Evaluation of defect in hospital buildings

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Abstract. There are many complaints and criticisms in media and research literature on defects in hospital buildings despite the consistent increase in maintenance expenditures. This research investigated the nature of defects in private hospital buildings. Primary data for the study were collected through a survey questionnaire administered to hospital building users. Based on the findings, the defects that often require frequent maintenance are leaky faucets, defective doors, defective windows, broken lights, and faulty ventilation. The major conclusion drawn from the survey was that although there are many different defects in the buildings, the urgency at which they require maintenance interventions varies. Therefore, in order to avoid value mismatch and resource misallocations, resources and attention should be directed to the defects that are more important to the users and the other should be included in the next maintenance rolling programme. Maintenance management should be implemented to achieve good maintenance, capable to meet the expected requirements of the end-user and increase building performance and reduce the maintenance backlog.

Keywords: building users, Satisfaction, Building Performance, Maintenance organisation

1. Introduction

A hospital building is one of the most complex buildings. The corporate objectives of the hospital organization, placed the building in a strategic position Thus, any inadequacy with the building facilities, will seriously affect the achievement of the prime objectives of the hospital. The condition of the hospital building is correlated with the satisfaction or dissatisfaction of the users. Based on the media report and examinations of government reports, there are a lot of complaints from hospital users on the performance of the hospital buildings on account of the defects. Defects in the building could cause psychological and illness problems to the users and will increase the users’ dissatisfaction. The occurrence of defects in hospital buildings is due to lack of maintenance, poor design, and poor workmanship that can lead to psychological and illness issues to the users. About 75% of the building cost in use is attributed to defects in the building works and about 90% of the lifetimes of building projects require maintenance works. Maintenance is required when the building performance is not meeting the required quality and standards [1]. The degree of maintenance demand differs mainly on whether private or public hospitals [2]. It also differs based on procurement strategies and maintenance expenditure. In Malaysia, the ratio of maintenance expenditure is 1: 5 for a public and private hospital. In other words, the private hospital
invested 5 times that of public hospitals for maintenance annually. High maintenance costs, poor satisfaction, and loss of productivity could be avoided or reduced with systemic maintenance process. Therefore, the research investigated the defects in private hospital buildings in an effort to frame the maintenance management process for the hospital maintenance organization.

2. Background and theoretical framework
Hospital buildings are procured to create a suitable, conducive, and adequate environment that can support and encourage patients’ recovery and allow medical and on-medical staff to perform their duties productively. A failure in the supply of these essential services is a loss in value to hospitals and customers. There is an increasing demand for hospitals in Malaysia. To meet the increasing demand, new hospitals are established and the existing hospital is extended and refurbished to meet the growing demand and increased customer requirements. There are 144 public hospitals/ special medical institutions and 210 private licensed hospitals in Malaysia [3]. However, despite the increase in investment in the construction of new hospitals and upgrading and expansions of the existing hospitals, hospitals have remained inadequate. This inadequacy is affecting the condition and performance of hospital buildings [4]. However, academic literature, media reports, and government-sponsored research revealed that there are recorded cases of defects in the hospital buildings [5,6,7,8]. Results from a fire safety audit conducted on 46 hospitals built more than 50 years ago, revealed the existence of many defects in the buildings including faulty electrical networks and outdated systems [9]. Due to the increasing rate of defects in the hospital buildings, the hospital buildings are now described as “Rumah Sakit” (or sick house). Although research on hospital buildings is receiving attention recently, there is a dearth of research on the evaluation of building defects in hospitals.

2.1. Defect in hospital buildings
Words including deficiency, damage, default, deterioration, and decay are often used to describe the defect. Here, a building defect is defined as an undesirable or inadequate condition in the buildings that affect the serviceability, performance, structural condition, or appearance of the buildings [10]. Building defects can manifest within the structure, fabric, services, and other facilities of the defective building. Examples of defects include cracked, damaged, or deteriorated brick/block walls, clogged water closets and faulty lifts, faulty windows and doors, and leaking showers. Defects are contagious because if it is not addressed on time, it would not only get worse, but will also destroy the adjoining components, elements or building parts. Building defects can be identified by the users themselves or thorough inspection by those concerns with maintenance management. Buildings, as Olanrewaju et al [10] explained, are not procured for their own sake rather for the services (i.e., comfort, protection, and esteem) that the buildings provide to the users. Hence, users should be the objectives of all defect’s management philosophy and science. Building users are the entity or group of individuals or the organization who are interested in the condition and performance of the building. Users are affected by the performance of the building and the building is also affected by the activities of users. The degree of defects in the building is a measure to evaluate the functional performance of the buildings. Although building defects can be generally attributed to a lack of good construction practices, but are often cause and in fact aggravated by a lack of good maintenance practices. Defect set up inner psychological tension in the users if the defect is not rectified in terms of quality and time. Therefore, information on nature, degree, and kind of defects will dictate when to undertake the repair work and allow future works to be programmed and financed as part of the maintenance rolling programme [11]. A significant aspect of building maintenance management is defect management.

3. Method of data collection and analytics
The questionnaires were administered to the building’s users through an online survey (14/07/2020 to 28/08/202020). The building users were asked based on evidence to tick the degree to how often the specific defect appears/exist in their buildings. The defects were measured on a 6-point continuum scale of 1 to 6, where 1 denotes Not at all, 2 denotes Least often, 3 denotes Less often, 4 denotes Often, 5 denotes Very Often and 6 denotes Extremely Often and standard deviation. The severity of the defects is determined by the Average Frequency Index (AFI) (Equation 1). The average relative is based on the
cumulative weighting of the initial frequency score of each of the constructs. This method is preferred because it takes into account the effect of the weight the building users attached to their decision

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AFI = \frac{\sum_{i=1}^{6} a_i x_i}{\sum_{i=0}^{6} x_i} \times 100
\]  

(Equation 1)

Where constant expressing the weight given to the group; \( x_i \) is the frequency of the responses, \( i = 1, 2, 3, 4, \) and 5 and 6 described as below: \( x_1, x_2, x_3, x_4, x_5, x_6 \) are the frequencies of the responses corresponding to \( a_1 = 1, a_2 = 2, a_3 = 3, a_4 = 4, a_5 = 5, a_6 = 6 \) respectively. For interpretation, an AFI score of 1.00 – 16.67 denoted not at all, 16.68–33.33 denoted least often, 33.34–50.00 denoted less often, 50.01–66.67 denoted often, and 66.67–83.33 denoted very often and 83.34 – 100 denoted extremely often. There is a pooled difference of 1.0 between each of the scales. The defects with the highest AFI score are considered as the defects requiring more maintenance. All the constructs were positively worded. The questionnaire was piloted before the final version was finalised. One-way t-test, Omega, convergent validity, mode, a standard deviation was performed. Bartlett’s test was conducted to enhance the correctness of the instruments. For the one-way t-test, the null hypothesis was that each of the defects does not exist in the hospital building (\( H_0: U=U_0 \)) and the research hypothesis was that each of the defects exist in the hospital building (\( H_r: U\geq U_0 \)). \( U_0 \) is the population mean. The critical level was set as 5. The small standard errors were also computed. The standard error measures the accuracy of the extent to which the sample mean is close to the population mean. A small standard error is an indication that the sample mean is a more accurate replication of the actual population mean. 17 defects that affect buildings and engineering services were identified and addressed to the building users. The defects were important sources of complaints that hospital maintenance organizations received from building users in their respective hospitals. The building users are encouraged to add any other defect they considered critical to the hospital building. This also includes how the defects specifically affect their service delivery and other functions that hospital buildings are expected to perform:

- Not at all often; if the user agreed that the particular defect has not occurred before and will not require any maintenance.
- Least often; if the user agreed that the particular defect occurred at the lowest time since using the building and maintenance is slightly required.
- Less often; if the user agreed that the particular defect occurred a few times since using the building and maintenance is less required.
- Often; if the user agreed that a particular defect occurred frequently and lead to regular maintenance demand.
- Very urgent; if the user agreed that the particular defect has a very significant impact on the operation of the building and the maintenance demand is very urgent.
- Extremely urgent; if the user agreed that the particular defect has an extreme impact on the operation of the building and the kind of maintenance requires is greatly urgent.

4. Analysing the results of the survey

The survey pooled 538 forms and 207 completed responses were received during the survey period spanning over one month. The results of which are presented and discussed in the following sections.

4.1. Analysing the respondents’ profile

The users held key positions and have diverse experiences with the buildings (Table 1). More than 60% of the building users are medical staff and the remaining are non-medical and executive staff. More than 50% of the building users have been using the hospitals for more than 4 years (Figure 1).
Table 1. Positions of the Respondents

| Positions                        | Frequency | Percentage (%) |
|---------------------------------|-----------|----------------|
| Doctor                          | 36        | 17.4           |
| Nurse                           | 77        | 37.2           |
| Therapist                       | 14        | 6.8            |
| Pharmacist                      | 6         | 2.9            |
| Cashier                         | 6         | 2.9            |
| Cleaner                         | 10        | 4.8            |
| Food Service Worker             | 8         | 3.9            |
| Security Guard                  | 6         | 2.9            |
| Hospital Engineer               | 10        | 4.8            |
| Information Technology Staff    | 6         | 2.9            |
| Receptionist                    | 4         | 4.8            |
| Technician                      | 5         | 2.4            |
| Executive                       | 13        | 6.3            |
| Admin                           | 6         | 2.9            |
| Total                           | 207       | 100.00         |

Figure 1. Respondent’s experience with the buildings

4.2. Results of the descriptive statistics
The Omega value of the reliability for the defects is 0.851 and the validity ranges from 0.6 to 0.89. The Kaiser's Measure of Sampling Adequacy was significant $\chi^2 (91) = 857.560, p<0.001$, $N=830$, indicating the data were drawn from the same population and that the defects were related. These data also mean there are no multicollinearity problems in the data. The descriptive statistics on how often the defects occurred in the buildings are contained in Table 3. The survey found that approximately 37% of the users measured that the defects were rare. But according to some 6% of the users, the defects least often occurred in the building even as 17% of the building users measured that defects less often occurred. Meanwhile, about 23% of the hospital building users have experienced the defects in the buildings often. Approximately, 17% of the building users, however, measured that the defects occurred in the buildings very or extremely often. The cumulative AFI score for all the defects is 46.18%, while the cumulative standard deviation (SDV) was 17.02%. To interpret, while the defect may be less in some of the hospital buildings, they are very rampant and critical in some of the hospital buildings.
Table 2. Descriptive of the types of performance services.

| Defect             | 1 | 2 | 3 | 4 | 5 | 6 | SD  | AFI  | Occurrence |
|--------------------|---|---|---|---|---|---|-----|------|------------|
| Leaky Faucet       | 9 | 20| 59| 78| 36| 5 | 20.50| 60.18| 1          |
| Defective Doors    | 30| 0 | 79| 79| 53| 0 | 19.14| 60.01| 2          |
| Defective Windows  | 42| 11| 22| 66| 61| 5 | 19.25| 58.68| 3          |
| Broken Light       | 12| 16| 73| 79| 23| 4 | 19.42| 57.84| 4          |
| Plugged toilet     | 31| 8 | 92| 92| 36| 5 | 20.50| 57.51| 5          |
| Faulty Ventilation | 41| 7 | 50| 84| 22| 3 | 23.85| 53.84| 6          |
| Wall Cracks        | 42| 25| 47| 55| 38| 0 | 18.32| 51.84| 7          |
| Defective Lifts    | 87| 0 | 19| 62| 39| 0 | 20.84| 47.34| 8          |
| Cracked Tiles      | 84| 10| 45| 18| 49| 0 | 18.85| 44.84| 9          |
| Electrical Problems| 101| 11| 25| 47| 23| 0 | 18.97| 40.34| 10         |
| Leaky Roof         | 102| 17| 32| 22| 34| 0 | 16.35| 39.51| 11         |
| Ceiling Collapse   | 129| 15| 27| 11| 25| 0 | 11.87| 33.01| 12         |
| Water Seepage      | 148| 8 | 19| 5 | 28| 0 | 8.72 | 30.51| 13         |
| Roof Corrosion     | 150| 10| 6 | 16| 25| 0 | 4.85 | 30.34| 14         |
| Gas Leakage        | 166| 17| 0 | 11| 13| 0 | 10.17| 24.84| 16         |

5. Discussion of defects in the hospital building

Because of space constraints, only the first 7 frequent defects will be briefly discussed. The findings show that the most frequently defects in hospitals are related to faucets. Faucet is common in the hospital because water is required for various types of functions. Therefore, it is not surprising to find that faucet leakage is a perennial problem in hospitals. Most of the leakage is due to use or misuse which is compounded by poor maintenance. The impact of faucet leakage is huge. For instance, it may lead to water seepage, tile failure, and water wastage. The data show that 78 of the users agreed that faucet often needs repair work. In fact, more than 45 of the building users believe that faucet leakage occurred very often or extremely often in the buildings. Defective Doors are the second common defect in hospital buildings. A total of 53 of the building users indicated that doors need repair work very often. While 45 of the building users agreed that doors required less repair work. The remaining 30 building users agreed that the door does not need repair work at all. The most common problems with the door are that the doors do not open properly. It was found that most of the hospitals face defective doors. The causes of defective doors were classified into design, workmanship, materials, and lack of protection (Isa et al., 2011).

The results of the survey show that the majority of building users agree that windows often need repair work. In fact, 66 building users measured it to require maintenance and 61 of the building users believed that door defects occur very often in the buildings. However, this seems to be counter-intuitive because widows at the hospitals are not often open. The causes of defective windows included poor design, use of unsuitable materials, poor workmanship during installation and fabrication (Isa et al., 2011). Seventy-nine of the building users agreed that lighting often needs repair work. Seventy-three of the users believe that the defect in lighting less often occurred. Light fittings and appliances need repair work very often. Lightning in the hospital is very important because doors and windows are often closed. Proper lighting in the hospital would help to improve the user’s productivity. Poor lighting will limit concentration levels significantly which could lead to reduced performance levels (Bermudez, 2014). Faulty ventilation systems turned out to be a common defect in hospitals. In fact, about 60% of the building
users measured faulty ventilation as often, very often, and extremely often. Hospital buildings need adequate ventilation systems to refresh all the air in order to reduce airborne infections (Villafruela et al., 2019). Therefore, it is not surprising that the defect in the ventilation was measured by users as critical. The results of the survey show that the majority of users resolved that cracks in walls often occurred. About 50% measured that defect walls often and very often occurred. Cracks on internal walls may cause by poor initial design, use and poor maintenance.

6. Conclusion
This study has been able to identify, quantity, and categorized defects in the university buildings. The identification and analysis of the degrees of the defects contribute to directing university maintenance organizations on maintenance management. This is crucial if universities desire to succeed in modelling a systemic maintenance management system for their buildings and engineering services. Defect classification is a very strategic function of maintenance organizations. In order to maximize the maintenance budget, the resource should direct to the extremely urgent defects then the very urgent, and finally to the ones that are not very urgent. Probably it is the only way, that the ever-inadequate fund will be spent judiciously and users’ satisfaction can be achieved and maximized accordingly. The defects addressed in this paper do not include defects that relate to substructure works (foundations cracking, foundation bowing, foundation settlement).

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