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Performance-Based Facility Management – An Integrated Approach

ABSTRACT:

Increasing demand for healthcare services worldwide creates continuous requirements to reduce expenditure on "non-core" activities, such as maintenance and operations. At the same time, owners, users, and clients of healthcare expect improved performance of built-facilities and minimized risks. The objective of this research was to develop an integrated Facility Management (FM) model for healthcare facilities. The core of the model is based on the strength of identified effects of parameters, such as maintenance expenditure and actual service life, on the performance and maintenance of healthcare facilities. The proposed Integrated Healthcare Facility Management Model (IHFMM) addresses three core fields of FM: maintenance, performance, and risk. This paper presents a case study carried out in an Israeli acute care hospital, in which the IHFMM was implemented (Phase I) and the findings were examined and evaluated three years later (Phase II). The findings reveal a high correlation between the outcomes observed in the second phase of the case study and the predictions made in the first phase.

Keywords: Case Study, Facility Management, Healthcare, Maintenance, Performance, Risk.

INTRODUCTION

Increased competitiveness in the business sector puts considerable pressure on companies to reduce expenditure on "non-core" activities, such as maintenance. This encourages buildings' owners and users to increase their expectations and requirements of facilities. Facility managers are thus expected to attain lower operational costs and risks through effective and efficient management of facilities, without compromising their performance.

Over the past three decades, the field of Facility Management (FM) has witnessed significant development, mainly due to the following five global trends: (1) increased construction costs, particularly in the public sector; (2) greater recognition of the effect of space on productivity; (3) increased performance requirements by users and owners; (4) contemporary bureaucratic and statutory restrictions that decelerate the procurement of new construction projects; and (5) recognition that the performance of high-rise and complex buildings is highly dependent on their maintenance (Shohet, 2006). As a result, the traditional "maintenance manager" has become a "facility manager," and is one of the key individuals in an organization's continuity and success (Atkin and Brooks, 2000). The facility manager is responsible for making strategic and operational facilities-planning decisions that affect the organization's business performance (Cotts et al., 2009). This is particularly true in healthcare facilities, that are considered to be among the most complicated and difficult types of facilities to manage, maintain, and operate.

This paper describes the implementation of performance indicators in the context of the Integrated Healthcare Facility Management Model (IHFMM), as developed in the frame of this research, on a case study.

BACKGROUND

The following paragraphs review three topics related to current trends in healthcare Facility Management: Strategic Facility Management, FM in Healthcare, and Risk Management in Healthcare Facilities.

Strategic Facility Management

Facility Management has traditionally been regarded in the old-fashioned sense of cleaning, repairs and maintenance (Atkin and Brooks, 2000). A decade ago, FM responsibilities broadened to encompass "buying, selling, developing and adapting stock to meet wants of owners regarding finance, space, location, quality and so on" (O'Sullivan and Powell, 1990). It was the recognition of the effect of space on productivity that stimulated the development of the Facility Management discipline (Alexander, 1996; Brown et al., 2001; Douglas, 1996; Neely, 1998; Then, 1999). From the 1990s onward, there has been a trend toward more open markets, and especially toward gradually increased competition, as a result of globalization (Hamer, 1994). Now, at the beginning of the 21st century, it is recognized that property is a cost-center that can contribute to profit, and as such requires effective management. Buildings are expensive to maintain and adapt, yet whatever their use, any "good" building should be habitable, secure, durable, energy efficient and adaptive. As stated by the International Facility Management Association (IFMA, 2004), FM is taken to be: "A profession that encompasses multiple disciplines to ensure functionality of the built environment by integrating people, place, process and technology."

FM in Healthcare

Drivers of healthcare Facility Management are discussed extensively in the literature. Gallagher (1998), for instance, defines the following six issues as encouraging successful implementation of healthcare FM: strategic planning, customer care, market testing, benchmarking, environmental management, and staff development. Amaratunga et al. (2002) demonstrate a model developed for assessing the impact of the organization's FM cultural processes (SPICE-FM) on a hospital facility, and conclude with a definition of the following attributes as key processes for successful implementation of FM: service requirements management, service planning, service performance monitoring, supplier and contractor management, health and safety processes, risk management, and service coordination. The SPICE-FM model focuses on management processes rather than on the technical aspects of FM (e.g. maintenance management and physical performance monitoring.) The authors of this paper argue that the technical aspects are still missing, and therefore, deserve further study. Shohet and Lavy (2004) identify the following six core domains within the area of healthcare Facility Management: maintenance, performance, risk, supply services management, development, and Information and Communications Technologies (ICT), which integrates between the other domains.

The healthcare sector in many countries suffers from a lack of resources, as reflected in different financial reports (AHA, 2004; British Ministry of Finance, 2003). This trend might adversely affect non-core activities of healthcare providers, and primarily Facility Management aspects, such as maintenance and operations. Ritchie (2002) posits that improving the delivery of healthcare services, as well as the services' performance and quality, can be achieved by paying similar attention to the quality of service as is paid to financial issues. The reforms made by the UK government in the National Health System (NHS) during the 1980s and the 1990s improved efficiency by increasing the responsibilities given to the management level (Procter and Brown, 1997). Payne and Rees (1999) elucidate workplace change, together with the increasing level of technology, as the two motives that should direct the government to develop new forms of hospitals, by re-engineering existing facilities. This finding was validated in Waring and Wainwright's (2002) case studies.

Risk Management in Healthcare Facilities

O'Donovan (1997) defines the term 'risk management' as: "A process where an organization adopts a proactive approach to the management of future uncertainty, allowing for identification of methods for handling risks which may endanger people, property, financial resources or credibility." The author concludes that risk management should be a high priority for any healthcare facility, and it is achieved through a risk management program, in which risks are identified, analyzed, classified, and controlled. Okoroh et al. (2002) found that one of the facility manager's principal duties in healthcare FM is to identify, analyze and economically control "those business risks and uncertainty that threaten healthcare assets or cause loss of earning capacity in hospitals." The researchers then propose the following seven main levels of possible risks in healthcare organizations: customer care, business transfer risks, legal risks, facility transmitted risks, corporate risks, commercial risks, and financial and economic risks. While it present a very thorough and comprehensive study, most risks identified by Okoroh et al. (2001) (e.g., clinical strategy, national minimum wage, and medical technology innovation) cannot be controlled by any actions taken by a facility manager or by implementing any FM processes. Therefore, this paper focuses only on those risks associated with the regular day-to-day operation of healthcare facilities, which are typically regulated and monitored by the FM department. Holt et al. (2000) classify the risks faced by FM organizations into two categories: (1) pure risks, in which business survival is threatened, or its objectives have failed to be achieved; and (2) speculative risks, which may result in negative effects. These studies emphasize the need to develop generic risk databases appropriate to FM. Williams (2000) introduces the integration of value engineering (tactical) and value management (strategic) to the implementation of FM risk management. The review of past studies shows that risk management has achieved maturity in FM, at both the strategic and tactical levels. Nevertheless, no insightful research has been carried out in healthcare facilities risks, an area which is rich in critical systems such as medical gases and communications that are sensitive to critical or highly critical failures

From this review of literature, it is argued that the effectiveness of healthcare services will increase with the growth and development of the Facility Management profession towards a proactive, strategic discipline. This will change the position of FM in healthcare organizations, to a more central part of the organization – a position that will help shape organizational decisions and processes (Nelson, 2004; Cotts et al., 2009).

THE INTEGRATED HEALTHCARE FACILITY MANAGEMENT MODEL

The Integrated Healthcare Facility Management Model (IHFMM) provides insight into the assessment of parameters that affect maintenance, performance, and risk in healthcare facilities, e.g. occupancy, age, and performance of buildings. The proposed model consists of three main interfaces: Input Interface, Reasoning Evaluator and Predictor, and Output Interface, which are divided into five phases (A to E), as presented in Figure 1.

The Input Interface requires the user to provide parameters that are related to the facility, while the Output Interface provides the user with a review of the main topics analyzed by the reasoning interface. The Reasoning Evaluator and Predictor Phase implements fifteen procedures used by the model for computing the Key Performance Indicators (KPI's) for the facility in question. Two main principles outline the design of the IHFMM, as follows:

1. The structure of the database is object-oriented, enabling adaptability of the database to diverse healthcare buildings; and
2. The model links three core issues of healthcare FM: maintenance, performance, and risk. It can be expanded to incorporate operations and energy, business management, and development aspects in future development.

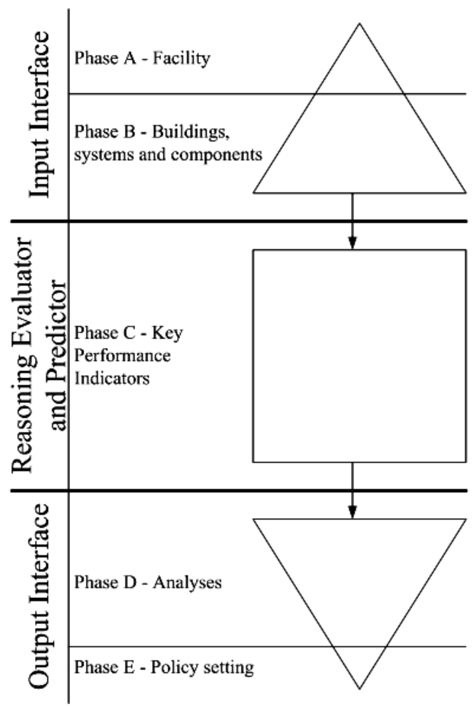

Figure 1 Architecture of the IHFMM model

The following paragraphs depict the rationale and functions of the major procedures, as developed in the IHFMM. These represent six out of the fifteen developed procedures, and they were selected as the core of the model.

Building Performance Indicator (BPI)

The BPI aims to compute the actual physical performance score for each system in a given building, for each building and for the entire facility (Shohet, 2003). It provides a physical performance indicator, measured on a 100-point scale. Weighting the performance indicator in a building level is based on a Life-Cycle Cost (LCC) analysis of all the components in that building. The BPI takes into consideration the design parameters and the construction technology as the weights are derived by the LCC of the particular design and construction of the building. This means that the BPI combines the physical performance of components and their financial weight for the particular design, i.e. the higher the LCC of a building system, the higher its share in the BPI is, and vice-versa. The BPI for building i is calculated by using Equation (1):

$$BPI_i = \sum_{j=1}^{10} \left(AP_{i,j} * \frac{LCC_{i,j}}{LCC_i} \right) \tag{1}$$

Where: BPI is the Building Performance Indicator, $AP_{i,j}$ is the actual physical performance score for system j in building i, $LCC_{i,j}$ is the Life-Cycle Costs for system j in building i, and LCC_i is the total Life-Cycle Costs of building i.

This procedure performs a physical assessment of the building and its systems and components. Nevertheless, instead of being a tool that is used only to assess the physical condition of a building, it also incorporates a financial aspect that supports the weighting of the different systems in a building while taking their LCC into consideration. It provides the facility manager with a new perspective that creates a simultaneous link between the physical performance score and the financial aspects of building components.

Facility Coefficient (FAC_y)

The facility coefficient procedure computes the adjusting coefficient for the Annual Maintenance Expenditure (AME) to the age of the facility and to prevailing service conditions. This coefficient is affected by the type of environment (whether marine or in-land environment), its occupancy (low, standard, or high), the actual age of the buildings in the facility, and the particular configuration of the buildings in terms of the amount, type of construction, and quality of the components used (Lavy and Shohet, 2007I). This coefficient expresses the required maintenance resources for implementing a preventive maintenance policy. Each building is then compared with a standardized hospital building, with the characteristics of location in an in-land environment (more than 1,000 meters from the Mediterranean coastline), standard occupancy (a yearly average of 10 occupied patient beds per 1,000 sq-m of floor area), and high quality of components. For example, a facility coefficient of 1.15 represents a predicted addition of 15% for maintenance resources compared with a standard hospital building, under standard service conditions.

In the framework of this research, six simulations were conducted to examine the predicted maintenance along the designed life cycle of a hospital building under different service conditions. The conclusions drawn from these simulations reveal that the AME may vary from 9.0% lower (in-land environment and low occupancy) to 18.6% higher (marine environment and high occupancy) in comparison with the standard conditions. This observation is significant, since it means that the AME in built facilities depends significantly on factors such as the environment that the facility is located in, and even more, it depends on the occupancy and on its actual age of the facility. Consequently, the implementation of this coefficient elucidates uneven allocation of resources in healthcare facilities, and can also explain that the particular conditions of each facility should be taken into account.

Annual Maintenance Expenditure (AME) and Normalized Annual Maintenance Expenditure (NAME)

This indicator, measured in $US per sq-m built, expresses the amount of resources spent on maintenance during a fiscal year, and combines expenditures on in-house personnel, outsourcing, and materials and spare parts (Shohet et al., 2003). This indicator may be used to compare the expenditures in a facility from one year to another, as well as to compare maintenance expenditures between different facilities. Therefore, breaking the AME into its sources of labor may provide significant information to decision-makers, as well as encourage effective labor distribution decisions.

The Normalized Annual Maintenance Expenditure (NAME) is defined as the AME divided by the facility coefficient. It eliminates the effects of actual building age, occupancy, environment, and design by normalizing the Annual Maintenance Expenditure into an indicator that can be compared with facilities at different age and under different service conditions.

Projected Performance

Similar to the BPI, this procedure computes performance scores of the building, systems, and components on a 100-point scale. This procedure aims to project the future level of performance for the different elements in a building (Lavy and Shohet, 2007II). In order to predict the performance of each component, it is assumed that its deterioration pattern is either linear or non-linear (Moubray, 1997). Then, each building system is weighted according to its share in the building LCC.

The projection of a building's performance aims at forecasting the future performance based on actual monitoring of its performance. In this research, performance projection patterns were developed for 51 main building components. Based on this, future performance can be projected for each system, for the building as a whole, and for the entire facility that may be composed of several buildings. This study proposes the use of different patterns of deterioration not only to predict the performance of a single element in a building, but to project the performance for the entire building and of the facility, using LCC as the weighting principle for the building's various systems. Moreover, it allows decision-makers to break each building down into its particular systems, and to analyze it at a great level of detail, down to its components. Furthermore, the model is flexible and able to accommodate any change in deterioration patterns. This means that if future research reveals that the deterioration pattern of a particular component is exponential, changes in the databases can be effected respectively with no significant effort.

Maintenance Efficiency Indicator (MEI)

This procedure aims to compute the Maintenance Efficiency Indicator, which indicates the efficiency with which maintenance activities are implemented. The MEI calculation requires three other indicators: (1) the Annual Maintenance Expenditure (AME), (2) the Building Performance Indicator (BPI), and (3) the Facility Coefficient (FAC(y)), using Equation (2).

$$MEI = \frac{AME}{BPI * FAC(y)} \tag{2}$$

MEI embeds the type of construction and the particular design of the hospital in the following ways: AME is computed according to the reinstatement and Life Cycle Costs of a typical acute care hospital building, and the BPI and FAC(y) are also adjusted to the construction of an acute care hospital. Shohet et al. (2003) surveyed a sample of 25 public acute-care hospitals in Israel, and defined the possible range of MEI for healthcare facilities as: (1) lower than 0.37, representing a high efficiency and/or scarce resources; (2) 0.37 to 0.52, representing a standard efficiency; and (3) higher than 0.52, indicating inefficient utilization of resources. This procedure provides senior decision-makers with valuable information regarding the effectiveness of maintenance implementation in the different buildings and facilities. This indicator can also be used as a yard stick for the allocation of maintenance resources, in cases where limited resources are available.

Building Risk Indicator (BRI)

This procedure aims to determine the risk level for each system in each of the buildings surveyed. Risk level is defined as an ordinal scale with five categories of risk: Highly Critical, Critical, Marginal, Low, and Negligible. The hypothesis used in the development of this procedure was that the BRI for a building system is affected by the following three parameters: (1) the actual performance score of each component in that system (as described in the BPI section above); (2) the maintenance policy implemented (preventive vs. break-down maintenance); and (3) the design parameters (e.g., earthquake resistance design according to local standards) for that system.

The use of performance scores and maintenance policies for determining the level of risk is demonstrated in the following example for the Elevators system. A performance score of 90 points or higher defines a negligible risk level in the control panel component. The lower the performance of this component, the higher its risk level is. Adding the maintenance policy to this picture, a negligible level of risk is defined by checking the following statement: "Inspection of elevators is implemented twice a year by an authorized inspector, and in crowded buildings, detailed inspection (including control system, command board, mechanical condition, etc.) of elevators is implemented monthly, or more frequently." On the other hand, a Highly Critical risk is defined by: "Inspection of elevators is implemented less than twice a year by an authorized inspector." All other risk categories between these two levels are defined specifically and referred to as Critical, Marginal, or Low. A similar approach was used in determining the risk level for the other building systems and components. The values presented in this example are parametric, and were developed as an average of the responses received from a survey of five Israeli healthcare facility managers in different public acute-care hospitals; therefore, these are the model's default values. Nevertheless, since these are parametric figures, the minimum acceptable threshold was left open for each facility manager to define, according to the particular requirements of each type of building and for each user's needs.

VALIDATION OF THE MODEL – A CASE STUDY

Method

The IHFMM was evaluated by conducting two case studies in acute-care hospital facilities. The case studies investigated the effectiveness of the developed model in terms of maintenance, performance, and risk management. Furthermore, validation included the implementation of several sensitivity analyses on the model's results. The following paragraphs describe one of the two case studies, its results and conclusions, and how these conclusions may induce operational recommendations.

Implementation of the case study was subdivided into three main phases, as follows: (1) a field survey conducted in 2001; (2) recording of all non-regular replacement and maintenance activities implemented between 2001 and 2004; and (3) a field survey conducted in 2004, similar to that carried out in 2001. The reason for these phases was to investigate and to compare the different results, obtained in the same hospital, across a time span of three years.

The following paragraphs elucidate the parameters of this hospital, the results of applying the model on its 2001 data, including the model's policy setting, and the results from applying the model on its 2004 data, including a comparison between 2001 projected performance and risk and the corresponding findings observed in the 2004 survey. It should also be mentioned that the financial analyses are based on the assumption that the annual interest rate is 4%.

Results and Analyses – 2001 Field Survey

The main parameters and Key Performance Indicators obtained from 2001 vs. 2004 surveys are introduced in Table 1.

Table 1 Parameters and KPI's for 2001 vs. 2004 surveys

Parameter/KPI	2001	2004
Floor area (sq-m)	39,000	42,000
No. of patient beds	301	301
No. of buildings	24	24
No. of buildings surveyed	5	5
% of floor area surveyed	74.5%	69.2%
AME ($US/sq-m)	25.6	25.8
BPI	78.2	74.7
Facility Coefficient	0.6293	0.7564
MEI	0.521	0.457

From these figures it can be seen that almost three-quarters of the built floor area was surveyed in 2001, and the average BPI in the surveyed areas was found to be satisfactory (78.2 points). The low facility coefficient reflects the relatively new portfolio of buildings, in-land environment, and very low occupancy. Consequently, the MEI was deduced to be in the range that reflects high maintenance expenditure in comparison with actual performance, although the actual performance is itself relatively high. Figure 2 demonstrates this point by comparing the case study hospital to the hospitals population in this study. This figure elucidates that the BPI vs. NAME of the case study hospital in 2001 places it on the marginal line that represents low efficiency of maintenance (MEI=0.52). This finding suggests modifications in the implementation of maintenance work methods, such as considering the distribution of sources of labor, and investigating the maintenance policies of the hospital (preventive as against corrective). Furthermore, the major recommendation for the decision-makers in this facility is to shift toward the MEI=0.45 line. This can be accomplished by improving performance, while at the same time decreasing the expenditure for maintenance.

Actual performance may also be broken into each of the particular buildings, as shown in Table 2. Here, we can see that one building performed at a good level (Building 1), one at a satisfactory-marginal level (Building 4), and three buildings at a deteriorating level (Buildings 2, 3, and 5). The model projected that by 2004 these buildings would be found at the bottom range of this performance category (Building 2), or even in a run-down condition (Buildings 5 and 3), unless substantial corrective maintenance was carried out. These results were further broken down and analyzed from a system perspective, as well.

Table 3 summarizes risk levels measured in 2001 and 2004 surveys. Three building systems were detected as being in the Highly Critical risk level: the sanitary system (in Building 2), the communications and low-voltage (in Building 2), and the interior finishes (in Building 3). Eight additional building systems were observed as having a Critical risk: the electricity, sanitary system, HVAC, and communications and low-voltage (in Building 3), the exterior envelope and electricity (in Building 2), and the structure and exterior envelope (in Building 5). These findings, together with the performance scores and projections, may be used by the facility manager in the specific hospital for organizing and setting priority of maintenance activities. For example, it may be seen that both Buildings 2 and 3 carry the highest number of systems in Highly Critical or Critical risk levels. Adding the low BPI, it can be deduced that major modifications are needed for maintaining these two buildings. It can also provide a horizontal picture of how each building system is taken care of across the campus. For example, four building systems were found to be at Highly Critical or Critical risk in more than one building: sanitary system, communications and low-voltage, electricity, and exterior envelope. This implies that special consideration may be required for policy setting and its implementation in these four building systems.

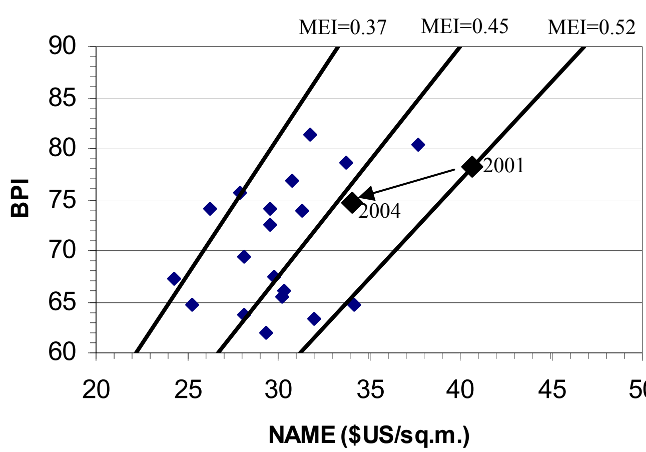

Figure 2 BPI vs. NAME of the case study hospital

Table 2 Comparison of performance of buildings between 2001 and 2004 surveys

Building #	Actual performance – 2001	Projected performance – 2004	Actual performance – 2004
1	88.3	82.9	81.1
2	66.2	60.4	62.4
3	64.9	59.2	60.1
4	75.1	69.7	81.2
5	65.1	59.4	63.0
Total	78.2	72.7	74.7

Analysis of the 2001 field survey showed an actual performance of 78.2 points, an Annual Maintenance Expenditure of $25.6 per sq-m, and a Maintenance Efficiency Indicator of 0.521. Assuming that between 2001 and 2004, no large replacement or major capital renewal would be carried out, other than implementing periodical maintenance activities, the predicted performance for 2004 was 72.7 points. Assuming improved efficiency of maintenance (MEI ranging from 0.45 to 0.52), a predicted Annual Maintenance Expenditure ranging from $24.7 to $28.6 per sq-m is required. This means that the Annual Maintenance Expenditure will vary from 3.5% lower to 11.5% higher than its value in 2001.

Table 3 Comparison of risk levels for the 10 building systems between 2001 and 2004 surveys

	2001 survey					2004 survey				
Building Number	1	2	3	4	5	1	2	3	4	5
Building System	Risk level*					Risk level*				
Structure	N	M	M	N	C	N	M	M	N	C
Exterior envelope	L	C	M	L	C	L	C	M	L	C
Interior finishes	N	M	HC	M	M	L	C	HC	N	C
Electricity	L	C	C	L	M	L	C	C	N	M
Sanitary systems	L	HC	C	L	M	L	HC	C	L	M
HVAC	N	M	C	M	N	L	L	C	N	N
Elevators	L	M	M	L	M	M	M	M	L	M
Fire protection	N	N	M	N	M	N	N	M	N	M
Communication and low-voltage	M	HC	C	M	N	M	M	HC	N	N
Medical gases	N	-	N	N	M	N	-	N	N	M

* HC = Highly Critical; C = Critical; M = Marginal; L = Low; N = Negligible.

Field Survey Results and Analyses – 2004 Survey

The main parameters and KPIs obtained from the 2004 survey are introduced in Tables 1 and 2 and in Figure 2, and can be compared to the observations found in the 2001 survey. The FM department invested moderately in replacement and capital renewal during the years 2002 to 2004. In these three years, the total floor area of the hospital was expanded by approximately 7.7% in comparison with the floor area observed in 2001. However, no change was observed in the number of patient beds. In order to be consistent with the performance comparisons, the same five buildings were surveyed in 2004 as in 2001, with a built floor area constituting 69.2% of the hospital's floor area. The Annual Maintenance Expenditure in 2004 was found to be similar to the 2001 survey. The actual performance score in the facility was found to be 74.7 points, which indicates a marginal performance. The facility coefficient in 2004 shows an increase of more than 20% in comparison with the coefficient computed in 2001. Consequently, the Maintenance Efficiency Indicator in 2004 reflects improved efficiency, which falls into the range that indicates a reasonable efficiency (Figure 2).

The actual performance score found in the hospital for the 2004 survey is higher by 2.0 points in comparison with the predicted performance, mainly due to a slight investment in maintenance and replacement. Yet, it is lower by 3.5 points in comparison with the actual performance found three years earlier. Performance scores break down into the particular buildings; it can be seen that for Buildings 1, 2, and 3, the performance measured in 2004 is comparable to the predicted performance in 2001. Substantial differences between the predicted performance for 2004 and the actual scores were found in Buildings 4 and 5. These differences were caused by a large renovation project in Building 4, in which $5,500,000 was invested in most of the building systems, and a significant improvement of the electricity system in Building 5. Nevertheless, the performance level is still predicted to decline to a condition of deterioration for Buildings 2, 3, and 5 within the next few years.

Concerning risk levels found in the 2004 survey, Table 3 shows that three building systems were identified in Highly critical risk, two remained there from the 2001 survey: the sanitary system (in Building 2), and the interior finishes (in Building 3), while the communication and low-voltage (in Building 3) joined this category. In addition, nine building systems were found to carry a Critical risk, out of which seven remained in this category from 2001. The two systems added to this list were the interior finishes in Buildings 2 and 5, to make this building system be in a Highly Critical or Critical risk in three out of the five buildings.

The results presented in this case study reinforce the validity of the IHFMM, as can be seen by the fairly accurate predictions of AME, BPI, and BRI. The 2001 survey found low maintenance efficiency, and as a result, several steps were recommended. Over the three-year period, an improvement was witnessed in the efficiency; however, the building performance showed a decrease of 3.5 points mainly due to wear and tear. Although the expenditure on maintenance is usually predicted to be higher due to the ageing of buildings, the fact that a similar budget was observed in both phases of the case study contributed to the improvement in maintenance efficiency. Performance scores were found to provide accurate estimates of the performance predicted within the period of three years. These indicators, in addition to the BRI, may provide the facility manager with a solid estimate for the current and future needs of the buildings.

CONCLUSIONS

Facility managers, in general, must consider a large variety of factors in their decision-making processes. Yet, existing methods for supporting these processes are limited, particularly at the strategic level of Facility Management. This paper focused on the identification of principal parameters affecting the performance, maintenance, and risk aspects of facilities. The model developed in this paper proposes a simultaneous analysis of the complexities involved in the field, such as dealing with the appropriate maintenance expenditure for a given level of performance, or improving efficiency in maintenance activities. These complexities are dealt with by almost all facility managers of public as well as private facilities; nevertheless, this point is even more crucial and significant in healthcare facilities that operate 24 hours a day, 7 days a week, and support critical infrastructures of healthcare such as medical gas and power to operating theatres. The research contributes to establishing generic risk database for healthcare facilities.

The case study presented here is one of two case studies that were conducted as part of the validation of the model and examination of its applicability. Both of these case studies show high correlations and significant results, by being capable of predicting different FM-related aspects, such as the performance and maintenance budgets. This research enables the Facility Management discipline to become more structured and quantitative, and it expands the existing body of knowledge on the subject of FM by simultaneous analysis of healthcare FM core parameters.

Based on this research, guidelines may be outlined for the methodological design and operation of facilities from a life cycle perspective. The development of the analytical quantitative model may significantly contribute to the understanding of the area of Healthcare Facilities Management, as well as to providing the means for measuring efficiency, and improving FM performance. A later stage of that development may also suggest a model that analyzes different types of buildings according to their exclusive attributes. Adjusting the model requires several revisions, such as inserting new databases of building components that will assure the suitability of the developed model and the capability to implement it in different types of buildings, such as office buildings, educational campuses, public buildings, military facilities, etc.

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About the Authors

Sarel Lavy, Ph.D., Assistant Professor, Department of Construction Science, College of Architecture, Texas A&M University, College Station, TX 77843-3137, USA, e-mail address: slavy@archmail.tamu.edu

Dr. Lavy is a faculty member in the Department of Construction Science, which is one of four departments in the College of Architecture at Texas A&M University. He also serves as the Associate Director of the CRS Center for Leadership and Management in the Design and Construction Industry, as well as a fellow of the CRS Center, the Center for Health Systems and Design, and the Center for Heritage Conservation in the College of Architecture at Texas A&M University. Dr. Lavy's principal research interests are: facilities management in the healthcare and education sector, maintenance management, and performance and condition assessments of buildings.

Igal M. Shohet, D.Sc. C.E. Associate Professor, Head – Construction Management Program, Department of Structural Engineering, Ben-Gurion University of the Negev, P.O.B. 653, Beer Sheva 84105, ISRAEL, e-mail address: igals@bgu.ac.il
Dr. Shohet's principal research interests are: maintenance and performance management of complex infrastructures such as healthcare, laboratories, and transportation facilities; extreme events engineering and management in the built environment; procurement methods; and construction safety. Dr. Shohet's maintenance and performance management models are implemented in the last decade in healthcare facilities in Israel, and in civil infrastructures in Israel and in the USA. Prior to joining Ben-Gurion University in 2004, Dr. Shohet served as a faculty member and senior researcher in the faculty of Civil and Environmental Engineering and the National Building Research Institute in the Technion for 8 years.