Priority Setting for Healthcare Facilities Maintenance

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Abstract: Priority setting in the health care field is a necessary activity because of the scarce resources and the choices amongst competing demand for those limited resources. This paper adopts a prioritization model for maintenance management to rank the maintenance works. The adopted model introduces the Building Status, Physical Condition, and Importance of Usage, Effects on Users and Cost Implication as the major criteria that are used in setting up the maintenance priorities for a major public healthcare facility in Jordan. The model suggests that the weight of each criterion in the multi-attribute prioritization model be determined with a more accurate and quantitative method by using the Analytic Hierarchy Process (AHP). This paper makes a contribution by proposing a modification to the AHP approach through determining the weights of each criterion in the multi-attribute prioritization model.

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1. Introduction

According to Marc et al (2012), the main challenge to all health systems is managing finite resources to address unlimited demand, moreover, the healthcare managers may face new dependencies such as; headquarters domination, investor demands, or internal competition (Julianne and Jeffrey, 2013). In most developing countries which are considered as low- and middle-income countries, the rationale behind their processes is the ad hoc style and sometimes implementing series of nontransparent choices that reflect the competing interests of governments, donors, and other stakeholders. Nevertheless, more explicit processes, in a growing number of countries are under development.

The last decades have seen growing interest in the health-promotion perspective (Marziye et al., 2013; Hemat et al., 2011; Karin et al., 2013) and in recent years, several reforms to the health systems around the world have altered the work environment and the services (Denis et al., 2013), as defined by Sarah and Albert (2012). Setting priorities is to give higher importance to some things over others, and in health it aims to determine what is most important, in the context of limited resources. Amanda et al (2012) mentioned that many developing countries have used the 'priority-setting'' approaches to choose between interventions over others, reference to (Peter et al., 2012), each country should establish its own systems to reflect the legal and social framework supporting their health systems. Frances et al (2012) has also added that all health systems should be effectively organized, well managed, and collaboratively-oriented care. 'Priority-setting'' approaches are also applied on the maintenance management as the priorities can be set for planned maintenance. However, the maintenance is considered an essential activity to keep the production process going.

In this research, a modified Multi- Attribute Approach is used, this approach starts by defining a number of major factors that should be considered by maintenance managers, then the priorities for planned maintenance are also set whereby every maintenance work is measured and given a score with respect to each criterion selected earlier. Finally, the weight of each criterion is determined in the multi-attribute prioritization model, this step is the main addition to the original method (Multi- Attribute Approach).

Rapid technological advances and innovations, which stimulate higher performance requirement, coupled with the complexity of modern facilities, force facilities managers, as well as hospital engineers to consider new patterns for enhancing the comfort, security, safety, and cost effectiveness of the buildings they manage and operate (William 1966).

Consequently, the planning must be based on a well-structured maintenance program. Thus, assessment and setting of priorities is the way to address the lack of maintenance funds, and to ensure carrying out these works according to main plans, limited resources, and element status.

Several methods have been implemented to apply the best model for priority setting of building maintenance. Such methods include Roués Formula System, Priority Category Matrix, Point Accumulation System, the Multi-Attribute Approach, and the Modified Multi-Attribute Approach.

Despite the well known benefits of setting priorities, little effort has been put into the development of systematic approaches of priority work by drawing upon maintenance database and factors that often influence the decision-making in planned maintenance. Also few attempts have been made to investigate the pros and cons of current practices of maintenance priority setting (Encon and Albert, 2004).

The Facility Management (FM) field in Jordan is not given the needed attention neither in research nor in practice. Thus, the aim of this study is to apply the Analytic Hierarchy Process (AHP) for setting maintenance priorities at a major public health facility in Jordan.

2. Background

2.1. Facility Management (FM) and Maintenance

The Facilities Management (FM) is a resource management that includes people, property and process management expertise to provide essential services in support of the organization (Nik-Mata et al., 2011). The effective FM services enhance the ability to respond effectively to changes while implementing the organization strategies.

Maintenance plays an essential role in achieving the organizations' goals (Christopher, 2013) and the maintenance system is essential for organizations' success (Antti and Mats, 2011). Moreover, the maintenance policy may influence company profit through affecting the losses in production times (Al-Najjar, 2012).

There are small numbers of researches highlighting the maintenance effect on company business (Basim and Martin, 2013). On the other hand, Sealy (1987) studied some of the main purposes of maintaining buildings such as: retaining the value of investment, maintaining the building in a condition that continues to fulfill its function, and presenting an acceptable appearance. Nik-Mata et al (2011) also mentioned that many organizations have re-evaluated the effect of FM in making a business successful; taking into consideration the value that can be added by effective facility management and the consequences of poorly-managed facilities.

Reference to an analysis that has been done by Alani et al (2002), 100 percent of the public sector organizations utilize maintenance assessment methods for their prioritization of maintenance management jobs.

Regarding the priorities and categories of maintenance, Hassan (1997) presented a case study about factors affecting demand for maintenance in Washington hospital. In this study, Hassan attempted to forecast the demand for maintenance by collecting general statistics.

In addition, Shohet and Lavy (2004) stated that the increasing competitiveness in the business sector forces facilities managers to reduce expenditure on "non-core" activities. Consequently, the integration of different domains related to facilities management (FM) motivates the development of a quantitative model, which may contribute to both; the planning of FM activities and to the improved effectiveness of FM units. Thus, they proposed a model which provides insight into the assessment of parameters that affect maintenance and operations in healthcare facilities. The proposed model is divided into three main phases: input interface; reasoning evaluator and predictor phase; and output interface. In general, the input interface receives data from the user on a particular facility. The input data is then analyzed by the reasoning evaluator and predictor, which stores knowledge on both past cases and on developed models (knowledge-based predictor model). Finally, the output interface analyses the facility's indicators, using the same modules used by the input interface. The interfaces are forward related, i.e. information received by the input interface is analyzed by the reasoning evaluator and predictor, resulting in indicators and recommendations that are subsequently processed by the output interface.

2.2. Performance Concept

Successful companies measure their performance in order to stay competitive and cost effective in their business; this is the reason behind the great amount of attention that the performance measurement (PM) received recently (Nik-Mata et al., 2011).

Building performance is a potential "success factor" by facilities managers which should be linked to the circumstances and the needs of the organization. James (1996) stated that the performance concept is the most systematic approach for appraising buildings; it is solution-oriented as opposed to problem center. Franklin (1999) concluded that the systematic application of the performance concept throughout the building process is prevented as a result of gaps in basic knowledge, inadequacies in procedural infrastructure and lack of working tools.

2. 3. Performance Evaluation

Reddy (1993) developed a model of evaluation, utilized in the renovation of military facilities. The model is based on three functions: Physical parameters, Functional parameters, such as geometry, safety, system compatibility, facility location and peripheral infrastructure. Organizations that maintain a large number of facilities use this kind of procedure numerous times and thus try to adapt the implementation of the procedure for extensive use. However, Gray and Baired (1996) classified the building evaluation techniques according to two broad approaches: Empirical and Theoretical methods; Empirical methods use trial or test evaluation, whereas theoretical methodologies apply rigorous systematic, validated, and reliable techniques.

Mailvaganam and Alexander (2000), developed a multi –phase procedural processing model of repair activities, which is based on such user –friendly building evaluation.

Caccavelli and Genre (2000) developed a methodology for summarizing the current state of building and estimating the cost of various works, as well as refurbishment needs, with respect to energy conservation. The methodology is made up of 50 elements between one to six types per elements; each is ranked according to one of the following categories: good state, slight degradation, medium degradation, poor state (requires replacement).

Marc et al (2012) define the operation and maintenance costs as the ongoing monthly expenses that are required to keep the technologies and the materials or supplies needed to maintain the required benefits.

Shohet and Lavy (2004) described the effects of three factors on the performance and maintenance of hospital buildings; sources of labor, level of building occupancy, and age of the building, while developing a comprehensive model for hospital maintenance management using four key performance indicators.

2.4. Priority Evaluation

Van and Dekker (1998) presented an integration of optimization, priority setting, planning and combining of maintenance activities, and derived penalty functions which can act as a priority criterion function. Maintenance approaches have been mainly categorized into corrective and preventive maintenance (Ashok et al., 2012), since preventive maintenance can suffer a large backlog compared to corrective maintenance; the penalty functions were developed as priority functions where long-term objective is the average costs. These functions are negative before optimal execution time of a component, zero exactly execution at time and increases thereafter. They are expected in money terms and are additives. The paper also presented a number of models such as the standard inspection model and the efficiency model, which uses penalty functions as well. Moreover, Spedding et al (1995) developed a method termed the multi-attribute system; this method is based on a comprehensive study of several different methods for the determination of maintenance priorities criteria for the determination of maintenance priorities.

In addition, Shen and Lo (1999) modified the old model for priority setting in planned maintenance in which priority of a criterion is ranked according to their relative importance; subsequently, a weighting should be assigned to each criterion based on experts judgments where every maintenance work to be identified in a condition survey or inspection should be measured, and a score is given to calculate the priority index which determine priority ranks.

The main addition to the original method is to decide the weighting of each criterion in the multi-attribute prioritization model with more accurate, objective, and quantitative method which was called the Analytic Hierarchy Process (AHP).

AHP was designed by Saaty (1980) in the 1970s to help decision-makers in organizing the complex problems into smaller parts, starting from the primary goal then objectives and finally the alternative actions. The AHP is considered as a powerful and flexible decision-making process that aims to set priorities and help to make the best decision when having qualitative and quantitative data.

“AHP not only helps decision- makers arrive at the best decision, but also provides a clear rationale for decision”, Expert Choice (2002). Through the AHP, the Decision- makers can make simple pair-wise comparison judgment throughout the hierarchy to arrive at overall priorities for the suggested alternatives, However, the best maintenance decision conclusion is often taken using heuristics, backed up by qualitative assessment, supported by quantitative measures (Uday et al., 2013).

3. Methodology

In this paper, a modified Multi- Attribute Approach is used whereby every maintenance work identified in an inspection process will be measured and given a score with respect to each criterion selected earlier. Subsequently, the Analytical Hierarchy Process and a pair-wise comparison will be conducted among the alternatives in order to create hierarchal arrangements with the purpose of making sound priority maintenance decisions.

3.1. Data Collection

Gathering data from a major public healthcare facility’s maintenance department was done by interview method. Data included facility parameters (built-up area, occupancy, age of building, and maintenance inputs {material, labor, and money}) as well as information related to the maintenance policy.

Moreover, examination of the current physical condition for the healthcare facilities and study of the failure cases for some of these facilities have been done through the visual inspections.

3.2. The Multi-Attribute Approach for Prioritizing Maintenance

In this process of setting priorities for planned maintenance, a number of major factors are normally considered by maintenance managers. Criteria used for priority setting will be ranked according to their relative importance, and subsequently a weighting will be assigned to each criterion. Every maintenance work identified during a condition survey or inspection will be measured and a score will be given.

Suppose *n* criteria C1, C2, ..., Ci, …, Cn are used in the prioritization process, their relative weights are W1, W2, …, Wi, …, Wn, and work j was scored Sj1, Sj2, …, Sji, …, Sjn against criteria C1, C2 ,…, Ci, …, Cn . The overall priority index for job j can then be calculated by using the following formula:

The criteria used in the prioritization process and their weightings may be different among local authorities. This reflects the differences in their maintenance objectives, policies and practices. Five major criteria have been identified as the most commonly used criteria in setting up of maintenance priorities. They are: Building Status (BS), Physical Condition (PC), Importance of Usage (IU), Effects on Users (EU), and Cost Implication (CI). These special criteria sometimes override the standard criteria. For instance, a low priority could be assigned to a maintenance job according to the standard criteria.

In order to ensure consistency, the research team designed detailed guidelines for assigning scores to maintenance works to be used by surveyors; as the scoring process is critical to the success of the method, and should establish a common base for the scoring process.

3.3. The modified multi-attribute approach using (AHP)

The main modification to the original method is to determine the weighting of each criterion in the multi-attribute prioritization model by using the Analytic Hierarchy Process (AHP).

The criteria, the used prioritization process and their weights are set based on analyzing the maintenance objectives and the organization policies. Fig. 1 shows a flow chart of this process.

3.4. Introduction to the analytical hierarchy process (AHP)

The analytical hierarchy process was developed to allow individuals and groups to deal with multi-criteria decision problems; by incorporating both subjective and objective data into a logical hierarchy framework. AHP provides decision makers with an intuitive and common-sense approach to evaluate the importance of every element of a decision through a pair-wise comparison process; the hierarchy has at least three levels: the goal, the criteria and the alternatives.

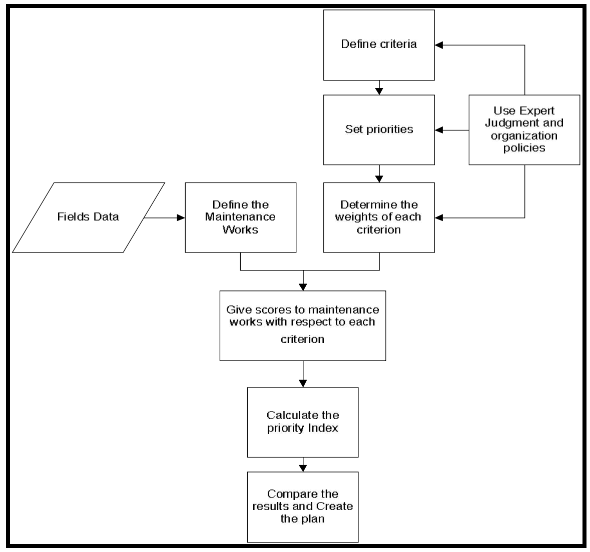

Figure 1. The flowchart of the Modified Multi-Attribute Approach

3.5. Formulation of pair-wise comparison matrix

Each pair-wise comparison involves assessing the relative importance of one factor using a ratio scale. Table 1 through Table 4 show the matrix form and the commonly used guidelines for assigning scores while Table 5 represents fundamental ratio scale in pair- wise comparison suggested by Satty (1990).

By answering the question " Which is the most important factor i or j ?" the pair-wise comparison matrices are formed. If the decision maker believes that the "effects on users" are moderately more important than "cost implication", a value of 3 can be assigned to "effects on users".

3.6. Modifications to the Proposed Model

• The model was developed for different systems in various buildings; it is modified here to prioritize maintenance works for different systems in the same building, thus, the criterion BS that represents the relative importance of one building over anther have been eliminated

• The research team expanded the use of the proposed model to prioritize maintenance works for various elements in the same system; due to scarce resources allocated for maintenance works.

• As the scoring techniques were not introduced in the original model the research team developed some scales to help in assigning the scores for the different criteria, whereby, having a definite meaning to each score reduces subjectivity to a large extent.

Table 1. Pair-wise comparison matrix (A comparison of i (i.e. BS) with respect to j (i.e. PC)).

With Respect To Goal	BS	PC	IU	EU	CI	Weighting
BS						
PC						
IU						
EU						
CI						

Table 2. Guidelines for assigning scores related to the state of the Physical Condition (PC) as well as the Effect on User (EU) criteria.

Score	Explanation
1	Minor problem relating to aesthetics or convenience.
2	Damage to the image of the organization or decrease of moral due to frustration caused by the defects
3	Serious discomfort to the users of the building.
4	Serious disruption of the normal activities in the building, or health or safety problems, but does not pose immediate danger.
5	High risk of health or safety problems which pose serious potential danger to occupants or users of the building.

Table 3. Guidelines for assigning scores related to the state of the Important of Usage (IU) criterion

Score	Explanation
1	Minor important relative to other systems.
2	The unit supports few services.
3	The unit is used for many purpose and functions.
4	Functioning of this unit is important to the building.
5	Functioning of this unit is very important to the building.

Table 4. Guidelines for assigning scores related to the Cost Implication (CI) criterion

Score	Explanation
1	Deferred maintenance does not affect the implication cost, and maintenance works do not affect the services provided by the building.
2	Deferred maintenance affects the implication cost, while maintenance works do not affects the services provided by the building.
3	Deferred maintenance does not affect the implication cost, and maintenance works affects the services provided by the building.
4	Deferred maintenance affects the implication cost, and maintenance works affects the services provided by the building.
5	Deferred maintenance causes great financial problems, also maintenance works highly affect the services provided by the building

4. Description of Healthcare Facility

Maintenance management of any healthcare facility building is one of the most complex subjects in the field of facilities management. Contributing to this is the great complexity of hospitalization buildings, the high criticality of mechanical and electrical systems, and the shortage of maintenance budgets. Moreover, performance and operation of the buildings are affected by numerous factors; these include actual occupancy relative to planned occupancy, age of buildings, building surroundings, managerial resources invested, and labor sources.

These important and complicated issues related to maintenance in healthcare facilities require facility managers to find new ways to improve the comfort, safety, energy consumption and cost effectiveness by continuously dealing with different issues, such as maintenance policies, preferred sources of personnel, maintenance organizational effectiveness, and so on.

A sequence of interviews has been conducted with a number of employees in the maintenance department and in the financial department. The following sections shows the result of these interviews.

Table 5. Fundamental ratio scale in pair- wise comparison. Saaty (1990)

Intensity of importance	**Definition**	**Explanation**
1	Equal importance	Two activities contribute equally to the objective
3	Weak importance of one over another	Experience and judgment slightly favor one over another
5	Essential or strong importance	Experience or judgment strongly favor one over another
7	Very strong or demonstrated importance	An activity favored very strongly over another; its demonstrated in practice
9	Absolute importance	The evidence favoring one activity over another is of highest possible order of affirmation
2, 4, 6, 8	Intermediate values between adjacent scale value	When a compromise in judgment is needed
Reciprocals of above nonzero	If activity i has one of the above nonzero numbers assigned to it when compared with activity j, then j has the reciprocal value when compared with i	A reasonable assumption
Rationales	Ratio arising from the scale	If consistency were to be forced by obtaining n numerical values to span the matrix

Table 6. Major building characteristics for the financial year 2012-2013

Variable			Value
Built-up area (m^2)			65043
Number of actual patient beds (beds)			600
Level of occupancy (beds/1000 m^2)			9.22
Age of building (years)			35
Hospital budget (10^3 JD) One Jordanian Dinar = to 1.41 US Dollars			60000
Total annual maintenance expenditure and its distribution	Total annual maintenance budget (10^3 JD)		2282
	Annual external contractors budget (10^3 JD)		364
	Annual workshops and projects budget undertaken by in-house personnel (10^3 JD)		477
	Annual materials budget (10^3 JD)		223
	Annual overhead expenses	Water (10^3 JD)	301.5
		Electricity (10^3 JD)	360
		Communications (10^3 JD)	40
		Fuel (10^3 JD)	516.5
Annual maintenance expenditure per patient bed (JD)			3803
Annual maintenance budget (% of hospital budget)			3.8
Annual overhead expenses budget (% of ***AME***)			53

4.1. Facility characteristics

The total built-up area of the building is 65043 m2, with 600 patient beds that reveals a level of occupancy to be 9.22 beds per 1000 m2 built-up in the hospital. The total annual maintenance expenditure was found to be 2.282 million Jordanian Dinar (i.e. 35.08 JD/m2) or (3803 JD per patient bed) in the financial year 2012-2013. Table 6 represents a summary of the healthcare facility characteristic.

Fig. 2 shows the percentage of the maintenance budget distribution (In 2012-2013) and Fig. 3 shows the distribution of the effective annual maintenance budget for the same period.

It is obvious that the total annual maintenance expenditure includes expenses that should not be accounted for in the maintenance budget; such as overhead expenses (i.e. water, electricity, and fuel). Since these are not in fact spent on the core aspects of the maintenance works, so the effective annual maintenance expenditure should be used instead of the given total AME. However in this case-study both values will be used to calculate MEI to reveal the affect of this consideration on the maintenance efficiency. Table 7 summarizes the difference between the two AMEs.

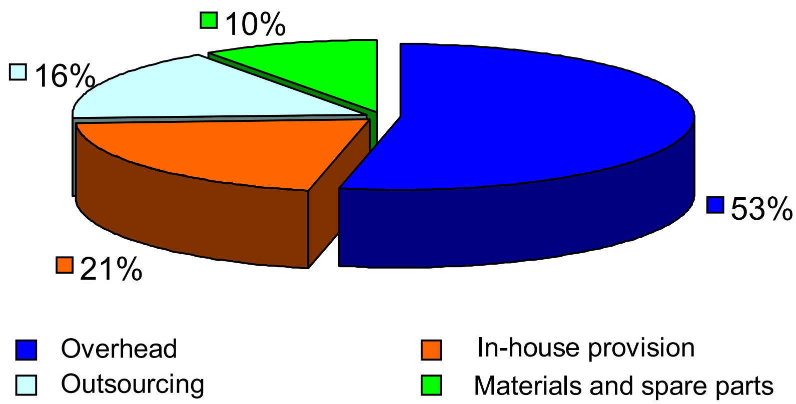

Figure 2. Distribution of the total annual maintenance budget

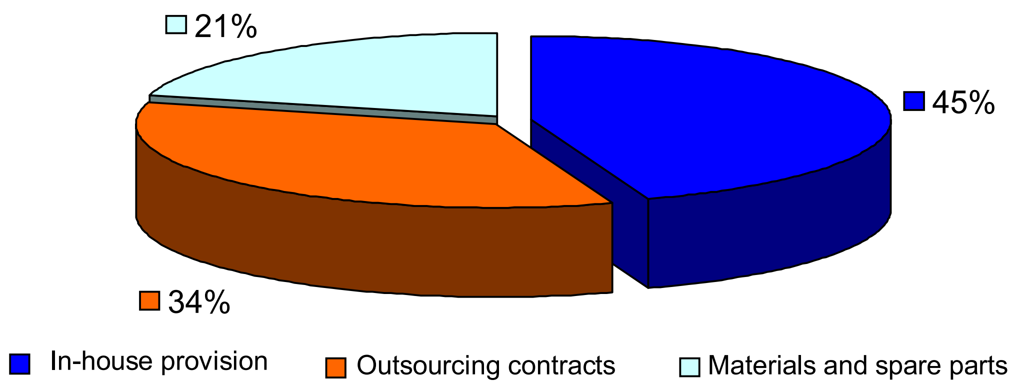

Figure 3. Distribution of the effective annual maintenance budget

Table 7. Total and effective annual maintenance expenditures

Variable	Total	Effective
Annual maintenance expenditure (10^3 JD)	2282	1064
Annual maintenance budget (% of hospital budget)	3.8	1.77
Annual maintenance budget(JD/ m^2)	35.08	16.36
Annual maintenance budget (JD/bed)	3803	1773

4.2. FM and Maintenance Management Polices for the Healthcare Facility

Maintenance policy was explored by interviews with the managers of the maintenance department. This section outlines the maintenance policy and major practices:

4.2.1. Maintenance types

Major maintenance works are corrective (implemented at the breakdown of the equipment), 90% of the department efforts is focused on maintaining the medical equipment for the essential services. Time-based maintenance is also implemented for the medical equipment to follow their operational and maintenance manuals instructions. The preventive and corrective maintenance for other systems is done for limited areas; such as the hospitals floors, doors, windows, painting, and lamps replacement. It is obvious that these works are implemented as a result of the intensive use. On the other hand, the major works are ignored like: the works that target the structural system which are never implemented.

4.2.2. Improvement

The Maintenance Department prepares its share of the annual balance by adding 10-15% to the last year budget. The healthcare facility joined different quality assurance programs to improve the facility quality that guarantees patient satisfaction, such as the PHR plus, ISO and other international quality management associations.

4.2.3. Labor maintenance

70% of the maintenance works are implemented by the in-house provision such as painting, tiles replacement, and other major maintenance projects. Outsourcing is used for maintaining elevators and medical equipments as stated in their warranties, and as a result of the lack of experience of the in-house provision. Outsourcing forms 16% of maintenance costs.

.4.2.4. The implementation of the model

Analysis of the collected data will be performed in order to set maintenance works priorities needed for Structural, Exterior, and Interior Systems as well as the elements of the candidate system, and to evaluate the efficiency of the healthcare facility management.

4.2.5. Priority Setting Analysis

In this section maintenance works will be prioritized among the different three systems, then the system that has highest priority will be broken down to its elements in order to determine which element has the highest priority to be maintained to ensure a high-quality execution of the planned maintenance.

The first system is The Exterior System which includes specific areas and components to consider such as; roof, gutters and downspouts, site drainage, foundations, exterior walls, windows, doors, features and details, Table 8 shows the calculation of the weights with respect to each goal.

Table 8. The pair-wise comparison matrix

With respect to goal	PC	IU	EU	CI	Weighting
PC	1	5	1/3	4	0.310
IU	1/5	1	1/5	4	0.162
EU	3	5	1	7	0.479
CI	1/4	1/4	1/7	1	0.049

Sample of the calculations used in the previous table are shown below:

✓ For PC:

$$1 + 5 + (1/3) + 4 = 10.333$$

✓ Having done this operation (horizontal summation) for each criterion we obtain:

IU = 5.4

EU= 16

CI= 1.643

✓ By summing up these values, one obtains:

Sum = PC + IU + EU + CI

= 10.333 + 5.4 + 16 + 1.643

= 33.376

✓ Dividing the horizontal summation for each criterion on Sum to obtain the relative weight used to obtain the weighted score PI

For PC:

W_1 = 10.333/33.376

= 0.310

✓ For PC:

S1 = 3

In order to calculate the Weighted score we used the Eq. (W1* S1)

For example the PC criterion weighted score is calculated as follows

0.310 * 3 = 0.930

Table 9 shows the weighted scores of the other criteria:

✓ For IU: S2 = 3

✓ For EU: S3 = 3

✓ For CI: S4 = 2

Table 9: Criteria scores and weighted score

Criteria	Score	Weighting	Weighted score
PC	3	0.310	0.930
IU	3	0.162	0.486
EU	3	0.479	1.437
CI	2	0.049	0.098

The calculated Priority Index (PI) = 2.951

Sample of calculations:

✓ For Exterior system:

$PI = S_j = S_{j1}*W_1 + S_{j2}*W_2 + \ldots + S_{ji}*W_i + \ldots + S_{jn}*W_n$

= ∑ Weighted scores for criteria

= 0.930 + 0.486 + 1.437 + 0.098

= 2.951

= 0.930 + 0.486 + 1.437 + 0.098

= 2.951

The second system is The Interior System which includes internal walls, interior doors, interior ceiling, interior windows; Table 10 shows the calculation of the weights with respect to each goal.

Table 10. The pair-wise comparison matrix

With respect to goal	PC	IU	EU	CI	Weighting
PC	1	1/2	1/4	7	0.240
IU	2	1	1/3	7	0.283
EU	4	3	1	8	0.438
CI	1/7	1/7	1/8	1	0.039

In order to calculate the weighted score, we used the same equation that was used before, Table 11 shows the details:

Table 11: Criteria scores and weighted score:

Criteria	Score	Weighting	Weighted score
PC	2	0.240	0.480
IU	4	0.283	1.132
EU	2	0.438	0.876
CI	3	0.039	0.039

Calculation of Priority Index (PI) = 2.605

Finally, the Structural System which includes the equipment and tools used in the operations; Table 12 shows the calculation of the weights with respect to each goal.

Table 12. The pair-wise comparison matrix

With respect to goal	PC	IU	EU	CI	Weighting
PC	1	3	8	5	0.481
IU	1/3	1	4	5	0.293
EU	1/8	1/4	1	5	0.181
CI	1/5	1/5	1/5	1	0.045

In order to calculate the weighted score we used the same equation that was used for the exterior system, Table 13 shows the details:

Table 13. Criteria scores and weighted score:

Criteria	Score	Weighting	Weighted score
PC	2	0.481	0.962
IU	5	0.293	1.465
EU	2	0.181	0.362
CI	5	0.045	0.225

Calculation of Priority Index (PI) = 3.014

Using the *PIs* for the three systems above, the priority rank for each system can be determined after arranging them in a descending order:

PI for the Structural System = 3.014

PI for the Exterior System = 2.951

PI foe the Interior system= 2.605

Thus, $PI_{Structural} > PI_{Exterior} > PI_{Interior}$;

Maintenance works for the Structural System have the highest priority to be executed according to its rank revealed by the Priority Index. If the resources are sufficient to execute other maintenance works, the Exterior System should be maintained since it has the second highest Priority Index, otherwise it will be backlogged to the next year maintenance plan with the Interior System.

The structural system is mainly divided into Columns, Beams, and Slabs. Each element will be analyzed to calculate its Priority Index; Table 14 shows the comparison matrix between these three items.

Table 14: The pair-wise comparison matrix:

Structural System Items	With respect to goal	PC	IU	EU	CI	Weighting
Columns	PC	1	3	5	5	0.432
	IU	1/3	1	4	5	0.319
	EU	1/5	1/4	1	5	0.199
	CI	1/5	1/5	1/5	1	0.049
Beams	PC	1	5	4	5	0.450
	IU	1/5	1	4	5	0.306
	EU	1/4	1/4	1	5	0.195
	CI	1/5	1/5	1/5	1	0.048
Slabs	PC	1	3	3	5	0.419
	IU	1/3	1	3	4	0.291
	EU	1/3	1/3	1	5	0.233
	CI	1/5	1/4	1/5	1	0.058

After calculating the weights for each criterion the weighted scores are calculated as shown in Table 15.

Table 15. Criteria scores and weighted score

Item	Priority Index	Criteria	Score	Weighting	Weighted score
Columns	2.373	PC	1	0.432	0.432
		IU	5	0.319	1.595
		EU	1	0.199	0.199
		CI	3	0.049	0.147
Beams	2.658	PC	2	0.450	0.90
		IU	4	0.306	1.224
		EU	2	0.195	0.39
		CI	4	0.048	0.144
Slabs	2.514	PC	1	0.419	0.419
		IU	5	0.291	1.455
		EU	2	0.233	0.466
		CI	3	0.058	0.147

PI values for the structural elements above can be determined after arranging them in ascending order:

PI for the Columns =2.373

PI for the Slabs = 2.514

PI foe the Beams = 2.658

Thus, $PI_{Columns} < PI_{Slabs} < PI_{Beams}$

Maintenance works for the beams have the highest priority to be executed according to its rank revealed by the Priority Index, if the resource is enough to execute other maintenance works, the Slabs should be maintained since it has the second highest Priority Index, otherwise it will be backlogged to the next year maintenance plan.

5. Conclusions

This paper proposed a modified Multi- Attribute Approach that has been applied to a major public healthcare facility in Jordan. This approach starts by defining a number of major factors that should be considered by maintenance managers, and then the priorities for planned maintenance are also set whereby every maintenance work is measured and given a score with respect to each criterion selected earlier.

The weight of each criterion is determined in the multi-attribute prioritization model. Four major criteria have been identified: Physical Condition (PC), Importance of Usage (IU), Effects on Users (EU) and Cost Implication (CI) then the suggested approach has been applied in order to set maintenance works priorities needed for Structural, Exterior, and Interior Systems as well as the elements of the candidate system, and to evaluate the efficiency of the healthcare facility management.

The results show that the maintenance works for the Structural System have the highest priority to be executed according to its rank revealed by the Priority Index. Actually, the healthcare maintenance policies are suffering from many shortcomings as the top management may not actually realize the importance of maintenance and the need to improve its practices. In addition, maintenance at the healthcare facility is also suffering from some practices such as 30% reduction of the ***AME*** suggested by the maintenance department and abandonment of some spare parts used for equipment preventive maintenance because it occupies a large space of the storerooms. On the other hand, the lack of training for the maintenance team who is responsible for the in-house maintenance is one of the major issues that are faced by the maintenance departments. As mentioned in this study 70% of the maintenance works are implemented by the in-house employees and training them is important to improve their skills and keep them updated with all the new techniques.

Based on the result, the authors recommend that top management and maintenance department maximize the use of resources and improve maintenance management by setting the priorities for the order of the execution of maintenance works. Namely, identify the priority criteria and, present high-quality training for surveyors to assess the building status related to these criteria. This study indicates the need to set the structural system on the top of the planned maintenance program, and the need of having commitment toward planned maintenance.

Furthermore, the top management is recommended to develop the required research that help to improve the general understanding of maintenance concepts, adopting new planning, prioritizing and assessment methods, counting for density, usage, environmental, technological, and economical changes. In addition, actions should be taken to develop and improve the database for the healthcare facility that will make the research process easier and more adaptable in the future.

Regarding the priority models in general, the authors recommend the development of precise definition of the priority criteria scores to eliminate subjectivity. However, future research should aim at investigating the pros and cons of the current practices setting. Since the development of more appropriate prioritization system in the area of building maintenance has not been pursued vigorously. In addition, priority setting in health care should not be considered a problem resolved by one survey or declaration but it is a continuous process requiring investigating and developing new methods for prioritization.

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