

# Cleaner Maintenance and Production Management in Three Health Institutions in Medellín, Colombia

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**Abstract** — Objective: to perform a diagnosis of the state of biomedical equipment maintenance management in the emergency areas of three (3) institutions of level three of medical complexity in the city of Medellín, Colombia. The realm is within the cleaner production in health research project. Methodology. A survey was designed based on the Cleaner Production Sector. Guide: in hospitals, clinics and health centers, where a checklist was obtained to review the state of maintenance management of the most complex biomedical equipment used in the emergency room. Results: maintenance management of the most complex biomedical equipment is very good in hospital 1 and excellent in hospitals 2 and 3. Metrology and maintenance management in the biomedical equipment of the emergency area of all three hospitals is excellent. Conclusion: maintenance management is very important for financial savings in institutions, since they can thus reduce equipment downtime without harming the provision of healthcare services, along with reducing costs in the purchase of spare parts and generation of waste, which causes a negative impact on the environment

**Keywords** — Biomedical equipment, maintenance management, hospitals, biomedical metrology, cleaner production.

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## GESTIÓN DE MANTENIMIENTO Y PRODUCCIÓN MÁS LIMPIA EN TRES INSTITUCIONES DE SALUD DE MEDELLÍN, COLOMBIA

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**Resumen**—Objetivo: Realizar un diagnóstico del estado de la gestión del mantenimiento de equipos biomédicos en el área de urgencias de tres (3) instituciones de nivel tres de complejidad médica de la ciudad de Medellín, Colombia, dentro del proyecto de investigación producción más limpia en salud. Metodología: Se diseñó una encuesta a partir de la Guía Sectorial de Producción más Limpia, en hospitales, clínicas y centros de salud, donde se obtuvo una lista de chequeo para la revisión del estado de la gestión

de mantenimiento de los equipos biomédicos más complejos utilizados en urgencias. Resultados: La gestión de mantenimiento de los equipos biomédicos más complejos es muy buena en el hospital 1 y excelente en los hospitales 2 y 3; la metrología y gestión de mantenimiento en los equipos biomédicos del área de urgencias de los tres hospitales es excelente. Conclusión: La gestión de mantenimiento es muy importante para el ahorro económico en las instituciones, ya que se pueden reducir tiempos muertos de los equipos sin afectar la prestación de los servicios, aparte de que se reducen gastos en la compra de repuestos, y generación de residuos causantes de impactos negativos al medio ambiente.

**Palabras clave** — Equipos biomédicos, gestión de mantenimiento, hospitales, metrología biomédica, producción más limpia.

## GESTÃO DE MANUTENÇÃO E PRODUÇÃO MAIS LIMPA EM TRÊS INSTITUIÇÕES DE SAÚDE DE MEDELLÍN, COLÔMBIA

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**Resumo**—Objetivo: Realizar um diagnóstico do estado da gestão da manutenção de equipamentos biomédicos na área de urgências de três (3) instituições de nível três de complexidade médica da cidade de Medellín, Colômbia, dentro do projeto de investigação produção mais limpa em saúde. Metodologia: Desenhou-se uma pesquisa a partir da Guia Setorial de Produção mais limpa, em hospitais, clínicas e centros de saúde, onde se obteve uma lista de verificação para a revisão do estado da gestão de manutenção dos equipamentos biomédicos mais complexos utilizados em urgências. Resultados: A gestão de manutenção dos equipamentos biomédicos mais complexos é muito boa no hospital 1 e excelente nos hospitais 2 e 3; a metrologia e gestão de manutenção nos equipamentos biomédicos da área de urgências dos três hospitais é excelente. Conclusão: A gestão de manutenção é importantíssima para a poupança econômica nas instituições, já que podem-se reduzir tempos mortos dos equipamentos sem afetar a prestação dos serviços, aparte de que se reduzem despesas na compra de repostos, e geração de resíduos causantes de impactos negativos ao meio ambiente.

**Palavras-chave**—Equipamentos biomédicos, gestão de manutenção, hospitais, metrologia biomédica, produção mais limpa.

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### I. INTRODUCTION

In addition to intervening in the transformation of illnesses for the good of persons, healthcare service providers are generators of a series of negative impacts caused from different processes and inputs used to carry out medical attention procedures and other such activities which support the object of their very nature in society [1].

The implementation of better practices in social and environmental responsibility in Clinics and Hospitals of the Medellín Health Cluster, stemming from Clean Production and Sustainable Consumption (PL&CS, in Spanish), has been ratified in Colombia through the National Production and Sustainable Consumption Policy, since 2010 [2]. The aims are to improve corporate responsibility practices in public and private institutions, to generate added value from the production and sustainable consumption of goods and services, to make rational use of natural resources, to prevent risk and danger that harm human health and the environment, and to increase productivity and competitiveness in institutions of the different economic sectors of the country, as well as, in international markets [3].

Maintenance management today involves cleaner production processes [4], whose goal is to reduce the impact on the environment, along with reducing costs incurred in residual production and atmospheric

emissions [5]. Thus, since 2013, the Instituto Tecnológico Metropolitano (ITM), the Institución Universitaria Pascual Bravo (IU Pascual Bravo) have been carrying out a study on the state of maintenance management in the emergency room service of three levels III and IV health providers in the metropolitan area of the city of Medellín, Colombia, all within the context of the research project for cleaner production in healthcare.

### II. METHODOLOGY

A survey was designed for three health providers involving the Sector Guide for Cleaner Production and the Enablement resolutions 1441 of 2014 [1], [6], where a checklist was created for the review of the state of maintenance management of high and mid risk biomedical equipment used in emergency services (vital signs monitors, defibrillators, blood pressure monitors, servo-control incubators, electrocardiographs and mechanical ventilators) (Table 1). For this, the checklist was divided into three major areas: maintenance of biomedical equipment used with 14 logs focused on defining the existence of maintenance protocols, types of maintenance employed, personnel in charge of maintenance, equipment life-record sheets, work orders, maintenance plans and programs and record sheets for equipment.

Also, metrology and maintenance management of the biomedical equipment with 12 logs in order to determine the way equipment calibration is articulated and coordinated, personnel in charge of maintenance management, budget plan for maintenance and plans for enablement, certification and accreditation the health provider has defined for the next few years [6].

After each log on the checklist, a value from 0 to 10 is assigned, according to the following criteria: Table 1.

**C:** Completely complies (10 points),

**N.C.:** Non Compliance (0 points),

**C.P.:** Complies partially (5 points).

**Table 1.** Verification checklist for maintenance management

Points	Checklist				
	Parameters	C	N.C	C.P	Comments
1	Maintenance of medical equipment used in the emergency room				
2	Metrology and maintenance management in medical equipment used in the emergency room				

This is to obtain a qualitative value and percentage for each area evaluated in the three healthcare providers selected for the diagnosis, as Table 2 shows. Finally, strengths (F), improvement opportunities (OM) are established and recommendations (R) are made to the institutions.

**Table 2.** Qualitative and percentage evaluation for each evaluated area

Points	Rating	
	Qualitative	Percentage (%)
1	Complies, or Non-complaint	0
2	Insufficient	0 to 30
3	Acceptable	31 to 50
4	Good	51 to 70
5	Very good	71 to 90
6	Excellent	91 to 100

### III. RESULTS

According to the parameters established in Table 2, results presented in Table 2 were obtained. This allows for identifying that the evaluated institutions have systems for maintenance planning and biomedical equipment calibration. It should be noted that calibration of biomedical equipment is made by the institution itself on some

occasions, while on other occasions, this service is provided by outside suppliers. This is subject to institutional capacity and the characteristics of the equipment.

In addition, within the review, we were able to find that biomedical engineering departments are also in charge of maintenance of hospital infrastructure.

**Table 3.** Comparison of results of the three institutions evaluated

Hospital Valuation				
		1	2	3
Qualitative	G-Mtto	Very well	Excellent	Excellent
Percentage (%)	Mtg	Excellent	Excellent	Excellent
	G-Mtto	86	92	92
	Mtg	96	100	100

**G-Mtto:** Maintenance of biomedical equipment  
**Mtg:** Metrology and maintenance management of biomedical equipment.

Maintenance management of biomedical equipment used in the emergency rooms of institution 1 is very good, with a valuation of 86%. This result, despite being competitive, is a warning for the hospital to improve its indicators by applying self-assessments and internal improvements, as well as offering high quality and responsible services. This result is obtained from the analysis of Table 2 and from the checklist applied to some high-risk equipment (vital signs monitors, defibrillators, blood pressure monitors, servo-control incubators, electrocardiographs and mechanical ventilators) of the emergency room service, Fig. 1.

Metrology and Maintenance Management of biomedical equipment in the emergency area is excellent with a valuation of 96%, value obtained from Table 2 and the instructional analysis applied to the groups of the aforementioned equipment, Fig. 1.

Maintenance Management of biomedical equipment used in Hospitals 2 and 3 is excellent, with a valuation of 92%. It should be noted that the 92% result for maintenance management is due to the fact the total productive management (TPM) is unknown, as well as the reliability centered maintenance (RCM). This does not imply there are no serious failures in the maintenance management process but that there is no use of modern maintenance strategies that would help the process be faster and more efficient. The application of the aforementioned strategies could improve, not only the results of the study, but also productivity and healthcare service provided by the hospital.

Metrology and Maintenance Management of biomedical equipment in the emergency room is excellent,

with a valuation of 100%, value obtained for some high and mid-risk equipment (vital signs monitors, defibrillators, blood pressure monitors, servo-control incubators, electrocardiographs and mechanical ventilators) of the emergency room service, Table 2 and Fig. 1.

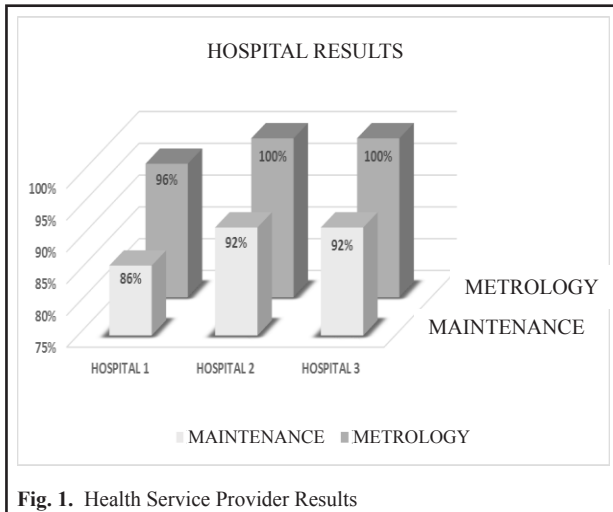


Fig. 1. Health Service Provider Results

Fig. 1 and Table 2 show there is very good maintenance management at these three institutions, which significantly reduces the number of emergency interruptions of high, mid and low-risk equipment used in the emergency service provision, as well as, in the spare parts used. As such, contaminants and residues generated by this activity are also reduced, thus aiding in cleaner production in the healthcare sector, along with the conservation of the planet [7].

In general, these institutions present, according to the checklist designed for the collection of information, maintenance management that, albeit has room for improvement, demonstrates the capacity and disposition to adopt new improvements within the planning of maintenance management and metrology. Duly noted is the importance of personnel hired, technology acquired, as well, as its cost effectiveness, so as to prolong technical reliability.

#### IV. DISCUSSION

Maintenance management is a scientifically proven methodology that integrates efforts from various areas of the institutions, rationally using resources, planning, controlling, and guiding the organization toward its ends and objectives. This methodology also enables the optimization of the use of existing technological tools, as well as, the execution time of the different activities performed by operators, technicians and assisting personnel, in order to guarantee that the different equipment and devices will receive the needed corrective and preventive maintenance measures necessary, at the right time [8].

All of the above enables greater performance and reliability of the equipment and medical devices, which will increase their quality level, availability and safety. This, in turn, will improve the health services provided by these institutions, since they will always have updated, timely and reliable information on each one of the pieces of equipment, enabling the right decisions at the time for corrective or preventive maintenance and/or replacement parts for medical technology [9].

As the results show, from the percentage value of the findings for each area evaluated in the maintenance of the biomedical equipment used in emergency room services and metrology and maintenance management of the biomedical equipment, it is necessary to implement improvement plans for some aspects, such as personnel training in the use of tools and in modern maintenance tendencies so as to channel them adequately, thus providing quality health services at reasonable costs [10].

Public and private health sectors require quality standards for the follow-up, control and transparency in the provision of healthcare services [11] so that they will be able to slowly gain credibility and trust from users and improve the image of biomedical equipment management in emergency rooms of health care providers. This would generate a perception of safety and trust in the target user population of the different equipment and services [12].

#### V. CONCLUSIONS

Maintenance management is important for healthcare providers in order to preserve their property, equipment, facilities, tools and safe, efficient and economical working conditions, anticipating damages or repairing them. This way, institutions will achieve financial savings for spare parts, consumables, direct and indirect workmanship, emergency maintenance, etc. Equipment downtime can be reduced without harming the provision of healthcare and the reliability and availability of equipment will increase. Finally, generation of residues and contaminants which causes negative environmental impact will decrease.

Taking into account the Ministry of Health and Social Protection Resolution 1441 of 2014, wherein procedures and conditions are defined for healthcare providers, we found the emergency areas of the surveyed institutions to have the necessary high and mid-risk equipment to provide adequate healthcare services. Maintenance management of the most complex biomedical equipment is very good in hospital 1 and excellent in hospitals 2 and 3. Metrology and maintenance management in biomedical equipment from the emergency areas of all three hospitals is excellent, Table 2 and Fig. 1.

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