

# Environmental sustainability in medication processes performed in hospital nursing care

Sustentabilidade ambiental nos processos de medicação realizados na assistência de enfermagem hospitalar

Patricia de Oliveira Furukawa<sup>1</sup>

Isabel Cristina Kowal Olm Cunha<sup>1</sup>

Mavilde da Luz Gonçalves Pedreira<sup>1</sup>

Patricia Beryl Marck<sup>2</sup>

## Keywords

Nursing service, hospital; Nursing process; Environment; Waste management

## Descritores

Serviço hospitalar de enfermagem; Hospital, Processos de enfermagem; Meio ambiente; Gerenciamento de resíduos

## Submitted

February 14, 2016

## Accepted

July 29, 2016

## Corresponding author

Patricia de Oliveira Furukawa  
Napoleão de Barros street, 754,  
04024-002, São Paulo, SP, Brazil.  
patricia.furukawa@unifesp.br

## DOI

<http://dx.doi.org/10.1590/1982-0194201600043>



## Abstract

**Objective:** Sustainable actions performed by the nursing team in an intensive care unit during medication processes were examined, after which interventions were proposed to improve environmental sustainability in the hospital setting.

**Methods:** Before and after study, using the Lean Six Sigma methodology applied in an intensive care unit. The sample was comprised of 648 medication processes performed by the nursing team. The data was collected via observation routes and analyzed quantitatively.

**Results:** The post-intervention results included: reduction of materials such as plastic bags (37.1%), reduction of hormonal anti-inflammatory drugs (67.1%), increased removal of labels from plastic bags to be recycled (146.9%) and proper waste disposal (32.2%), with a statistically significant difference ( $p \leq 0.05$ ).

**Conclusion:** The intervention strategies implemented, based on an analysis of the problem, validation and prioritization of the actions had a positive influence on reduction, recycling and proper disposal of waste with benefits for the institution, environment and human health.

## Resumo

**Objetivo:** Foram analisadas ações sustentáveis realizadas pela equipe de enfermagem de uma unidade de terapia intensiva durante os processos de medicação e proposto intervenções para a melhoria da sustentabilidade ambiental na área hospitalar.

**Métodos:** Estudo antes e depois usando a metodologia *Lean Seis Sigma* aplicada em uma unidade de terapia intensiva. A amostra foi composta por 648 processos de medicação realizados pela equipe de enfermagem. Os dados foram coletados por meio de roteiros de observação e analisados quantitativamente.

**Resultados:** Os resultados pós-intervenções incluíram a redução dos materiais como sacos plásticos (37,1%), redução de sobras de anti-inflamatórios hormonais (67,1%), aumento na remoção de etiquetas de sacos plásticos para serem reciclados (146,9%) e descarte correto de resíduos (32,2%) com diferença estatística significante ( $p \leq 0.05$ ).

**Conclusão:** As estratégias de intervenções implementadas a partir da análise do problema, validação e priorização das ações teve influência positiva na redução, reciclagem e disposição correta dos resíduos com benefícios para a instituição, meio ambiente e a saúde humana.

<sup>1</sup>Escola Paulista de Enfermagem, Universidade Federal de São Paulo, São Paulo, SP, Brazil.

<sup>2</sup>University of Victoria, Faculty of Human and Social Development, Canada.

**Conflicts of interest:** there are no conflicts of interest to declare.

## Introduction

The theme of environmental sustainability, permeated by immense concern for the scarcity of natural resources and the lives of all living beings, has been widely discussed within the scientific and political community.<sup>(1,2)</sup> There is currently a broad consensus that global human activities have been largely responsible for the environmental impact experienced in the world.<sup>(1,3)</sup>

Health services are important from an environmental perspective not only for the impact it may generate, but also for the critical role they play in promoting health and the preservation of life. This makes it difficult for hospitals to justify behavior that could be a threat to human health, through contributing to increasingly reduced natural resources, energy shortages and inefficient waste management.<sup>(4)</sup>

Considering that nursing generally represents the majority of employees in a hospital, it is a major consumer of resources and generator of waste. As the largest group of workers in the health sector, nursing teams can have a significant influence on the improvement of environmental sustainability in health services and, for this reason, should be involved in sustainability practices.<sup>(1,5,6)</sup> However, studies indicate low levels of knowledge and practices in relation to preservation of the environment, rational use of resources and waste management practices by health professionals, including nurses.<sup>(7-9)</sup>

Among the main hospital nursing care activities are medication processes. These processes consume materials and generate waste, as in the case of pharmaceuticals, which are a cause of growing concern due to their potential impact on the environment, since even in low concentrations, they can affect the metabolism of various organisms and cause an imbalance among their populations.<sup>(10)</sup> Besides the impact of pharmaceuticals, medication processes also generate normal recyclable and non-recyclable waste, as well as potentially infectious waste and sharps which represent a risk to public health and the environment.<sup>(11)</sup>

In light of this global problem and the need to conduct further research in the area of health, especially nursing, with practical experience related to preservation of the environment and use of resources,<sup>(12)</sup> this study examined sustainability actions associated with medication processes and proposes interventions to improve environmental sustainability in the hospital environment.

## Methods

This is a before and after study. First of all, the structure of the Intensive Care Unit (ICU) was observed, followed by observation of the nursing practices related to sustainable actions in medication processes. The findings provided direction for determining the independent variables, as well as the study of additional variables that could influence the dependent variables.

To supplement the results analysis in terms of the impact of the interventions, institutional information was used, related to the amount of waste generated in the unit, using as an indicator: kilograms, according to the type of waste per patient per day (kg/type of waste/per patient/day).

To achieve the study objectives, Lean Six Sigma process analysis methodology was also used. Lean Manufacturing methodology, which stemmed from the Toyota Production System of Japan, is an initiative which seeks to eliminate waste, i.e., eliminate that which has no value for customers and to streamline processes, in order to enhance the quality and safety of the product or service, among other benefits. The reason for using this approach to guide the study is to reduce the use of water, materials and pharmaceuticals in medication processes, without, however, undermining patient safety. The Six Sigma approach developed by Motorola identifies the extent to which any process strays from the goal, that is, the ability of the process to generate products within pre-established specifications. It involves stages of definition, measurement, analysis, implementation of improvements and pro-

cess control (DMAIC), which is in line with the objectives of the study to monitor actions before and after interventions and improve medication processes from the point of view of environmental sustainability.<sup>(13)</sup> So, although they propose different approaches to obtain improvements, they complement each other and have been implemented in an integrated way under the name of Lean Six Sigma, by companies, including hospitals, that are seeking better results in terms of productivity and the quality of their products or services.<sup>(14)</sup> The successful application of Lean Six Sigma has also been reported in the area of health as a method by which hospitals can control costs, reduce the likelihood of errors and improve patient safety and health care quality.<sup>(15,16)</sup>

The study was conducted in a large hospital (446 beds) of a charitable, nonprofit nature, located in the city of São Paulo - Brazil.

The sample was comprised of actions that were observed in relation to medication processes carried out by the nursing team during the four shifts (morning, afternoon, night A and night B). To be representative, the sample size calculation was based on the mean number of medications administered monthly in the unit, with a confidence interval of 95%. Considering that in 2012, an average of 1,710 doses of medication were administered to each patient per month, 324 processes were examined in the pre and post-intervention stages, totaling 648 processes. The observation of the sample included actions by 99 professionals (58.2%) in the pre-intervention period and 97 (57.1%) in the post-intervention stage.

The sample included actions performed by professionals, more specifically by those who authorized their participation in the study through signing a free and informed consent form. These actions were contained in the daily prescription of the patient (non-emergency); with prescription for administration by enteral, topical and parenteral routes and; performed by the nursing team (nursing technicians and nurses).

Excluded from the study were actions related to blood components, vaccines, enteral and parenteral

feeding; with prescription for administration by other routes of access and; carried out by nursing professionals from another sector or by professionals from another health area.

The independent variables were comprised of strategies for improving the medication processes performed by the nursing team. These improvements included:

- install water flow regulating devices on all the faucets in the rooms;
- place identification labels on the medications when sealing the packaging, and not on the plastic bags, so that the bags will not be prevented from being recycled;
- deliver materials and single dose medications dispensed by the pharmacy without plastic bags;
- standardize smaller dosages of hormonal anti-inflammatory drugs to avoid waste and disposal of these medications;
- review the institutional waste classification;
- purchase and install containers for non-recyclable waste in the rooms;
- adjust and install chemical waste containers in the rooms in accordance with Brazilian law;<sup>(17,18)</sup>
- train and raise awareness of the team.

The dependent variable was defined as the practice of sustainable actions in medication procedures carried out during hospital nursing care in accordance with the 3R Policy: reduce, reuse and recycle.<sup>(19)</sup> These actions included: reduction in packaging and use of plastic bags for transporting medication; reduction of left-over medications; reuse of plastic containers and bags; removal of labels from packaging for recycling; and proper waste disposal.

The additional variables included: structure of the ICU (lighting, faucets, waste containers, availability of paper, packaging and medical and hospital supplies); characteristics of nursing professionals involved in the medication processes (age, gender, work shift, job category, education, years of experience, length of time working in the institution and previous training in environmental awareness and waste disposal); characteristics of patients involved in the medication processes (in

isolation or not); characteristics of the medications (name, type of pharmaceutical and route of administration) and; amount of waste generated per patient per day in the ICU.

The data collection was performed in two stages: before and after the interventions corresponding to the period from January 21 to February 20, 2013 and September 23 to October 30, 2013, respectively. During the pre-intervention stage, the structure of the ICU was examined via an observation route developed and applied by the researcher for the 41 beds of the unit in the period from January 20 to 25, 2013. The medication processes were observed through the use of an instrument created by the researcher based on Lean Six Sigma tools: Detailed Process Map and Ishikawa Diagram. The observations encompassed the following stages: withdrawal, preparation and administration of medications.

The data collection was carried out by nurses who were part of the project team and had received prior instruction on how to fill out the instrument. Before starting the collection, the nurse selected the medication process through the medical prescription, collected the free and informed consent form from the professional involved in the medication process to be examined, and afterward started the data collection, without intervening in the process being measured.

For the data collection related to the amount of waste generated in the ICU, an institutional waste collection spreadsheet was used, filled in each shift by the Cleaning Service of the hospital. Data was measured in reference to the stages prior to and after the interventions, corresponding to the waste collected during the months of November 2012 and October 2013, respectively.

The data obtained was stored in an electronic database and submitted for tabulation on electronic spreadsheets from the program Microsoft Excel. The quantitative variables were presented according to mean, standard deviation (SD), minimum and maximum value (min-max) and the qualitative variables according to absolute and relative frequency.

After the quantitative analysis of the data obtained in the pre-intervention stage, the following Lean Six Sigma tools were used: Cause and Effect Matrix and Impact Effort Matrix, in order to prioritize the problems to be solved. From this analysis, an action plan was developed outlining the improvements to be implemented, based on the causes/roots of the problems identified by the team using the tool of brainstorming.

After the interventions, the data was analyzed and the variables associated through inferential statistics, according to the nature of the variables studied, with the level of significance to reject the null hypothesis set at less than or equal to 0.05. For this purpose, the software Minitab® Version 16.1 was used.

The study was carried out in compliance with national and international standards of ethics in research involving humans (Brazil register/Platform CAAE - *Certificado de Apresentação para Apreciação Ética*: 06279412.1.0000.5505).

## Results

In the analysis of the structure of the 41 beds in the ICU, it was noted that all (100%) of the lamps were fluorescent and energy-saving, as standardized by the hospital. However, even though there was natural lighting in 29 beds (70%), the lights were constantly on during the data collection. In terms of availability of water, 28 (68%) had automatic self-closing taps and 20 (49%) had flow regulating devices. The physical space available for distribution of waste containers was limited and there were containers alongside all the beds for recyclable waste (paper, plastic and metal), infectious waste and sharps. However, there were no containers for recyclable waste (such as glass), normal non-recyclable waste and chemical waste. A considerable amount of consumables related to the medication process was also noted, such as syringes, needles, cotton, cotoplast and non-sterile gauze in the rooms of patients in isolation that were discarded after the patient's discharge without having been used. Paper and plastic packaging was freely available throughout the ICU.

With respect to the analysis of the medication processes, in the pre-intervention period 19.8% of them were related to patients in isolation whose waste, therefore, is disposed of differently according to Brazilian law. As far as the product characteristics of the medications, most (41.7%) are considered dangerous to the environment and human health.

In terms of the profile of the professionals in the pre-intervention period, the age range was from 20 to 64 years (mean ± standard deviation = 32.4 ± 7.8 years), where the majority were women (59.6%). Twenty-three professionals (23.2%) were from the morning shift, 30 (30.3%) from the afternoon shift, 19 (19.2%) from night shift A and 27 (27.3%) from night shift B. In regard to professional category, most (88.9%) were nursing technicians and the rest (11.1%) were nurses. Sixty professionals (60.6%) reported having completed high school, 33 (33.3%) had or were working on a university degree, (23 completed and 10 not completed), and six had or were working on a specialization degree (five completed and one not completed). The time of experience of these professionals ranged from

0.08 to 32 years (mean ± standard deviation = 6.3 ± 5.3 years). The length of time in the institution also ranged from 0.08 to 32 years (mean ± standard deviation = 5 ± 6.3 years). The percentage of professionals who reported having received previous training in environmental awareness and waste disposal was 94.9%.

In the pre-intervention period, 324 medication processes were monitored with a total possibility of 866 sustainable actions that depended solely on the practices of the professional. Each employee participated, on average, in 3.3 processes (standard deviation = 2.2), with a mean percentage of correct sustainable actions of 69.5% (standard deviation = 23.1%). In the post-intervention stage, 324 medication processes were observed, with a total of 1,020 sustainable actions. Each employee participated, on average, in 3.3 processes (standard deviation = 2.1), with a mean percentage of sustainable actions of 79.84% (standard deviation = 18.4%), with p-value= 0.001. Thus, there was an increase in post-intervention ecologically correct actions with a statistically significant difference (Chart 1).

**Chart 1.** Comparison of sustainable actions according to the stages of the medication process performed by the nursing team before and after interventions

Stages of the process and interventions	Pre intervention	Post intervention	p-value
Withdrawal of medication			
Reduce: use of plastic bags for transporting medications	41.8	26.3	0.02**
Reuse: plastic bags stored for reuse	19.6	28	0.417**
Recycle and discard properly: disposal of plastic bags	91.8	90.9	
Preparation of medications			
Reduce: hormonal anti-inflammatory drug leftovers	78.9	25.9	0.001**
Recycle and discard correctly:			
Removal of labels from plastic bags to be recycled	32.4	80	0.000**
Proper disposal of plastic bags	95	97.7	0.145**
Proper disposal of materials with little or no organic material (cotton, gauze and other)	25.8*	72.6	0.000**
Proper disposal of primary packaging (syringes)	63.6	84.4	0.002**
Proper disposal of primary packaging (needles)	80	87.5	0.466**
Proper disposal of primary packaging (vials)	64.3	93.8	0.000**
Proper disposal of primary packaging (bottle-vials)	36	89.6	0.000**
Proper disposal of primary packaging (wrappings)	9.52	35.9	0.001**
Proper disposal of hormonal anti-inflammatory drugs	11.1	84.6	0.000**
Administration of Medications			
Recycle and discard properly:			
Proper disposal of materials with little or no organic material (gloves, masks and caps)	45.2*	88.5	0.000**
Proper disposal of primary packaging (syringes)	55.4	78.9	0.000**
Proper disposal of primary packaging (needles)	54.6	93.1	0.000**
Proper disposal of primary packaging (bottle-vials)	32.1	50.9	0.000**
Proper disposal of primary packaging (plastic bottles)	66.6	47.6	0.459**

\*Proper disposal related to patients in isolation; \*\*Pearson's Chi Square; \*\*\*Fisher's Exact Test



As a result, there was a reduction in the use of materials, such as plastic bags (37.1%), reduction in leftover hormonal anti-inflammatory drugs (67.1%), increased removal of labels from plastic bags to be recycled (146.9 %), and improvement in proper waste disposal (32.2%), especially those related to primary packaging for medications considered hazardous to the environment and human health, with a statistically significant difference of  $p < 0.05$ . The reuse of plastic bags, although the percentage increased, was not statistically significant.

Figure 1 gives some examples of interventions applied in the medication process by the nursing team during the study.

As shown in table 1, in the post-intervention period there was a major decrease in total waste generation (38.6%), due to reductions in materials used and infectious waste, sharps and normal non-recyclable waste. There was an increase in recyclable waste, albeit not significant, since this waste was generally discarded properly before the inter-

ventions and due to lower waste generation, as in the case of plastic. Increased chemical waste was due to the segregation of medications which are now properly discarded. Based on the data, it is estimated that there was a reduction of 5,324.9 kilos in one month, in just the ICU.

The financial savings obtained by the ICU included: 59.9% reduction in the cost of treating infectious and sharps waste due to decreased generation of these wastes; 37.1% reduction in plastic

**Table 1.** Comparison of the amount of waste generated by the ICU before and after the interventions

Type of waste	Interventions		Results (%)	p-value**
	Before*	After*		
Infectious and sharps	8.76	3.51	-59.94	0.000
Chemical	0.001	0.6	>100	0.000
Normal non-recyclable	3.76	3.06	-18.62	0.002
Normal recyclable	1.19	1.24	+4.2	0.645
Total	13.7	8.41	-38.6	0.000

\*Mean kilos of waste/per patient/day; \*\* T-test for independent samples



**Figure 1.** Examples of interventions applied in the medication process

bag purchases due to decreasing their use for transporting medications; 40.7% reduction through purchasing lower dosage anti-inflammatory vials (difference between 40 and 125 mg vials) which previously generated leftovers that were discarded. There were also direct financial savings from the 4.2% increase in the sale of recycled waste, designated for the hospital volunteer service.

## Discussion

This study has some limitations. Although the sample selection was evenly distributed between the units and shifts, it was not possible to perform a randomized controlled study due to the characteristics of the unit and the work of the nursing team. The choice of the interventions was based on the application of analysis tools used in Lean Six Sigma methodology which recommended priority actions. Therefore, other realities might require different sustainable actions to improve processes.

Health establishments are also significant energy and water consumers.<sup>(20)</sup> In terms of total mean energy consumption, large hospitals consume 3,301 kWh / bed, with 26.04% corresponding to lighting and 4.76% to heating water.<sup>(21)</sup> Although the hospital under study had measures for clean energy efficiency, waste on the part of professionals was noted, thereby demonstrating the need to educate the team in regard to rational consumption of resources.

In reference to water, climate change and its impacts have caused drought, melting of glaciers and depletion of aquifers, further exacerbating water shortages. Health services can save this precious natural resource through close monitoring of water use and the installation of efficient technologies.<sup>(20)</sup> Flow regulators, automatic self-closing taps and taps equipped with sensors can cut water consumption by up to 50%.<sup>(22)</sup> One study found that automatic self-closing taps can lead to water savings of up to 71% in surgical hand hygiene.<sup>(23)</sup> In another, researchers found that for turning off taps, leg operated taps are more economical than elbow-operated ones.<sup>(24)</sup>

Conscious consumption is the first step toward sustainability, in that at an individual level, people can adopt new attitudes and practices.<sup>(25)</sup> However, although many sustainable actions in health services depend on the practices of professionals, the causes of environmental problems also need to be analyzed according to the institutional context. Hospital systems and policies can hinder proper practices and it is essential to identify solutions that encourage professionals and promote environmental sustainability regardless of the motivation of workers.

To control infections, materials from patients in isolation should not be shared and should be discarded as infectious waste, even if not used. Another study also found that 10% of the materials for patients in isolation materials are discarded without being used.<sup>(26)</sup> The unnecessary accumulation of supplies in the patient's room results in undue expenditures on materials and waste treatment. Professionals need to make an effort to keep fewer supplies in patients' rooms to avoid the loss of these materials when patients are transferred or discharged.

One study found that the materials most frequently cited as sources of waste in hospitals are medications, followed by printed paper.<sup>(26)</sup> Nurses are in a position to act as educators regarding products and materials, and reduce waste. Nurses, pharmacists and health system managers also play a role in advocating for changes in the way pharmaceuticals are produced and made available to the market.<sup>(27)</sup> The large volume of disposable packaging, such as cardboard and plastic to envelop the medication, in addition to packaging used to separate medication into unit doses and transport them between the pharmacy and the units, generate a significant amount of waste daily.

To ensure proper recycling and waste treatment, waste needs to be separated at the time and place of its generation, which requires different containers according to its physical, chemical and biological characteristics, its physical condition and the risks involved.<sup>(18)</sup> In other waste management studies, re-

searchers also detected problems in the separation stage.<sup>(9,28,29)</sup> Limited physical space in intensive care units, due to the large amount of equipment, technology and professionals, hinders the installation of different waste containers inside the room. The lack of containers for normal non-recyclable waste in the rooms causes nursing teams to discard waste as infectious waste, increasing gas emissions and treatment costs. Treating infectious waste costs, at least, five times more than normal waste.<sup>(30)</sup>

Although chemical waste containers were available in the hospital that was studied, the nursing team only requested them in specific cases, such as for disposal of chemotherapy waste. Most of the processes examined involve medications that pose a risk to public health and the environment. If chemical waste is disposed of incorrectly, it may be sent directly to the landfill, exposing urban sanitation workers and recyclers to direct contact with toxic agents, in addition to facilitating environmental contamination. In other cases, if hazardous chemical waste is separated as infectious waste and sent for heat treatment, besides not reducing the chemical risk, it promotes the release of toxic gases and vapors.<sup>(17)</sup>

In this study, cost savings were achieved by wasting fewer plastic bags and reducing leftover anti-inflammatory drugs, by treating infectious and sharps waste and increasing the sale of normal recyclable waste. As hospitals strive to control costs, it is important to bear in mind that promoting sustainability practices yields not only environmental benefits, but also economic ones for the institution.

## Conclusion

The analysis of medication processes revealed problems related to the physical structure, equipment, materials, methods, work environment and personnel, that weakened proper sustainable actions by the nursing team. The proposed interventions primarily involved the installation of efficient technologies to save on natural resources such as water, investment in suitable containers, changes in work methods to reduce materials and facilitate recycling and appropriate waste treatment, changes in

institutional policies and training of the team. The changes in processes resulted in better attitudes on the part of professionals and reduced waste, indicating the need for hospitals to not simply leave the role of collaborating with the environment up to staff members, since institutional problems can also constitute obstacles to these practices.

## Acknowledgments

To the Coordination for the Improvement of Higher Education Personnel (CAPES) for the sandwich PhD scholarship awarded to Furukawa PO.

## Collaborations

Furukawa PO, Cunha ICKO, Pedreira MLG and Marck PB contributed to the conception of the study, data analysis and interpretation, critical review of the relevant intellectual content and final approval of the version to be published.

## References

1. Fitzpatrick J. The impact of healthcare on the environment: improving sustainability in the health service. *Nurs Times*. 2010; 106(9):18-20.
2. Anderko L, Chalupka S, Gray WA. Greening the 'proclamation for change': healing through sustainable health care environments. *AJN*. 2013; 113(4):52-9.
3. IPCC (Intergovernmental Panel on Climate Change). Summary for policymakers. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. New York: Cambridge; 2014; p. 1-32.
4. Ulhøi JP, Ulhøi BP. Beyond climate focus and disciplinary myopia. The roles and responsibilities of hospitals and healthcare professionals. *Int J Environ Res Public Health*. 2009; 6(3):1204-14.
5. Anaker A, Elf M. Sustainability in nursing: a concept analysis. *Scand J Caring Sci*. 2014; 28(2):381-9.
6. Kangasniemi M, Kallio M, Pietila AM. Towards environmentally responsible nursing: a critical interpretive synthesis. *J Adv Nurs*. 2014; 70(7):1465-78.
7. Camponogara S, Ramos FR, Kirchhof AL. Reflexivity, knowledge and ecological awareness: Premises for responsible action in the hospital work environment. *Rev Lat Am Enfermagem*. 2009; 17(6):1030-6.
8. Mathur V, Dwivedi S, Hassan MA, Misra RP. Knowledge, attitude, and practices about biomedical waste management among healthcare personnel: A cross-sectional study. *Indian J Community Med*. 2011; 36(2):143-5.
9. Maroufi M, Javadi M, Yaghoubi M, Karimi S. Function of nurses and other staff to minimize hospital waste in selected hospitals in Isfahan. *Iran J Nurs Midwifery Res*. 2012; 17(6):445-50.
10. Carvalho EV, Ferreira E, Mucini L, Santos C. [Legal and toxicological aspects of medication discharges]. *Rev Bras Toxicol*. 2009; 22(1/2):1-8. Portuguese.



11. Kwakye G, Brat GA, Makary MA. Green surgical practices for health care. *Arch Surg* 2011; 146(2):131-6.
12. Camponogara S, Viero CM, Erthal G, Erthal G, Rossato GC. [Nursing and environment: a bibliographic review] *Rev Enferm UFSM*. 2011; 1(3):472-80. Portuguese.
13. Werkema, C. [Lean Six Sigma: Introduction to Lean Manufacturing tools] 2a ed. Rio de Janeiro (RJ): Elsevier; 2011. Portuguese.
14. Silva IB, Miyake DI, Batocchio A, Agostinho OL. [Integrating the promotion of Lean Manufacturing and Six Sigma methodologies in search of productivity and quality in an auto parts manufacturer] *Gest. Prod.* 2011; 18(4):687-704. Portuguese.
15. Egan S, Murphy PG, Fennell JP, Kellit S, Hickley M, McLean C, et al. Using Six Sigma to improve once daily gentamicin dosing and therapeutic drug monitoring performance. *BMJ Qual Saf.* 2012; 21(12):1042-51.
16. Carboneau C, Bengé E, Jaco MT, Robinson M. A Lean Six Sigma team increases hand hygiene compliance and reduces hospital-acquired MRSA infections by 51%. *J Healthc Qual.* 2010; 32(4):61-70.
17. Centro de Vigilância Sanitária. Divisão Técnica de Ações sobre Meio Ambiente. Portaria CVS n. 21, de 10 de setembro de 2008. [Approving the technical standard on hazardous waste management of drugs in health services.]. *Diário Oficial do Estado; Poder Executivo, São Paulo, SP*, de 11 setembro de 2008. Portuguese.
18. Brazil. Ministério da Saúde. ANVISA - Agência Nacional de Vigilância Sanitária. Resolução da Diretoria Colegiada - RDC n. 306, de 7 de dezembro de 2004. [It provides for the technical regulation for the waste management of health services] *Diário Oficial da União; Poder Executivo, Brasília, DF*, de 10 de dezembro de 2004. Portuguese.
19. United Nations. Sustainable Development. United Nations Conference on Environment & Development. Agenda 21. Rio de Janeiro, 1992. [cited 2014 Jul 24]. Available from: <https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf>.
20. World Health Organization, Health Care Without Harm. Healthy Hospitals - Healthy Planet - Healthy People. Addressing climate change in health care settings. 2009. [cited 2014 Apr 30]. Available from: [http://www.who.int/globalchange/publications/climatefootprint\\_report.pdf](http://www.who.int/globalchange/publications/climatefootprint_report.pdf).
21. Szklo AS, Soares JB, Tolmasquim MT. Energy consumption indicators and CHP technical potential in the Brazilian hospital sector. *Energy Convers Manag.* 2004; 45(13-14):2075-91.
22. United Kingdom. Department of Health. Environment and sustainability. Health technical memorandum 07-04: water management and water efficiency - best practice advice for the healthcare sector. 2013. [cited 2016 Feb 10] Available from: [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/147948/HTM\\_07-04\\_Final.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/147948/HTM_07-04_Final.pdf).
23. Petterwood J, Shridhar V. Water conservation in surgery: A comparison of two surgical scrub techniques demonstrating the amount of water saved using a 'taps on/taps off' technique. *Aust J Rural Health.* 2009; 17(4):214-7.
24. Somner JE, Stone N, Koukkoulli A, Scott KM, Field AR, Zygmunt J. Surgical scrubbing: Can we clean up our carbon footprints by washing our hands? *J Hosp Infect.* 2008; 70(3):212-5.
25. Costa DV, Teodosio AS. [Sustainable development, consumption and citizenship: a study on the (dis)articulation of the communication of civil society organizations, government and companies] *Rev Adm Mackenzie.* 2011; 12(3):114-45. Portuguese.
26. Castilho V, Castro LC, Couto AT, Sasaki NY, Nomura FH, Lima AF, et al. Survey of the major sources of waste in the health care units of a teaching hospital. *Rev Esc Enferm USP.* 2011; 45(n.spe):1613-20.
27. Becker J, Méndez-Quigley T, Phillips M. Nursing role in the pharmaceutical life cycle. *Nurs Adm Q.* 2010; 34(4):297-305.
28. Pereira MS, Alves SB, Souza AC, Tipple AF, Rezende FR, Rodrigues EG. Waste management in non-hospital emergency units. *Rev Lat Am Enfermagem.* 2013; 21(Spec):259-66.
29. Vogt J, Nunes KRA. Recycling behaviour in healthcare: waste handling at work. *Ergonomics.* 2014; 57(4):525-35.
30. Walkinshaw E. Too much of a good thing? *CMAJ.* 2011; 183(18):1309-10.