The Causal Factors of Elevator Maintenance

Subjects: Construction & Building Technology

Contributor: Hassan Alassafi, Khalid Saad Al-Gahtani, Abdulmohsen Almohsen, Ghasan Alfalah

Maintenance is crucial for healthcare facilities in terms of both the continuity of operations and annual costs. Many maintenance issues are associated with design decisions that pave the way for added costs in later lifecycle stages. Some systems, e.g., elevators, are sources of maintenance costs; additionally, elevator outages are significant issues for multi-floor healthcare facilities. Considering the maintainability of elevators from the early design stages helps to highlight potential maintenance issues in later stages. This also assists in mitigating costs by avoiding design decisions that result in future maintenance costs.

Keywords: facility management ; construction management ; maintainability ; elevators maintenance ; FMECA ; design defects ; healthcare facilities ; elevator design

1. Introduction

Maintenance plays a vital role in all hospital services and refers to the complicated variety of systems, with various levels of technology, used in hospitals; the potential consequences of the failure of these systems necessitate high availability and functional safety measures [1]. The demand for healthcare services and hospitals is increasing globally, attributable to population growth, population aging, and consumer behavior [2]. Maintenance is essential to hospital performance [3][4][5]. Furthermore, design-stage problems are considered a more significant source of facility maintenance issues compared to problems in the construction stage [6]. When facility maintenance is not considered sufficiently at the design stage, unforeseen maintenance issues may add a cost parameter to the facility management stage. During the design stage, decisions are usually focused on the initial costs, and this does not reflect the significant impact of these decisions on the later stages [7].

As mentioned, these concerns signify a cost component among buildings' lifecycle costs that can be avoided if maintenance is contemplated sufficiently in the design stage. However, not many owners consider this a priority issue [8] [9]. Factors such as cost, longevity, and performance have long been the focus during the design stage, while other factors, including maintainability, have been underrated [10][11]. Al-Hammad et al. cited faulty designs as the reason for maintenance cost escalations [12]. Hence, maintenance problems and faulty designs are related to the level of maintenance input during the design stage. Building maintainability is determined by design selections that address or overlook maintenance concerns at the early stage of design and construction [9]. When maintenance concerns are addressed sufficiently at the design stage, the maintainability of the design is improved, which results in future maintenance cost savings. Feedback from facility management professionals on design-caused maintenance issues is a suitable approach to achieve this maintainability improvement. Designing for building maintainability includes the processes performed to reduce defects and maintenance needs throughout a facility's lifecycle [13]. This issue focuses on the need for a maintainability assessment during the design stages to alleviate the impact of design decisions and predict future maintenance costs. This helps to reduce maintenance by enhancing the maintainability of the design. Therefore, an overall lifecycle cost reduction can be achieved.

Healthcare facilities contain several building service systems that are essential for the continuity of serving their purpose of providing healthcare to the public. The cost component and the annual growth in costs may cause serious concern regarding the continuity of healthcare facilities. In Saudi Arabia, for example, it is projected by the National Committee for Legislation and Standardization of Operation and Maintenance (NCLOM) that the future operation and maintenance of healthcare facilities will grow by an average of 10% annually from 2014 to 2030 if the current rates of growth continue [14]. Investigating the maintainability of healthcare facility service systems during the design stages helps to minimize maintenance needs and can lead to potential maintenance cost reductions. However, it is common to exclude the healthcare facility maintenance perspective while the project is in the design stage because of a lack of communication between the design and maintenance teams [15]. The maintenance of healthcare facilities can be considered with regard to the various systems utilized to run such facilities.

Mechanical, electrical, and plumbing (MEP) service systems in complex projects, such as high-tech, healthcare, and transportation projects, comprise up to 50% of the initial costs [16][17]. Among these mechanical systems, elevators are effective systems that are used in the daily operation of healthcare facilities. Although elevator maintenance is considered a cost, it provides a critical service in terms of the transport of patients. A cross-sectional case review study in Australia on incidents relating to the intra-hospital transfer of critically ill patients found that around 39% of the incidents encountered during transport were equipment-related, and 10% were due to elevator accessibility [18].

2. Studies on Elevators in Healthcare Facilities

The focus was only on commercial buildings. Moreover, multiple studies on building maintainability have been conducted for a number of building types, but few have attempted to investigate elevators. The studies in **Table 1** followed different methods of approaching the maintainability of buildings and the assessment thereof, but all of them sought to list and evaluate building defects as part of the various methods adopted to improve maintainability. Until now, there have been insufficient numbers of maintainability studies on elevators in healthcare facilities, despite the heavy usage of elevators in healthcare facilities.

Table 1. Previous research on maintainability.

Authors	Building Type	Location	Elevators Defects	Impact Factors of Defects	Comparison
Siti et al. [19]	General buildings	Singapore	26	Not stated	This study provided a framework for an elevator maintainability evaluation and sought to understand maintainability issues via a questionnaire distributed among practitioners.
Chew et al. [20]	High-rise commercial buildings	Singapore	114	This study analyzed elevators' economic defects, system performance, safety, and comfort impact.	This study focused on commercial buildings, and the impact of defects did not consider healthcare-related building use. It includes defects that occurred during the construction and operation stages.
De Silva et al., 2016 [21]	High-rise Building	Sri Lanka	-	10 risk factors	This study followed a risk-based framework that can measure maintainability by listing. It used an artificial neural network (ANN) tool to forecast maintainability in the early stage of a building. It serves as a decision tool to reduce maintenance costs.
De Silva and Ranasinghe [22]	Condominium	Sri Lanka	-	-	This study followed a risk-based maintainability assessment by investigating defects and problems. Although building service defects were the most serious maintainability issues, this study did not specify the defects of the elevator system.
Hassanain et al., 2014 [23]	Higher education	Saudi Arabia	-	-	This study investigated the defects of the heating, ventilating, air-conditioning, and cooling (HVAC) systems from maintenance professionals' point of view. It presented evaluated maintainability lists built to help designers avoid common maintenance issues.

The elevator systems investigated previously in maintainability studies follow a similar breakdown of elevator components, with some differences (**Table 2**). For one, Siti et al. [19] presented five main component groups that included various common maintainability issues. The breakdown of components adopted by Chew et al. [20] included a larger breakdown that specified subcomponents. The subcomponents may be present within a single component or in more than one. Another study by Chew and Das [24] listed the main components in a manner that combined the main approaches of the studies of both Siti et al. [19] and Chew et al. [20].

Table 2. Elevator components.

Siti et al. [19]	Chew et al. [20]	Das and Chew [21]
Traveling performance Machine rooms Hoistway and elevator pit Elevator car Elevator lobby	Components: Machine room Lift hoistway Lift car Lift pit Lift landing Sub-components: controller, governor machine, machine room, traction machine, traction motor, brake assembly, guide rail, wire rope, shaft, car interior, car door, car top, car bottom, door operator, travelling, landing door, lift landing, and smoke detector	Machine room and equipment Lift car Car and lobby door Hoistway Ropes Landing Lift pit

Researchers aim to use the experience of healthcare facility management experts in a proper framework that helps to improve elevator maintainability by achieving two objectives. The first objective is identifying a list of elevator maintenance issues caused by their design, and the second is evaluating and ranking the maintenance issues based on their criticality.

During the design stage, the designers can utilize this study's output regarding the maintainability of elevators to enhance the decision-making process. Such a proactive approach eliminates unfavorable design decisions and improves the maintainability of healthcare facility design by reducing the undesirable effects of future maintenance needs.

References

1. Ciarapica, F.E.; Giacchetta, G.; Paciarotti, C. Facility management in the healthcare sector: Analysis of the Italian situation. Prod. Plan. Control 2008, 19, 327–341.
2. Hosking, J.E.; Jarvis, R.J. Developing a replacement facility strategy: Lessons from the healthcare sector. J. Facil. Manag. 2003, 2, 214–228.
3. Chotipanich, S. Positioning facility management. Facilities 2004, 22, 364–372.
4. Shohet, I.M.; Lavy-Leibovich, S.; Bar-On, D. Integrated maintenance monitoring of hospital buildings. Constr. Manag. Econ. 2003, 21, 219–228.
5. Shohet, I.M. Key performance indicators for strategic healthcare facilities maintenance. J. Constr. Eng. Manag. 2006, 132, 345–352.
6. Mohammed, M.A.; Hassanain, M.A. Towards improvement in facilities operation and maintenance through feedback to the design team. Built Hum. Environ. Rev. 2010, 3, 72–87.
7. Seeley, L.H. Building Maintenance; MacMillan Press Ltd.: London, UK, 1976.
8. Arditi, D.; Nawakorawit, M. Designing buildings for maintenance: Designers' perspective. J. Archit. Eng. 1999, 5, 107–116.
9. Dunston, P.S.; Williamson, C.E. Incorporating maintainability in constructability review process. J. Manag. Eng. 1999, 15, 56–60.
10. Meier, J.R.; Russell, J.S. Model process for implementing maintainability. J. Constr. Eng. Manag. 2000, 126, 440–450.
11. de Silva, N.; Dulaimi, M.F.; Ling, F.Y.; Ofori, G. Improving the maintainability of buildings in Singapore. Build. Environ. 2004, 39, 1243–1251.
12. Al-Hammad, A.; Assaf, S.; Al-Shihah, M. The effect of faulty design on building maintenance. J. Qual. Maint. Eng. 1997, 3, 29–39.
13. BCA (Building and Construction Authority). Design for Maintainability Checklist Version 1.3; BCA: Singapore, 2016. Available online: https://www.bca.gov.sg/BCA_Consultation/others/DfM_Checklist_3_Sep2016.pdf (accessed on 1 March 2019).
14. The National Committee for Legislation and Standardization of Operation and Maintenance. The Committee Final Report; The National Committee for Legislation and Standardization of Operation and Maintenance: Riyadh, Saudi Arabia, 2016.
15. Pati, D.; Park, C.S.; Augenbroe, G. Facility maintenance performance perspective to target strategic organizational objectives. J. Perform. Constr. Facil. 2010, 24, 180–187.
16. Clemente, J.; Cachadinha, N. BIM-Lean synergies in the management on MEP works in public facilities of intensive use—A case study. In Proceedings of the 21th Annual Conference of the International Group for Lean Construction,

Fortaleza, Brazil, 29 July–2 August 2013; pp. 751–759.

17. Gelnay, B. Facility management and the design of Victoria public hospitals. In Proceedings of the CIB Working Commission 70: Facilities Management and Maintenance Global Symposium, Glasgow, Scotland, 18–20 September 2002; pp. 525–545.
18. Beckmann, U.; Gillies, D.M.; Berenholtz, S.M.; Wu, A.W.; Pronovost, P. Incidents relating to the intra-hospital transfer of critically ill patients. Intensive Care Med. 2004, 30, 1579–1585.
19. Siti, N.A.; Asmone, A.S.; Chew, M.Y.L. An assessment of maintainability of elevator system to improve facilities management knowledge-base. IOP Conf. Ser. Earth Environ. Sci. 2018, 117, 012025.
20. Chew, M.L.; Das, S.; Sulaiman, N.H. Quantifying maintainability parameters for vertical transport system. In Proceedings of the 11th International Conference on Durability of Building Materials & Components, Istanbul Technical University, Istanbul, Turkey, 11–14 May 2008; pp. 11–14.
21. De Silva, N.; Ranasinghe, M.; De Silva, C.R. Risk analysis in maintainability of high-rise buildings under tropical conditions using ensemble neural network. Facilities 2016, 34, 2–27.
22. de Silva, N.; Ranasinghe, M. Maintainability risks of condominiums in Sri Lanka. J. Financ. Manag. Prop. Constr. 2010, 15, 41–60.
23. Hassanain, M.A.; Al-Hammad, A.M.; Fatayer, F. Assessment of defects in HVAC systems caused by lack of maintenance feedback to the design team. Archit. Sci. Rev. 2014, 57, 188–195.
24. Das, S.; Chew, M.Y. Generic method of grading building defects using FMECA to improve maintainability decisions. J. Perform. Constr. Facil. 2011, 25, 522–533.
