COST OF HEALTHCARE PRODUCTS PROCESSING: AN INTEGRATIVE REVIEW

Custo de processamento de produtos para saúde: uma revisão integrativa

Costo de procesamiento de productos de salud: una revisión integrativa

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ABSTRACT: Objective: To analyze the knowledge produced in the last decade on hospital costs related to the processing of reusable healthcare products (HP) performed in Sterile Processing Departments (SPD) and processing companies. **Method:** Integrative literature review, with searches in the following databases: Cumulative Index to Nursing and Allied Health Literature (CINAHL), Medical Literature Analysis and Retrieval System Online (MEDLINE), Latin American and Caribbean Health Sciences Literature (LILACS), Scopus, and Scientific Electronic Library Online (SciELO). The selected articles were published between 2009 and April 2019. The initial search resulted in 782 articles and, after applying the inclusion and exclusion criteria, the final sample consisted of 15 studies, which were analyzed in full. **Results:** Authors of most studies compared the cost of different technologies employed in the processing of HP to achieve savings, or evaluated the reduction of waste-related expenditures, mainly with the reduction of the size of surgery trays to reduce the processing cost. **Conclusion:** The processing of HP proved to be a measure that promotes economy when properly selecting the technologies involved in the process and avoiding waste.
Keywords: Hospital costs. Health management. Economics, nursing. Sterilization.

RESUMO: Objetivo: Analisar o conhecimento produzido na última década sobre custos hospitalares relacionados ao processamento de produtos para saúde (PPS) reutilizáveis em Centros de Material e Esterilização (CME) e empresas processadoras. **Método:** Revisão integrativa da literatura, com buscas nas bases de dados Cumulative Index to Nursing and Allied Health Literature (CINAHL), Medical Literature Analysis and Retrieval System On-line (MEDLINE), Literatura Latino-Americana e do Caribe em Ciências da Saúde (LILACS), Scopus e Scientific Electronic Library Online (SciELO). Os artigos selecionados foram publicados entre 2009 e abril de 2019. A busca inicial resultou em 782 artigos e, após a aplicação dos critérios de inclusão e exclusão, a amostra final compôs-se de 15 estudos, que foram analisados na íntegra. **Resultados:** A maioria dos trabalhos comparou o custo de diferentes tecnologias empregadas no processamento de PPS para obter economia, ou avaliou a redução de gastos com desperdício, principalmente com a diminuição do tamanho de bandejas cirúrgicas para redução de custo com o processo. **Conclusão:** O processamento de PPS mostrou ser medida que gera economia quando se selecionam adequadamente as tecnologias envolvidas no processo e se evitam os desperdícios.
Palavras-chave: Custos hospitalares. Gestão em saúde. Economia da enfermagem. Esterilização.

RESUMEN: Objetivo: Analizar el conocimiento producido, en la última década, sobre los costos hospitalarios relacionados con el procesamiento de productos de salud (PS) reutilizables en los Centros de Materiales y Esterilización (CME) y las empresas de procesamiento. **Método:** revisión integral de la literatura, búsqueda en las bases de datos CINAHL, MEDLINE, LILACS, SCOPUS y SciELO. Los artículos seleccionados se publicaron entre 2009 y abril de 2019. La búsqueda inicial resultó en 782 artículos y, después de aplicar los criterios de inclusión y exclusión, la muestra final consistió en 15 estudios, que se analizaron en su totalidad. **Resultados:** La mayoría de los estudios compararon el costo de diferentes tecnologías utilizadas en el procesamiento de PS para obtener ahorros o evaluaron la reducción de los gastos de residuos, principalmente con la reducción del tamaño de las bandejas quirúrgicas, para reducir el costo del proceso. **Conclusión:** El procesamiento de PS demostró ser una medida que genera ahorros, cuando las tecnologías involucradas en el proceso se seleccionan adecuadamente y se evitan los desperdicios.
Palabras clave: Costos de hospital. Gestión en salud. Economía de la enfermería. Esterilización.

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INTRODUCTION

The Sterile Processing Department (SPD) is an integral part of the hospital complex, in addition to being inherent, indispensable, and vital to the healthcare process. It is considered a technical support unit, whose purpose is to provide properly-processed healthcare products (HP) and safe conditions for attending sick and healthy individuals[1].

Considering the growing increase in healthcare costs, hospital institutions face a constant challenge, which makes it necessary for SPD professionals to acquire knowledge of concepts and techniques related to cost accounting as a tool for resource management[2].

Cost management is an administrative process, whose focus is to make decisions in order to distribute the available resources in a rational and efficient way. In addition, the aim of this process is to achieve results that meet the purposes of the institution, based on the knowledge of economic analysis, which allows making more assertive decisions[3].

Waste in the healthcare field aggravates the existing financial difficulties due to scarcity of resources, and is characterized by unnecessary expenditures, by the use of the available resources in an uncontrolled, irrational, and inconsequential way in the production of processes, products, or procedures for assisting the patients[4].

Thus, at this moment, nurses must have knowledge of hospital costs and thoroughly master the activities that compose the developed work processes, in such a way to improve those that add value to the final product and to eliminate the unnecessary ones, without damages to the quality of the processing result[5].

Although reducing costs in healthcare services is a difficult task due to the nature of the care provided, healthcare decisions, combined with economic principles, gain more and more prominence when considering the disparity between resources and the growing demands of the population[6].

Thus, the relevance of the SPD for healthcare quality and costs is highlighted. It is necessary to reflect and economically analyze the costs of HP processed in SPD or in processing companies, in order to outline the planning and decision-making by the nurse manager.

OBJECTIVE

To analyze the knowledge produced in the last decade on hospital costs related to the processing of reusable HP performed in SPD and processing companies.

METHOD

This is an integrative literature review study, which was conducted aiming at gathering and synthesizing studies related to the investigated theme. This type of review defines the current knowledge on a specific topic, since it is performed to identify, analyze, and synthesize results from independent publications on the same subject[7].

In order to confer scientific criticality to this study, such steps were followed: identification of the research problem or question; literature search, which included the definition of inclusion and exclusion criteria of the articles; data evaluation to define information to be extracted from the selected articles; critical analysis of the included studies; and presentation of the integrative review[8].

Our guiding question was: what is the knowledge produced, according to the literature, on hospital costs related to the processing of reusable healthcare products in SPD and processing companies?

The bibliographic survey was conducted in April 2019 and carried out on the following databases: Cumulative Index to Nursing and Allied Health Literature (CINAHL), based on the EBSCOhost research platform; Medical Literature Analysis and Retrieval System Online (MEDLINE), based on the PubMed platform; Latin American and Caribbean Health Sciences Literature (LILACS); Scopus, from Elsevier; and Scientific Electronic Library Online (SciELO).

Descriptors chosen to conduct the search consisted in terms included in the Health Sciences Descriptors (DeCS) and in the Medical Subject Headings (MeSH) — in Portuguese, Spanish, and English languages — namely: *administração de materiais no hospital/administración de materiales de hospital/materials management, hospital*; *esterilização/esterilización/sterilization; custos e análise de custo/costos y análisis de costo/costs and cost analysis;* and *economia da enfermagem/economía de la enfermería/economics, nursing.*

Descriptors were crossed using the Boolean operator "AND" in the following combinations: *materials management, hospital AND sterilization; materials management, hospital AND costs and cost analysis; sterilization AND costs and cost analysis; sterilization AND economics, nursing*. Filters available in the full text and in the Portuguese, English, and Spanish languages were employed.

Articles of the sample consisted in those published in the last 10 years, between 2009 and April 2019, which were

available at no cost, full text, in English, Portuguese, and Spanish, and whose title and/or abstract referred to the theme. Literature reviews, letters, editorials, theses, dissertations, and monographs were excluded.

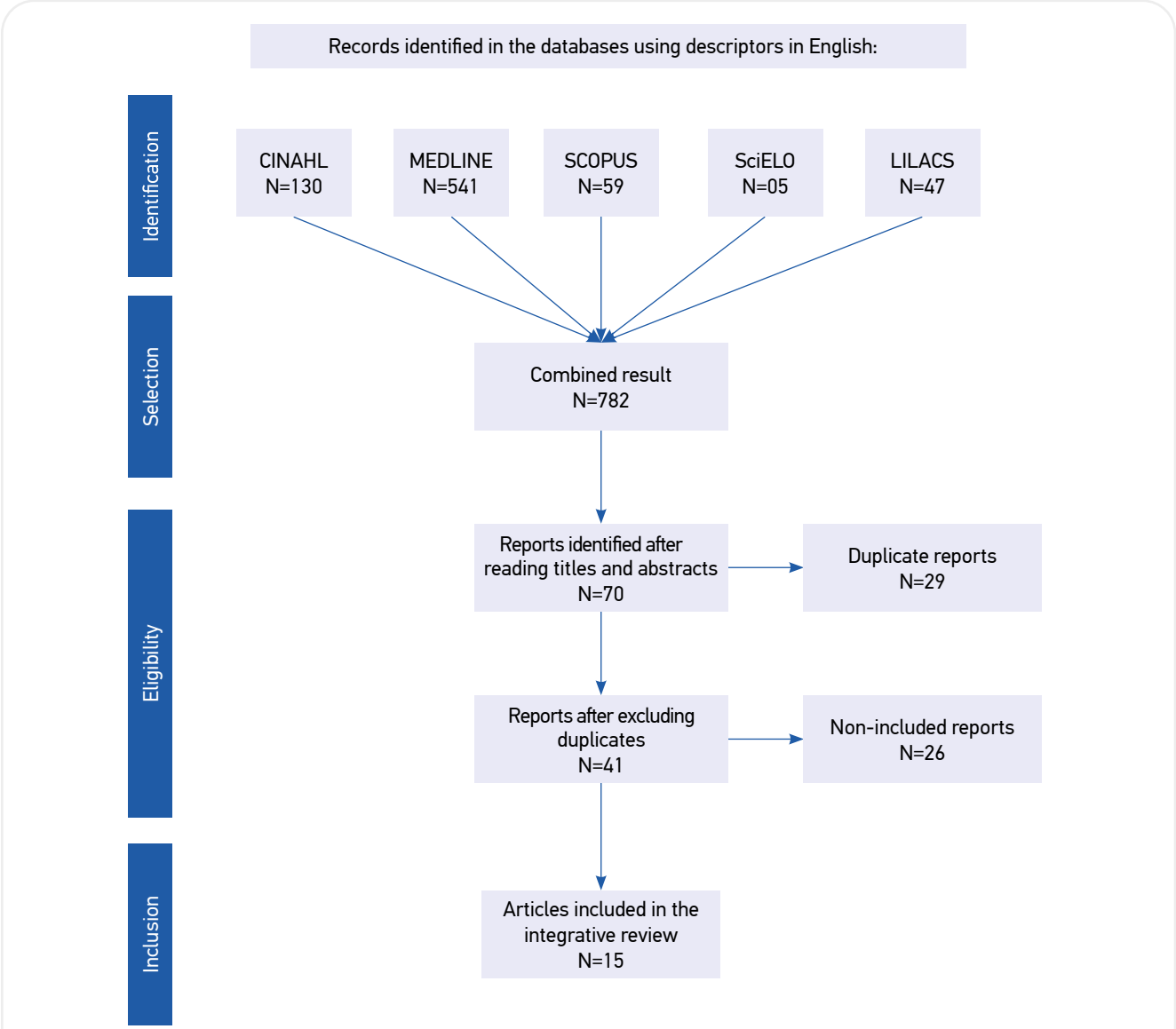
Initially, the title and/or abstract were analyzed, as demonstrated in Figure 1.

For data collection, an instrument adapted from the model validated by Ursi and Galvão[9] was used, which included the following items: identification of the original article, methodological characteristics of the study, evaluation of methodological rigor, studied interventions, and findings.

Data extracted from the studies included in the research were descriptively compiled in a previously-prepared chart, which included the following aspects: name of the article; authors and year of publication; objectives; results; conclusions. A descriptive synthesis of the collected data was carried out.

RESULTS

Of the 15 articles analyzed, 7 (46%) were selected from the MEDLINE database; 4 (27%), from LILACS; 3 (20%), from CINAHL; and 1



CINAHL: Cumulative Index to Nursing and Allied Health Literature; MEDLINE: Medical Literature Analysis and Retrieval System Online; SciELO: Scientific Electronic Library Online; LILACS: Latin American and Caribbean Health Sciences Literature

Figure 1. Selection process for inclusion of studies in the integrative review.

(7%), from Scopus. No article was linked to the SciELO database, since those found in such platform were repeated in other databases. Regarding the research locations, 7 (46%) were developed in the United States of America; 6 (40%), in Brazil; 1 (7%), in Germany; and 1 (7%), in Uganda. Of these, 9 (60%) articles were published in English, and 6 (40%) were published in Portuguese.

Based on the analysis of the selected articles, the studies were categorized into three themes: evaluation of costs of different technologies employed in HP processing; evaluation of waste reduction in HP processing; and comparison between the cost of reusable products and single-use ones. Each of these themes is presented in Charts 1, 2, and 3.

Chart 1. Evaluation of costs of different technologies employed in the processing of healthcare products.

Authors, year, country	Objective	Method	Results	Conclusions
Souza et al., 2015, Brazil[1]	To evaluate the application of the ABC costing system to the SPD of a public hospital.	Applied, descriptive, exploratory, case-study type of research.	Values of the cost objects were: disinfected product, BRL 3.03; sterilized product, BRL 6.05; light/single packaging, BRL 4.46; small box/clothing, BRL 6.34; and medium box/clothing, BRL 6.18. The large box accounted for BRL 14.16.	ABC costing is effective for evidence-based management practice in SPD.
Vital et al., 2016, Brazil[2]	To analyze the cost of packaging materials used in the SPD by the ABC method.	Descriptive, and observational study with documentary analysis.	A cotton fabric packaging cost, in a processing, from BRL 9.309 (40 × 40 cm) to BRL 13.517 (1.4 × 1.4 m). Values found for double-wrapping of surgical packaging materials ranged from BRL 1.45 (20 × 40 cm) to BRL 1.32 (20 × 50 cm, 30 × 30 cm, and 30 × 40 cm).	The use of surgical packaging materials is the most economical measure for the institution.
Krohn et al., 2019, Germany[10]	To assess the costs of four packaging alternatives, considering equal quality of sterility for the respective systems.	Analytical study. Statistical tests were applied and the *EasyFit Professiona* software, version 5.6, was used.	The sterile container without inner wrap proved to be the most economical option, at a price of 2.05 Euros. The option of two non-woven wraps proved to be more expensive, at a price of 3.87 Euros.	Different packaging alternatives for sterilization make difference in time and costs. Each SPD must analyze its own situation.
Stipanich et al., 2018, Brazil[11]	To compare the costs of different processes for supplying materials for respiratory therapy in a general hospital.	Observational study, with documentary review.	Purchasing permanent materials with sterilization in SPD-INST consisted in an expensive processing. The greatest difference in values was found in the manual resuscitator: BRL 1.10 (SPD-INST), BRL 1.98 (SPD-OUT), and BRL 26.70 (DM); and the slightest difference were found in the IMV circuits: BRL 1.77 (SPD-INST), BRL 5.52 (SPD-OUT), and R $ 7.04 (DM).	The supply process carried out in the SPD-INST proved to be more advantageous, with lower costs, in relation to sterilization in SPD-OUT and the purchase of DM.
McCreanor and Graves, 2017, United States of America[12]	To economically evaluate the sterilization of thermosensitive materials, mainly endoscopes, using low-temperature by hydrogen peroxide plasma instead of steam autoclave.	Analytical study using the Monte Carlo simulation.	Low-temperature sterilization is more expensive than steam; however, in the long-term, savings are achieved in the repair of instruments. Based on the model's calculations, these savings are likely to be in the range of USD 738,832 in a 10-year period.	Investments in low-temperature systems promote economy in the long-term by reducing the need for repairs of instruments.

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Chart 1. Continuação.

Authors, year, country	Objective	Method	Results	Conclusions
Jerico and Castilho, 2010, Brazil[13]	To identify the cost of disinfecting and sterilizing hospital devices.	Exploratory, descriptive, and case-study type of research. The ABM model was adopted.	Costs per processing cycle/load: Physical disinfection, BRL 12.63; chemical disinfection, BRL 9.95; LTSF sterilization, USD 255.28; and SSUP sterilization, USD 31.37. Cost per product group: thermosensitive semi-critical, USD 0.28, was the lowest value; and thermo-resistant critical instrumental, USD 1.75, was the highest value.	The application of ABM in the investigated SPD is feasible for cost management.

SPD: Sterilization Processing Department; SPD-INST: Institution's Sterilization Processing Department; SPD-OUT: Outsourced Sterilization Processing Department; DM: Disposable Material; IMV: Invasive Mechanical Ventilation; ABM: Activity-based management; ABC: Activity-based costing; LTSF: Low-temperature-steam-formaldehyde sterilization; SSUP: Saturated steam under pressure

Chart 2. Evaluation of waste reduction in the processing of healthcare products.

Authors, year, country	Objective	Method	Results	Conclusions
Nast and Swords, 2019, United States of America[14]	To reduce urology trays in such a way over 50% of the instruments will be used, leading to decrease in costs.	Prospective and analytical study. The Student's t-test was applied.	Authors found trays with a utilization percentage of 21.1% prior to the reduction, and which increased to 48.2% after reduction; and also trays with utilization percentage of 41.9%, prior to the reduction, and which increased to 71.7% after reduction. Savings from USD 7.48 to USD 70.18 per procedure were calculated.	The initiative to reduce the size of surgical trays proved to be an opportunity to reduce costs.
Cichos et al., 2017, United States of America[15]	To show the effect of standardization of surgical trays on the number of sterilized instruments and the impact on costs in a teaching hospital.	Case study, based on the Lean methodology.	The results ranged from trays that contained 79 instruments and decreased to 59 (75%), to trays that contained 113 instruments that decreased to 50 (44%). The estimated savings ranged from USD 55 for each video-assisted thoracoscopic surgery to USD 96 for each thoracotomy.	Reducing the processing of unused instruments reduces costs and the weight of trays, which may reduce the incidence of wet loads.
Isaacson et al., 2017, United States of America[16]	To characterize all aspects of resources used for decontamination and sterilization of reusable flexible ureteroscopes in order to propose cost reduction methods.	Prospective and observational study. The authors applied the ABC costing method.	The average total time of single processing was 229± 74.4 min, including 47.7 min in the endoscopy service, and 126.5± 55.7 min of drying. The total cost for reprocessing a ureteroscope was USD 96.13.	Although repair costs consist in the main option for cost reduction, the authors highlighted the drying technique, which can reduce the time and costs of reprocessing.
Van Meter and Adam, 2016, United States of America[17]	To identify and estimate the costs of sterilization of unused instruments in elective gynecological surgeries.	Analytical, observational study with secondary data collection. In the statistical analysis, the z-test was used for two ratios.	The percentage of used instruments was 20.5%. The value found for sterilization of instruments was USD 3.19. This correlates with the value of USD 232.160 concerning wastes of the sterilization of unused instruments.	Reduction of instruments in surgical trays, especially in laparoscopy, has a high potential for cost reduction.

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Chart 2. Continuação.

Authors, year, country	Objective	Method	Results	Conclusions
Paula et al., 2015, Brazil[18]	To quantify the number of instruments used and unused during surgery and to estimate costs of the sterilization process.	Quantitative, descriptive, field, and observational study. The authors also used secondary data.	The average of unused instruments was 52%. There was an average waste per surgical box of BRL 7.28, in the case of cesarean delivery, an average of BRL 9.71 per surgical box used in hysterectomy.	In one month, an average of BRL 1,584.17 would be wasted with the sterilization of unused instruments in surgeries.
Stockert and Langerman, 2014, United States of America[19]	To demonstrate the considerable cost of unused instruments in the institution's SPD.	Observational study. Authors performed descriptive statistics and linear regression for data analysis.	The highest percentage of use was 21.9% in neurosurgery. The average processing cost per instruments can range from USD 0.10 to USD 0.51, or over.	Attention to surgical tray composition may result in immediate and significant cost savings in the work performed at SPD.

ABC: Activity-based costing; SPD: Sterilization Processing Department.

Chart 3. Comparison of utilization costs of reusable and single-use products.

Author	Objective	Method	Results	Conclusions
Tomé and Lima, 2015, Brazil[6]	To identify the direct cost of reprocessing cotton-woven surgical drapes that are part of the surgical LAP.	Quantitative, exploratory-descriptive case study.	The average monthly cost for the use of surgical LAP accounts for USD 13,987.08, whereas the average monthly cost for the consumption of disposable surgical kits and disposable drapes for auxiliary tables corresponds to US $ 29,127.15.	The cost obtained from the processing of cotton-woven surgical drapes, which are part of the surgical LAP packs, was USD 9.72.
Kuznik et al., 2012, Uganda[20]	To compare costs for male medical circumcisions using reusable equipment and disposable kits.	Exploratory study.	The average cost of reusable circumcision kits was USD 8.46. The cost of a disposable kit ranges from USD 15.60 to USD 20.80. Therefore, the average savings per reusable kit ranges from USD 7.14 to USD 12.34, or from 46 to 59%.	The use of reusable kits in male medical circumcision procedures results in savings of 46 to 59%.
Yung et al., 2010, United States of America[21]	To assess the total cost of reusable ultrasonic shears and compare it with the costs of disposable equipment.	Prospective study. Descriptive statistics was performed with *SAS* software, version 9.1.3 for Windows.	The purchase cost for disposable shears was USD 307, and the total reprocessing cost was USD 43.73 per use. The reuse of ultrasonic shears resulted in savings of USD 196.40 per case.	The use of reusable shear is more economical, with an increase in the number of uses.

LAP: Laparotomy pack.

DISCUSSION

In the course of hospital health care, with the increasing costs in the field of health care, alternatives have been sought to achieve savings in procedures associated with it, strengthening the need for knowledge related to the basic principles of cost accounting on the part of professionals working in SPD, mainly nurses. Therefore, these professionals must use their knowledge on the subject as a management tool to support the arguments and negotiations with hospital managers, creating opportunities to improve the efficiency of the service's performance, rationalizing resources, and monitoring the productivity[22].

Cotton fabric is one of the oldest materials regarding sterilization packages used for the processing of HP. Currently, it is widely used for sterilization with saturated steam under pressure, and its advantages are economy, and properties of memory and resistance, which are close to levels deemed ideal[23]. However, in the literature, the economy of cotton woven fabric as packaging material has not yet been confirmed when compared to the cost of disposable surgical packaging materials[2].

Authors of a study conducted in the state of Bahia, Brazil, identified a similar result, according to which the cotton fabric packaging material accounted for the highest monthly cost, and surgical packaging paper had the lowest cost when compared to other materials. This demystifies the existing paradigm in Brazilian SPD, according to which cotton fabric would be the cheapest packaging material[24].

The rigid container is another permanent packaging material that, at the same time, packs and protects surgical instruments, keeping them sterile until their use. These containers can be made of aluminum, stainless steel, or plastic, and use disposable or reusable filters[25]. The high cost of such material would be a disadvantage. However, this value can be diluted by the number of reutilizations, which can promote economy, as demonstrated by research[10].

When using a rigid container, it is not recommended to use another type of packaging material inside or outside it, since this can hinder the air exit, the penetration of the sterilizing agent, and the drying step[25].

According to the literature, there are significant differences in cost between different processing methods for reusable HP in SPD, with high-level disinfection being a cheaper process than sterilization, and steam sterilization as a cheaper process than low-temperature sterilization[1,12,13].

Although more profitable, the excessive use and poor maintenance of equipment make steam sterilization inefficient over time. Nevertheless, replacing this method with hydrogen peroxide plasma sterilization would increase the costs associated with sterilization procedures for the unit[26]. Thus, the simultaneous and appropriate use of both methods, steam sterilization and hydrogen peroxide, may be more convenient[26].

Regarding the management of the SPD, the outsourcing of HP processing, carried out by processing companies, proved to be a more expensive option than the processing conducted in the institution's SPD, according to a study carried out on ventilatory support materials[11].

The safety of sterilization conducted in the institution's SPD and in an outsourcing company is the same. Nevertheless, off-site sterilization has higher costs than other options, and greater possibility of delays in supply[27]. Conversely, with the outsourcing of the processing, there is a reduced need for trained personnel and support of inputs in the hospital[27].

Checking the instruments in surgical trays, in order to decrease the number of commonly processed instruments that are unused in surgical procedures, has been one of the most adopted strategies by surgery services to reduce waste and, consequently, the costs, achieving significant savings. This fact was pointed out by researchers[14,15,17-19], especially in cases where surgical trays were used in endoscopic surgeries[15,17], considering that instruments require more elaborate and time-consuming processing[17].

Waste is related to the development of activities that do not favor the produced products or services, but rather unnecessary costs and expenses[4]. Thus, the investigation of waste sources related to material resources, processes, and personnel is imperative in public and private organizations. Many steps in the processes can also generate waste, causing inefficiency and delays in the work process[4].

In addition, the Association for the Advancement of Medical Instrumentation® (AAMI) and the Association of periOperative Registered Nurses (AORN) associate the weight of surgical trays with a higher risk of wet packs after sterilization, recommending a maximum weight of 25 pounds[28].

The use of costing methods, based on the mapping of steps that compose the processing of materials, has been used as a measure to reduce costs in HP processing, enabling to adopt suggestions for redirecting resources[16].

Processes involved in healthcare organizations require evaluation and control of their efficiency, productivity, and quality, since cost-related issues have implications for the amount of services provided to patients and, by the mapping, we can visualize the resource consumption and, consequently, its optimization[5].

Despite technological advances in the manufacture of single-use HP, when economically comparing the use of these materials with equivalent reusable ones, the latter are still more cost-effective, despite the cost of processing carried out in SPD[11,20,21].

Several devices, such as cotton-woven surgical drapes and surgical instruments, are manufactured to enable reutilization until their maximum effectiveness and functionality, which can lead to cost reduction and reduction in the amount of waste generated by single-use products. Nevertheless, it is necessary to ensure, at the time of decision-making, that these products remain safe for being used with the patient[29].

This study has limitations, since we cannot assess the environmental impacts caused by certain technologies used in the

processing of HP or by single-use products as well as the impact related to patient safety and health care-associated infections (HAIs).

FINAL CONSIDERATIONS

According to the analysis of the 15 articles published in national and international journals, it was found that the processing of HP in the institution's SPD proved to be a measure that achieves savings when cost management is employed, by properly selecting the technologies involved in the process and avoiding waste. Moreover, according to our results, despite technological advances in the manufacture of single-use products that replace reusable HP processed in the institution's SPD, the use of reusable materials is still the most economically-viable alternative.

It should be emphasized that, although the cost variable is a relevant factor, other non-financial aspects must be considered such as patient safety and the environmental impacts that involve the different HP processing methods.

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REFERENCES

1. Souza WR, Spiri WC, Lima SAM, Bernardes A, Luppi CHB. Utilização do custeio baseado em atividades em centro de material e esterilização como ferramenta gerencial. Rev Eletr Enf [Internet]. 2015 [acessado em 14 abr. 2019];17(2):290-301. Disponível em: http://dx.doi.org/10.5216/ree.v17i2.27540

2. Vital JS, Miranda LN, Nagliate PC, Vasconcelos EL. Analysis of cost of sterilization packaging using costing based activities. J Nurs UFPE On Line [Internet]. 2016 [acessado em 14 abr. 2019];10(8):2877-85. Disponível em: http://doi.org/10.5205/reuol.9373-82134-1-RV1008201613

3. Oliveira DF, Dedavid BA. Transformações ocorridas no tecido de algodão utilizado como embalagem no processo de esterilização de materiais: um estudo de caso [dissertação]. Porto Alegre: Pontifícia Universidade Católica do Rio Grande do Sul; 2016. 105 p.

4. Castilho V, Castro LC, Couto AT, Maia FOM, Sasaki NY, Nomura FH, et al. Survey of the major sources of waste in the health care units of a teaching hospital. Rev Esc Enfermagem USP. 2011;45(Núm. Esp.):1613-20. https://doi.org/10.1590/S0080-62342011000700012

5. Tomé MF, Lima AFC. Mapeamento do processo de reprocessamento de campos cirúrgicos de tecido de algodão. Rev SOBECC. 2015;20(4):197-201. http://dx.doi.org/10.5327/Z1414-4425201500040003

6. Tomé MF, Lima AFC. Custo direto de reprocessamento de campos cirúrgicos de tecido de algodão: um estudo de custo. Rev Esc Enferm USP. 2015;49(3):494-501. http://dx.doi.org/10.1590/S0080-623420150000300018

7. Souza MTS, Silva MD, Carvalho R. Revisão Integrativa: o que é e como fazer. Einstein. 2010;8(n. 1):102-6. http://dx.doi.org/10.1590/s1679-45082010rw1134

8. Whittemore R, Knafl K. The integrative review: updated methodology. J Adv Nurs. 2005;52(5):546-53. http://doi.org/10.1111/j.1365-2648.2005.03621.x

9. Ursi ES, Gavão CM. Prevenção de lesões de pele no perioperatório: revisão integrativa da literatura. Rev Latino-Am Enferm. 2006;14(1):124-31.

10. Krohn M, Fengler J, Mickley T, Flessa S. Analysis of processes and costs of alternative packaging options of sterile goods in hospitals: a case study in two German hospitals. Health Econ Rev. 2019;9(1):1. https://doi.org/10.1186/s13561-018-0218-2

11. Stipanich C, Goulardins JB, Medeiros M, Maria F, Tanaka C. Comparação de custos em diferentes processos de abastecimento de materiais de fisioterapia respiratória em um hospital público de porte extra. Rev Pesq Fisio. 2018;8(2):230-8. http://dx.doi.org/10.17267/2238-2704rpf.v8i2.1927

12. McCreanor V, Graves N. An economic analysis of the benefits of sterilizing medical instruments in low-temperature systems instead of steam. Am J Infect Control. 2017;45(7):756-60. https://doi.org/10.1016/j.ajic.2017.02.026

13. Jerico MC, Castilho V. Gerenciamento de custos: aplicação do método de custeio baseado em atividades em centro de material esterilizado. Rev Esc Enferm USP. 2010;44(3):745-52. https://doi.org/10.1590/S0080-62342010000300028

14. Nast K, Swords KA. Decreasing operating room costs via reduction of surgical instruments. J Pediatr Urol. 2019;15(2):153.e1-e6. http://doi.org/10.1016/j.jpurol.2019.01.013

15. Cichos KH, Linsky PL, Wei B, Minnich DJ, Cerfolio RJ. Cost savings of standardization of thoracic surgical instruments: the process of Lean. Ann Thorac Surg. 2017;104(6):1889-95. http://dx.doi.org/10.1016/j.athoracsur.2017.06.064

16. Isaacson D, Ahmad BA, Metzler I, Tzou DT, Taguchi K, Usawachintachit M, et al. Defining the costs of reusable flexible ureteroscope reprocessing using time-driven activity-based costing. J Endourol. 2017;31(10):1026-31. http://doi.org/10.1089/end.2017.0463

17. Van Meter MM, Adam RA. Costs associated with instrument sterilization in gynecologic surgery. Am J Obstet Gynecol. 2016;215(5):652.e1-5. http://dx.doi.org/10.1016/j.ajog.2016.06.019

18. Paula JRA, Silva RCR, Vedovato CA, Boaventura AP. Instrumentais nas caixas cirúrgicas: avaliação de custo. Rev SOBECC. 2015;20(2):73-80. https://doi.org/10.5327/Z1414-4425201500020003

19. Stockert EW, Langerman A. Assessing the magnitude and costs of intraoperative inefficiencies attributable to surgical instrument trays. J Am Coll Surg. 2014;219(4):646-55. http://dx.doi.org/10.1016/j.jamcollsurg.2014.06.019

20. Kuznik A, Lamorde M, Sekavuga DB, Picho B, Coutinho A. Medical male circumcision for HIV/AIDS pevention in Uganda: the cost of disposable versus re-usable circumcision kits. Trop Doct. 2012;42(1):5-7. http://doi.org/10.1258/td.2011.110297

21. Yung E, Gagner M, Pomp A, Dakin G, Milone L, Strain G. Cost comparison of reusable and single-use ultrasonic shears for laparoscopic bariatric surgery. Obes Surg. 2010;20:512-8. http://doi.org/10.1007/s11695-008-9723-4

22. Tome MF, Lima AFC. Custo do reprocessamento de campos cirúrgicos de tecido de algodão: um estudo de caso [dissertação]. São Paulo: Escola de Enfermagem da Universidade de São Paulo; 2014. 120 p.

23. Freitas LR, Tipple AFV, Felipe DP, Rodrigues NSR, Melo DS. Embalagem de tecido de algodão: análise do uso em hospitais de médio e grande porte. Rev Eletr Enfer [Internet]. 2012 [acessado em 28 mar. 2019];14(4):811-20. Disponível em: https://doi.org/10.5216/ree.v14i4.16612

24. Souza AS, Sória DAC, Araújo JO, Silva MT, Andrade NC. Embalagens para esterilização: suas aplicações e recomendações na prática hospitalar. Rev Pesq Cuid Fundam Online. 2010;2(Supl.):316-9. http://dx.doi.org/10.9789/2175-5361.rpcfo.v0.931

25. Associação Brasileira de Enfermeiros de Centro Cirúrgico, Recuperação Anestésica e Centro de Material e Esterilização. Diretrizes de práticas em enfermagem cirúrgica e processamento de produtos para saúde. 7ª ed. São Paulo: SOBECC; Barueri: Manole; 2017.

26. Sanjuana GOM, Iris CH, Federico MQJ. Análisis de costos em três métodos de esterilización. Rev Enferm IMMS [Internet]. 2006 [acessado em 28 jun. 2019];14(3):131-5. Disponível em: https://www.medigraphic.com/pdfs/enfermeriaimss/eim-2006/eim063c.pdf

27. Dehnavieh R, Mirshekari N, Ghasemi S, Goudarzi R, Haghsoost AA, Mehrolhassani MH, et al. Health technology assessment: off-site sterilization. Medical J Islam Repub Iran. 2016;30:345.

28. Seavey R. High-level disinfection, sterilization, and antisepsis: current issues in reprocessing medical and surgical instruments. Am J Infect Control. 2013;41(5 Supl.):S111-7. http://dx.doi.org/10.1016/j.ajic.2012.09.030

29. Evangelista SS, Santos SG, Stoianoff MAR, Oliveira AC. Analysis of microbial load on surgical instruments after clinical use and following manual and automated cleaning. Am J Infect Control. 2015;43(5):522-7. http://dx.doi.org/10.1016/j.ajic.2014.12.018.