442.85	[a]US$ 3,818.92
Seah et al.	0.939	[a]US$ 3,354.12 (<1 year	(...)	(...)

(2018)	(very high)	old); US$ 4,489.91 (1 to 5 yr old); US$ 5,450 (6 to 10 yr old); US$ 6,485.91 (11 to 16 yr old)		
Hop et al. (2016)	0.924 (very high)	[a]US$ 29,671.72	[a]US$ 3,708.96	[a]US$ 2,452.11
Mushin et al. (2018)	0.920 (very high)	$ 31,486.12	$ 11,245.04	$ 2,862.37
George et al. (2016)	0.909 (very high)	[a]US$ 98,556.53	[a]US$ 7,581.26	[a]US$ 4,125.50
Jeevan et al. (2014)	0.909 (very high)	[a]US$ 8,851.62	[a]US$ 1,427.66	[a]US$ 1,148.58
Haikonen et al. (2014)	0.895 (very high)	[a]US$ 30,768.66 for first admission and US$ 33,398.46 including re-constructive surgeries	[a]US$ 3,313.20	(...)
Santos et al. (2016)	0.843 (very high)	[a]US$ 11,473	[a]US$ 1,166.07	[a]US$ 717.06
Karimi et al. (2015)	0.774 (high)	[a]US$ 2,810	[a]US$ 380.24	US$ 195
Latifi et al. (2017)	0.774 (high)	[a]US$ 2,766	(...)	[a]US$ 196.17
Emami et al. (2016)	0.774 (high)	$ 7,450	$ 366.99	$ 382.05
Arslan et al. (2013)	0.767 (high)	[a]US$ 651.48	[a]US$ 46.32	[a]US$ 49.68
Eser et al. (2016)	0.767 (high)	[a]US$ 6.64 and US$ 212.77 (conventional treatment) US$ 10.58 and US$ 529.91 (surgical treat-ment)	(...)	(...)
Anami et al. (2017)	0.754 (high)	[a]US$ 39,594.90	[a]US$ 1,419.17	US$ 1,330.48
Santos et al. (2017)	0.754 (high)	[a]US$ 646.72	(...)	(...)
Ter Meulen et al. (2016)	0.666 (me-dium)	[a]US$ 1,058.25	[a]US$ 132.28	[a]US$ 190.99
Ahuja et al. (2013)	0.624 (me-dium)	[a]US$ 1,060.52 (2013)	[a]US$ 25.13	US$ 134.96
Gallaher et al. (2015)	0.476 (low)	[a]US$ 559.85	[a]US$ 2.65	[a]US$ 24.23
Kao et al. (2018)	(...)	[a]US$ 50,415	[a]US$ 1,035	[a]US$ 765.02

HDI: Human Development Index. *Values converted into US dollars by the authors. [a] Data calculated by the authors. Calculated as the ratio between the average total body surface area and treatment total cost. Calculated as the ratio between hospital stay length and the average treatment total cost. (...) not available

Discussion

In the present review, the mean cost of treatment per patient ranged from US$ 10.58 (21) to US$ 125,597.86 (9), the cost of 1% of total body surface area burned from US$ 2.65 (26) to US$ 11,245.04 (12), and the cost of hospital treatment per day, from US$ 24.23 (26) to US$ 4,125.50 (13). Most countries had high and very high HDI. Most took place in hospitals and used a retrospective design. The studies estimated direct costs, which were extracted mostly using bottom-up methods, including primarily acute care costs.

Even though WHO has shown that most burn victims are in low-income or developing countries, the research is concentrated primarily in developed countries, a fact confirmed in the present review. Knowledge about the true extent of the problem is hindered by the scarcity of data (28).

Incidentally, differences in costs can be explained by the different care protocols adopted (such as not conducting early surgical procedures) and technologies used (different types of dressings), in addition to infrastructure, important elements that influence the cost of care. Furthermore, patient and injury characteristics can also influence costs.

Fatal injuries have a profound effect on society in general, and costs of care provided (1). The present review found one Brazilian study carried out with ICU patients (22) in which the elevated mean cost per surviving patient was lower than non-surviving patient.

Cost of care obtained using the bottom-up method was higher than that obtained through top-down costing. Even considering possible differences that may exist in the profile of burns and care protocols, the discrepancy in these findings can be partially explained by the economic methodology employed. The bottom-up costing method identifies the components and procedures carried out with inpatients in great detail in retrospective or prospective cohorts. The top-down method uses groups of patients with aggregated data extracted from national registries (29, 30). Thus, the present review confirms that costs calculated based on data disaggregation (top-down costing) can be lower than those calculated using bottom-up methods (31, 32).

Regarding the components of costs included by the studies, most of the time, only acute care was analyzed (direct care costs). The costs of this important stage of treatment have been neglected, probably because of the difficulties involved in non-care (indirect and/or intangible) cost studies, which require considerable human, financial and time resources. Rehabilitation strongly impacts the costs of burn care and should not be underestimated (33, 34). In Brazil, there are few studies that evaluate the costs of burn care in hospitals (22, 35).

Analyzing the costs obtained by studies that focused on burn care from admission up to first hospital discharge, considering 1% of TBSA and the cost of hospital care per day, showed very different results. In the present review, the cost of care was not influenced just by the TBSA; greater or less need for intensive care and surgical procedures that prolong length of hospital stay also affected the direct costs of hospitalization. Ethnicity, gender, burn depth, presence of inhalation injury and burn mechanism (36) prolonged hospital stays and can significantly alter treatment costs.

Actions and costs were described for a mass casualty incident that caused a surge in patients with severe burns in hospitals, in which the mean total cost of care was elevated (27). These authors highlighted the importance of the response capacity of emergency services and hospitals in mass casualty incidents involving patients with severe burns. The situations reported showed that planning, being prepared to identify the maximum capacity of local burn centers, and referrals to other centers could help improve response in catastrophic conditions.

One limitation of the present review is that the comparisons were limited by the fact that the studies were carried out in specialized units. Furthermore, most of the authors carried out cost

studies, not complete economic evaluations. This can explain the results according to the CHEC instrument. This helps improve the reliability and validity of this and other studies for decision-makers (37).

According to the Agency for Healthcare Research and Quality of the Department of Health and Human Services of the United States, there are still differences regarding: (i) the criteria for judging that an economic evaluation is of sufficiently high quality to be useful; (ii the importance of different aspects of the evaluation; and (iii) the extent to which high quality with respect to one aspect of an evaluation can compensate for lower quality with respect to another aspect of the evaluation (37).

Furthermore, the present review did not allow for the calculation of indirect costs such as lost wages, prolonged care for deformities, emotional trauma, and commitment of family resources, factors that contribute to socioeconomic impact (30). Other social costs, including those associated with law enforcement, as well as the pain and suffering of family members, were not considered (38).

Conclusion

Hospital care costs of burn victims are high and show wide discrepancies among countries. Medical costs and other losses caused by fatal and non-fatal burn injuries differ considerably among demographic groups, care protocols, and country HDIs.

Differences in the economic methodologies employed greatly influence the cost estimates identified. There were substantial differences in the estimated costs of burn care when using disaggregated secondary data and when using the bottom-up method.

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Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

Conflict of interest

The authors declare that there is no conflict of interest.

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