



Preliminary Study on Decision Making Factors to Replace Medical Equipment in Hospital

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Abstract: Maintaining medical equipment in hospital is a cost-deprived process yet is a crucial process that needs to be looked into. Maintaining is an ongoing process that starts with installation and ended up with disposed. The cost for maintaining equipment is often held a large portion in life cycle costing and huge amount of money need to be allocated to complete this process. The cost invested on maintaining the medical equipment should be worth the value without comprising the safety requirement and regulations. However, there are circumstances where hospitals are unable to decide when to dispose the equipment especially when the equipment reach the end of its life, incur high repairing cost, aging, and frequent failed to function. Management of hospital come into dead end solution as there are lack of proper guidelines on maintaining medical equipment and therefore the equipment may be over maintained or under maintained. This paper provides a review of 100 papers from credible sources on maintaining activities of equipment to identify factors that are important for decision making to replace the medical equipment.

Keywords: medical equipment, replacement, maintenance

1. Introduction

Healthcare industry is an aggregation of sectors within the economic systems that provides goods and services to treat patients with curative, preventive, rehabilitative and palliative care. It comprises of dentists and doctors, protective care and nursing, pharmacies, allied medical, health services and hospitals. This industry has become one of the world's largest and fastest-growing industries where it consumes over 10 per cent of gross domestic product (GDP) of most developed nations (Saniuk *et al*, 2015). Hospital institutions are surviving by relying on the number of patients seeking for the treatment in their premises. Advanced technology of medical equipment provided is one of the factors that contribute to enhance the quality of services rendered to the patients (Bloom, 2006). Medical equipment is a vital

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facility use for prevention, diagnosis or treatment of illness and few other health purposes (Desphande & Modak, 2002). The Global Industry Classification Standard and Industry Classification Benchmark distinguish the healthcare industry as two main groups; healthcare equipment and services and pharmaceutical, biotechnology and related life sciences (Backlund & Akersten, 2003). Therefore, designing plans for managing medical devices in one way of strengthening healthcare services (Canada, 2003).

In order to ensure medical equipment is properly managed and in line with the safety requirements and regulations, Medical Equipment Management Plans (MEMP) is established and practiced in most hospitals across the globe (Ireson, Clyde & Richard 1995). MEMP provides the procedure on how to manage the equipment as well as the procedure to maintain the equipment at minimum cost without compromising with the safety standards of equipment. MEMP can be a great tool in maintaining medical equipment in economical way only if this system is efficiently reliable. One of the important elements in MEMP is disposal and replacement of medical equipment (International Atomic Energy Agency, 2007; Islam, 2010). This element can greatly impact the financial spending of hospital if it is not being attentively focused on. The general practice of disposal and replacement of medical equipment were made based on the age and functionality of the equipment rather than having a right mechanism to assist the decision-making process. There has lack of scientific, realistic and comprehensive assessment of medical equipment replacement decision. Most of equipment replacement methods are very dependent on inadequate reliable information and poor analysis of relative costs, age and availability. Poor decision making in maintaining medical equipment may lead to negative impacts such as premature replacement or over maintained of medical equipment. Premature replacement is a process of renewing or replacing the medical equipment albeit the equipment is newly purchased and barely breakdown (Kelly, 1998; Małgorzata, 2016). Over-maintain medical equipment is maintaining the equipment though it has reached the end of life and frequently breakdown (Rausand, 1998; Mostafa, 2014). Both cases do not provide an economical and practical practice to hospitals as cost incurred will be very high (Rausand & Arnljot, 2003; Ronda, 2008). Thus, this paper provides a preliminary finding of factors in developing a framework of decision making in maintaining medical equipment in hospital. This paper reviews 100 papers from credible sources on maintaining activities of equipment. From these papers, it then identifies factors that are important for decision making in maintaining or condemning medical equipment.

1.1 Archival Analysis of Factors

Table 1-Type of sources based on healthcare and other industries

Industry	Type of Source	Total Number
Healthcare	Hospital's Policy	10
	Paper	18
	Article	3
	Book	2
Others	Paper	53
	Article	1
	Book	13
Total		100

Based on 100 papers from credible sources, the factors of decision making were retrieved. These sources were from research papers, articles, books and hospital's standard operation policy (SOP) manuals. Selection of these papers was started by literature sources and followed by three iterations of screening and filtering. The first iteration process was to screen out duplication of papers. The second iteration process was by screening the titles and abstracts papers and excluded disparate articles. The last iteration was based on the content of the paper. Research papers from medical equipment industry is quite low in number therefore paper with similar research interest were included. The search was conducted using the search boxes of ScienceDirect, Web of Science database, and IEEE Explore. The key words (Figure 1) that were used for the research were mix of "medical equipment", "health equipment", "equipment" on different variation and combined with the "OR" and "AND" operators followed (decision OR selection) AND (maintenance OR maintain OR replacement OR disposal OR condemn) AND (factor OR attribute OR criteria OR

criterion). Hospital SOP were taken from credible hospitals by using search title “replacement policy and factors for medical equipment”, “management of medical equipment in hospital”, “to replace or to condemn medical equipment” and “decision making to replace or to maintain medical equipment”. The filtered sources were divided into two categories of industry: healthcare engineering and others engineering. Data were collected from the sources published from 1949 to 2017 (Table 1). Hospital’s policies were retrieved in separate search platform.

2. Methodology

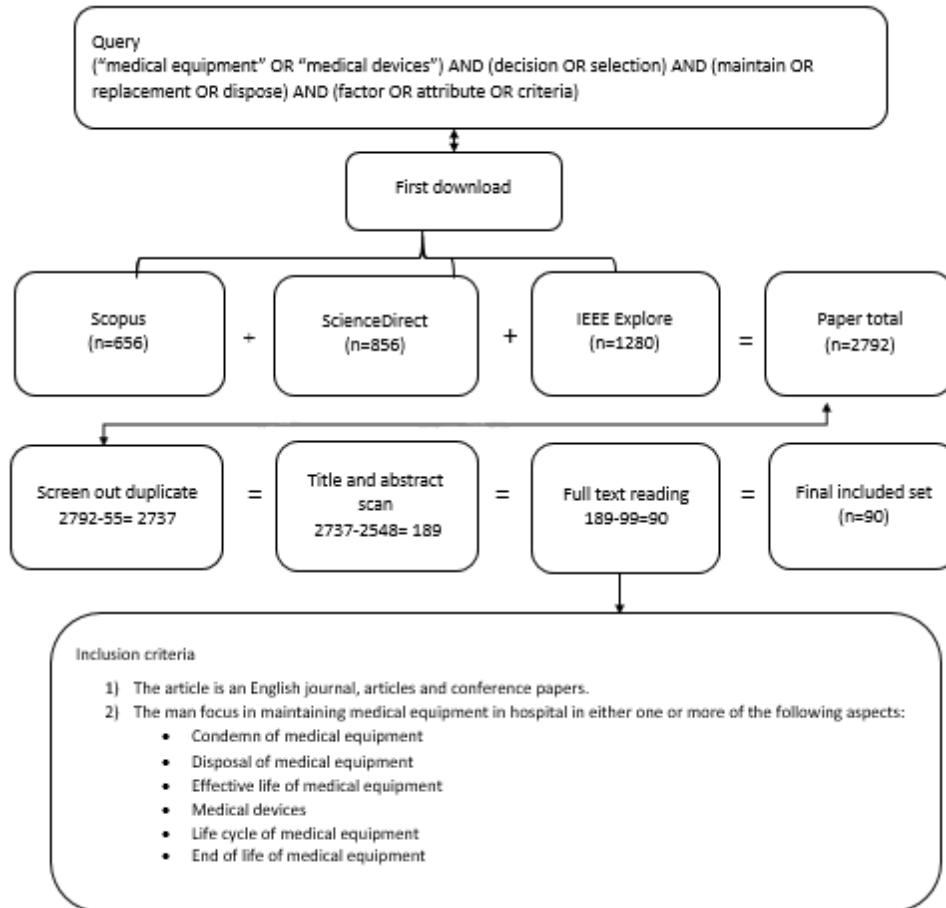


Fig. 1 - Flow chart of study selection, including the search query and inclusion criteria

The papers selected in this research were varies due to the need to collect adequate information to support the research objectives. SOP from well-established hospitals that accredited by the government was included into this research. The initial query resulted in 2792 papers where it was then finalized into 100 sources. Few analysis and filtration have been applied in order to come out with the final factors on the first stage of filtration, forty six factors has been identified and later being grouped into same categories before being finalized into final thirteen. The final thirteen factors were selected based on highly mentioned and repeated (≥ 10) across all sources (Fig. 2).

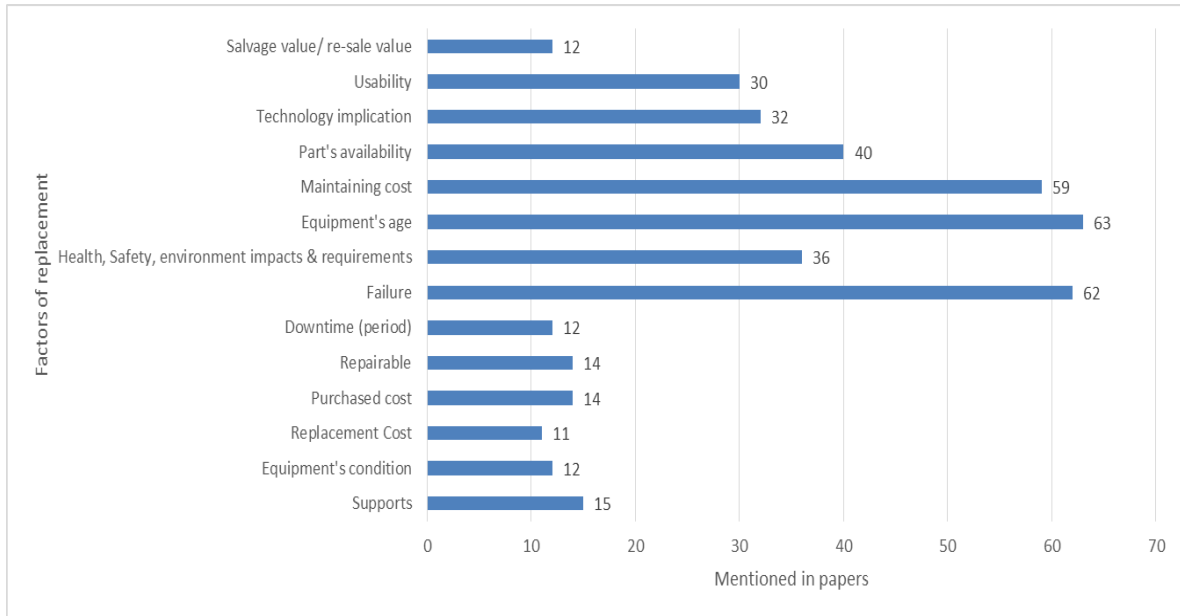


Fig. 2- Final factors to maintain or condemn medical equipment in hospital

3. Result and Discussion

Few analysis and filtration have been used in this research. The sources were retrieved from year 1949 to 2017 (Fig. 3). On the first stage of filtration, forty-six factors were identified and later being grouped into same categories before being finalized into final thirteen. Final thirteen factors were selected based on highly mentioned and repeated (≥ 10) across papers (Fig. 1). First factor to replace the medical equipment is salvage value. Salvage value is also known as estimated re-sale value. Second factor identified is usability. It indicates the condition of the medical in the state of functioning. This factor is related to the equipment's condition factor. The condition of equipment will determine whether the equipment can be used or vice versa.

Technology factor in this research context is implying on two perspectives which are the impact of the technology to patient safety and how technology is safe for the equipment as well as user. Part's availability is denoting on the availability of parts to support any replacement needed. In common practice in hospitals, user will be notified by the manufacturer if the parts have obsoleted or discontinued. Maintaining costs factors consists of all costs involved in maintaining the equipment from the equipment being installed until the equipment being disposed. Life expectancy defines the possibility of the equipment to maintain functional and usable. In other term, equipment's age is used to show how long the equipment has been operating and how long it may continue functioning or its remaining lifetime. This context is similar with the other terms that been used in other papers such as life span and useful life of equipment (Tsang, 1995; Waeyenberg & Pintelon, 2002).

Health, safety, environment impact and requirement are the factors that concerning the impact of medical equipment to the health of patient and user and the safety of the equipment to both parties and environment (Vatn, 2008). This factor implies whether the equipment is conforming to the requirements either from the authorities or manufacturer. Some medical equipment may contain chemical, unclean and infectious compound therefore this factor is highly being considered in many papers.

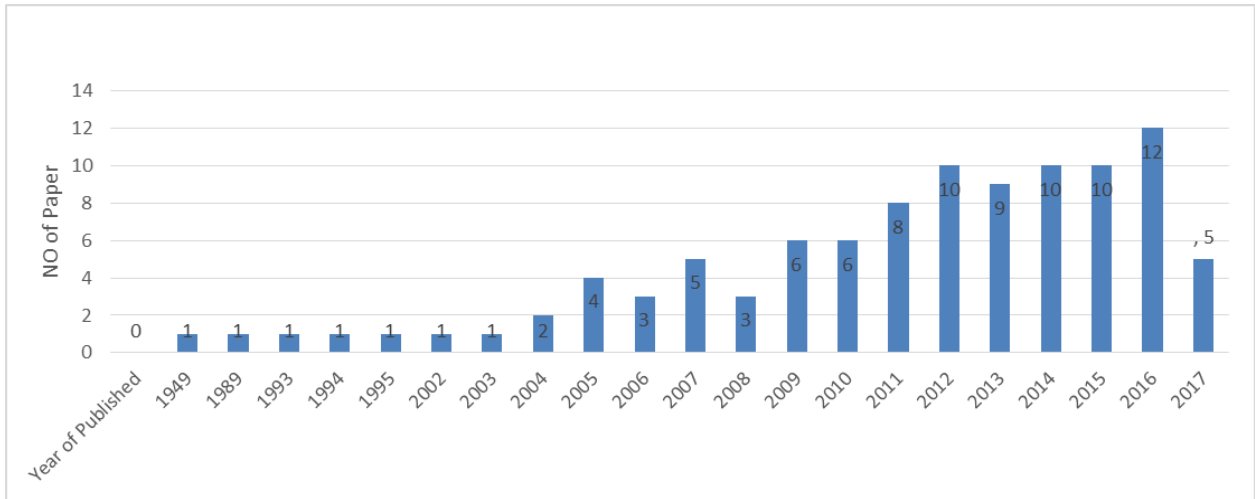


Fig. 3- Number of sources extracted based on year of published

Failure factor includes the risk of failures, rates of failures, user error, incidents, and number of failures (Narayanan, 2012). Downtime of equipment reflects on the period where the equipment failed to function before it is back to normal (Bassem, Ahmed & Never, 2010). This term is opposite of uptime. Repairable factor includes serviceable and beyond economical repairs. This factor is to determine whether the equipment need to maintain or condemn depends on whether the equipment can be serviced or repaired in order to be used. Replacement cost is the cost of the new equipment to be purchased in replace to the existing equipment and the cost to dispose the equipment (Wang, 2000). Supports factor implies on the availability of support in technical, clinical, operation and availability of alternative equipment.

4. Conclusion

The objective of this paper is to provide a platform in identifying the factors for decision maker in hospital to decide on the right decision whether to maintain or condemn the equipment based on critical factors. An effective and appropriate maintenance practices on the hospital equipment contributes an efficiency within health sector thus increased the health outcomes and keeping equipment in good working condition by increasing reliability and availability whilst reducing failure rate. A strong healthcare system represents an important part of a community's vitality and sustainability thus it needs to be safe, timely, effective, efficient and patient-centered. Through a proper management system, hospitals are able to examine the need for and performance of medical equipment and application of analytical approaches towards managing an asset over different stages of its life cycle.

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