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Summary

Currently, where the country's political and economic situation directly impacts the health sector, hospitals are required to improve their performance in a structured and sustainable way. Thus, from the point of view of engineering and health technology administration, this work presents how the frequency with which preventive maintenance routines can be redefined, with gains for the hospital organization and without harm to the patient, based on objective criteria . This work shows how preventive maintenance in different periods, such as: daily, weekly, monthly and annual, were effective in improving the lifespan of autoclaves in three different hospital units in the city of São José dos Campos-SP. Fifteen autoclave devices were analyzed, divided into two categories regarding volume. Devices with volumes of 12 and 42 liters were identified as brand 1 and devices with volumes of 19 liters were identified as brand 2. After the implementation of preventive maintenance for these autoclaves, the results in terms of the number of patient visits increased by 5% and 2% for brands 1 and 2 respectively, in addition to the reduction in the active time of these devices, decreasing from 87% for brand 1 and 75% for brand 2 per year. It was concluded that preventive maintenance responds best to the cost-benefit of the autoclaves studied.

Key words: Equipment management; Continuous improvement, Management

Abstract

Currently, where the political and economic situation of the country directly impacts the health area, hospitals are required to improve their performance in a structured and sustainable way. Thus, from the point of view of engineering and administration of health technology, this work presents how the periodicity with which preventive maintenance routines can be redefined, with gains for the hospital organization and without harm to the patient, based on objective criteria. This work shows how preventive maintenance for the different time periods such as: daily, weekly, monthly, and annual were effective for improving the life of the autoclaves of three different hospital units in the city of São José dos Campos-SP. We analyzed 15 autoclaves devices divided into two terms regarding volume. The devices with volumes of 12 and 42 liters were identified as mark 1 and the devices with volumes of 19 liters were identified as mark 2. After the implementation of preventive maintenance of these autoclaves, the results regarding the number of patient visits increased by 5% and 2% for brands 1 and 2, respectively, in addition to the decrease in the active time of these devices, decreasing from 87% to mark 1 and 75% to mark 2 per year. It was concluded that preventive maintenance responds better to the cost-benefit of the autoclaves studied.

Keywords: Equipment management; Continuous Improvement, Management

1. Introduction

In Brazil, the Collegiate Board Resolution [RDC] 02/2010, establishes the minimum criteria, to be followed by health care establishments [EAS], for the management of health technologies used in the provision of health services, in order to guarantee its traceability, quality, efficacy, effectiveness and safety and, where appropriate, performance, from entry into the healthcare establishment to its final destination, including the planning of physical, material and human resources, as well as the training of the professionals involved in the process of these (Agência

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National Health Surveillance [ANVISA], 2010).

Maintenance definitions nowadays can be divided into 3 types: preventive maintenance, corrective maintenance and predictive maintenance. Preventive maintenance according to Almeida, 2007 “all preventive maintenance management programs assume that machines will degrade with a typical picture of their particular classification”. Therefore, the maintenance feasibility study includes statistical data on some variables such as average time between failures, manufacturer characteristics, variability of the work environment and meeting the specific standard of the device.

Corrective maintenance is considered the oldest type of maintenance according to Smith, 1993 as it does not require any type of maintenance planning, just physical material and a technical level to correct the specific device. Without any analysis of repetitive reasons or questioning the reason for the breakage, just a repair when the device breaks.

Predictive maintenance is considered the most effective preventive maintenance on equipment as it uses statistical methods based on assisted monitoring of the life of the equipment, combined with costs and the device's breakdown rate (Xavier and Branco Filho 2000). It is maintenance that always seeks continuous improvement where each maintenance carried out (preventive or corrective) is analyzed to improve predictive intervention in the equipment (Otani; Machado, 2008).

Despite the need to ensure safety in hospital environments, only a small number of hospitals in underdeveloped countries have preventive maintenance programs, citing a lack of personal and financial resources (Cook, 2001; Morais, 2004). Brazil, like other developing countries, is still behind in terms of awareness of the importance of managing and maintaining medical equipment. It is estimated that there are 6,000 generic types of medical equipment in the world, with more than 750,000 different models and brands. However, only 7% of annual expenditure on medical equipment worldwide comes from underdeveloped countries (Cook, 2001; Morais, 2004).

Despite active legislation, there are no defined time intervals between equipment preventive maintenance activities. Therefore, it is suggested to follow the manufacturers' standards, especially when it comes to new hospitals or clinics, with no previous history of behavior and performance. Over time, with better knowledge of the behavior of such equipment in operation, the types and severity of breakdowns or defects, accidents and incidents that have occurred, other maintenance intervals than those offered by manufacturers can be proposed.

As healthcare costs have been growing over the years and technology is also part of this increase, there is a need for better practices for the effective management of these resources. Choosing an adequate frequency for the maintenance of hospital equipment becomes a challenge for engineering and maintenance services which, in line with administrative guidelines, aim to rationalize maintenance expenses arising from medical care equipment, in a more efficient way. technical and scientific.

To apply this work in practice, adopting criteria for including equipment in maintenance programs, focusing on preventive maintenance, should also help to define not only what types of equipment to include in the program, but also how frequently the maintenance routine should be carried out. carried out. Autoclave devices were chosen for the job.

2 Material and Methods

It was decided to carry out a survey of the existing autoclave devices in three Hospital Units in the same group A, B and C (data not authorized for publication). And demonstrate results of improvement in the maintenance process and reduction in the average time between equipment failures, in addition to demonstrating a financial return to the institution with the increase in productivity of autoclave machines.

2.1 Study location and number of machines

The study consists of an active analysis of equipment already existing in the institution, which aims to comply with RDC 02. 15 national brand devices were analyzed (Table 1) from three different units A, B and C of the same institution in the City of São José dos Campos – SP.

Of the 15 devices researched, we divided them into two categories: 12 liter and 42 liter machines will be called brand n°1 machines and the 19 liter machines we will call brand n°2 machines.

After collecting data from this group of equipment, preventive maintenance analyzes were carried out and evidence was produced to improve the institution's equipment management process.

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Table 1. Autoclaves analyzed

Gadgets		Brand	Volume (liters)	Age of
Autoclave 1	A	1	12	4 years and 9 months
Autoclave two	A	1	12	4 years and 9 months
Autoclave 3	A	1	12	4 years and 9 months
Autoclave 4	A	1	42	4 years and 9 months
Autoclave 5	A	1	42	4 years and 9 months
Autoclave 6	A	1	42	4 years and 9 months
Autoclave 7	B	1	42	5 years and 9 months
Autoclave 8	B	1	42	5 years and 9 months
Autoclave 9	B	1	42	5 years and 9 months
Autoclave 10	B	1	12	3 years and 7 months
Autoclave 11	B	1	12	3 years and 7 months
Autoclave 12	W	two	19	8 years and 1 month
Autoclave 13	W	two	19	7 years and 3 months
Autoclave 14	W	two	19	7 years and 3 months
Autoclave 15	W	two	19	7 years and 3 months

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Source: Research data.

2.2 Autoclave conditions

The machines are made of the same manufacturing materials and of the same type, they are saturated steam autoclaves, electrically heated through shielded resistances insulated with a fiber ceramic blanket with the internal chamber made of 304 stainless steel. The average lifespan of all equipment is 5 years and 6 months, and the oldest equipment is 8 years old and has had 1 month of constant use.
The product sterilization process is also standardized as follows: which contains the material accommodation and heating process, 5 minutes of sterilization at 134ºC. The material drying process takes 20 minutes. The sterilization capacity of all machines varies from 12 liters, 19 liters and 42 liters.
As they are units of the same group and the nursing management is the same, all sterilization processes follow the same nursing protocol, where material storage, machine cleaning and electrical supply are the same for all units.
The rooms were air-conditioned and the temperature varied between 19ºC and 21ºC, the relative humidity of the environment where the equipment was located was approximately 60%.

2.3 Preventative Maintenance Plan

The preventive maintenance plan applied in the units was divided into daily, weekly, monthly, semi-annual and annual stages, detailed below and followed as shown in figure 1. All items must be filled in with the hospital's own service order and registered with to the hospital management system.
Chemical and biological indicators must be seen in each institution in the way that the hospital infection control center must follow according to the standards of ANVISA (National Health Surveillance Agency) (RDC 15) and SOBECC (Brazilian Society of Surgical Center Nurses), so the brand, model, how and when to use these products will not be demonstrated in this article.

Daily plan
- Clean the camera and door sealing trim
- Check the printer
- Check the condition of the door handle and lock

Weekly plan

- All of the above
- Change the distilled water in the reservoir
- Do an internal cleaning

Monthly plan

- In addition to the previous items
- Clean and unclog filters and valves
- Check and retighten the contacts of the electrical system and hydraulic connections

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- Perform a function test on the safety valve;

Semiannual plan

- All of the above
- Clean and unclog pipes and hydraulic components
- Check the door closing system

Annual plan

- In addition to the previous items
- Adjust the water flow of the vacuum pump
- Perform calibration of protection and control instruments
- Perform validation and thermal qualification on the machine
- Perform validation of security and control elements
- Analyze the door closing system
- Check machine grounding
- Carry out hydrostatic testing and evaluation.

Associated with the plans for different periods mentioned above, we join the preventive plans found in the Autoclave Operational Manual (Figure 1) indicating to employees in the equipment management sector to be guided by the equipment intervention deadlines as a way of complementation.

PLANO DE MANUTENÇÃO	Diário	Semanal	Mensal	Semestral	Anual
	CLIENTE			SERCON	
ELÉTRICA					
Verificar corrente das resistências de aquecimento				●	
Verificar a necessidade da troca das resistências					●
Verificar a regulagem do relé térmico da bomba de vácuo				●	
Verificar corrente da bomba de vácuo				●	
Verificar o aterramento				●	
Verificar disjuntor da entrada de instalação				●	
Verificar o reaperto dos contatos elétricos				●	
HIDRÁULICA					
Limpeza dos elementos hidráulicos				●	
Verificar a necessidade da troca das válvulas solenoides					●
Verificar a necessidade da troca das válvulas de retenção					●
Verificar a vazão da bomba de vácuo				●	
Verificar o funcionamento das válvulas				●	
Verificar o tempo de entrada de agua				●	
Verificar o reaperto das conexões hidráulicas				●	
Verificar possíveis vazamentos na câmara interna				●	
MECÂNICA					
Avaliação hidrostática					●
Limpeza da guarnição da porta com álcool	●				
Limpeza da câmara interna	●				
Troca da agua destilada do reservatório		●			
Limpeza do filtro sinterizado		●			
Limpeza e conservação do gabinete (chaparia e isolação)	●				
Verificar necessidade da troca da guarnição					●
Verificar válvula fusível				●	
Verificar termostato de segurança				●	
Verificar válvula de segurança				●	
Verificar nivelamento e assentamento do equipamento				●	
Verificar sistema de fechamento da porta / Micro de porta				●	
Verificar o estado do filtro sinterizado do dreno				●	
Verificar necessidade da troca do filtro sinterizado do dreno					●
CALIBRAÇÃO					
Troca da válvula de segurança					●
Trocar manômetro					●
Trocar termostato					●
INDICAÇÃO E CONTROLE					
Verificar fita de impressão e quantidade de papel	●				
Verificar indicadores de temperatura e pressão				●	
UTILIDADES					
Verificar tensão da rede elétrica				●	
Verificar tubulação de entrada de agua				●	
Verificar tubulação de saída para esgoto				●	

Figure 1. Preventative maintenance plan for autoclaves. The legend indicates green colors as a periodic check item and red colors as safety items (SERCON).
Source: Research data

3 Results and Discussion

After searching the reports of the 3 units under study (A, B and C), the main points of interest were analyzed, being able to observe the main parameters presented in Tables 2 and 3, which helped to begin the process of improving the conditions for maintenance of autoclaves.

As they are units in the same group of a hospital, all the following procedures are followed and carried out with close dates (as soon as possible) to optimize the technician's time and minimize the period of machine undergoing preventive maintenance

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in the units.

Table 2. Data analyzed in the brand 1 autoclave

I have analyzed		Average time part exchange
Garrison	Monthly	Change every 6 months
Valve in security	Yearly	Exchange average variant from 2 to 4 years
Cleaning of the Camera internal	Monthly	None hole camera in 8 years
Analysis in chain at resistance	Monthly	Exchange average of resistance to every 8 months
Physical integrity at resistance	Monthly	Exchange average of resistance to every 8 months
	Monthly	Just exchanged one unit after 3 years
Grounding of the device	Monthly	He can to generate burn at the equipment, but none proven evidence
Analysis of reservoir of water	Monthly	Never changed the reservoir

Source:Survey data

Table 3. Data analyzed in the brand 2 autoclave

I have analyzed		Average time rework estimated or part exchange
Garrison	Monthly	Change every 6 months
Valve in security	Yearly	Variant mean from 2 to 4 years
Cleaning of the Camera internal	Monthly	None hole camera in 5 years
Analysis in chain at resistance	Monthly	Exchange average of resistance to every 12 months
Physical integrity at Resistance	Monthly	Exchange average of resistance to every 12 months
Current check in the pump vacuum	Quarterly	No exchanged bomb in vacuum of this Brand

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Monthly Grounding of the device	Rework only if not was made

Source:Survey data

After the inclusion of this maintenance program with the machines studied, we identified an exponential increase in the maintenance cost, where the number of interventions with the device increased considerably, from at least monthly to daily interventions and many more items in monthly maintenance. As a result, the machine downtime rate also reduced, according to the data mentioned in the next items a and b.

3.1 Brand 1 Devices

Before the studies began, the breakdown rates for this brand's equipment were one breakdown per device every 4 months on average and the service time varied according to the broken part.
Each year, brand 1 machines were stopped on average (without production or canceling procedures) for 423 hours per year. After the inclusion of the preventive maintenance program mentioned in this study, it is estimated that the machines will be able to be stopped for 55 hours per year, reducing the machine downtime per year by 7 times.

3.2 Brand 2 Devices

Before the studies began, the breakdown rates for this brand's equipment were one breakdown per device every 6 and a half months on average and the service time varied according to the broken part.
Each year, brand 2 machines were stopped on average (without production or canceling procedures) for 172 hours per year. After the inclusion of the maintenance program mentioned in this study, it is estimated that the machines will be able to be stopped for 49 hours per year. Reducing machine downtime per year by 3 times.
These results were clear in terms of the reduction in the time of equipment downtime per year in the institutions studied. Following the natural flow of strategic planning, the company turns its attention to its interior, analyzing its strengths and weaknesses, practicing the failure analysis methodology capable of improving the performance of equipment and the company. Allowing you to determine internal strategies as a means of establishing organizational purpose in terms of long-term objectives, action programs and resource allocation priorities.
Maintenance has reacted quickly to these changes; This new stance includes a growing awareness of how much equipment failure affects safety and the environment, greater awareness of the relationship between maintenance and product quality, greater pressure to achieve high availability and reliability of the installation, while at the same time seeks to reduce costs. These changes are demanding new attitudes and skills from maintenance people, from managers, through engineers and supervisors, to performers (Pinto and Xavier, 2009).

Based on the report of the “International Electrotechnical Commission [IEC]” (IEC 60513,1976) and the “Plant, Technology and Safety Management [PTSM]” program of the “Joint Commission on Accreditation of Healthcare Organization [JCAHO]”, it is observed that concern for patient and user safety was essential for the adoption of preventive maintenance measures in hospital environments. Problems with medical equipment due to breakage or malfunction can be fatal in hospitals (Morais, 2004). Maintenance plays a fundamental role in this context, as in any other context where one wishes to maintain the production of goods or services, equipment, machinery and facilities, always subject to the limitation of the useful life of items (Morais, 2004; Lucatelli, 2002). No matter how qualified health professionals are, we cannot talk about quality and safety if the functionality and safety of equipment and installations are not guaranteed (Morais, 2004).
When analyzing the data shown in the results, it was verified that both machines suffered a significant improvement in the availability time of each piece of equipment, generating a higher production of the equipment itself.
than that already used before the study. This generates greater safety for the patient as the sterilization processes are more monitored, reducing the generation of failures in the sterilization process and estimates were made regarding the increase in the number of patients treated, with an increase of approximately 5% in the number of patients treated in sectors with equipment for machines cited as Brand 1 and an increase of approximately 2% in patients treated in sectors with equipment for machines cited as Brand 2.
All maintenance procedures, whether corrective or preventive, must be duly recorded on control sheets, so that the profile of the equipment that makes up the hospital's assets can be traced, and thus the best way to manage this asset can be defined. . When carrying out this work, it was observed that incompletely completed records hindered and limited the application of the method. The most frequent findings were in

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blank fields in the histories, and fields that, although filled in, did not present satisfactory reliability. However, so that the data can become statistics and actually reflect the needs that a maintenance team encounters when mobilized on an emergency mission, it is necessary to complement this analysis. Therefore, it remains open for future work to complement this topic, which once completed will bring great optimization to the maintenance service on hospital equipment, in this case, autoclaves in emergency situations.

Final considerations

The execution of this study provided a perception mainly of the simplicity and usefulness of some fully accessible tools, as acting in a systemic and organized way is a differentiator that defines the success and failure of the business. Perhaps it is necessary to disseminate this knowledge in a simpler and more generalized way, given the context, it is highlighted that the application and implementation of preventive measures and quality tools does not require a significant investment, its methodology brings a very clear discernment of the problems, execution , cost, time. Preventive maintenance showed good results in terms of time of equipment downtime per year and number of patients treated within this longer period of active autoclave devices, in addition to better quality of operation of sterilization devices.

With the implementation of the preventive system in this equipment, we were able to analyze a financial return for the units of the hospital medical group. Because with the equipment availability index we can analyze that the corrective maintenance index tends to zero and with the increase in services in the sectors we are able to measure the greatest financial return for the institution. Equipment survival can increase by 20% to 30%, compared to equipment without preventive maintenance operating in hospitals and clinics. In addition to the financial returns mentioned above, it is estimated that the useful life of the equipment can exceed 15 years. Monitoring the thickness of the internal camera is the biggest point that concerns us for the useful life of the equipment.

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