

Management audit applied to the maintenance department in hospital facilities

Auditoría de gestión aplicada al departamento de mantenimiento en instalaciones hospitalarias

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Abstract

This work is related with the operations control in the maintenance department of hospital center, through management audits and their implementation. The study was carried out in five hospitals, with the aim of evaluate the performance of the maintenance function; as well as to demonstrate that the most critical component in the results of a management audit is the human resource. For development of the work, a survey was applied at managers and workers of the center, as a technique for data collection. In addition, monitoring tools such as Ishikawa diagram

and Brainstorming were used. The study showed, among others, that technological problems, such as the availability of assets, are usually associated with a shortage of resources; however, its root cause is a mismanagement by the staff in charge of this activity in the maintenance departments. The application of the proposed method evidenced that the most critical component in the results of a management audit is the human resource.

Key words: audits, hospital maintenance, management.

Resumen

El presente trabajo está dirigido al control de operaciones en el departamento de mantenimiento de entidades hospitalarias, a través de auditorías de gestión y su puesta en práctica. El estudio se realizó en 5 instituciones hospitalarias, con el objetivo de evaluar el desempeño de la función mantenimiento; así como demostrar que el componente más crítico en los resultados de una auditoría de gestión es el recurso humano. Para el desarrollo del trabajo se aplicaron encuestas a directivos y trabajadores del centro como técnica recolección de datos y se emplearon herramientas de control como el diagrama de Ishikawa y tormentas de Ideas. El estudio demostró, entre otras, que los

problemas tecnológicos, como es el caso de la disponibilidad de los activos, generalmente se asocian a la escasez de recursos, sin embargo, su causa raíz es una mala gestión por parte del personal encargado de esta actividad en los departamentos de mantenimiento. La aplicación del método propuesto evidencio que el componente más crítico en los resultados de una auditoría gestión es el recurso humano.

Palabras claves: auditoría, mantenimiento hospitalario, gestión.

Introduction

The audit, in a broad sense, has been carried out for several centuries, starting with the development of national statistics on births and deaths in the Domesday Book from 1066, the Paris Records from 1597, the Population law from 1840 and the first national census of England in 1801.

In 1918, the American College of Surgeons defines the principles of hospital organizational structure and the minimum criteria for accreditation audit, giving rise to the era of inspection in the medical sector. Since then, the term Medical Audit has been long used with different meanings depending on the context where it is applied[1]. It is defined as the systematic critical analysis of the quality of medical care, including diagnostic and therapeutic procedures, use of resources and the results of them with an impact on the clinical outcomes and quality of life of patients [2]. Subsequent publications define it as a process to improve the quality of patient care and its impact through systematic reviews considering explicit criteria and the implementation of change and accompanied of feedback processes by providers [3, 4].

However, these definitions do not include two important components in the audit process. First, the need to prepare the participants in the audit with the aim to promote and carry out the necessary changes in the professional behavior; and second, the requirement to demonstrate improvements in the quality and / or cost-effectiveness relation of care provided as a result in an audit participation. The origin of the management audit dates back to the early 30's and 40's in the United States due to the growth of the federal government, with the aim of determining how federal agencies spend and control properly, in order to determine that the federal

government agencies will spend and will control their assignments properly and comply with the respective laws. From this date, many definitions for these types of audit are given. A management audit is the bridge, and sometimes the catalyst between a traditional financial auditing and a method of administrative services to solve one or more problems.

Applied to the hospital sector the management audits take place in the departments of technical assistance, responsible for maintaining the availability of their assets at appropriate levels and thus ensure the quality of medical care and the cost-effectiveness of care provided.

To perform a maintenance audit is as simple as checking how the maintenance management process is performed in a hospital. The aim pursued with auditing is not to judge the persons responsible or question their way of working; is to identify those points susceptible to optimization and propose organizational and management changes to achieve an improvement of the system. This instrument provides an overview of the structure, relationships, procedures and personnel, associated with good maintenance practice; this is the first step in deciding and implementing improvements in maintenance management and compliance with the accreditation standards. Finally, are based on the collection of documentary evidence to demonstrate the proper performance of a company, department or area in particular taking into account their operational context.

Recent research has reported many benefits in the performing of management audit as a control of maintenance activities [5, 6].

Acosta y Troncoso [7], in their study titled, Maintenance assessment in hospital, have detected technological discipline problems in the maintenance area, mainly caused by the lack of control and exigency for many years, which indicates that things are being done correctly at an average level of 26.57 % in the four facilities studied. García, Cuadros and López [8], applying the technique of auditing as a management tool in primary care to improve the energy efficiency and environmental impact of a health facility, demonstrating that with an average investment of € 11,601 per health facility is possible to reduce energy consumption in 10,801 kW / h, saving up € 2,961 per year in an average payback period of 3.92 years and avoiding the emission of 7010 kg of CO₂. On this subject Jacobs and Visser [9], have developed a collection of conference in the seventh edition AFRICON whose aim was evaluating the management of maintenance department at Eskom electricity, by highlighting the suitability of its management; however, they highlighted some areas that require attention, for the purpose of optimizing the maintenance function.

Moreover, the authors Maisarah y Mohamad [10], in a case study performed at a hospital in Malaysia to evaluate five key elements such as, political leadership, plans and procedures, training and guidance, monitoring and supervision, and service performance; used the management audit tool. Additionally, authors like Carnero, Bana and Duarte, promote the use of audits in the health sector through models to assess the tasks of a maintenance department [11-13].

Summing up, the management audit is a tool with ample benefits to prove the level of excellence of a maintenance department. The starting point is the change of mentality that should assumed the company executives to assimilate the results of this tool, before the new paradigm on maintenance management [14, 15].

The main objective of the research is to evaluate the performance of the maintenance function in hospital facilities; as well as demonstrate that the most critical component in the results of a management audit is the human resource. During the last decade, many research on this subject has been registered, it can be highlighted that many of them are focused on identifying and prioritizing maintenance processes; ending with a final report. Reviewing the results of the investigations previously consulted, it can be concluded that the human resource is the fundamental cause of most of the problems detected in an audit. This research starts from the same principle, identification and prioritization of the maintenance processes, but this time making emphasis on human resources, proposing a method for the adequate selection of the minimum personnel necessary to develop optimally the maintenance function in hospital facilities.

Method

Subjects or Participants

To apply the audit, it was selected five hospitals with a high impact in the capital. The criteria for selecting the sample is based primarily on the specialization of the services provided by each hospital and the number of patients receiving, nationals and foreigners. Below are listed the audited entities:

- A General Hospital,
- A Children Hospital,
- An Orthopedic Hospital,
- An Ophthalmological Hospital,
- An Institute of Cardiology and Cardiovascular surgery

Before performing an audit of maintenance, it is necessary to prepare a set of documents, whose analysis will be part of the work of the person in charge of realizing. However, the most important job of the auditor is that which can be done on the field, in the equipment, the warehouses and with the maintenance staff [16]. The

method proposed is valid for any type of hospital, although at times small modifications can be made to better adopt it to the reality of the audited hospital. The value of the sample was ten workers per hospital, considering that the basic staff of the maintenance department in the hospitals audited is 15 workers as average. It was also taken into account that they are specialized hospitals, so the workers interviewed are those ones, who accumulate more experience in the development of their functions.

Procedure

The aspects evaluated for the 50 people interviewed have a range of evaluation from 1 to 5 points, where 1 is equivalent to deficiency and 5 is equivalent to excellence.

- Equipment availability
- Response to a Service Request
- Monitoring and control of biomedical equipment
- Staff training
- Quality of work executed by the maintenance technicians
- Workload of maintenance technicians
- Control of the work executed by the maintenance technicians
- Effectiveness of annual maintenance planning
- Department performance

With the results of the survey, it was applied as a second tool the brainstorming. This technique allowed the team to analyze the possible solutions to common problems detected in the five audited hospitals. They participated in the analysis mainly, the boss of the technical services of maintenance in each hospital, and the main specialists of each service. The following points were the result of brainstorming performed in each of the hospitals audited.

- a) Management activities: The ideas identified at this point are summarized in verifying the effectiveness of planning, job control executed, the response to a service request, etc.
- b) Maintenance activities: The key was to identify and evaluate the type of maintenance applied and tasks performed.
- c) The biomedical equipment: Another aspect to develop is referred to the equipment; this is a key point in the audit process, here, technical documentation will be identified. The classification, availability, monitoring and control of the technologies installed are also point of analysis.
- d) Maintenance staff: This is one of the critical aspects in developing our audit, the maintenance workers are those responsible for the proper functioning of the above aspects, and the goal here is to know the composition of the staff of the department and their level of qualification.
- e) Organizational structure: It was identified the position occupied by the maintenance department in the general company organization chart and was identified the hierarchical levels and with functional dependencies.
- f) Department structure: Identify the sections of technical specialties and generate ideas on how it is organized. The magnitude of the department will depend on the amount of service, size, equipment and technological level of health institutions in its charge.

Figure 1 show as a summary the basic aspects in order to evaluate and identify the degree of operating at maintenance department in any hospital, regardless of its complexity.

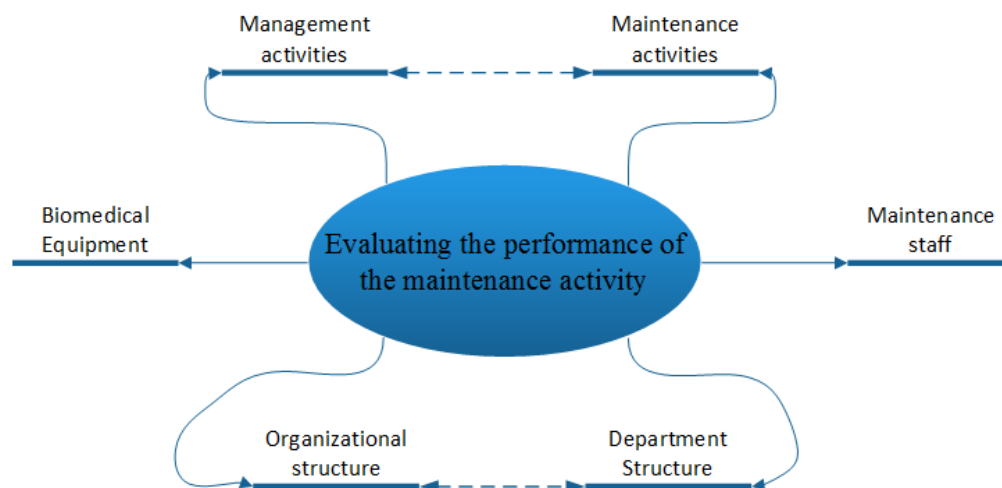


Fig. 1. Brainstorming diagram

Subsequently, another technique is applied known as Ishikawa diagram or fishbone diagram [17]. This diagram is a verbal tool that represents the relationship between an effect (problem) and all the possible causes

that influence in the effect. Figure 2 shows the Ishikawa diagram, used to organize the points identified in the audit.

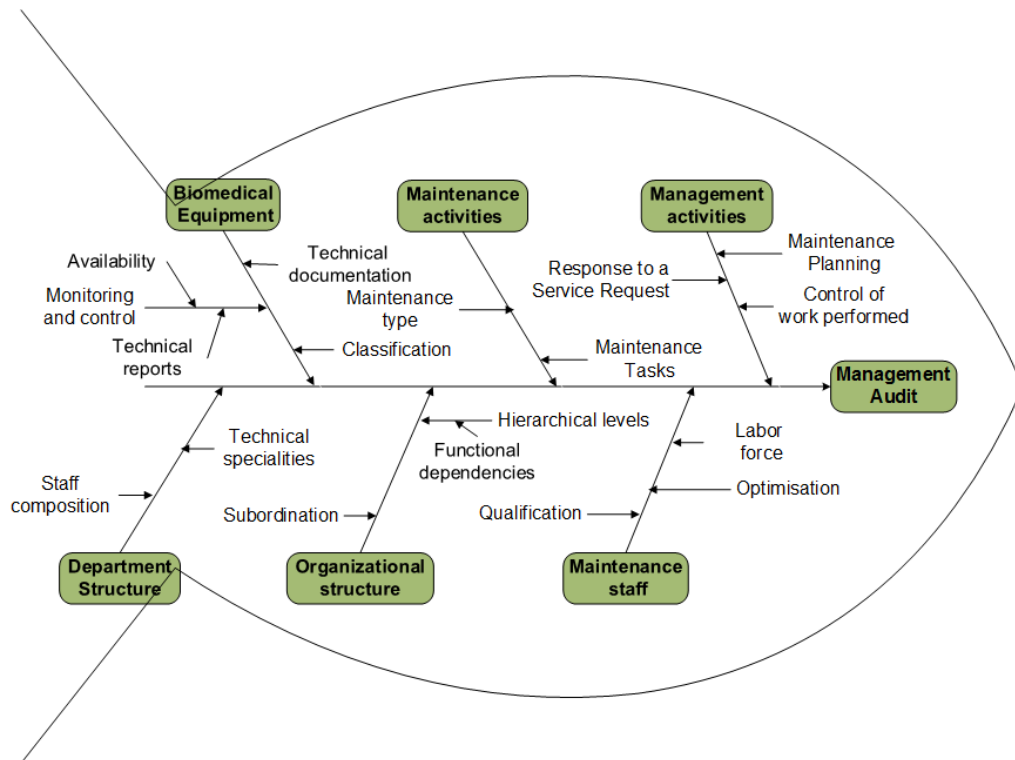


Fig. 2. Ishikawa diagram [7]

Finally, a method it's proposed to optimize the functions of the maintenance department. This procedure was applied to each ones of the technical specialties in table I, according to the (CNE) [18]. The procedure basically depends on three aspects, the burden of annual maintenance plan (CPA), the time available for the technical department (FT) and the amount of equipment to be serviced (CE). With these results we can estimate the necessary staff (PN) to perform the maintenance function, giving answer to the most critical component of the audit; human resources.

Table 1. Maintenance Technical Specialties

Nomenclature	Specialty	Nomenclature	Specialty
ELM	Electromechanical	LEOP	Laboratory and electro-optical
EM	Medical Electronics	OF	Ophthalmology
END	Endoscopy	OP	Medical Optics
EZT	Sterilization	OSG	Oxygen and Gas Systems
EST	Stomatology	SV	Salon and vacuum
IM	Medical images		

Results

The first result obtained is associated with the processed values of the survey. The values are averaged and tabulated for each hospital as shown in the maintenance radar map in figure 3. This type of representation facilitates the comparison between the different points analyzed in the survey with a scale of 1-5, with the following characteristics:

- 1) Without criteria
- 2) Bad
- 3) Regular
- 4) Good
- 5) Very good
- 6) Excellent

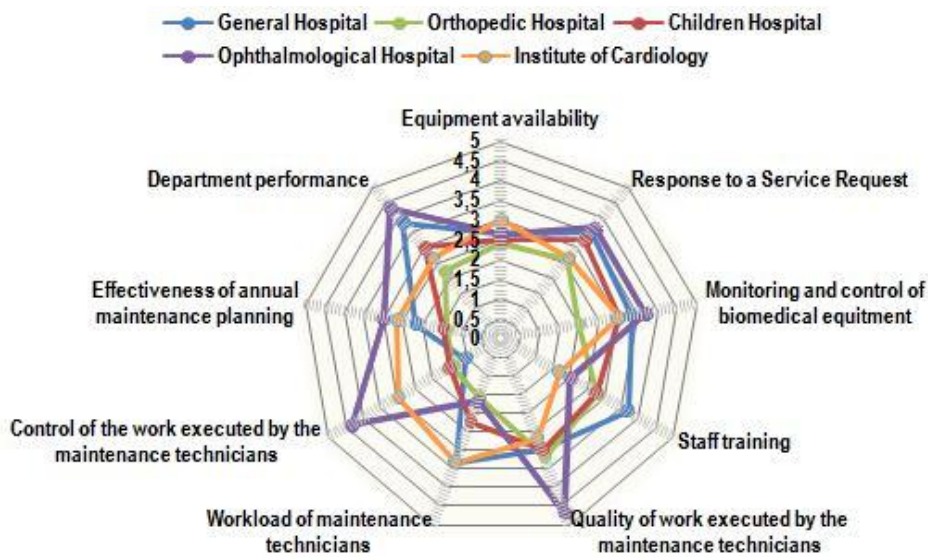


Fig. 3. Processed values of the survey

Another outcome of interest is shown in the graph of Figure 4. It shows an example of the burden onto maintenance plan per technical specialties, in the five hospitals under study. We can see that this parameter depends directly on the hospital’s complexity, that is, the number of equipment (CE) and systems that must be assisted routinely, causing variations in the workload of maintenance technicians in each hospital (CPA).

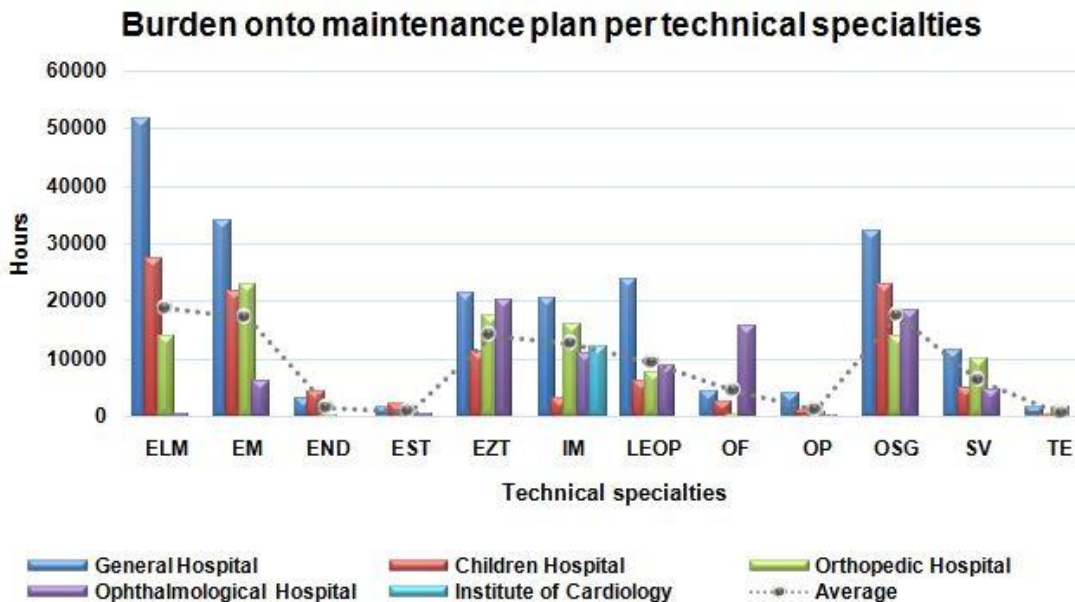


Fig. 4. Burden onto maintenance plan per technical specialties

The human resource has a direct impact in this process. Considering the above point, it was analyzed in detail this critical component in the audit.

Table 2 shows an example of the calculations made for selecting the minimum staff needed to undertake the inspection activities and preventive maintenance (IMP) in the Children Hospital. It was used the same method for the remainder of the audited hospitals.

Table 2. Selection of maintenance staff

Specialty	CE	CPA (HRs)	PN
Electromechanical (ELM)	179	454,33	1,05
Medical Electronics (EM)	109	363,00	0,8
Endoscopy (END)	26	72,00	0,16
Sterilization (EZT)	44	185,00	0,43
Stomatology (EST)	27	34,25	0,07
Medical images (IM)	18	50,00	0,11
Laboratory and electro-optical (LEOP)	37	100,00	0,23
Ophthalmology (OF)	24	42,50	0,09
Medical Optics OP	31	16,00	0,03
Oxygen and Gas Systems (OSG)	86	382,83	0,88
Salon and vacuum (SV)	35	83,00	0,19
Total			4,04

Where,

- CE: Number of equipment
- CPA: Burden onto the maintenance plan
- PN: minimum staff

As it might be expected, it is impossible to hire a person and a half or half a person. The objective here is to concentrate the technicians in technical specialties to gain quality of service, so it was decided to group the specialties with equipment of similar technology and get a real value for the number of technicians needed to execute the maintenance actions of that equipment. The result is shown in figure 5.

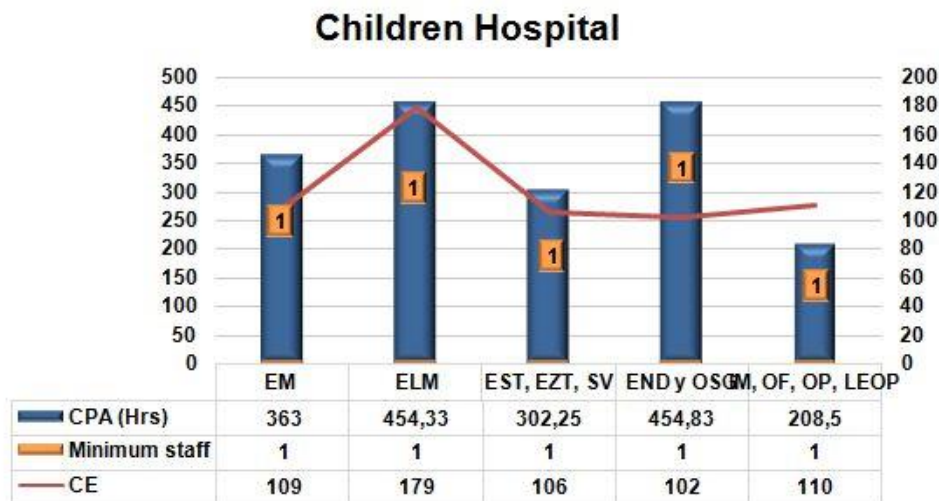


Fig. 5. Staff minimum necessary for the Children Hospital

Discussion

The first aspect to be analyzed is related with the figure 3, specifically the equipment availability case. According to Knezevic, availability is a feature that summarizes quantitatively, the functionality profile of a team, it's an extremely important measure and useful in those cases where the user must make decisions among several alternative possibilities.

According to surveys conducted, the availability of the equipment in these centers, it's less than the average of the processed values, qualitatively this means that, at least twice in five times that you want to use the equipment it's out of service. This affects directly the quality of services that the hospital can provide. These results suggest that we should centralize our work efforts towards this first aspect. We recommend starting with a known technique, that is, the brainstorming to identify and group the main causes for the underperformance of this equipment. Afterwards it is possible to use another technique that form part of the tool group to achieve the total quality of a service, such the well-known Pareto chart.

If we continue reviewing the diagram in figure 3, we can observe, that in response to a request for service, the effectiveness of planning, monitoring and control of equipment installed; the values obtained are above average of the processed values, this totally contradicts the values obtained of the department's performance.

Many authors interviewed evaluated as good the work in these departments, masking the main cause of these problems. From this, we can conclude that is not enough to culminate the report of auditing with the results of an interview. This technique provides only partial information, which is useful when initiating an investigation but it is not enough to propose solutions. However, the radar map also provides other aspects of interest, as is the case of unstable causes; events in which the standard deviation is too high. For the case under analysis, we refer to staff training, the control of the work executed by the maintenance technicians as well as workload of maintenance technicians. Let us analyze one of these aspects in detail.

The workload of maintenance technicians, is an aspect conditioned by the burden of the preventive maintenance plan, see figure 4. To reduce this effect, we can use the option of hire third parties. In this case, we decided to differentiate the biomedical equipment according to classification rules established by the by the national regulatory agency, and outsource at first instance the maintenance of those equipment whose risk class is equivalent to Class III and to assist the remaining equipment according to the availability of technical in the department, according with risk class.

An example of the calculations made for selecting the minimum staff needed to undertake the inspection activities and preventive maintenance (IMP) is showed in table II. Each maintenance technician must work a certain number of hours per year; therefore, the technician accumulates a reserve of annual time that are to be used in IMP and other unforeseen activities. It is advisable calculate the annual reserve time available to implement activities of IMP and the total burden onto maintenance plan. With these two parameters, it is possible to estimate the minimum necessary staff in a hospital maintenance department. Those persons who have some experience in the process of determining the staff know that it is necessary to consider several factors, regardless of the quantitative method or method of calculation used.

Another aspect to consider when selecting our staff is the selection of the maintenance inventory. It is need to achieve a high degree of compromise between general maintenance inventory (includes all the equipment of the hospital) and technical maintenance inventory (only those equipment serviced by the hospital technicians). Removing equipment from our technical inventory in order to decrease the number of worker needed to execute the actions of the department could bring serious problems. It must consider that the equipment that has been excluded from our technical inventory should be contracted to third parties, or establish a corrective action plan to ensure patients safety in the provision of service.

According to the Malagón, Galán and Pontón advices [19], we should assign one biomedical engineer per maintenance specialties or for at least every 4 or 5 of the technicians calculated. In the case under analysis, the minimum staff needed is five specialized technicians and at least two professionals in medical engineering or bioengineering, according with the result in figure 5.

Conclusion

The results of this research show that the audit technique is a valuable tool in identifying and prioritizing problems in a company; as well as emphasizes that the most critical component in these cases is the human resource. All the aspects surveyed depend directly on the human factor. Technological problems, such as the availability of assets, are usually associated with a shortage of resources; however, its root cause is a mismanagement by the staff in charge of this activity in the maintenance departments. Thus, the fact of implement methodologies or procedures to ensure the selection and proper adjustment of staff is an appropriate alternative that provide a good operating performance of the department.

References

1. Fraser RC, Khunti K, Baker R, et al. Effective audit in general practice: a method for systematically developing audit protocols containing evidence-based review criteria. *British Journal of General Practice*. 1997;3(47):743-6.
2. Hardman E, Joughin C. *Focus on clinical audit in child and adolescent mental health services*. London: Mc Graw Hill; 1998.
3. Stang A, Hartling L, Fera C, et al. Quality Indicators for the Assessment and Management of Pain in the Emergency Department: A Systematic Review. *Pain Research and Management*. 2014;19(6):179-90.
4. Henneman EA, Gawlinski A, Giuliano KK. Surveillance: a strategy for improving patient safety in acute and critical care units. *Critical Care Nurse*. 2012;32(2):9-18.
5. Hashim AE, Samikon SA, Hasim MS, et al. Facilities management audit in managing healing facilities in public health care built environment: User satisfaction viewpoint. *Environment Behaviour Proceedings Journal*. 2016;1(4):83-92.
6. Parida A, Kumar U, Galar D, et al. Performance measurement and management for maintenance: a literature review. *Journal of Quality in Maintenance Engineering*. 2015;21(1):2-33.
7. Acosta-Palmer H, Troncoso-Fleitas M. Auditoria integral de mantenimiento en instalaciones hospitalarias, un análisis objetivo. *Ingeniería Mecánica*. 2011;14(2):107-18.
8. García J, Cuadros F, López Rodríguez F. Energy audit: a management tool in health centers. *Gaceta sanitaria*. 2011;25(6):549-51.
9. Jacobs T, Visser J. Evaluation of the maintenance management function for a control plant at a substation. In: 7th AFRICON; Gaborone, Botswana: IEEE; 2004.
10. Ali M, Nasbi WM. Audit assessment of the facilities maintenance management in a public hospital in Malaysia. *Journal of Facilities Management*. 2009;7(2):142-58.
11. Carnero MC. Auditing Model for the introduction of Computerized Maintenance Management Systems. *International Journal of Data Science*. 2015;1(1):17-41.

12. Carnero MC. Evaluating a Maintenance Department in a Service Company. *International Journal of Mathematical Models and Methods in Applied Sciences*. 2009;1(3):230-7.
13. Bana-e-Costa CA, Carnero MC, Oliveira MD. A multi-criteria model for auditing a Predictive Maintenance Programme. *European Journal of Operational Research*. 2012;217(2):381-93.
14. Galar D, Kumar U, Parida A, et al. Auditorías de mantenimiento: Una nueva visión del mantenimiento. *Ingeniería y gestión de mantenimiento*. 2011;1(76):16-29.
15. Christersson M, Rothe P. Impacts of organizational relocation: a conceptual framework. *Journal of Corporate Real Estate*. 2012;14(4):226-43.
16. Pintelon L, Van-Puyvelde F. Maintenance performance reporting systems: some experiences. *Journal of Quality in Maintenance Engineering*. 2006;3(1):4-15.
17. Espinosa F, Dias A, Salinas G. A procedure for assessing the risks of innovation in the management of industrial maintenance. *Ingeniare*. 2012;20(2):242-54.
18. Herrera Galán M. Planificación del mantenimiento de equipos médicos a través del ajuste de plantilla. *Revista Cubana de Ingeniería*. 2015;6(3):61-7.
19. Malagón Londoño G, Galán Morera R, Pontón-Laverde G. *Hospital Administration*. España: Editorial Médica Panamericana; 2008.