Healthcare facilities management: state of the art review

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Abstract

Following increases in national demands on healthcare facilities and services, healthcare facilities management (FM) has gradually matured to become an established research and development topic. This paper reviews the state of the art in the main domains related to healthcare FM and defines the central themes in the development of a healthcare FM model. FM, maintenance management and performance management are reviewed in a wider context, and the main domains of healthcare FM are discussed. The five salient topics included in healthcare FM are maintenance management, performance management, risk management, supply services management, and development. These five core domains are interrelated, and can be integrated using information and communications technology, which provides the desired environment required for the challenging decision making and development prevalent in healthcare FM.

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Introduction

The discipline of facilities management (FM) has evolved from increasing pressures for the economic operation of the built environment. Despite the ever-growing demand for lower operational costs, facilities managers must ensure that facilities are constructed, managed and maintained efficiently without compromising their performance. Furthermore, decision makers involved in the maintenance of complex buildings should have expertise in many different but related areas, such as building management, human resource management and environmental protection. This paper describes the most recently published literature in the domains related to healthcare FM, as well as in information and communications technology.

FM

Definitions

A decade ago, FM was defined as: "the integral planning, realization and management of buildings and accommodation, services and resources which contribute towards the effective, efficient and flexible attainment of organisational goals in a changing environment" (Regterschot, 1990). The current trend is to view FM as "the management of non-core company assets to support and increase the efficiency of the main business of the organisation" (Nelson and Alexander, 2002). The International Facility Management Association (IFMA) defines FM as "the practice of coordinating the physical workplace with the people and work of the organisation" (International Facility Management Association, 2003), while the British Institute of Facilities Management (BIFM) defines FM as "the integration of multi-disciplinary activities within the built environment and the management of their impact upon people and the workplace" (British Institute of Facilities Management, 2003). FM is also defined as "an integrated approach to maintaining, improving and adapting the buildings of an organisation in order to create an environment that strongly supports the primary objectives of that organisation" (Barrett, 1995, 2000). Alexander (1996) maintained that FM is "the application of the total quality techniques to improve quality, add value and reduce the risks involved in occupying buildings, and delivering reliable support services". Then (1999) recognised that "the FM role is to meet the business challenges that confront the organisation it is supporting, for reaching the optimum balance between people, physical assets and technology",

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and Amaratunga and Baldry (2002a) concluded that successful FM is the achievement of the goals of an organisation at "the best combination of efficiency and cost". All of the above definitions stress that successful FM is highly dependent on cost effectiveness and performance management. The definition of FM in this research is therefore "the application of integrated techniques to improve the performance and cost effectiveness of facilities to support organisational development".

There are, notwithstanding, three common paradoxes in the literature with regards to FM (Grimshaw, 1999, 2003; Price, 2002):

(1) FM is recognised as a strategic discipline, while most of its practitioners are found at the operational levels of their organisations;
(2) FM aims to be at the heart of any organisational development, while many FM services are delivered by external professionals; and
(3) FM aspires to manage changes within organisations, while in most cases it is reactive in nature.

Future FM development and establishment implies the development of strategic, proactive tools and their implementation as an integrated part of business development.

Maintenance

The literature offers many definitions of the term "building maintenance" (Armstrong, 2002; British Standards Institution, 1993; El-Haram and Horner, 2002; Vanier, 2001). These definitions lead to the conclusion that maintenance combines technical and administrative actions aimed at keeping the component in appropriate condition for use, or restoring it to such a condition.

The main goal of maintenance, according to the economic approach adopted by Jardine *et al.* (1997), is "to minimise the maintenance-related operating costs". This definition, however, ignores the condition and performance of the building. Vatn *et al.* (1996), by taking a business-oriented viewpoint, proposed that the main objectives of maintenance are the maximisation of personnel safety together with the minimisation of the total cost loss, the total operational costs, the environmental threat, and the risk of material damage. In this research, "maintenance" is defined as "ensuring the continuous cost-effective fitness-for-use of buildings at a specified building performance level". This definition strongly connects building maintenance with building performance and its cost effectiveness.

Performance

Background

In the past, building performance usually dealt with issues such as energy efficiency, fire safety, comfort conditions and spatial efficiency (Douglas, 1994; Preiser, 1995). However, this situation has changed gradually, and nowadays building performance is growing in significance, mainly due to the fact that standards have developed, as have occupants' requirements. Buildings are required to be productive and durable, and provide stable and efficient internal environments. In many existing buildings, such increased expectations and demands are not met as a matter of course, due to accelerated deterioration, inadequate maintenance, or a combination of the two (Douglas, 1996; Neely, 1998). The performance concept evolved as a consequence of this. Becker (1999) defined the application of the performance concept in buildings as a three-step process:

(1) human needs are translated into user requirements;
(2) the requirements are transformed into technical performance requirements; and
(3) these requirements are implemented in the design and occupancy phases of the building.

Hattis (1996) described the performance concept, as it relates to buildings, as a matrix in which one axis consists of building parts (e.g. materials, elements, components and systems), which together make up the physical fabric of the building, and the other axis consists of building attributes (e.g. structural safety and serviceability, health and hygiene, acoustics and durability), which are defined by the user requirements.

According to Neely (1999), the main motives for the development in the implementation of FM performance include changes in organisational roles and external demands, an increase in national and international competition, and an increase in the power of information technology (IT). FM requires different quantitative and qualitative measures of performance in order to compare buildings on several levels, e.g. actual versus past performance, actual versus expected performance, and one facility versus other similar facilities (Kincaid, 1994a, Macsporran and Tucker, 1996; Preiser and Schramm, 2002). These requirements led to a need to develop building performance evaluation techniques.

Alexander (1996) found that FM performance measurement is one of the most essential issues in the effective implementation of a facilities strategy. Performance measurement can also be defined as "the process of quantifying the efficiency and effectiveness of an action" (Amaratunga and

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Baldry, 2002b). Duffy (1990) stated that the process of measuring performance should be operational (valid and reliable), inventive, performance-based (directly related to the organisational success) and comparative (both within and between organisations). In addition, issues important to organisational success may be determined by applying performance measurement. Hence, FM performance measurement may assist facilities managers in their tactical and strategic decision making (Neely *et al.*, 1995; Neely, 1999; Varcoe, 1996).

The term "benchmarking" is often used to describe performance measurement. Spendolini (1992) defined it as a "continuous, systematic process for evaluating the products, services, and work processes of organisations that are recognised as representing best practices for the purpose of organisational improvement".

Applications

The field approach to the identification and assessment of performance is usually based on observations. Pitt (1997) suggested that such work take the form of a condition survey, in which qualified surveyors or engineers record the condition of the different building components. Benchmarking may be applied to different aspects within the FM domain, and may be implemented on two levels, i.e. inter- and intra-organisational. On an inter-organisational level, a comparison is made between the performance of different organisations, whereas on an intra-organisational level, a comparison of financial issues, maintenance expenditure, operation costs and so on is performed between different divisions of the same FM organisation (Williams, 2000).

Dorsch and Yasin (1998) analysed publications related to benchmarking, and emphasised that most of the benchmarking knowledge was developed by practitioners rather than by the academic community. Various studies have been conducted on the measurement of FM performance, such as the assessment of performance as an aspect of a building maintenance program (Kincaid, 1994b; Sinclair, 1996), the development of performance indicators applicable to hotels (Chan *et al.*, 2001), the development of performance indicators applicable to office buildings (Preiser and Schramm, 2002), and so on. Hinks and McNay (1999) suggested 172 performance indicators, which were subdivided into eight main performance dimensions:

(1) business benefit;
(2) equipment;
(3) space;
(4) environment;
(5) change management;
(6) maintenance services;
(7) consultancy; and
(8) general.

Physical building performance is included in the "environment" category and is composed of several indicators, such as the level of heating, level of lighting, level of ventilation, and water management.

Past studies have identified the essential need for performance in FM. However, progress has been achieved in the area of benchmarking and not in the measurement of facility performance.

Healthcare FM

Scope of healthcare FM

The provision of FM and other non-core activities to healthcare organisations has been growing gradually, as has its impact on the quality and effectiveness of healthcare services. Gelnay (2002) considers healthcare FM as one of the key elements for the successful delivery of healthcare services. Nevertheless, he noted that in most of the hospitals examined, the facilities manager was not yet involved in the briefing, designing and cost-analysing stages. Payne and Rees (1999) proposed that healthcare FM should be a flexible theme because, in general, organisations differ from one another, and this is also true for healthcare organisations. Yet, researchers also stressed that facilities managers must be involved in the decision-making processes and that this is especially important in healthcare facilities. Gallagher (1998) reviewed the main areas in which successful healthcare FM has been implemented in the National Health Service (NHS) in the UK. These issues include strategic planning, customer care, market testing, benchmarking, environmental management and staff development. It can be seen that all of these sources reinforce the understanding that the effectiveness of healthcare services will increase with the growth and development of the FM profession. This in turn will lead to a change in the position of FM in the healthcare organisation and FM will become a central part of the organisation – one that will help shape its decisions and processes.

Rees (1997, 1998) examined the development of the FM profession within the NHS in the UK, and found that NHS Trusts tend to integrate non-core services (e.g. risk management, energy efficiency, cleaning, security, etc.) under the umbrella of an FM department. It was also observed that although in 90 per cent of the Trusts

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FM directors were involved in policy decision making, the senior FM director was a board level executive member in only 24 per cent of the Trusts. Andaleeb (1998) investigated the effect of the following five salient factors on the satisfaction of healthcare users:

(1) level of communication between staff and patient;
(2) competence, skills and experience of service providers;
(3) facility quality;
(4) positive staff reaction toward patients; and
(5) cost of treatment versus patient expectations.

The facility quality score was found to be the second highest for a single factor, rating 4.22 out of a total of five points. Multiple regression analysis showed that facility quality has the least impact on user satisfaction (0.16), but in fact, the facility's impact is quite high, considering the fact that financially it accounts for only 3 per cent of the total healthcare service provider turnover.

Key performance indicators (KPIs)

Various measurement tools have been developed for monitoring different aspects of healthcare facilities. Pullen *et al.* (2000) developed a tool that can contribute to the complicated management of hospital facilities. They identified the principal factors affecting hospital performance, such as hospital size, occupancy, asset value, income and operating costs. These factors led to the development of seven KPIs, four of which include hospital revenue. As such, these indicators are appropriate for use in hospitals in the private sector rather than in public hospitals, which are not expected to make any profits. Furthermore, these KPIs do not refer to any aspect of facility performance. Shohet (2003a) and Shohet *et al.* (2003) described a method in which four KPIs were developed for performance-based maintenance management of hospital buildings. The methodology integrates indicators for monitoring and benchmarking of building performance (the building performance indicator, or BPI), the provision of maintenance services, the efficiency of maintenance, and organisational effectiveness. The principal indicator (BPI) monitors the performance of ten building systems based on performance rating scales. The systems are integrated into a 100-point indicator, based on the weight of their life cycle costs (LCC) in the LCC of the entire facility. Lavy and Shohet (2003) implemented these four indicators in a case study of a hospital facility in Israel. Examination and validation of these indicators led to the conclusion that further development is needed in order to extend them to performance, risk, and operations management of healthcare facilities.

Supply service management

Additional topics dealt with extensively in the healthcare FM literature are maintenance and operations expenditure and sources of FM services. Nesje (2002) examined the distribution of FM expenditures at St Olavs Hospital in Norway, and found that maintenance, energy and cleaning costs each account for one third of the total operation costs of the hospital. In light of the limited budgets allocated to operation and maintenance, he concluded that appropriate indicators are needed for FM resource allocation. Gelnay (2002) indicated that the operations and maintenance expenditure of hospitals is highly dependent on the required level of performance, intensity of use, occupancy, and type of equipment. As a result, he emphasised that, although FM plays an important role in healthcare service providers, resources allocated to FM as part of the total hospital budget are still insufficient.

The growing dominance of requirements for cost effectiveness and higher performance forces facilities managers to obtain an optimum level of resources in order to achieve the desired performance. This objective necessitates competent services and flexible FM, which are achieved by combining in-house provision and outsourcing of FM services. Franceschini *et al.* (2003) suggested a model by which the outsourcing of services may be successfully implemented. This model incorporates the following four main phases:

(1) internal benchmarking analysis (determining what to outsource);
(2) external benchmarking analysis (selecting the outsource service provider);
(3) contract negotiation (formalising relationships between the organisation and the outsourcer); and
(4) outsourcing management (during the term of the contract).

Although this model is general, its implementation in healthcare facilities may assist facilities managers in dealing with the large variety of issues and areas under their responsibility.

Other literature deals with the outsourcing of healthcare services. Powell (2002), for example, reviewed the outsourcing of all FM services in Leicester Royal Infirmary. Powell's conclusions from this review were that full outsourcing of hospital FM can be successful if the outsourcing is carried out on the basis of detailed employment and inspection procedures, and is based on the outsourcer's involvement in the strategic decisions made by the hospital. Shohet (2003b) found that the efficiency of outsourcing depends on the level of hospital occupancy. In an examination of 17

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Israeli hospital facilities, he found that hospitals with standard to low occupancy levels can save about 8 per cent of their expenditure through outsourcing of maintenance services, while hospitals with higher occupancy levels than average can save about 6 per cent of their maintenance expenditure using in-house labour sources. These findings were explained by the fact that at high occupancy levels, deterioration is intensive and requires the availability of internal work sources for corrective maintenance.

Risk management

O'Donovan (1997) defined the term "risk management" as:

> [...] a process where an organisation 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 and credibility. Risk management activities are designed specifically to identify actual or potential hazards exposed to patients' and staff safety, and effectively to reduce those hazards.

She concluded that risk management should be placed at high priority for any healthcare facility, and is to be achieved by managing a risk management programme, in which risks are identified, analysed, classified, and controlled. Okoroh *et al.* (2002) found that one of the facilities manager's principal duties is to identify, analyse and economically control "those business risks and uncertainty that threaten healthcare assets or cause loss of earning capacity in NHS Trust hospitals". Thus, they proposed the following seven main levels of possible risks in healthcare organisations:

(1) customer care;
(2) business transfer risks;
(3) legal risks;
(4) facility transmitted risks;
(5) corporate risks;
(6) commercial risks; and
(7) financial and economic risks.

Holt *et al.* (2000) classified the risks faced by FM organisations into two main 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 either a positive or negative effect.

The researchers proposed that additional research is needed in order to develop and investigate generic risk databases appropriate to FM. Williams (2000) introduced the integration of value engineering (tactic) and value management (strategic) to the implementation of FM risk management.

This review of past studies shows that risk management has achieved maturity in FM, at both the strategic and the tactic levels. No insightful research has been carried out in healthcare facilities risks, an area which is abundant in critical systems, such as medical gases and communications.

Information technology

Introduction

The current development of computer applications in the area of FM is still slow, particularly due to a lack of the as-built information required by such applications (Yu *et al.*, 1997). There is, however, increased interest on the part of the healthcare sector in artificial intelligence (AI) and ICT, which can be found in more practical applications than ever before (Clark and Metha, 1997; Waring and Wainright, 2002). AI is often developed in terms of various methods (e.g. constraint-based programming, fuzzy logic, genetic algorithms, logic programming, artificial neural networks, case-based reasoning (CBR), etc.) which have been developed over the last three or four decades (Watson, 1999). The potential of the various IT methods for use in healthcare FM is reviewed below.

Review of IT techniques

Constraint-based analysis and programming was developed mainly in order to solve scheduling problems. These problems contain constraints that must be fulfilled and other preferences that are to be satisfied (Fahle *et al.*, 2002; Hopegood, 1993). Fuzzy logic is a methodology based on an input vector that computes an output vector by applying a set of linguistic conditional statements or rules (Costa *et al.*, 1996). Fuzzy logic can deal with multi-variable, non-linear, and time-varying processes (Stylios and Groumpos, 1999). Genetic algorithms are a search and optimisation technique based on genetics and inspired by natural evolution (Leite *et al.*, 2002; Lingras, 2001). In order to solve a problem, the optimum is sought within several possible required solutions (Goldberg, 1989). Logic programming is a combination of logic and procedures, and consists of the following components:

- an alphabet of symbols;
- a set of deduction rules;
- a set of axioms; and
- a definition of functions within the logic (Cercone and McCalla, 1987; Garcia and Chien, 1991).

The artificial neural networks technique is inspired by biology, and is based on the computational

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power of the human brain. Similar to the biological brain, a neural network consists of interconnected processing elements that bring neurons together in order to make decisions. Artificial neural networks, however, are limited to purely numerical input and output, and an extremely large body of data sets must be available for training of the network. In general, the size of these data sets should be proportional to the number of elements in the network (Chao and Skibniewski, 1998; Edwards *et al.*, 2000; Fausett, 1994; Flood and Kartam, 1994; Garrett *et al.*, 1997; Yau and Yang, 1998a). CBR is a potentially suitable AI technique for solving the FM problem, and as such it will be discussed in greater detail below.

ICT

Telemedicine, a relatively new discipline, uses ICT to provide medical information and services in the healthcare industry. Waring and Wainwright (2002) criticised the effectiveness and success of ICT in the NHS, citing the neglect of political and organisational issues through the technical implementation of ICT to be among the reasons for its lack of success. Sigala (2003) examined the productivity of ICT in the hotel industry, concluding her research with the conclusion that a more strategic approach to ICT implementation and management is required in order to optimise ICT value. The study found that all three ICT capabilities (information, systems integration and architecture) should be managed and aligned with business strategy and operations. Ng and Li (2003) reviewed the relationships between organisations' knowledge management and ICT using the Hendriks model for knowledge management, which claims that the concept of knowledge management can be fully understood only as a management concept. It was stressed that ICT fits in better with a knowledge management strategy aimed at codification of the knowledge.

ICT employs a wide range of technologies. Recent studies that researched the effectiveness and the efficiency of this discipline in information-intensive industries found that ICT can be optimised when its implementation is aligned with the business strategy and operation. Although ICT plays an increasingly important role in the healthcare industry, relatively little investment has been made in the application of ICT in this industry. This trend can be attributed to the individual basis on which healthcare organisations operate, and the lack of codified methods for management. ICT implementation in healthcare FM would be enhanced by the development of quantitative methods as well as structured, strategic means towards healthcare FM.

CBR

CBR was originally motivated by a desire to understand how people remember information for the purpose of solving their problems. Subsequently, it was recognised that people commonly do so by remembering how similar problems were solved previously (Watson, 1999). Thus, CBR makes the most of specific knowledge gained in earlier experienced concrete cases, or in other words, it reuses its experience in order to produce a solution to a new problem (Aha, 1998; Kim and Han, 2001). Arditi and Tokdemir (1999) found the CBR approach to be more successful than artificial neural networks. In CBR, each case is represented by a number of fields in various forms (e.g. numerical, logical, alphabetical and strings), which makes the input and output more understandable than in other applications. The researchers stressed that the strength of a CBR system is due to its ability to retrieve quickly and accurately from its case base only those cases that are relevant. Cunningham and Bonzano (1999) concluded that CBR is particularly appropriate in cases in which the influences and interactions between different variables are not fully defined.

Many studies can be found in the literature that use the CBR approach to solve complex problems, with the majority of applications being in the field of medicine (Ozturk and Aamodt, 1998). However, in the last decade, CBR has also been used for a variety of purposes in construction engineering (Brandon and Ribeiro, 1998; Burke *et al.*, 2000; Chua *et al.*, 2001; Dzeng and Tommelein, 1997; Roddis and Bocox, 1997; Yau and Yang, 1998a, b). There are, however, no CBR applications that deal with healthcare FM.

Like the human body, constructed facilities are system-intensive entities in which the malfunctioning of one system propagates to other systems. Since CBR has exhibited high efficiency in the field of medicine, it may indeed also prove itself to be a promising approach for diagnosing and treating built facilities.

Discussion

Core domains of healthcare FM

This literature review summarises the current state of the art in both the academic and professional communities with regards to healthcare FM. It can be seen that the facilities manager's role is most important, especially in that the facilities manager can affect the facility's strategy and still be responsible for a variety of issues (i.e. maintenance management, performance management, risk management, etc.) that must be performed well in order to ensure successful continuing operation of

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the facility. The following is a discussion of the core domains of healthcare FM as observed by this review, after which an integrated approach for healthcare FM is proposed.

According to the literature, the following core domains may be identified within the area of healthcare FM: maintenance management, performance management, risk management, supply services management, development, and ICT as an integrator.

Maintenance management

Maintenance management is one of the main domains of knowledge with which FM is faced. It includes not only the budgeting and priority setting of the different maintenance activities according to the preferred maintenance policy, but also service life planning. In order to achieve the optimal balance between minimisation of cost and maximisation of performance, facilities managers can implement two main alternatives:

(1) maximisation of performance level while maintaining a limited maintenance budget; or
(2) minimisation of costs subject to a minimum required performance level of the building.

Performance management

Performance monitoring and management must be carried out based on quantitative means that will enable characterisation of the facility's systems. Moreover, it may also assist in comparing the performance of a facility to other healthcare facilities, and in this way identify the points of strengths and weakness for each facility. This procedure requires the identification, characterisation, and definition of several KPIs which will be suitable for either public or private healthcare facilities. These indicators may also be used as benchmarks for cost effectiveness of performance. This review indicates a need to develop additional KPIs, in which the main efforts will be placed on seeking links between performance, maintenance, operations and energy expenditure and cost effectiveness.

Risk management

Risk management has gradually become one of the core themes faced by healthcare facilities managers. In hospitals, different building systems and components, such as medical gases, fire protection systems, electricity, etc. must exhibit high levels of performance, since any minor breakdown may lead to both casualties and financial losses. The current trend of cutting maintenance budgets adversely affects risk levels by increasing the related risks, and hence forces facilities managers to allocate an increasing portion of their time to solving risk management problems. Risk management can be introduced into FM at the operational and strategic levels using value engineering and value management.

Supply services management

Supply services management was discussed previously in reference to maintenance management. The topic, however, has an even broader aspect. It was previously noted that when dealing with maintenance and non-core activities, facilities managers must find the optimal mix of maintenance proficiencies for the use of in-house and outsourcer staff. Furthermore, supply services management also means determining the best combination of other services, such as cleaning, security, gardening, catering, and laundry. FM is therefore required to find the best contractual and financial arrangements for monitoring and analysing outsourcer performance, and to assimilate the change through organisational learning.

Development

This domain encompasses a broad range of subjects pertaining to the mid- and long-range development of a facility. This domain includes strategic long-term planning, upgrading of existing facilities, rehabilitation, renovation, remodelling and reconstruction. It is widely discussed in the literature on the subject: however, further research is required on the correspondence between the development of healthcare needs and the supporting facilities.

ICT

Last, but perhaps most important, is IT. Facilities managers are today required to be able to analyse all kinds of printout results, and to deduce rapidly what steps to implement next. This literature review emphasises the increased need and interest in the development of ICT applications in the domain of healthcare FM. The recognition of different phenomena related to maintenance and operations problems is of great importance in the understanding of FM. Moreover, the complexity involved in, and between, the different FM themes can be solved and better understood if ICT is implemented.

Healthcare FM: political and social drivers

Political and social drivers in healthcare FM are also a topic frequently discussed in the literature, especially with regards to the healthcare system in the UK (NHS). Ritchie (2002) separates it into two levels: at the national level, efficient delivery of healthcare services is one of the Government's commitments; while at the local level, general

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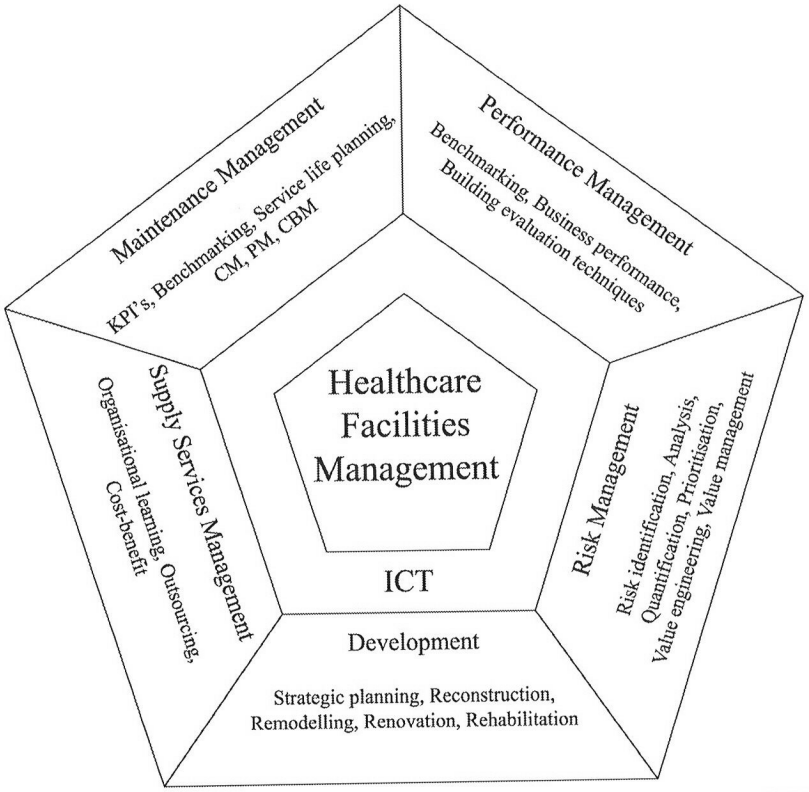
practitioners and Trusts are committed to maximise their performance, using the constraints of available resources. The author emphasised that chief executives and board members of Trusts should focus on the quality of the services just as they focus on financial issues, and thus, in his opinion, improvement will be achieved in the delivery of healthcare systems and operations, and also in the service's performance and quality. In the late 1980s and early 1990s, the UK Government implemented several reforms that improved hospitals' efficiency by increasing the role of management (Procter and Brown, 1997). Okoroh *et al.* (2001) argued that raising the efficiency, innovation and added value of NHS Trusts can be accomplished by minimising and distributing the risk among providers and purchasers, together with the fact that this should be carried out by the Government. The authors also elucidated that healthcare services perform in a dynamic environment, and as such, the success of FM implementation is based on the integration of strategic and operational tools. Consequently, they support opening the NHS market to competition, which will lead, in the author's opinion, to an efficient use of resources, and to better cooperation between the public and private sectors. Waring and Wainwright (2002) characterised the social situation in several hospital case studies as a lack of communication between different departments. This strengthens the need to establish a communications instrument to connect these departments, both between themselves and with the senior management level. Payne and Rees (1999) pointed to the changing workplace, together with the move to computers and technology, as two motives that should direct the Government to develop a new form of hospitals, by re-engineering existing facilities.

Summary

As presented in this discussion, the six healthcare FM core domains are closely interconnected. It would be impossible and unacceptable to attempt to separate maintenance management and supply services management or performance and risk management. Thus, the proposed healthcare FM model that this state-of-the-art review proposes is a pentagon (as shown in Figure 1), in which each of the five sections reflects one topic in healthcare FM. All five topics are interconnected, and a modification of one will also affect the others. The topics are integrated by an integrated facilities management model (IFMM) through the application of ICT, which is the sixth feature introduced in this review. The IFMM provides an integrated knowledge-base environment for healthcare FM, and is described in Shohet and Lavy (2004).

Figure 1 Healthcare facilities management core domains



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