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Costs comparison in different supply processes of respiratory physiotherapy materials in an extra public hospital

Comparação de custos em diferentes processos de abastecimento de materiais de fisioterapia respiratória em um hospital público de porte extra

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RESUMO | INTRODUÇÃO: Todos os anos, milhões de dólares são gastos para equipar e manter os centros de esterilização hospitalar no mundo. Materiais de terapia respiratória são essenciais para o suporte de vida e têm um grande impacto nas complicações clínicas. Fornecer materiais de terapia respiratória com higiene apropriada em um hospital é um desafio para os gestores devido ao impacto clínico e de custos. **OBJETIVO:** Comparar os custos de diferentes métodos de abastecimento de materiais de fisioterapia respiratória em um hospital geral, de porte extra, terciário e público. **MÉTODOS:** Consistiu em um estudo observacional, baseado em revisão documental e análise crítica de indicadores de gestão hospitalar, e analisou materiais utilizados em fisioterapia respiratória, classificados como semicríticos, incluindo ressuscitador manual, nebulizador, kit para pressão positiva contínua nas vias aéreas, circuito ventilatório para ventilação mecânica não invasiva e invasiva. **RESULTADOS:** Comparado ao processo de aquisição de materiais descartáveis, o processo de abastecimento no Centro de Material e Esterilização (CME) institucional gera uma economia anual com valores calculados em US$ 289.679,26; em comparação com o CME terceirizado, o processo de suprimento no CME institucional economiza um montante de US$ 257.041,11 por ano. **CONCLUSÃO:** Este foi o primeiro estudo brasileiro a realizar uma análise de custos nesse contexto. O processo de abastecimento com a higienização de materiais de fisioterapia respiratória na CME-INST mostrou-se mais vantajoso com menores custos quando comparado ao processo de abastecimento com higienização na CME-EXT ou custo de aquisição de MD. A economia anual estimada considerando o consumo médio mensal neste estudo ultrapassou US$ 250.000,00. A análise de custos detalhada fornece informações cruciais e pode permitir uma melhor gestão financeira.

PALAVRAS-CHAVE: Desinfecção. Esterilização. Custos hospitalares. Custos e análise de custo. Administração de materiais no hospital.

ABSTRACT | INTRODUCTION: Every year millions of dollars are expended to equip and maintain the hospital sterilization centers in the world. Respiratory therapy materials are essential to life support, and have a major impact on clinical complications. To provide respiratory therapy materials with appropriate hygiene in a hospital is a challenge for manager due to clinical and costs impact. **OBJECTIVE:** To compare costs of different methods of providing respiratory therapy materials in a general, extra, tertiary and public hospital. **METHODS:** It consisted of an observational study, based on document review and critical analysis of hospital management indicators, and analyzed materials used in respiratory therapy, classified as semi-critical products, including manual resuscitator, nebulizer, kit for Continuous Positive Airway Pressure (CPAP), ventilatory circuit for non-invasive and invasive mechanical ventilation. **RESULTS:** Compared to the supply process of disposable materials acquisition, the supply process in the Institutional Central Sterilization Supply Department generates an annual savings with values calculated at US$ 289,679.26; while compared to the Outsourced Central Sterilization Supply Department the supply process in the Institutional Central Sterilization Supply Department saves an amount of US$ 257,041.11 annually. **CONCLUSION:** This was the first Brazilian study to conduct a cost analysis in this context. The supply process with the cleaning of respiratory physiotherapy materials in the Institutional Central Sterilization Supply Department was more advantageous with lower costs when compared to the Outsourced Central Sterilization Supply Department or cost of acquisition of disposable materials. The annual savings estimated considering the average monthly consumption in this study exceeded US $ 250,000.00. Detailed cost analysis provides crucial information and can enable better financial management.

KEYWORDS: Disinfection. Sterilization. Hospital costs. Cost analysis. Hospital materials management.

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Introduction

Innovations in technology have changed the healthcare scenario, mainly in the critically ill patient area. Currently, a variety of health products are available to address the needs of patients, especially the equipment used for respiratory support and its accessories. In addition to the benefits of upgrading the available equipment, the demands with technical maintenance and accessory supply chain have also increased. Professional management with in-depth knowledge of processes and costs related to the provision of health care products is essential, especially in institutions where resources are scarce[1]. Every year millions of dollars are spent to equip and maintain hospital sterilization centers in the world[2].

Respiratory therapy materials are essential for life support and have a major impact on clinical complications with close association with nosocomial pneumonia, especially in patients under mechanical ventilation. Nosocomial pneumonia is a high prevalent hospital-acquired infection, affecting 1 in each 10 inpatients; it is associated with increased morbidity and mortality, hospital length of stay and financial burden[3-5]. It is usually due to aspiration origin, mainly by secretions of the upper airways, followed by exogenous inoculation of contaminated material or gastrointestinal reflux[6]. Ventilator-associated pneumonia (VAP) is the most common infection in the ICU. The incidence varies from 9% to 68%, depending on the diagnostic method and the population studied. Its lethality varies between 33% and 71%, and the case-fatality ratio can reach up to 55% with cases of VAP, reaching 86% of cases of hospital-acquired pneumonia[7,8]. The economic consequences of VAP are huge. Its impact on the Canadian health care system, for example, was estimated in CND 46 million per year[9]. In Turkish, the additional cost of VAP in medical-surgical intensive care units was found to be USD 5,980.00 per patient3. This studies are still limited in Brazil.

The cross infection may be caused by failure in the appropriate hygienization either by disinfection or sterilization of hospital materials[10]. Many authors have pointed the inadequate hygienization of respiratory therapy materials, with lack of disinfection or sterilization protocols, favoring resistant strains of microorganisms as one of the factors that contribute to hospital pneumonia[5-11].

Central Sterilization Supply Department (CSSD) plays a crucial role in most medium and large hospitals. In certain countries, CSSD is even mandatory to meet with the government stipulations for hospital license. Surgical tools and treatment instruments are sterilized by CSSD before and after use, wherever applicable. In our country the process within the CSSD includes reception, pre-cleaning, cleaning, drying, evaluation of the integrity and functionality, preparation, disinfection or sterilization, storage and distribution of the materials[12].

To provide the respiratory therapy materials with appropriate hygienization in a hospital is a challenge for manager due to clinical and costs impact. Searching for the safe quality of assistance with costs within the annual budget requires a continuous management effort. Therefore, the aim of this study was to compare the costs of different supply processes of respiratory therapy materials in a general, large, tertiary, public hospital.

Methods

This was an observational study with document review and critical analysis, based on the hospital management indicators. The protocol of this study plan was approved by the Ethics Committee of Faculdade de Medicina da Universidade de São Paulo (Approval Number: 267/17).

It was conducted in a general, extra, tertiary and public hospital in the city of São Paulo, which has 107 beds in Intensive Care Units (ICU), with clinical and surgical patients, 645 beds of wards, 33 beds in emergency unit and 45 surgical rooms. This hospital has its own CSSD (INST-CSSD), whose processed material is classified as Class II, which means that the CSSD can sterilize non-critical, semi critical and critical health products[13]. However, the capacity of this center is not enough to provide all the hygienized material needed due to the profile of patients in the hospital with a high respiratory therapy demand. For this reason, in addition to this first supply process

granted by INST-CSSD, the hospital has a second process provided by a signed contract with an outsourced CSSD (OUT-CSSD); during periods of peak seasonality, a third process is used with the acquisition of disposable material (DM), if necessary, to avoid the lack of these essential materials in the assistance.

The current study included materials used in respiratory therapy, classified as semi-critical products[13]. Semi critical health products are materials that come in contact with colonized mucous during ventilatory assistance, anesthesia or inhalation therapy; these materials should be cleaned and submitted to, at least intermediate level of disinfection, with sanitizing products in accordance with sanitary standards, or by physical thermo disinfection process, prior to use in another patient. Those used in ventilation or inhalation therapy may not be disinfected by liquid chemical immersion using aldehyde-based sanitizers[6].

The five respiratory materials included in this study were: (1) Manual resuscitator - used for manual ventilation, in cases of respiratory failure, previous to endotracheal ventilatory prosthesis installation, and during intervals in which the pulmonary mechanical ventilator is not used; (2) Nebulizer - used for oxygen administration as the treatment of low tissue oxygen concentration; (3) Kit for Continuous Positive Airway Pressure (CPAP) – comprising a corrugated trachea, pressure valve and face mask, used in non-invasive mechanical ventilation for the treatment of respiratory failure; (4) Ventilatory circuit for non-invasive mechanical ventilation (NIV) – an interface circuit of connection between the face mask of the patient and the mechanical ventilation equipment; (5) Ventilatory circuit for invasive mechanical ventilation (IMV) – the interface circuit between the endotracheal prosthesis of the patient and the mechanical ventilator.

The study has considered the monthly average consumption of respiratory therapy materials based on 2014 January to July, and analyzed costs with: supply process 1 - acquisition of permanent materials with hygienization in INST-CSSD; supply process 2 - acquisition of permanent materials with hygienization in OUT-CSSD, and; supply process 3 - acquisition of DM. The data for analysis were obtained by a documentary research of the monthly indicators of departments directly involved in the supply of these materials such as: the board of the INST-CSSD, Division of Administration, Division of Human Resources and the Division of Budget and Cost.

The costs of supply process 1 were evaluated by categories classified as: (1) disinfection process, (2) machinery operation, (3) human resources, and (4) material wrappers. For the disinfection process, the amount expended with energy (watts) and water (liters) was obtained from the machinery's handbook. For direct cost in monetary values for watts of energy and liter of water consumed, the calculation was done using the detailed energy and water supply company's bills. The amount spent on hygienization products were obtained from the Division of Administration.

Regarding the machinery costs, it was included: (1) the monthly depreciation, considering 240 months, using a linear method for full use of the equipment; (2) the costs for the renovation of the room to receive the machinery; (3) the monthly contractual value of preventive machinery maintenance; (4) thermal qualification of thermo disinfection equipment and sealers complete operational process and performance. This annual validation is in accordance with Resolution 15 of the Agência Nacional de Vigilância Sanitária[12], establishing the qualification of installation, operation and performance of the equipment used in the automated cleaning of products for the health. The costs of microbiological validation were calculated over the commercial contract, proportionally to the materials in this study.

The human resources costs were obtained from the payroll, considering the employees that operate the machinery gross payment. The reference calculated was the human resource cost per unit of hygienized material. The cost per unit of material was calculated based on the production capacity of material per cycle and the time elapsed in each cycle; the cost per day considered 16 hours of operation a day; the cost per month considered the 30 working days in the month.

Costs of material wrappers took into account the winner price per unit of wrapper offered in the bid concurrence for the acquisition of wrapper.

The costs of supply process 2 were calculated per unit of hygienized material in the OUT-CSSD, which was the winner price per unit offered in the bid concurrence for a commercial agreement for sterilizing materials.

The costs of supply process 3, the acquisition of DM, it was considered the smallest price out of three offers found in the market.

In parallel, it was considered the difference in purchase price of disposable and permanent material, due to the variable lifetime of permanent materials, losses or damages of components. This fact demanded the calculation of the number of hygienization to reach the break-even point between costs of acquisition with disposable and permanent material, as a function of the material lifetime. The permanent material replacement was considered through the entries registered in the stockroom of the hospital.

The difference between different supply processes was estimated for annual expenses to provide data for annual report and budget planning.

Results

The monthly average consumption of the respiratory therapy materials of this study, were 794 manual resuscitators, 618 nebulizers, 86 CPAP kit, 33 NIV circuits and 303 IMV circuits.

Table 1 shows the detailed costs of the supply process 1 per cycle of production.

Table 1. Cost per cycle for inputs from the thermodynamics process. machinery operation. human resources and materials packaging

Input of the thermo disinfection process			
Inputs. units	Unitary value	Consumption/Cycle	Cost/cycle
Electricity kWh	0.2	39.57	7.91
Hot water L	0.01	60	0.54
Cold water L	0.03	60	1.8
Osmosis Water [a] L	0.02	33	0.66
Enzyme Detergent L	200	0.08	16
Drying Detergent L	200	0.04	8
Machinery Operation			
			Cost/cycle
Depreciation [b]			2.67
Preventive maintenance			0.5
Microbiological validation			0.13
Human Resources			
	Salary with Charges	Value / Time	Cost/cycle[c]
Nursing technician (144 hours / month)	2.518.20	17.49	20.3
Packaging of materials			
		Unitary value	
Packing 30 x 45 cm[d]		0.65	
Packing 45 x 60 cm[e]		1.44	

aSeparation process in which a solvent is separated from a low molecular weight solute. The reverse osmosis process aims to ensure maximum water purity; bExpenses resulting from the wear and tear or obsolescence of fixed assets; Loading / unloading (40 minutes) + packing materials (30 minutes); dManual resuscitator. Nebulizer. CPAP kit. Circuit NIV; eIMV Circuit. Values calculated in US$, quoted on 01/22/2016.

The capacity per cycle of production was 15 units of manual resuscitator, 10 units of nebulizer, 10 units of CPAP Kit, 15 units of circuits NIV, and 10 units of IMV circuits, the final cost per material processed in INST-CSSD was calculated, as shown in Table 2.

Table 2. Final cost per material processed in institutional CSSD

Materials	Inputs	Operation	Human Resources	Packing	Total
Manual Ressuscitator	2.33	0.22	1.35	0.65	4.55
Nebulizer	3.49	0.33	2.03	0.65	6.50
CPAP Kit	3.49	0.33	2.03	0.65	6.50
NIV Circuits	2.33	0.22	1.35	0.65	4.55
IMV Circuits	3.49	0.33	2.03	1.44	7.29

Values calculated in US$, quoted on 01/22/2016.

Table 3 shows the costs per material in supply process 1, 2 and 3.

Table 3. Costs for material processed in institutional CSSD. In outsourced CSSD and for refueling by disposable material.

Material	INST-CSSD	Outsourced CSSD	Disposable
Manual Ressuscitator	4.55	8.17	110
Nebulizer	6.5	8.91	45
CPAP Kit	6.5	22.75	178
NIV Circuits	4.55	23.06	52.5
IMV Circuits	7.29	22.75	29

*Values calculated in US$, quoted on 01/22/2016.

Table 4 shows the breakeven point for permanent and disposable materials considering the investment required.

Table 4. Breakeven of disposable material and permanent investment

Respiratory Materials	Investment Difference[a]	INST-CSSD cost	Breakeven[b]
Manual Ressuscitator	190.00	4.55	42
Nebulizer	110.08	6.50	17
CPAP Kit	0.00	6.50	0
NIV Circuits	43.50	4.55	10
IMV Circuits	61.00	7.29	8

aCost of acquisition of permanent material subtracted from the cost of acquisition of disposable material; b When revenues are equal to costs and expenses. So it is the moment when a product ceases to cost and starts to make a profit. Values calculated in US$, quoted on 01/22/2016.

Considering the monthly average consumption, Table 5 shows the annual cost calculated for supply processes 1 and 3.

Table 5. Difference of annual cost with permanent material processed in institutional CSSD and disposable material

	Permanent Acquisition	Processing	Disposable Acquisition	Difference
Manual Ressuscitator	36.000.00	36.150.50	873.840.00	801.689.50
Nebulizer	137.711.04	39.630.10	274.320.00	96.978.86
CPAP Kit	85.440.00	10.999.69	301.176.00	204.736.31
NIV Circuits	4.608.00	1.802.06	20.790.00	14.739.94
IMV Circuits	3.240.00	26.510.08	105.444.00	75.693.92
Total	266.999.04	115.092.43	1.575.570.00	1.193.478.54

Values calculated in US$, quoted on 01/22/2016.

Similar calculation for values of supply process 2 compared to supply process 3 showed the total difference to US$ 257,041.11/year.

Discussion

In the healthcare system to reduce costs without impact in quality of services and patient's safety is always a challenge. The current study aimed to compare the costs of three supply processes of respiratory therapy materials, INST-CSSD, OUT-SSD and DM. Findings showed resource savings with the first supply process, which is in accordance with standards specified in national legislation6, as well as in European[14] and American standards and quality certifications[15]. The detailed cost analysis provided crucial information and may allow better financial management.

The INST-CSSD uses thermodisinfection by automatic thermo-washer's disinfectors machines. This way of thermodisinfection performs disinfection with a high level of safety, reaching a microbial load reduction of minimum lethality above theoretical values. The microbial morbidity varies with the temperature and the pathogen exposure time and consists of material cleaning, followed by high level disinfection using humid heat in temperatures above 80° C for up to 10 minutes. The thermodisinfection constitutes a technological innovation in the INST-CSSD; it provides a standardized hygienization, which is the best practice of respiratory therapy materials with reduced risks for workers. The cycle is automated and consists of pre-washing, washing, rinsing, thermodisinfection and drying. The INST-CSSD uses the deionized water (reverse osmosis) to the rinse, as recommended[16,17].

The current study revealed that supply process 1 was less expensive compared to supply process 2 while the supply process 3 has proven to be the more expensive option. It should be noted that permanent materials acquisition is a strategic investment since item supports the re-process above the break-even point. As the materials are not identified with a serial number, it was not possible to track and count re-process of the material. Therefore, the number of entries registered in the stock room by acquisition of permanent material for the replacement was taken into account.

Compared to the supply process 3, the supply process 1 generates an annual savings with values calculated at US$ 289,679.26 while compared to supply process 2 the supply process 1 saves an amount of US$ 257,041.11 annually.

Previous report determines the CSSD as a key area for the success of surgical procedures and therapeutic care, directly linked to patient's safety with a financial impact on hospital costs10. The results of this study reinforce the CSSD as an important department to carry on a reduction of expenses.

The CSSD management ought to consider technical and clinical peculiarities of each material to be hygienized with attention to the machinery maintenance contracts, strategies for eventually needs of quick replacement, as well as seasonality, which increase the consumption of some materials. A proper supply chain integrating the CSSD board of direction, division of budget and cost, stockroom, division of human resources, the professional equip of assistance and hospital leadership is imperative for this management.

The current study has some limitations, including the difference in the hygienization methods performed in the OUT-CSSD and INST-CSSD. The OUT-CSSD promotes low-temperature sterilization after a high-level disinfection process, while INST-CSSD completes the action in high-level disinfection. However, this is a research limitation inherent to the studies that aim to explore the hygienization processes of hospital equipment in Brazil today, in function of the current regulatory norms and the market offers and demands, once contracts signed with external CSSD are performed nationally based on sterilization, which can be easily monitored.

Considering that the CSSD is not hospital's core business, hiring an outsourced CSSD would be an appropriate strategy. The effectiveness of the hygienization at high-level thermodesinfection has been showed in the literature and in this way it is relevant an action of the sanitary surveillance regulators to allow the practice in the specialized companies of high-level thermodesinfection as an

alternative to the sterilization at low temperature. If market competitiveness is stimulated, prices can become more attractive to the public budget.

It should be noted that in this study, data were acquired through documentary research of monthly indicators. Although there is a well-carried routine of meeting to analyses of the indicators, we should consider the possibility of an inconsistency of data due to the error in the management records.

Conclusion

The supply process with the hygienization of respiratory therapy materials in the INST-CSSD was shown to be more advantageous with lower costs when compared to the supply process with hygienization in OUT-CSSD or cost of DM acquisition. The estimated annual savings considering the average monthly consumption in this study exceeded USD 250,000.00.

Author contributions

Stipanich C designed the research, collected and analyzed the data, and wrote the manuscript. Goulardins JB analyzed the data, wrote and revised the manuscript. Medeiros MESA and Maria FP analyzed the data and revised the manuscript. Tanaka C designed the research and revised the manuscript.

Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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