https://doi.org/10.1016/j.jobe.2021.103428

Importance of hospital facilities management performance indicators: building practitioners' perspectives

Joseph H.K. Lai[1]*, Huiying (Cynthia) Hou[2], Betty W.Y. Chiu[3], David Edwards[4], P.L. Yuen[5], Michael Sing[6], Philip Wong[7]

[1] Department of Building Services Engineering, Faculty of Construction and Environment, The Hong Kong Polytechnic University (email: bejlai@polyu.edu.hk)
[2] Department of Building Services Engineering, Faculty of Construction and Environment, The Hong Kong Polytechnic University (email: cynthia.hou83@gmail.com)
[3] Department of Construction Technology and Engineering, Faculty of Science and Technology, Technological and Higher Education Institute of Hong Kong (email: h0499107@connect.hku.hk)
[4] School of Engineering and the Built Environment, Birmingham City University, United Kingdom (email: david.edwards@bcu.ac.uk)
[5] Institute of Healthcare Engineering and Estates Management (Hong Kong Branch) (email: info@iheemhk.org)
[6] School of Architecture and Built Environment, The University of Newcastle, Australia (email: michael.sing@newcastle.edu.au)
[7] Department of Building Services Engineering, Faculty of Construction and Environment, The Hong Kong Polytechnic University (email: ylp.wong@polyu.edu.hk)

*Corresponding author: Tel: (852) 2766 4697; Fax: (852) 2765 7198; Email: bejlai@polyu.edu.hk

Abstract
Hospitals are critical infrastructure assets and the strategic management of facilities within these buildings are quintessentially important to society who rely upon effective healthcare services. Despite their importance to the optimised functioning of hospital facilities, standardized performance evaluation measures such as key performance indicators (KPIs) have hitherto received scant academic attention. Understanding the views of practitioners working on the different lifecycle stages of a building will help to establish pragmatic KPIs for hospital facilities management (FM). Hence, a multi-stage study was undertaken, within which interpretivism and inductive reasoning was utilised to conduct a systematic review of extant literature on hospital FM and KPIs. In parallel, the initial stage of work shortlisted 18 KPIs, in four categories (physical, safety, environmental and financial), as essential for hospital FM performance evaluation. Using these indicators, a questionnaire survey was developed and disseminated to building practitioners in the hospital sector of Hong Kong. Data gathered was then analysed using both summary and inferential statistics. The analyses reveal that the practitioners generally regarded the physical and financial indicators as more important. When compared between the perspectives of the design/construction practitioners and the FM group, significant differences were found with three particular KPIs: *availability of fire services system, energy utilization index* and *carbon emissions per building area*. The paper concludes with direction for future research that seeks to analytically determine the importance weighting of each performance indicator identified, which is requisite for establishing a credible hospital FM performance evaluation scheme.

Keywords: facilities management, hospital, KPI, perception, performance, practitioner

1. Introduction

Performance evaluation is strategically important to the management of facilities in hospital buildings [1-2]. To engender effective performance evaluation, various tools have been developed and implemented, including benchmarking, balanced scorecard, post occupancy evaluation, and measurement by key performance indicators (KPIs) [3-7]. Among these tools, KPIs have been proved to be useful for: identifying important areas of organisation performance; selection of facilities management (FM) service providers; and measuring the performance of facilities in a holistic manner [8]. Over the past two decades, a plethora of FM KPIs studies have been conducted [9-15]. Hospital facilities represent critical infrastructures in society and have consequently received increasing attention from both practitioners and researchers. In practice, guidance on developing KPIs to monitor healthcare services has been produced [16], while similarly, academic studies have focused upon KPIs for facilities operation and management purposes [11-15, 17-22]. Although these studies commonly share the intention of developing KPIs for use in FM performance measurement, few have investigated the perspectives of different groups of building practitioners on the importance of the KPIs, which are among the healthcare FM research gaps [23].

Hospital buildings are equipped with sophisticated facilities that must perform reliably over a long lifespan. The life cycle of hospital buildings comprises different stages including design, construction and FM, which are inextricably linked with each other [24-25]. For example, an operational problem found with a lift in the FM stage could have antecedents linked to a fault in an earlier stage, such as construction or design [26, 27]. Therefore, understanding the views of practitioners working on the different lifecycle stages (with different job natures, roles or levels) will help establish pragmatic KPIs for hospital FM. Yet despite this palpable benefit, research in this area remains limited, albeit notable efforts have been made on KPI studies in the hospital sector.

To contribute new knowledge to this underexplored domain, a multi-stage study was undertaken, within which a systematic literature review was conducted to identify and scrutinize key literature on KPIs in hospital and general FM settings. In parallel, the initial stage of the study found 61 indicators that are applicable to hospital FM and, after a focus group study, 18 indicators were shortlisted as essential. On this basis, a questionnaire survey was devised to solicit the perceptions of hospital building practitioners about the importance of the shortlisted indicators. The survey data were analysed using summary and inferential statistical methods, including examination of the perspectives of different building practitioners on the importance of the indicators. Associated objectives were to: determine which of the KPIs were the most important in hierarchal order; and leading on from the former, signpost future direction of follow-on research that could yield multiple-criteria decision analysis to optimise FM in hospital buildings.

2. Methodology

From an epistemological perspective, a two-phase waterfall process was adopted for this research. In phase one, interpretivism and inductive reasoning [28-30] was employed to conduct a systematic review of extant literature to identify pertinent KPIs for managing facilities in hospital buildings. These KPIs then formed part of a questionnaire survey conducted in phase two. This virtuous circle of research literature informed questionnaire development is widely used within contemporary literature. For example, Owusu-Manu et al. [31] assessed policy provisions and institutional behavioural factors influencing rail infrastructure financing in developing countries; and Aghimien et al. [32] conducted a fuzzy synthetic evaluation of the challenges of smart city development in developing countries.

In phase two, and using knowledge accrued from phase one, a questionnaire survey data collection instrument was developed and distributed to practitioners with either relevant design and construction (DC), FM or other relevant experience accrued in hospital building management (refer to the section on 'data collection'). Using a pragmatic philosophy and deductive reasoning [33], quantitative primary data gathered was then analysed using both summary and inferential statistical analysis. This included: mean ranks of KPIs to determine the order of importance of KPIs identified; Kendall's tau-b test to examine the level of correlation between the rankings given by the different respondent groups; and Mann-Whitney U test to determine whether two independent groups of responses have the same rank distributions [34]. Cumulatively, this analysis design provided new in-depth insight into KPIs impacting upon FM in hospitals.

3. Systematic literature review

Following the four-step procedure of the Preferred Reporting Items for Systematic Reviews and Meta-analyses) PRISMA protocol [35], a systematic literature review on hospital or healthcare FM performance was conducted to: 1) identify the key literature focusing on the KPIs development for hospital/healthcare FM measurement; 2) compare the KPIs and their development methodologies in both hospital/healthcare FM and general FM studies; and 3) review the roles of FM and non-FM experts in FM KPIs studies.

Two renowned literature databases, SCOPUS and Google Scholar, were used as the main search engines for retrieval of publications germane to the context of this study. The keywords used in the search process were: hospital facilities performance, healthcare facilities performance, facilities management performance, and key performance indicator. The search rules used was ("hospital facilities performance" AND "key performance indicator) OR ("healthcare facilities performance" AND "key performance indicator") OR ("facilities management performance" AND "key performance indicator"), as depicted in Figure 1.

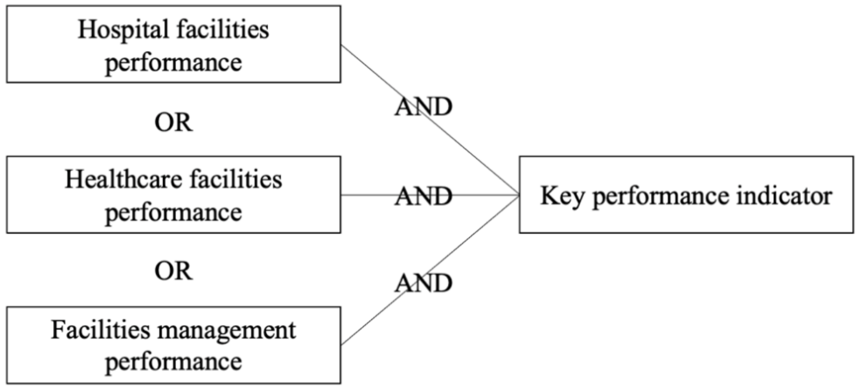

Figure 1. Key terms and their combination for literature search

The PRISMA process adopted was conducted in four stages:

- Stage 1: Using the above-mentioned search rule and search engines, a total of 545 publications published between 1989 and 2020 were retrieved (including journal papers, conference proceedings, and books).
- Stage 2: Manual cleansing was then adopted to exclude publications written in non-English languages, and conference proceedings and books - resulting in a shortlist of 303 publications.
- Stage 3: The abstract of each shortlisted paper was reviewed. Those with a focus on specific medical services or clinical care were excluded (i.e. those covering aspects relating to: service on the mental health crisis care pathway; intravitreal treatment services; ambulatory care pharmacy services; perinatal care; emergency physician management networks; and pressure injury). Thus, 160 articles remained.
- Stage 4: After reading further the full text of the articles identified in Stage 3, 27 key papers focusing on KPIs for hospital/healthcare FM and another 13 on KPIs for FM in general were selected for critical review. An overview of these 40 papers is shown in Tables 1 and 2.

Table 1. Key papers on KPIs for hospital/healthcare FM

Journal title (number of papers)	**Author(s) and year of publication**
Automation in Construction (1)	[36]
Benchmarking: An International Journal (1)	[37]
Building Research & Information (1)	[20]
Construction Management and Economics (3)	[38-40]
Engineering, Construction and Architectural Management (1)	[22]
Evidence-Based Complementary and Alternative Medicine (1)	[41]
Facilities (7)	[1, 42-47]
International Journal of Services, Economics and Management (1)	[48]

Journal of Building Engineering (1)	[21]
Journal of Construction Engineering and Management (1)	[49]
Journal of Facilities Management (1)	[50]
Journal of Health Management and Informatics (1)	[51]
Journal of Performance of Constructed Facilities (1)	[52]
Journal of Strategic Property Management (2)	[17, 53]
Perioperative Care and Operating Room Management (1)	[54]
Sains Humanika (1)	[55]
Studies in Health Technology and Informatics (1)	[56]
WSEAS Transactions on Business and Economics (1)	[57]

Table 2. Key papers on KPIs for general FM

Journal title (number of papers)	Author(s) and year of publication
Construction Management and Economics (1)	[58]
Facilities (8)	[9, 18-19, 45-46, 59-61]
International Journal of Health Care Quality Assurance (1)	[62]
Journal of Facilities Management (2)	[50, 63]
Journal of Strategic Property Management (1)	[2]

3.1 KPIs development in hospital facilities management performance studies

From the aforementioned literature identified, a notable shift of focus can be found over the past two decades. First, early healthcare FM studies possessed a focus on maintenance management performance of hospital or healthcare facilities, and the KPIs were developed based on building conditions and maintenance operation [1, 39, 43, 58, 64]. In a later period of time, healthcare FM performance was evaluated from multiple aspects. For example, Shohet and Lavy [1, 43] elaborated the scope of healthcare FM and suggested that an overall healthcare FM performance measurement should include: maintenance management; performance management; risk management; supply service management; and information and communication technology (ICT). Shohet [65] developed 11 KPIs to evaluate the overall healthcare facilities management from four perspectives, viz. asset development; organization and management; performance management; and maintenance efficiency. Omar et al. [55] outlined ten indicators that measure the effectiveness of maintenance management in Malaysian public hospital buildings. Shohet and Nobili [17] applied some previously-defined KPIs to assess the FM management performance of 42 clinics. Amos et al. [20] assessed hospital FM performance based on four aspects: quality; finance; learning and growth; and internal business. Lai and Yuen [47] expanded the scope of healthcare FM performance and adopted a six-aspect KPI framework, namely: safety; financial; physical; functional; environmental; and patient experience.

Second, both management personnel and users' perspectives have been included in KPI framework development and validation. Early KPI frameworks developed were based on the physical conditions of buildings and validated by building professionals such as building surveyors. The KPI frameworks developed were composed by one or more indices that quantify building conditions and transform objective building features into a scale that denotes the performance level. Shohet and Lavy [1] developed a building performance indicator (BPI) - by aggregating the weighted scores given to the building system components - for hospital building condition evaluation. Shohet and Lavy [43] also incorporated the managerial and user perspectives into a KPI framework and developed a hospital maintenance model with four KPIs: BPI; manpower source diagram (MSD); maintenance efficiency indicator (MEI); and managerial span of control (MSC). These KPIs were applied in a case study for hospital maintenance performance assessment [40], and a later study compared the performance and maintenance of hospital facilities and community clinics [53]. Pati et al. [52] discussed maintenance performance indicators based on some examples from hospitals, courthouses and office buildings. They defined hard and soft KPIs and suggested that both subjective and objective measures can be used for performance assessment. To develop comprehensive performance evaluation frameworks with a higher level of validity, two approaches are commonly adopted: (i) focus group meeting(s) to facilitate interactive discussion for shortlisting the essential KPIs; and (ii) questionnaire survey to include a larger number of professionals in validating the shortlisted KPIs. For instance, Lai and Yuen [47] utilised a literature review to identify 61 indicators (in four aspects: physical; safety; environment; and financial) that are applicable to hospital FM, followed by a focus group discussion that shortlisted 18 KPIs for forming a KPI framework.

3.2 Commonalities and differences between general and hospital FM KPIs

Both general FM KPI and hospital FM KPI frameworks were developed to capture the multi-dimensional facilities performance aspects. Generically, Hinks and McNay [9] identified 23 KPIs (e.g. no loss of business due to failure in service, customer satisfaction, provision of safe environment) for FM. Lavy et al. [44] conducted a review on FM KPIs and arranged the previously identified KPIs into four categories: financial; functional; physical; and survey-based. To generate a comprehensive list of KPIs that can be generally adopted in various types of facilities, Lavy et al. [45-46] conducted a study by identifying, categorizing and quantifying the core FM performance indicators through a combined literature review and industry opinion-based approach. Besides referring to previous KPI studies, Lai and Man [2] reviewed international evaluation schemes for buildings to identify KPIs for engineering facilities in commercial buildings. Based on a phase-hierarchy (P-H) model and a three-session focus group study, Lai and Man [18-19] further evaluated commercial building performance through the development of a KPI framework for facilities operation and maintenance (O&M). The P-H model, which is a two-dimensional matrix covering three phases (i.e. input, process and output) of facilities services delivery and three organizational levels (i.e. operational, tactical and strategic), was proved useful for systematic classification of FM KPIs.

The unique organizational mission and business drivers of hospitals were recognized and recommended to be integrated in hospital FM KPI identification and selection [66]. Amos et al. [20] and Amos et al. [21-22] are three recent studies focusing on developing and validating hospital FM KPI frameworks. In these studies, organizational business performance and human resources capacities organizations were measured for FM performance evaluation. In the study of Lai and Yuen [47], 61 indicators were identified as applicable to hospital FM. Classification of these indicators using the above-mentioned P-H model showed that most of the indicators can be used by practitioners at the tactical level to evaluate hospital FM performance.

3.3 FM and non-FM experts in FM KPIs studies

Expert opinions are invaluable as they engender a deeper understanding of actual practice and help to validate KPIs applied for general performance evaluation [67]. Consequently, it has been common for KPI studies to collect FM experts' opinions for the purpose of identifying or shortlisting KPIs that reflect soft FM performance. In FM performance studies, building professionals were historically selected as key members of the target expert groups. However, because soft aspects of FM (e.g. customer satisfaction, financial matters) are being increasingly recognised as important components of FM performance [68], professionals in non-FM sectors such as finance, human resource management and administrative management have also been included in expert groups. Table 3 indicates the professionals involved in KPIs development in previous FM performance evaluation studies.

Table 3. Experts involved in KPIs development for FM performance evaluation

Authors (year)	KPIs developed	Research design and methods	Experts/professionals involved
[9]	General FM performance KPIs in different aspects, including: Business benefit (e.g. value for money, no loss of business due to failure of premises services, sustainability of premises and functional environment); Equipment (e.g. equipment provided meets business needs, correction of faults); Space (e.g. effective utilisation of space); Environment (e.g. satisfactory physical working conditions, energy performance); Change management (e.g. effective communication, quality of end product); Maintenance/service (e.g. management of maintenance, reliability); and General (e.g. responsiveness to problems, customer satisfaction)	The study adopted Delphi method to: reach a group consensus on the relevant KPIs for FM function assessment in the context of business support for the organisation; and identify a list of KPIs and their applicability of the model composed by the identified KPIs based on two FM scenarios through discussions among eight group members.	Members from premises department, e.g. senior managers.
[43]	Core parameters and variables that affect FM performance in: Maintenance management (predicted annual maintenance expenditure, recommended maintenance policy for each building system); Performance and risk management (actual facility performance level, predicted risk level, predicted facility performance); and Energy and operations management (predicted annual energy consumption, predicted annual operations expenditure)	Literature and industry opinion-based qualitative approach was used to identify facilities performance KPIs and developed a measurement mechanism for each KPI.	Facilities managers of public acute care hospital facilities.
[69]	KPIs for airport safety and security: (1) Breach of security; (2) Evacuation in the case of emergency (fire, bomb threat, acts of terrorism); (3) Hysteria control; (4) Attack on airport facilities or installation; and (5) Destructive or	A case study approach was adopted and the data was collected through interviews, workshops and the internet and other media.	Key airport personnel.

	criminal behaviour (by passenger on board aircraft, directed at cargo on board aircraft)		
[70]	Performance management framework for healthcare FM: Control of healthcare associated infections (HAI); Organization and policy; Service levels; and Standards	The research was conducted in four stages: a literature review and expert interviews were conducted to identify the role of FM in the control of HAI and developed a conceptual framework (Stage 1); 26 semi-structured interviews with key parties in the control of HAI (Stage 2) and a questionnaire survey (Stage 3) were conducted to identify the current context of the control of HAI in domestic services; and a performance management framework (PMF) for control of HAI in domestic services was developed (Stage 4).	Experts from HAI and FM professionals from the National Health Service (NHS) in Scotland.
[61]	General FM performance: Client satisfaction; Cost-effectiveness; Response time; Service reliability; Health; Safety; Environmental compliance; Staff commitment; Client-service provider relationship; and IT application	Existing FM models were identified via literature review and compared through expert interviews. A questionnaire survey was then conducted to investigate the application of the performance models.	FM professionals - members from the British Institute of Facilities Management (BIFM) and Irish Property and Facility Management Association (IPFMA).
[51]	KPIs for hospital performance evaluation; examples include: Ratio of total revenue to total costs; Average expenditures per bed per stay; % Personnel costs of total costs; Average length of stay; Bed occupancy; Mortality rate; Cancelled operations; Hospital infection rate; Clinical errors; Mean length of stay in emergency department; Emergency Room waiting time; Staff satisfaction rate; Training expenditures per capita; and Patients satisfaction percentage.	A mixed methods approach was adopted in the study, composed by literature review, experts' panel and the Delphi method. The KPIs extracted from literature review were shortlisted by the experts' panel. A Delphi survey was conducted to validate the KPIs obtained from the previous stages.	Managers/directors of hospitals and professors/researchers with healthcare management background.
[19]	KPIs for facilities operation and maintenance: (1) Thermal comfort; (2) Indoor air quality; (3) Percentage users dissatisfied; (4) Ratio of total O&M cost to building income; (5) Actual costs within budgeted costs; (6) O&M cost per building area; (7) Work request response rate; (8) Number of completed work orders per staff; (9) Area maintained per maintenance staff; (10) Backlog size; (11) Failure/breakdown frequency; (12) Availability of fire services system; (13) Availability of lift; (14) Energy use index; (15) Greenhouse gas emission per building area; (16) Number of accidents per year; and (17) Number of lost work days per year.	A focus group meeting was conducted to collect both quantitative and qualitative data. The quantitative data was analysed to obtain the ratings on the importance of the indicators while the qualitative data was used to solicit opinions from O&M experts for indicators selection.	Experienced O&M professionals.

[20-22]	KPIs for hospital FM services: (1) Provision of prompt service / service response time; (2) Reliability of service; (3) Professional approach; (4) Responsiveness to problems; (5) Appearance of equipment and staff; (6) Effectiveness of help desk; (7) Timely / prompt release of cash for FM task; (8) Proportion of FM budget approved by management; (9) Cost-effectiveness in delivery FM; (10) FM staff training / development; (11) Employee turnover; (12) Promotions made; (13) Competence (possession of required skills); (14) Change management processes; (15) Stakeholders communication; (16) Achievement of goals and objectives / mission and vision achievement; (17) Top management commitment; (18) Use of ICT; (19) Achievement of service-level agreement for FM contractors; (20) Safety and accidents management; and (21) Effectiveness of FM planning	An exploratory sequential mixed methods approach was employed, encompassing interviews and questionnaire survey. The survey data was analysed to confirm performance scales through the use of Partial Least Squares Structural Equation Modelling [20-21] A list of KPIs was identified based on a comprehensive literature review and then was shortlisted using expert interviews. A questionnaire survey was conducted to rank the importance level of the KPIs and the survey results were analysed with factor analysis/principal component extraction method [22].	Directors of health services and their deputies, heads of estate and environmental management departments, health administrators and deputies, and sectional heads of the FM services, deputy director of administration, head of environment and house-keeping, director of hospital administration, head of acting environmental officer. Hospital staff including head administrator, deputy health administrator, medical superintendent, head of environmental services and housekeeping, head of estate management, assistant environment officer, assistant estate officer.

Table 3 illustrates that KPIs development for general FM performance usually involved only FM experts while for specific facilities (e.g. airport), non-FM experts were involved. This raises the question of whether the opinions of FM and non-FM experts on FM KPIs are different; note that both FM practitioners and non-FM practitioners (e.g. building designers and contractors), though playing different roles at different stages of a building life cycle, should collaborate with each other as part of a project management team [71]. Furthermore, most of the reviewed studies adopted a mixed methods approach, in which literature review and/or expert interview/discussion were used to identify and verify the KPIs, and a questionnaire survey was carried out to test the applicability of the identified KPIs.

Built upon the above review findings, this study used a systematic literature review followed by a questionnaire survey on the importance of the hospital FM KPIs that were shortlisted from a focus group discussion. In particular, this study concerns the unique operations of hospitals and investigate whether the profiles and roles of building practitioners affect their perceptions of the KPIs' importance. Besides covering the perspectives of building practitioners working on different building lifecycle stages, an innovation of this study lies in scrutinizing any significant difference in the KPIs' importance between the different groups of practitioners.

3.4 Building practitioners

In general, building practitioners' knowledge of site planning and management is useful for construction projects [72]. As the performance of hospitals has a profound impact on human health and well-being, the planning, design, construction and FM phases of hospital development and subsequent management requires a team of dedicated expert professionals equipped with diverse skills and competencies [73]. In previous studies, the opinions of building practitioners working on hospital/healthcare facilities were sought to support investigations into different activities in the building lifecycle, especially in the stages of design and FM. Kim et al. [74] explored designers' and medical staffs' perceptions about design elements for elder-friendly hospitals. Sommerich et al. [75] analyzed the opinions of architects and interior designers on hospital patient rooms designed by the hospital staffs. Lavy and Dixit [76] conducted a survey to collect opinions from facilities managers regarding the materials used for interior wall finishes and the criteria used to select them. Hassanain et al. [64] identified the factors that affect the maintenance cost of hospital facilities based on interview and survey data collected from experienced facilities managers. Yik et al. [77] used a questionnaire survey in studying the impacts of different procurement methods on the perceived performance of hospital engineering services.

As different groups of building practitioners are involved in different stages of a building life cycle and importantly, given their opinions provide valuable insights and practical implications to the building industry, various studies have solicited their opinions. For example, investigations conducted have focused upon: contractor selection [78]; contract disputes [79]; construction stakeholders management [80]; construction energy management [81]; construction project delay [82]; and project reputation [83]. In some other studies, opinions of multiple groups of building practitioners were collected to investigate issues such as adoption of green building practice [84], carbon emission reporting of buildings [85], building operation and maintenance manpower [86], issues that affect professional practices of building services engineers [87], and building information modelling (BIM) for building services engineering [34].

Recent studies also indicate that the occupational profiles (e.g. job nature, job level, work experience) of building professionals and their roles in the building industry (e.g. owners, service users) affect their perception towards building operations and performance. To increase the validity of the opinions collected, researchers have included multiple groups of building practitioners with different occupational profiles and roles in their investigations. For example, Saunders et al. [88] conducted a focus group discussion to investigate the knowledge level of life cycle assessment in the architecture, engineering and construction community, and the benefits and barriers to the practice of life cycle assessment. Members of the focus group included owners, engineers, manufacturers, contractors, architects and practitioners from nonprofit organizations. Hsieh et al. [89] adopted a fuzzy multi-criteria analysis approach to select planning and design alternatives for public office buildings, with opinion-based data collected from decision-makers who were from the owner, user and expert groups. Chiu and Lai [34] included both building service engineers and non-building service engineers with different job natures (e.g. design and construction) and different job levels (e.g. senior, middle and junior) in a survey for investigating the benefits and barriers of BIM in building service engineering.

In the process of hospital facilities planning, a variety of professionals are involved. Examples include: hospital administrators; specialists from various clinical branches; architects; engineers; and facilities managers. The roles of hospital staff need to be considered during the planning, design and construction of a hospital [24]. Past studies on hospital facilities planning and design have considered the occupational profiles of hospital staff and their opinions [90-91]. Yet, scant attention has been paid to the influence of occupational profiles and roles of building practitioners on the importance of hospital FM performance indicators.

3.5 Research gaps

Through the systematic literature review, the following research gaps were identified. First, as KPIs are facilities-specific and their development hinges on the opinions of concerned stakeholders, the KPIs developed in previous studies differ from each other. Thus, the first research gap is that KPIs for evaluation of FM performance in the context of hospitals in Hong Kong has not yet been investigated in previous KPI studies.

Second, previous studies showed that the scope of FM KPIs varies across different facilities aspects - ranging from core FM performance indicators to associated FM performance indicators such as human resource performance. Building professionals working on different building lifecycle stages and hence with different job natures, while required to collaborate on building projects, may have different perspectives on the importance of FM KPIs. Although some studies involved building professionals with diverse backgrounds in the process of KPIs identification, limited systematic analysis was made to investigate whether different job natures of the professionals lead to different perceptions of the KPIs' importance. This is a gap that the present study intended to address.

Third, building practitioners playing different roles (e.g. owner, service provider) may have different perceptions of the importance of FM KPIs. Likewise, the importance of the KPIs may be perceived differently by building practitioners at different job levels (i.e. junior, middle, senior). Yet whether these two premises are true and, if this is affirmative, to what extent the perceptions vary, were seldom studied in prior research on FM KPIs. These are among the knowledge gaps to be bridged by the present study.

4. Questionnaire survey

At the beginning of the study and as reported in the earlier work [47], an extensive literature review identified 61 indicators that are applicable to hospital FM; after a focus group study, 18 indicators belonging to four different aspects ("physical", "safety", "environment" and "financial") were shortlisted as essential for this present study. The shortlisted indicators, with their definitions tabulated in the Appendix, formed the basis for the questionnaire survey design.

The questionnaire was split into three sections. Section one provided background to the study and contacts details of the research team. Section two requested demographic data from the survey participants (e.g. work experience, job role and job level). Section three solicits the perceptions of the respondents on the importance level (from 1: "very low" to 5: "very high") of each of the 18 performance indicators. After a pilot test with feedbacks on the first version of the questionnaire, minor revisions were undertaken to refine the questionnaire prior to distribution in the main survey to building practitioners in the hospital sector of Hong Kong.

The full-scale survey was conducted with the support from the Hong Kong Branch of the Institute of Healthcare Engineering and Estates Management (IHEEM) - a professional institution specialized in the field of hospital facilities. To obtain as many responses as possible, the questionnaire was disseminated through multiple channels. First, an online survey, distributed via emails incorporated with a hyperlink to the electronic questionnaire, was made on the members of the IHEEM. Before closing the online survey, two rounds of emails were broadcast to remind the members to participate in the survey. Second, printed copies of the questionnaire were provided to the participants of a seminar held in a hospital. Third, printed copies of the questionnaire were distributed to the attendees of another seminar, which was organised by the IHEEM. The participants of these two seminars, who were building practitioners working on hospitals, were requested to join the survey. At the end of the seminars, the questionnaires they completed were collected by the research team.

4.1 Respondents' demography and data quality

To ensure that only quality data would be analysed, the survey responses were scrutinized in a screening process. Those with incomplete data provided were discarded. The remaining 103 responses, with all the required fields of the questionnaire completed, were taken for analysis. In checking the reliability and validity of the questionnaire, the Cronbach's alpha coefficient, which measures the internal consistency of the items being rated in each group under the questionnaire, was calculated. For the performance indicators in the physical, safety, environmental and financial groups, the calculated Cronbach's alpha coefficients were 0.730, 0.887, 0.769 and 0.820 respectively. These values, all being above the threshold value (0.7), show that the reliability and validity of the questionnaire are acceptable. Then, the questionnaire responses were analysed further, as in the following.

Close to half (44.66%) of the sample of useful responses came from FM or O&M practitioners (Table 4). Over one-third (37.86%) of the respondents belong to the design and construction (DC) group. When classified by job role, slightly less than half (44.66%) of the respondents played the role of hospital owner or its representative; the remaining respondents worked as service providers or others. Around half of the respondents worked at the middle job level; the remaining respondents were at the senior or junior levels. Most of the participants (76.70%) possessed five years or more work experience – this illustrates that the survey participants have accrued sufficient experience to contribute informed knowledge to the present study.

Table 4. Demographic details of survey respondents

Demography	Number	Proportion (%)
Job nature		
Design and Construction (DC)	39	37.86
Facilities Management (FM) (including O&M)	46	44.66
Others	18	16.67
Job role		
Owner/representative	46	44.66
Service provider	35	33.98
Others	22	21.36
Job level		
Junior	17	16.50
Middle	55	53.40
Senior	31	30.10
Work experience		
Less than 5 years	24	23.30

6-15	23	22.33
16-25	33	32.04
26-40	23	22.33

4.2 Importance levels and ranks of performance indicators

Further to the preliminary analysis of the survey data as reported in Lai et al. [92], detailed statistical analyses were conducted. Similar to the approach of an earlier study on performance indicators for commercial building facilities [93], the responses on the importance levels were processed to determine the mean value and rank of each of the performance indicators listed in the questionnaire. Table 5 shows the calculated mean values and the corresponding ranks; the first column shows the identification numbers of the performance indicators, with the letters denoting different performance categories: physical (P), safety (S), environmental (E), and financial (F).

Table 5. Mean value and ranks of KPIs

No.	KPIs	Mean	Rank
P4	Availability of lift system	3.981	1
P3	Availability of fire services system	3.932	2
F1	Actual costs within budgeted costs	3.874	3
F3	Energy cost per building area	3.786	4
P6	Average age of major facilities	3.767	5
E1	Energy utilization index	3.748	6
F2	O&M cost per building area	3.680	7
S1	Number of accidents per year	3.670	8
P1	Work request response rate	3.621	9
F5	Maintenance cost per building area	3.592	10
F6	Annual maintenance expenditure as a percentage of total replacement value	3.563	11
E2	Carbon emissions per building area	3.544	12
S3	Number of statutory orders per year	3.505	13
F4	Facilities cost per building area	3.485	14
P5	Facility condition index	3.476	15
S2	Number of unwanted (false) fire incident calls	3.427	16
S4	Number of statutory orders per 5 years	3.369	17
P2	Number of completed work orders per staff	3.291	18

The five most important performance indicators fall in the physical and financial aspects, of which *availability of lift system* (P4) was ranked the first, followed by *availability of fire services system* (P3), *actual costs within budgeted costs* (F1), *energy costs per building area* (F3) and *average age of major facilities* (P6). This illustrates that the respondents focus more upon measurements that are tangible and have financial implications to hospitals.

Conversely, safety indicators were regarded as relatively less important. *Number of statutory orders per 5 years* (S4) and *number of unwanted (false) fire incident calls* (S2) are the second and third least important indicators. The lowest-ranked indicator is *number of completed work orders per staff* (P2) and the remaining two of the five least important indicators are *facility condition index* (P5) and *facilities cost per building area* (F4). The mean ratings of these five indicators are all below 3.5 – an intermediate rating between 'moderate' and 'high' importance. Among these indicators, for example, *facility condition index* [94] is a common metric in some overseas places but was ranked low in this survey. The reason for this observation should be investigated in future. As for the remaining performance indicators lying in the range of importance levels between 3.500 and 3.750, they were regarded by the respondents as of 'moderate' to 'high' importance in evaluating hospital FM performance.

4.3 Comparisons between different groups of building practitioners

Further analyses were conducted to compare the responses between different groups of building practitioners. First, the grouping was made according to: (i) job nature; (ii) job role; and (iii) job level. Second, the mean importance levels of the performance indicators and the corresponding importance ranks were computed with respect to the individual groups. As length limitation prohibits a detailed presentation of all the calculated results here, the following shows only the most significant findings, which cover the five most important performance indicators in any one of the grouped rankings.

4.3.1 Job nature

When categorized by job nature, *availability of lift system* (P4) was regarded by the FM practitioners as the first and the third most important indicator, respectively (Table 6). Another physical performance indicator, *availability of fire services system* (P3), received a high ranking from the FM group but a moderate ranking (7th out of 18) according to the DC group. The differences in the rank of the *average age of major facilities* (P6) between the FM and DC groups are not substantial.

Table 6. Mean importance levels and ranks of the indicators (by job nature)

No.	Performance indicator	FM group		DC group	
		Mean	Rank	Mean	Rank
P4	Availability of lift system	4.065	1	3.821	3
P3	Availability of fire services system	4.022	2	3.615	7
F1	Actual costs within budgeted costs	3.935	3	3.718	4
P6	Average age of major facilities	3.826	4	3.641	6
F2	O&M cost per building area	3.804	5	3.564	8
F3	Energy cost per building area	3.696	7	3.898	2
E1	Energy utilization index	3.543	10	3.923	1
E2	Carbon emissions per building area	3.370	15	3.667	5

Among the financial performance indicators, *actual costs within budgeted costs* (F1) was given a relatively high rating, with a mean value of 3.935 and 3.718 pertaining to the FM and DC groups respectively. When compared with the DC group, the FM group rated O&M cost per building area (F2) as more important. Whereas *energy cost per building area* (F3) was rated high (2nd) from the perspective of the DC practitioners, it was just rated by the FM group as the seventh most important indicator.

Energy utilization index (E1), a common environmental performance indicator, was rated by the DC respondents as the most important but, intriguingly, its ranking is only moderate (10th), according to the FM respondents. Another environmental performance indicator, *carbon emissions per building area* (E2), was regarded by the FM group as of relatively low importance (15th), while it was ranked the fifth by the DC group. Ironically, this could be because the DC participants may be fully aware of the need to design and build sustainable and energy efficient buildings whereas the FM participants may believe that their building is already compliant and therefore believed that other factors were far more important. Future interview work is required to further explore this observed phenomenon with the FM practitioners.

4.3.2 Job role

With respect to job role (viz. owner/representatives versus service providers), similar results were found with the five top-rated performance indicators. *Availability of fire services system* (P3) and *availability of lift system* (P4) were regarded by the owner/representative and service provider groups as the top two performance indicators (Table 7). The differences in the rank of the *average age of major facilities* (P6) between the two respondent groups are not substantial.

Table 7. Mean importance levels and ranks of the indicators (by job role)

No.	KPIs	Owner/representative		Service Provider	
		Mean	Rank	Mean	Rank
P3	Availability of fire services system	3.978	1	3.829	2
P4	Availability of lift system	3.935	2	4.000	1
P6	Average age of major facilities	3.804	4	3.800	3=
F1	Actual costs within budgeted costs	3.913	3	3.800	3=
F3	Energy cost per building area	3.783	5	3.571	5

Note: = tied rank

The two groups also ranked the *actual costs within budgeted costs* (F1) as the third important indicator - with a mean value of 3.913 and 3.800 pertaining to the owner/representative and service provider groups, respectively. *Energy cost per building area* (F3), with mean importance ratings 3.783 and 3.571 corresponding to the owner/representative and service provider groups respectively, was ranked the fifth by both of the two groups.

4.3.3 Job level

Table 8 shows that *availability of lift system* (P4) was regarded as the most important indicator by practitioners working at all the three levels (senior, middle and junior). Another physical performance indicator – *availability of fire services system* (P3) – was also highly ranked: the second most important indicator, according to the practitioners working at the junior or senior level. The middle-level practitioners ranked this indicator (P3) as the fourth important.

Table 8. Mean importance levels and ranks of the indicators (by job level)

No.	KPIs	Junior		Middle		Senior	
		Mean	Rank	Mean	Rank	Mean	Rank
P3	Availability of fire services system	4.129	2	3.782	4	4.129	2
P4	Availability of lift system	4.161	1	3.855	1	4.161	1
S1	Number of accidents per year	4.032	3	3.582	8	4.032	3
S3	Number of statutory orders per year	3.839	5=	3.382	16	3.839	5=
E1	Energy utilization index	3.806	7	3.764	5	3.806	7
F1	Actual costs within budgeted costs	3.871	4	3.818	2	3.871	4
F3	Energy cost per building area	3.839	5=	3.800	3	3.839	5=

Note: = tied rank

As regards the safety performance indicators, both *number of accidents per year* (S1) and *number of statutory orders per year* (S3) received a relatively high ranking from practitioners working at the junior and senior levels. The middle-level practitioners, on the other hand, regarded *number of statutory orders per year* (S3) as relatively less important.

Among the financial performance indicators, *actual costs within budgeted costs* (F1) was given a relatively high rating by the three groups of respondents - with a mean importance rating of 3.871 pertaining to both the junior and senior groups, and a rating of 3.818 given by the middle-level practitioners. Whereas *energy cost per building area* (F3) was ranked the third from the perspective of the middle-level practitioners, it was rated by the junior and senior practitioners as the fifth most important indicator. Collectively, these results show that all three levels of practitioners are highly concerned with financial performance; note that effective use of resources will result in value-for-money FM services that are desirable to the hospital stakeholders, including not only the client but also numerous end users.

Energy utilization index (E1), a common environmental performance indicator, received a moderately high ranking from the middle-level practitioners, and it was given only an intermediate ranking (7^{th}) by the junior and senior groups. A plausible explanation is that although energy saving has long been emphasized as among the key goals towards sustainability, the degree to which energy could be saved diminishes when significant energy-saving measures have already been taken.

4.4 Correlation between different groups of rankings

To further examine the level of correlation between the rankings given by the different respondent groups on the 18 shortlisted performance indicators, Kendall's tau-b test, which can measure the degree of correspondence between pairs of grouped rankings and assess the significance of the degree of correspondence, was used. The value of Kendall's *tau b* was calculated using Eq. (1), where P and Q are number of concordant parts and discordant parts, respectively. Tx is the number of pairs tied on x but not on y whereas Ty is number of pairs tied on y but not on x. The Kendall's *tau b* values range from -1 (perfect disagreement) through 0 (independent) to +1 (perfect agreement).

$$tau\ b = \frac{P-Q}{\sqrt{(P+Q+T_x)(P+Q+T_y)}} \qquad (1)$$

At a significance level of 0.01 (two-tailed), the values of Kendall's tau-b between most pairs of the respondent groups, which were calculated using the SPSS software, were found to be significant (Table 9). Moderately positive correlations existed between the rankings given by the following pairs of respondent groups: (i) FM and DC; (ii) owner/representative and service provider; (iii) junior and middle; and (iv) middle and senior. No significant correlation was found between the rankings of the junior and senior groups. This finding is not unexpected, given the distinct levels of these two groups in an organization. With the senior practitioners focussing on strategic issues while the junior practitioners charged with the responsibility of handling operational matters, their difference in perspective should have resulted in their different perceptions on the importance of the performance indicators.

Table 9. Summary of Kendall's tau-b test results

Groups in comparison		Kendall's tau	p-value	Significant relationship
FM	DC	0.473**	0.007	Yes
Owner/representative	Service Provider	0.567**	0.001	Yes
Junior	Middle	0.470**	0.008	Yes
Junior	Senior	0.255	0.155	No
Middle	Senior	0.487**	0.005	Yes

** Statistically significant at the 0.01 level (2-tailed).

4.5 Comparison of performance indicators between respondent groups

To determine whether two independent groups of responses have the same rank distributions, the Mann-Whitney U Test was used. This test (at significance level α = 0.05) was applied using Eq. (2) to Eq. (4), where n_1 and n_2 denote the number of items in the groups 1 and 2 respectively. R_1 and R_2 indicate the sums of the ranks for groups 1 and 2 respectively; U stands for the test statistic. The computations for this test were processed using the SPSS software.

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - R_1 \quad (2)$$
$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - R_2 \quad (3)$$
$$U = min(U_1, U_2) \quad (4)$$

4.5.1 Job nature

Referring to the computed test statistics *U, z* and *p* (two-tailed) of the Mann-Whitney U Test (Table 10), in most of the cases the p-values exceed 0.05, indicating that no significant differences existed between the views of the DC and FM groups on the importance of most of the performance indicators. Yet, there are three exceptions: the *p*-values for a*vailability of fire services system* (P3) (U = 659.500, *p* = 0.028), *energy utilization index* (E1) (U = 927.500, *p* = 0.005) and *carbon emissions per building area* (E2) (U = 984.000, *p* = 0.018) are below 0.05, indicating that the two respondent groups had significant difference in their perceived importance of these three indicators. As revealed earlier (see Table 6), the FM respondents highly recognized the importance of the *availability of fire services system* in hospitals. If the fire services system is not working properly, the health and welfare of hospital end users will be jeopardised (particularly patients with disability in mobility).

Table 10. Summary of Mann-Whitney U Test results (DC vs. FM)

No.	KPIs	Group	Mean Rank	*U*	z	*P*
P1	Work request response rate	DC	38.240	711.500	-1.739	0.082
		FM	47.030			
P2	Number of completed work orders per staff	DC	42.260	868.000	-0.274	0.784
		FM	43.630			
P3	Availability of fire services system	DC	36.910	659.500	-2.200	0.028*

		FM	48.160			
P4	Availability of lift system	DC	39.380	756.000	-1.338	0.181
		FM	46.070			
P5	Facility condition index	DC	43.730	868.500	-0.272	0.785
		FM	42.380			
P6	Average age of major facilities	DC	39.920	777.000	-1.140	0.254
		FM	45.610			
S1	Number of accidents per year	DC	41.530	839.500	-0.526	0.599
		FM	44.250			
S2	Number of unwanted (false) fire incident calls	DC	43.370	882.500	-0.134	0.893
		FM	42.680			
S3	Number of statutory orders per year	DC	42.770	888.000	-0.082	0.935
		FM	43.200			
S4	Number of statutory orders per 5 years	DC	43.990	858.500	-0.352	0.725
		FM	42.160			
E1	Energy utilization index	DC	49.650	637.500	-2.504	0.012*
		FM	37.360			
E2	Carbon emissions per building area	DC	48.320	689.500	-1.984	0.047*
		FM	38.490			
F1	Actual costs within budgeted costs	DC	39.010	741.500	-1.507	0.132
		FM	46.380			
F2	O&M cost per building area	DC	39.910	776.500	-1.158	0.247
		FM	45.620			
F3	Energy cost per building area	DC	46.040	778.500	-1.138	0.255
		FM	40.420			
F4	Facilities cost per building area	DC	46.220	771.500	-1.198	0.231
		FM	40.270			
F5	Maintenance cost per building area	DC	41.270	829.500	-0.638	0.523
		FM	44.470			
F6	Annual maintenance expenditure as a percentage of total replacement value	DC	42.130	863.000	-0.328	0.743
		FM	43.740			

*Statistically significant at the 0.05 level (2-tailed).

For the two environmental performance indicators (E1 and E2), the DC group considered them as more important than the FM group did. This may be because the FM respondents care more about the long-term performance of the facilities in various aspects rather than only the environmental issues. Or it could mean, as stated previously, they assume that the building is already energy efficient and so rated other factors higher. Conversely, the DC group may consider that the two environmental indicators as essential in the identification of energy saving potential in the early design stage of hospital buildings. This concurs with the observations in Table 6, which show how these two respondent groups rank each of these indicators differently (i.e. E1 and E2).

4.5.2 Job role

From the computed test statistics of the Mann-Whitney U Test (see Table 11), the p-values in all cases exceed 0.05, which indicates that there were no significant differences between the views of the owner/representative and service provider groups with respect to the importance levels of the performance indicators. This observation not only concurs with the findings summarized in Table 7, where the ranking orders of the top five indicators pertaining to the two respondent groups are similar, but it also shows that the perspectives of the owner/representatives and service providers are in alignment.

Table 11. Summary of Mann-Whitney U Test results (owner vs. provider)

No.	KPIs	Group	Mean Rank	*U*	z	*p*
P1	Work request response rate	Owner/representative Service provider	42.210 39.410	749.500	-0.562	0.574
P2	Number of completed work orders per staff	Owner/representative Service provider	42.590 38.910	732.000	-0.746	0.456
P3	Availability of fire services system	Owner/representative Service provider	42.350 39.230	743.000	-0.625	0.532
P4	Availability of lift system	Owner/representative Service provider	40.110 42.170	764.000	-0.417	0.676
P5	Facility condition index	Owner/representative Service provider	42.480 39.060	737.000	-0.696	0.487
P6	Average age of major facilities	Owner/representative Service provider	40.910 41.110	801.000	-0.042	0.967
S1	Number of accidents per year	Owner/representative Service provider	42.170 39.460	751.000	-0.535	0.593
S2	Number of unwanted (false) fire incident calls	Owner/representative Service provider	41.550 40.270	779.500	-0.257	0.797
S3	Number of statutory orders per year	Owner/representative Service provider	39.350 43.170	729.000	-0.750	0.453
S4	No. of statutory orders per 5 years	Owner/representative Service provider	38.240 44.630	678.000	-1.253	0.210
E1	Energy utilization index	Owner/representative Service provider	41.270 40.640	792.500	-0.131	0.895
E2	Carbon emissions per building area	Owner/representative Service provider	42.780 38.660	723.000	-0.851	0.395
F1	Actual costs within budgeted costs	Owner/representative Service provider	42.210 39.410	749.500	-0.590	0.555
F2	O&M cost per building area	Owner/representative Service provider	44.500 36.400	644.000	-1.673	0.094
F3	Energy cost per building area	Owner/representative Service provider	42.090 39.570	755.000	-0.529	0.597
F4	Facilities cost per building area	Owner/representative Service provider	39.200 43.370	722.000	-0.866	0.386
F5	Maintenance cost per building area	Owner/representative Service provider	41.980 39.710	760.000	-0.457	0.648
F6	Annual maintenance expenditure as a percentage of total replacement value	Owner/representative Service provider	40.910 41.110	801.000	-0.041	0.967

4.5.3 Job level

Performance indicators are mainly used by practitioners at the strategic and tactical levels to measure and monitor the performance of facilities in buildings [18, 47]. Therefore, the ensuing analysis on the rankings of the 18 shortlisted performance indicators was premised upon the responses given by senior and middle-level practitioners. As the computed test statistics of the Mann-Whitney U Test reveal (see Table 12), in most of the cases the p-values exceed 0.05, indicating that there were no significant differences between the views of the two respondent groups on most of the performance indicators.

Table 12. Summary of Mann-Whitney U Test results (middle vs. senior)

No.	KPIs	Group	Mean Rank	*U*	z	*p*
P1	Work request response rate	Middle	40.020	661.000	-1.837	0.066
		Senior	49.680			
P2	Number of completed work orders per staff	Middle	43.550	849.500	-0.029	0.977
		Senior	43.400			
P3	Availability of fire services system	Middle	39.980	659.000	-1.833	0.067
		Senior	49.740			
P4	Availability of lift system	Middle	40.720	699.500	-1.465	0.143
		Senior	48.440			
P5	Facility condition index	Middle	43.080	839.500	-0.126	0.900
		Senior	43.740			
P6	Average age of major facilities	Middle	43.650	844.000	-0.083	0.934
		Senior	43.230			
S1	Number of accidents per year	Middle	40.450	684.500	-1.576	0.115
		Senior	48.920			
S2	Number of unwanted (false) fire incident calls	Middle	42.170	779.500	-0.693	0.488
		Senior	45.850			
S3	Number of statutory orders per year	Middle	39.540	634.500	-2.037	0.042*
		Senior	50.530			
S4	Number of statutory orders per 5 years	Middle	39.500	632.500	-2.048	0.041*
		Senior	50.600			
E1	Energy utilization index	Middle	43.280	840.500	-0.118	0.906
		Senior	43.890			
E2	Carbon emissions per building area	Middle	41.170	724.500	-1.260	0.208
		Senior	47.630			
F1	Actual costs within budgeted costs	Middle	42.580	802.000	-0.505	0.614
		Senior	45.130			
F2	O&M cost per building area	Middle	41.180	725.000	-1.249	0.218
		Senior	47.610			
F3	Energy cost per building area	Middle	42.850	916.500	-0.355	0.722
		Senior	44.660			
F4	Facilities cost per building area	Middle	42.950	822.500	-0297	0.767
		Senior	44.470			
F5	Maintenance cost per building area	Middle	43.150	833.000	-0.188	0.851
		Senior	44.130			
F6	Annual maintenance expenditure as a percentage of total replacement value	Middle	45.050	767.500	-0.830	0.407
		Senior	40.760			

*Statistically significant at the 0.05 level (2-tailed).

The two exceptions are: *number of statutory orders per year* (S3) (U = 634.500, p = 0.042) and *number of statutory orders per year* (S4) (U = 632.500, p = 0.041). Their p-values are below 0.05, which indicates that the two respondent groups had significant difference in their perceived importance of these two indicators. In fact, the earlier results in Table 8 show that senior practitioners, when compared with those at the middle level, placed a much higher importance on safety performance indicators, viz., S1 and S3. If the management of facilities is insufficient to safeguard building occupants' safety, serious consequences such as legal claims for personal injuries or property damages may rise, which, to the eyes of the senior management, are key issues that should be avoided.

4.6 Comparison with past studies and KPIs developed

The mechanisms of KPIs categorization and importance measurement in this study contribute to the body of knowledge in FM KPIs studies. As the categorization mechanism of FM KPIs of a specific organization type should reflect the operation and development trend of the respective industry, this study used a questionnaire survey to solicit industry practitioners' views on the importance of the identified hospital FM KPIs. The categorisation of KPIs in previous studies such as RodriguezLabajos et al. [95], which was based on a review on the estate performance measurement for nine international health-care organisations, was taken as reference in grouping the KPIs identified from the literature review process for the current study. While organizational performance aspects such as human resource management and internal business process contribute to the overall hospital FM performance, this study focused on KPIs that reflect the functional performance of hospital facilities (physical aspect) and performance aspects (safety, environmental and financial aspects) that are crucial to managing facilities at the strategic and tactical levels [47]. For example, instead of grouping "*maintenance cost per building area*" and "*annual maintenance expenditure of total replacement value*" under the maintenance performance category, this study classified them as KPIs in the financial performance category. Alongside these KPIs are "*actual costs within costs*", "*O&M cost per building area*", "*energy cost per building area*" and "*facilities management cost per building area*", which are capable of indicating the economic FM performance in both the short and long terms. A further characteristic of these KPIs is that their measurements can be made using numeric data obtainable from empirical FM records in future. This quantification approach will make the derivation of the KPIs objective and scientific, ensuring the reliability and credibility of the KPIs.

In the field of hospital FM studies, opinions of FM professional are often sought to validate and shortlist the intended KPIs with one or multiple research methods, such as interviews, focus group discussion and questionnaire survey [20, 22, 43, 51, 70]. Interviews and focus group discussions provide rich information of actual FM practice with regard to certain KPIs, while questionnaire surveys collect a larger scale of opinion-based data to test the generalisation level of the KPIs being studied [96]. It is for this latter purpose the above study was undertaken.

In recent years, questionnaire survey has been increasingly used as a data collection tool in hospital FM KPI studies. In these studies, statistical analyses were conducted to confirm the validity of KPIs in a sampled population [22] or to examine the influence of the KPIs on FM performance [21-22]. Assuming that the profile characteristics of sampled FM practitioners would influence their understanding of KPIs, statistical tests were conducted to identify the significance of difference in the responses of different respondent groups [20]. In the current study, the survey respondents were grouped by job nature, job role and job level, followed by a series of statistical tests on any significant difference between the different groups of responses. The test results essentially revealed which among the KPIs studied, as long as their importance levels are concerned, are different from the perspectives of the surveyed practitioners.

The KPIs studied above incorporated the KPIs developed in other, past studies in the realm of hospital FM. Yet as pointed out earlier, *facility condition index* is a rather common performance metric in some overseas places. It is worth investigating any reasons for having this indicator regarded by the surveyed practitioners as of low importance. Other indicators (e.g. "*Maintenance cost per building area*") seemingly have overlap in representation (c.f. "*O&M cost per building area*"). Whether such indicators should be combined in order to reduce the total number of KPIs, thereby enabling a more effective implementation of the KPIs in practice, is a further question to be explored in future.

5. Conclusions

Covering two renowned literature databases and using keywords pertinent to the topic of this study, the four-stage systematic literature review revealed that studies on performance indicators for hospital FM continue to grow. Besides the commonalities and differences between the literature identified, the review found that both FM and non-FM practitioners, such as design and construction practitioners, were involved in past studies on KPIs development. While research had investigated the opinions of different types of practitioners (e.g. designer, medical staff) on the importance of KPIs, studies that cross-compare the perspectives of different groups of building practitioners (with different job natures, job roles and job levels) are limited.

To bridge the above knowledge gaps, this study was conducted with a questionnaire survey to solicit the perceived importance of building practitioners on 18 hospital FM performance indicators that were shortlisted from an earlier focus group study. The indicators fell into four categories (i.e. physical, safety, environmental, and financial) and a series of statistical analyses on the primary survey data showed that the practitioners generally regarded the physical and financial performance indicators as more important. Availabilities of two critical facilities in hospitals (namely lift system and fire services system) were the top two performance indicators. Moderately positive correlations were found between the indicators' importance rankings pertaining to the different groups of the building practitioners, regardless of their job nature (owner vs. service provider) or job role (FM vs. DC). Yet, no significant correlation was found between the importance rankings corresponding to the junior and senior groups of participating practitioners, indicating that job level matters in determining the importance levels of the performance indicators.

The statistical analyses made on the importance of the performance indicators between different respondent groups unveiled that in most cases, no significant differences existed between the views of the respondent groups being compared. Nevertheless, when compared between the perspectives of the FM and DC groups, significant differences were found with three of the indicators, viz., *availability of fire services system* (P3*), energy utilization index* (E1) and *carbon emissions per building area* (E2). When comparisons were made between the respondent groups at different levels (senior vs. middle), significant differences were found with the two safety performance indicators (S1 and S2). While plausible reasons for these observations have been suggested in the preceding discussion, further work should take an interpretivist approach, for example using interviews or in-depth case studies, to verify the reasons suggested.

The practicality of the performance indicators in real-world hospitals should also be investigated further. To test the applicability of the indicators in practice (vis-à-vis the perception-based approach adopted in this present study), empirical data of hospital facilities should be collected (e.g. downtime of lifts - for determining indicator P4; and building energy consumption - for determining indicator E1). To further obtain a holistic evaluation of hospital FM performance, it is necessary to analytically determine the importance weighting of each of the performance indicators, for example, with a multiple-criteria decision analysis that makes use of the Analytic Hierarchy Process or the Analytic Network Process.

Like many other studies, the study reported above is not without limitations. First, the findings from the systematic literature review are limited by the literature databases covered and the keywords used in the literature search process. Review work in future may extend to cover other literature databases, using not only the keywords used in the search process of this study but also synonyms of those keywords. Second, although measures had been taken in this study to ensure the data quality and the reliability of the questionnaire, the sample sizes of the subgroups analysed are not large. Future studies of this kind should endeavour to enlarge the sample of responses such that the results of analysis could be generalized.

Acknowledgement

This study was supported by a grant from the Research Grants Council of the Hong Kong Special Administrative Region, China (Project No. PolyU 152155/17E).

Appendix

Table A.1 Performance indicators for hospital FM

Aspect	Performance indicator	Definition
Physical	[P1] Work request response rate	Ratio of number of FM work requests remaining in "request" status for less than 5 days to total number of work orders done over the assessment period.
	[P2] Number of completed work orders per staff	Ratio of number of FM work orders completed to average number of FM staff over the assessment period.
	[P3] Availability of fire services system	Ratio of uptime of fire services system to sum of its uptime and downtime over the assessment period.
	[P4] Availability of lift system	Ratio of uptime of lift system to sum of its uptime and downtime over the assessment period.
	[P5] Average age of major facilities (e.g. chiller, boiler)	Ratio of current year required renewal cost to current building replacement value.
	[P6] Facility condition index (FCI)	Ratio of sum of ages of the major facilities to number of major facilities.
Safety	[S1] Number of accidents per year	Number of accidents (injuries or casualties) arising from underperformance of facilities over the assessment period.
	[S2] Number of unwanted (false) fire incident calls per year	Number of unwanted (false) alarms arising from fire services equipment faults over the assessment period.
	[S3] No. of statutory orders per year	Number of statutory orders (e.g. abatement/ improvement notices etc. requiring investigations, repairs or rectifications etc.) issued by government departments over the past 12 months.
	[S4] No. of statutory orders per 5 years	Number of statutory orders (e.g. abatement/ improvement notices etc. requiring investigations, repairs or rectifications etc.) issued by government departments over the past 5 years.
Environmental	[E1] Energy utilization index	Ratio of total annual equivalent energy consumption over the assessment period to total internal floor area of the building.
	[E2] Carbon emissions per building area	Ratio of total amount of carbon emission over the assessment period to total internal floor area of the building.
Financial	[F1] Actual costs within budgeted costs	Ratio (in percentage) of total FM cost actually expended to total FM budget over the assessment period. (Note: FM cost includes costs for operation, maintenance, cleaning, security services, etc.)
	[F2] O&M cost per building area	Ratio of cost expended on O&M works during the assessment period to total internal floor area of the building.
	[F3] Energy cost per building area	Ratio of energy cost during the assessment period to total internal floor area of the building.
	[F4] Facilities management cost per building area	Ratio of FM cost during the assessment period to total internal floor area of the building. (Note: FM cost includes costs for operation, maintenance, cleaning, security services, etc.)
	[F5] Maintenance cost per building area	Ratio of annual maintenance expenditure during the assessment period to total replacement value.
	[F6] Annual maintenance expenditure of total replacement value	Ratio of annual maintenance expenditure during the assessment period to total replacement value.

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