Model HTM Application in Failure Analysis for Air Compressors in the Dental Service of Primary Health Care

Priscila Avelar and Renato Garcia

Abstract

This study presents a failure cause analysis in medical air compressors in dental services of primary health care in Santa Catarina, Brazil. The study classifies failures, from 2007 to 2016, associated with the three domains of the methodology developed for HTM: Human Resources (DHR), Infrastructure (DI) and Technology (DT). From these failures, 58% were associated to DT, 31% to the HRD and 11% to the DI. Data collection was from the HTM Information System of the IEB-UFSC CE and the application of HFMEA. This analysis identifies which failures are related to wear of parts due to their life cycle in DT. In the DI, the causes were the lack of electrical protection and inadequate electrical wirings with manufacturers and technical standards. In DHR, the lack of a manual purge procedure is a cause of failure. As a result, a checklist for functional equipment verification was implemented during the CE technical inspection, which identifies fault conditions and associated domains. For DT, a preventive maintenance program was implemented to replace oil and shorter its service life. In order to reduce the failures associated to the DI, adjustments were made in the compressor shelters with installation of electrical protection and resizing of the electrical system. For the failures associated with the DHR, didactic materials were developed for training with a proposal to improve operational routine, best practices and an installation program of automatic purger in units of greater demand for dental service. The results of these actions led to a reduction in the occurrence of failures and validated the application of HTM model developed for Primary Health Care is important contribution for add quality to primary health care system.

Keywords

Primary health care • Clinical engineering
HTM dental service

1 Introduction

The Brazilian MoH establishes in 2003 the National Health Policy, in which from the Brasil Sorridente Program seeks to guarantee promotion actions, prevention and recovery of oral health with expanded access to dental treatment, free of charge to Brazilians, through the Unified Health System (SUS) [1, 2].

In order to meet the epidemiological demands in dentistry, the primary health care system is structured by support units—health care centers—and reference centers—Dental Specialties Centers (CEA) and Immediate Care Units (UPA)—shown in Fig. 1. These structures are composed of different technological densities and function as a filter capable of organizing the flow of services in Primary Health Care System—HCS, from the simplest to the most complex.

The dental compressor is the main mean of supplying compressed air for the operation of the dental chair (pneumatic dental chair systems) and its components (dental and suction fittings). The technology management processes developed by Clinical Engineering seek to verify the conformity of the equipment from the analysis of causes involving failures, classified by the domains of human resources, infrastructure or by the technology itself.

This methodology, consolidated for the Clinical Engineering HTM model development by IEB-UFSC [3], establishes and implements actions in these domains that

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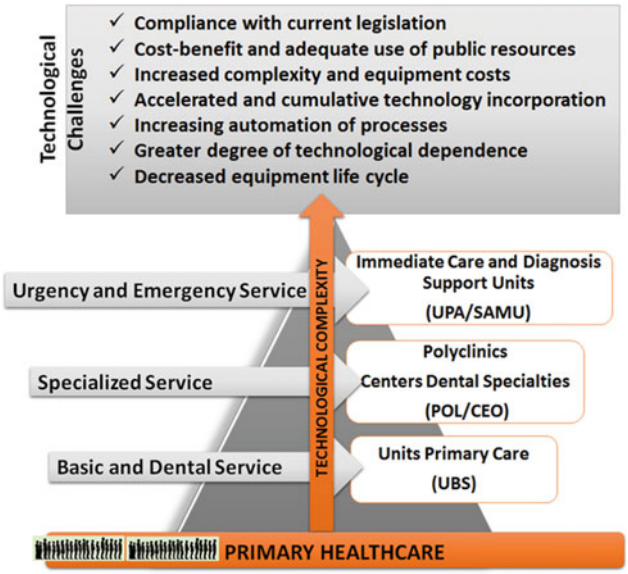

Fig. 1 Structure of primary health care system (PHCS) in Brazil

result in effectiveness, reliability and safety of the technological process and the fulfillment of health care demands.

The Health Technology Management (HTM) model, developed by IEB-UFSC Clinical Engineering, establishes and implements actions in the areas of human resources, infrastructure and technology. These actions seek as a result the effectiveness, reliability and safety of the technological process in health care.

In order for technology to have an impact on health care service quality, the technological process in health care is evaluated in order to obtain an infrastructure that provides the safe operation of medical equipment, the adequate and safe use of technologies by human resources, and the knowledge life cycle technologies to better plan and evaluate their cost-effectiveness.

The Clinical Engineering of the IEB-UFSC has validated and applied the HTM model for more than 15 years with the State Secretariat of Health of Santa Catarina [4–6] and in PHCS about 10 years in the primary health care centers of the Municipal Health Secretariat [7–9]. During this period, different peculiarities were identified of the HTM model applied in PHCS in relation to those practiced in Hospitals, such as logistics of technical visits to the sectors, complexity of the equipment, management and management processes, considering the three levels of attention among others.

The problems involve the inefficiency of the dental service by the dental compressor, are associated with several factors of human resources in the inadequate use due to little knowledge of the use of the technology and the lack of care regarding the water drainage procedure of the equipment; of infrastructure due to electrical installations without protection systems; and technology the frequency of failure due to wear of the parts caused by improper dimensioning of equipment for a dental office and the unavailability of the technology.

This study aims to present a cause-of-failure analysis of dental compressor equipment associated with the context of primary health care dental services based on this HTM model, in the Florianópolis city PHCS, Santa Catarina, Brazil, is composed of 63 health care units distributed in 5 regional (north, south, east, center and mainland) and 4 sanitary districts (north, south, center and mainland) which manage the health care units.

2 Methodological

The methodology, based on a structural model, Fig. 2, is based on out HTM model [3] and in HFMEA tool application [10, 11].

For contextualization of the problem is necessary to know the technological process in which the dental compressor is inserted. This stage was based on bibliographic references that show studies on dental service and HTM in PHCS.

After the contextualization of the research and description of the technological process in the study, data were collected in the Clinical Engineering Information System for the period from 2007 to 2016. Data obtained from Service Orders were classified according to the domains of the HTM model and identified potential causes of failure that supported the application of the HFMEA tool.

The application on out HTM model made it possible to know the history of failures that have impacted the dentistry service unavailability.

In the application of the HFMEA, after the definition of the analyzed process, it followed with: (1) identification of the failure modes being written the problem and its nonconformities; (2) potential consequences of the defect by seeking a brief description of the consequence that may occur; (3) prioritizing the failures through the level of risk, classifying and assigning weights as to the occurrence of the cause and seeking to identify the frequency of appearance of the defects for a given sample and the severity of the effect with the severity weighting in terms of failure effect. Failure detection has been weighed against the ability to detect failure before it reaches the clinical body, the ability to detect the defect during preventive and corrective maintenance; (4) Preventive actions in search of solutions to minimize failures.

With the results of the preventive actions by the HFMEA, it was structured in the PDCA cycle the actions in our HTM model implemented in the health care units of the PHCS in Florianópolis city, Brazil.

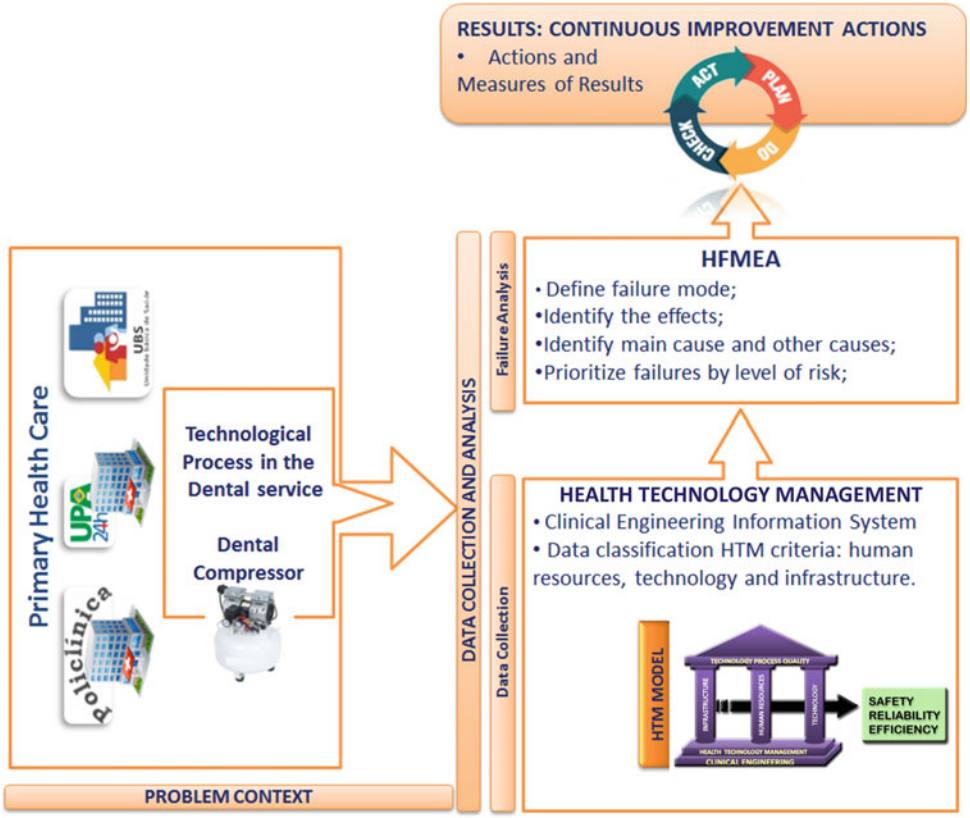

Fig. 2 Structural model: methodology application in the study of dental compressor failures in primary health care systems

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3 Results

In the analysis of the history of dental compressor management, from 2007 to 2016, 58% of clinical engineering activities involved technical problems of the technology itself, 31% of inappropriate use for human resources and 11% of problems with electrical network.

In addition to the management history classification in HTM domain, the HFMEA application made it possible to identify the incidence and repeatability of failure reasons. In Fig. 3, it presents the main problems and occurrence regarding the failures that caused repairs and corrective maintenance.

The CE aimed at achieving the reliability, effectiveness and safety of the technological process in dentistry, established short and medium term actions at the health care units of the PHCS. As shown in Fig. 4, actions in the HTM domains were structured in the PDCA Cycle and checked the results by indicators.

Fail mode	Occurrence	Detection			Repair Time (min)
		QUALY	PM	PC	
Motor locked	7	1	DE	DIP	120
External leakage	9	3	DE	DPP	30
Internal leakage	7	5	DO	DIP	120
Dead / blocked plug	5	3	DE	DIP	30
Connecting Rod	5	3	DP	DIP	60
Defective pressure switch	5	5	DE	DIS	60
Noise level	*	5	DO	DIP	60
Safety valve	*	5	DO	DIP	30

Domain HTM	Failure Analysis
Human Resources	Lack of water drainage
	Equipment is not switched off at the end of the day
Infrastructure (Electrical Grid)	Deregulated pressure switch
	motor locked
	Burnt capacitor
Technology	Leakage
	Lack of lubrication or Validity expired oil
	High noise level
	No pressure or Pressure regulation lack
	Reduced air production
	Piston Ring Wear
	Dirt on the filter

Fig. 3 Main faults that caused repairs and corrective maintenance of the dental compressor and results regarding the application of HFMEA

Fig. 4 Actions in the HTM domains were structured in the PDCA cycle and checked the results by indicators

With failure modes and classification by the three domains of the HTM model, it was possible to identify that human resource failures were related to the periodic change of professionals in the clinical area.

Examples of the action implemented by the CE were the installation of automatic purger or automatic drainage of water from the equipment reservoir, in units of greater demand of dental care. Operational manual drainage of water was performed in the absence of automation of the process, and distribution of flyer of best practices of conservation of the equipment. The installation of the automatic purger provided an 80% reduction of water drainage failures.

The problems with infrastructure of the dental compressor shelters are considered the most challenging, because of the non-conformity of the buildings (shelter) with technical regulations. The recurring failures caused by overloading voltage, current and oscillation of the grid, resulting in the issuance of technical advice to adapt the electrical network equipment shelters. In the shelters were installed electrical protection system and resized the electrical system for better equipment performance.

As for technology, incorporation studies with issuance of technical report were presented to health care managers. The diagnosis of the current situation of the dental compressor park allowed establishing the planning of acquisition of new equipment to replace the equipment at the end of its useful life. It was also implemented a functional checklist by CE in order to minimize corrective maintenance and identify fault conditions and associated domains. The implementation of the checklist allowed the standardization of the diagnosis of failures by the technical team of Clinical Engineering.

4 Conclusion

The process of identification and classification of dental compressor failures was performed by applying an analysis according to the criteria of the three domains is based on out HTM model and the HFMEA tool.

The application of the HTM model with the HFMEA tool provided the adequacy of the Clinical Engineering processes that sought: to reduce the failure to use the equipment improperly through operational training and installation of automatic purger; adequacy of infrastructure in the installation of electrical protection system and decision making in the renovation of the technology park.

The results of these actions led to a 30% reduction in the occurrence of failures and in the decision making process for the acquisition of new dental compressors. These actions allowed the validation of the HTM model and a contribution in the improvement of the dental services in PHCS.

This applied research, evidenced that there is not a single tool capable of answering all the problems of the CE in HTM activities. As observed, the management domains were associated to the HFMEA to support management decision making and specific model HTM for quality technological process improvement solutions over PDCA cycle.

Conflict of Interest The authors of this article declare that they have no conflict of interest.

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