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Key performance measures to control maintenance-associated HAIs

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Abstract:
Purpose: The aim of this research study is to improve the overall level of performance of HM services in the control of HAIs in the NHS. Hence, the identification of the critical success factors (CSFs) and key performance measures in the control of maintenance-associated HAIs.
Design/methodology/approach: The CSFs and performance measures in HM in IC were initially identified through the application of grounded theory analysis. In round one of the Delphi exercise, the complete lists of CSFs and performance measures were presented to the Delphi participants for refinement and modification. The results of the Delphi round one exercise were analysed manually and used to refine the rounds two and three Delphi instruments. In subsequent Delphi rounds, the results were recorded using statistical software called Statistical Package for Social Sciences Statistics (SPSS) version 21, and analysed through descriptive statistics.
Finding: In total, eight CSFs and fifty-three key performance measures are identified for reducing the burden of maintenance-associated HAIs in hospitals. For example, establishing clear lines of communication between the ICT (infection control team) and HM unit is important in the prevention of maintenance-associated HAIs in hospitals. Dust prevention is

also identified by the healthcare experts as an important measure to prevent the transmission of maintenance-associated HAIs in high-risk patient areas.
Originality/value: The findings of this research project provide healthcare authorities a list of CSFs and key performance measures for measuring performance in HM in IC. In doing so, the HM unit will be able demonstrate it contribution to the UK's government overall strategy for reducing the prevalence of HAIs in NHS hospitals.

Keywords: CSFs, Delphi, HAIs, maintenance, infection control, performance measures

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Introduction

Hospital-acquired infections (HAIs) are a major problem in the UK and worldwide. The European Centre for Disease Control and Prevention (ECDC) estimate the rate of HAIs in the UK to be 6.0% (ECDC, 2013). In that same study, it is estimated that 1,602 patients in acute care in the UK acquire HAIs every year. Although progress is being made to reduce rates of HAIs, UK is still lagging behind other Western European countries. Figures released by the ECDC (2013) show the rate of *C. difficile* in England higher than in the Netherlands, France, Spain, and Italy. Wales is only next to Hungary, which has the worst rate of *C. difficile* in Europe. High rates of HAIs are of course a huge financial burden for the NHS. The cost of HAI to the NHS is estimated at £1 billion/year (National Audit Office, 2004). Money spent on HAI could be invested into uses that are more productive, e.g. clinical services.

According to the National Audit Office statistics, better infection control practices could reduce the prevalence of HAIs by 15-30% (NAO, 2004). Epidemiological evidence suggests that HAIs can also be caused by the poor performance of Facilities Management (FM) services in infection control. FM services such as cleaning, maintenance, laundry, and catering have a high level of impact on causing HAIs. Of these services, the focus of this study shall mainly be on healthcare maintenance (HM). A thorough review of literature revealed HM as one of the areas with very low level of attention in the control of HAI.

Despite the role of HM in the control of HAI, it has not recieved the level of attention it deserves from healthcare authorities. According to Streifel and Hendrickson (2002), managers generally overlook the risk associated with construction-induced air pollution in hospitals. They do not spontaneously respond to mechanical ventilation deficiencies especially during construction works (Streifel, 2005). In addition, most contractors working on construction-related projects in hospitals are not yet accustomed to taking special precaution when tearing down, maintaining or renovating hospital buildings (Kidd *et al*., 2007). As a result, many patients in hospitals are exposed to the risk of acquiring HAIs. Even where special precautions have been taken, there is doubt whether in reality facilities actually manage special ventilation areas to the designed parameters specified in various guidelines (Streifel, 2005). Because the HM is always looking for ways to save money (Quayle, 1997, as cited in Riley *et al*., 2004), they often do not border to measure performance in infection control (IC). Where performance is measured, it is mainly on ad hoc basis to meet legislative compliance.

The aim of the research study was to identify the critical success factors (CSFs) and key performance measures to control maintenance-associated HAIs in Acute NHS Trusts in

England. This was achieved through the application of the Delphi aproach with selected NHS experts. This research paper is divided into six main sections. The first and second sections focus on the introduction and application of the Delphi technique respectively. In the other sections, the results of the three round Delphi exercises are examined.

Research method

Gupta and Clarke (1996: 185) define Delphi as a qualitative, long-range forecasting technique that elicits, refines and draws upon the collective opinion and expertise of a panel of experts.

A review of the literature suggests that the numbers of rounds in most Delphi studies are variable. Since a three round Delphi appears ideal for most studies (Delbecq *et al*., 1975, as cited in Skulmoski *et al*., 2007), this research study also had three Delphi rounds. The Delphi participants in this research study were purposively selected on the basis of their experience and knowledge of HM and IC. Since Delphi relies on expert opinion for credibility, stringent criteria were used for the selection of prospective Delphi participants. Prospective Delphi participants were considered eligible if:

1. They were people who were experiencing and labelling the reality under investigation. In this research study, this includes HM managers and IC members (i.e. IC doctors, nurses and microbiologist).
2. They occupied the position of HM manager or IC member in an Acute NHS Trust, and had work experience in the same role for at least five years.

The round one Delphi instrument was designed to elicit qualitative responses from the Delphi participants. The first section of the round one Delphi instrument was about the Delphi participants' generic information. In the second section, participants were provided with a list of performance measures grouped under eight CSFs. The Delphi participants were then given the task of identifying new ones. The results of the first round Delphi exercise (mainly section two) were used to modify the second round Delphi instrument. The Delphi participants provided comments and suggestions that led to re-wording, and in some instances, the re-structuring of sections of the Delphi instrument. Because of the small number of responses, the Delphi results were analysed manually.

In the second round of the Delphi exercise, participants were asked to rate the level importance of different performance measures in HM in IC. The rating was based on a four point likert scale, whereby, scales 1 and 2 (very important + important) represented the positive category and scales 3 and 4 (unimportant + very unimportant) the negative category. The Delphi participants were provided with clear instructions on how to complete the round two Delphi exercises. The completed round two Delphi were assigned the same unique numbers as in round one according to participants. These were saved in a folder entitled 'round two Delphi answers'. The performance measures were recorded using statistical software called Statistical Package for Social Sciences Statistics (SPSS) version 21, and analysed through descriptive statistics.

Consensus in this research study was achieved through the application of the arithmetical mean (hereafter the mean).

McDonald (2009) defines the mean as the sum of the observations divided by the number of observations. The popularity of the mean as the most commonly used statistics of central tendency (McDonald, 2009) makes it a suitable technique for establishing consensus in Delphi. Unlike other measures of central tendency, the mean takes into account every

variable in the dataset (McDonald, 2009). Thus, for a performance measure to be retained in a Delphi round, the Delphi participants needed a group mean score of at least 3.28. Any performance measure with a group mean score of less than 3.28 was re-submitted to the Delphi participants for re-rating. There is no standard criterion for defining and determining consensus in Delphi (Boote *et al*., 2006).

According to Boote *et al.* (2006), the criterion for determining consensus appears …to be an issue for the research team and their advisors.

Performance measures for which the Delphi participants had arrived at a high-level of consensus were retained in the second round of the Delphi exercise. However, those with low-level consensus were re-submitted to the Delphi participants for re-rating in round three of the Delphi exercise. The third round Delphi instrument contained twenty-five performance measures. For each of these performance measures, the Delphi participants were provided with their responses and the percentage score of the entire group in round two. They were then given the choice of either maintaining or re-rating the performance measures on a likert scale of 1–4. The third round Delphi exercise lasted for two weeks. Since the Delphi participants were the same as those who rated the round two Delphi questions, they were assigned the same unique numbers.

As there were two groups of Delphi participants, i.e. HM managers and IC members, it was necessary to investigate how they rated the performance measures in HM in IC. This was achieved through the application of the Mann-Whitney U test. The level of statistical significance in this study was set at $p = < 0.05$.

The results of Delphi round 1

Out of the 320 invitations sent to prospective Delphi participants via post, only 40 (13%) were returned. However, because of issues with the returned forms, only 27 (8.4%) Delphi participants were nominated for participation in the Delphi study. This included 14 (52%) IC members and 13 (48%) HM managers. Out of the remaining 13 Delphi nominees, four did not have the required level of work experience, which had been set at five years. In three of the forms, it was reported that the individuals had retired or no longer worked for the Acute NHS hospital. The last six forms contained email addresses that could not be read. Attempts to match the email addresses with names on the inventory did not help.

Although 27 NHS professionals accepted to take part in this research, not all of them returned the first round Delphi instrument. In total, only 20 (74%) Delphi participants returned the first round Delphi instrument. Out of this number, there were 11 (55%) IC members and 9 (45%) HM managers. On average, the work experience of the IC members and HM managers were 10 and 9 years respectively. One of the HM managers who participated in the Delphi exercise was also head of facilities in an Acute NHS Trust. The professional experience of the Delphi participants was more than the five years initially set for this research study. Thus, logically, it can be said that the Delphi participants had the required level of professional experience and knowledge to participate in this study.

In the first round Delphi exercise, participants were presented with a list of fifty-six performance measures grouped under eight CSFs. They were given the task of identifying new CSFs and performance measures. Although the Delphi participants did not identify any new CSF, they however identified eleven new performance measures. Out of the eleven performance measures, only six (identified as R2 in Table I) were added to the second round Delphi questions. Some of the round one Delphi instruments were received after the start of the second round of the Delphi exercise. Analysis of the Delphi instruments revealed five

new performance measures. Since the second round Delphi exercise had already started, these performance measures (identified as R3 in Table I) could only be included in the third round questions. As shown in Table 1, the Delphi participants only identified new performance measures for four CSFs.

Table I: Performance measures identified in Delphi round one

CSFs and New Performance Measures	Delphi Round included
A. Maintenance Resources Availability	
1. Develop processes to control the introduction of new equipment/fabric that can be maintained efficiently and reduce the risk of HAIs (cheap capital purchases may be more expensive to maintain in the long term and pose a risk of HAIs).	R.2
2. Use risk assessment in maintenance-associated HAIs to direct maintenance resources to highest-risk activities.	R.3
3. Involve the HMU and IC department in the purchase of maintenance materials and products.	R.3
B. Maintenance Strategies	
4. Prioritise and respond to building defects on time to minimise the risk of HAIs.	R.2
5. Introduce computer system that promotes mobility and allows maintenance staff to carry all the information they require, and communicate back to coordinators when job cannot be completed first time (so that parts/people can be planned in swiftly for revisit).	R.2
6. Both the HM and IC teams to develop a water safety plan (reviewed annually) to identify, manage and control risks of waterborne infections associated with maintenance activities.	R.3
C. Infection Control practices – ***Administrative Requirement***	
7. Ensure in-house staff and contractors work on the same clear guidelines.	R.2
8. Have an agreed HAI plan to control all construction on site. This needs to be reviewed annually to monitor/review/assess level of compliance and provide annual improvement action plan based on benchmark findings (based on previous years).	R.3
9. Develop a work culture that supports prioritisation of maintenance work in infection control.	R.3
D. Customer Satisfaction	
10. Ensure visual display of response to complaints.	R.2
11. Measure the number of completed maintenance jobs that fail to meet the required standard in infection control.	R.2

R.2 - Round 2, R.3 – Round 3

The results of Delphi round 2

In the second round of the Delphi exercise, the number of Delphi participants reduced from 20 to 15. Therefore, the rate of attrition from the first to the second Delphi rounds was 25%. Out of the fifteen responses, nine came from IC members, and six from HM managers. As reiterated earlier, for a performance measure to be retained in a Delphi round, the two groups of Delphi participants needed a combined mean score of 3.28 or above. In the second Delphi instrument, there were 62 performance measures. However, as shown in Table II, only 42 performance measures were retained in the second round of the Delphi exercise. Table II is divided into four sections to clearly show those performance measures which were retained under the eight CSFs. The remaining 20 performance measures with low-level consensus in round two constituted part of the round three Delphi instrument (refer to Table III). As shown in Table IIA, the Delphi participants agreed that securing adequate maintenance resources is important for mandatory and operational compliance in IC. The condition of hospital building and infrastructure is supposed to be reviewed and feed into investment program in IC. In addition, a process ought to be in place for the introduction of new and quality maintenance equipment/fabrics to prevent maintenance-associated HAIs.

Out of the seven performance measures that were categorised under maintenance strategies, only three were retained in round two of the Delphi exercise. The prioritisation and timely execution of all planned maintenance work posing the risk of HAI, as well as the introduction of a computer system to facilitate the coordination of maintenance staff and equipment around hospital are also important in IC. As shown in Table IIIA, the two groups

of Delphi participants disagreed significantly on a number of performance measures. For example, there was disagreement (p = .006) about the application of a computer-based system to control maintenance-associated HAIs (refer to Table IIIA). Disagreement (p = .029) also occurred about conducting daily checks of all critical maintenance equipment posing a risk of HAIs. On both performance measures, HM managers achieved a higher level of consensus than IC members did. All those performance measures with significant difference in opinion between HM managers and IC members were not retained in the second round of the Delphi exercise.

Table 1: Round Two CSFs and Performance Measures in HM in IC
Table 2A: Maintenance resource availability and strategies

CSFs and Performance Measures **A. Maintenance Resource Availability**	***N***	**Mean HMM**	**Mean ICM**	**Combined Mean**	**Mann-Whitney U test (*p*)**
1. Secure adequate resources for mandatory and operational compliance of the healthcare maintenance unit in infection control.	15	3.833	4.000	3.9333	.221
2. Review condition of hospital building services & infrastructure to feed into investment program	15	4.0000	3.7778	3.8667	.231
3. Develop processes to control the introduction of new equipment/fabric that can be maintained efficiently and reduce the risk of HAIs.	15	3.8333	3.8889	3.8667	.765
4. Quality maintenance materials and products to be purchased from reliable suppliers	15	3.3333	3.3333	3.3333	.842
B. Maintenance Strategies					
5. Ensure the timely execution of all planned maintenance work posing risk of infection.	15	3.8333	3.6250	3.7143	.411
6. Prioritise and respond to building defects within time-critical period to minimise the risk of HAIs	15	3.5000	3.6000	3.6000	.533
7. Introduce computer system to promote mobility and allow maintenance staff to carry all the information they require, and communicate back to coordinators when job cannot be completed first time.	15	3.6667	3.1111	3.3333	.084

Results are statistically significant at $p < 0.05$ level
(HMM - Healthcare maintenance manager; ICM – Infection control member

The CSF called infection control practices was divided into three sections: cleaning, transport and administrative requirements. In total, the three sections contained 18 performance measures. Out of the eight performance measures categorised under cleaning requirement, high-level consensus was achieved on six. There Delphi participants agreed on the prevention of airborne dusts dispersing into high-risk patient areas. Other important performance measures agreed by the Delphi participants are on hand hygiene compliance and use of personal protective equipment. Three important performance measures were also agreed under the transport requirement. This relates to the use of health and safety signage, transportation of maintenance waste, including clean and sterile equipment. Five important performance measures were agreed under the administrative requirement. The Delphi participants agreed that HM staff should inform charge nurses about the commencement of any work posing the risk of HAIs. Participants also agreed that in-house and contracted staff work under the same standards in IC, and that infection control policies and guidelines in IC be reviewed regularly. However, concerning the HM unit obtaining infection control permits from the IC department and assessing patients for risks of maintenance-associated HAIs, the two groups of Delphi participants disagreed significantly (p = .028). As shown in Table IIB, the mean score for IC members was 3.8889 (high-level consensus), and for HM managers it was only 3.1667 (medium consensus). Further disagreement (P = .066) also occurred about the adoption of a safe working system for maintenance staff in IC. Still, the level of consensus for this performance measure was higher for HM managers than IC members. One

performance measure was not retained under the administrative requirement. This was about the pre-employment health check and immunisation program for HM staff.

The CSF called risk assessment contained four performance measures. The Delphi participants agreed that all the stakeholders of the HM unit should be involved in risk identification and response. Besides educating HM staff on risk identification and responsibility, it is also agreed that a system be put in place for reporting, managing, and analysing complaints and incidents involving the HM unit in IC.

Table IIB: Infection control practices and risk assessment

C. **Infection Control Practices** - ***Cleaning Requirement***	***N***	**Mean HMM**	**Mean ICM**	**Combined Mean**	**Mann-Whitney U test (*p*)**
8. Provide active means to prevent airborne dust from dispersing into high risk patient areas.	15	4.0000	4.0000	4.0000	1.000
9. Compliance with hand hygiene whilst working in clinical areas	15	4.0000	3.7778	3.8667	.231
10. Compliance with the use of personal protective equipment as required	15	4.0000	3.7778	3.8667	.231
11. Report any injury especially if 'sharp' related, cover wounds or sores.	15	3.8333	3.5556	3.6667	.280
12. Maintenance staff must not work in clinical areas if any symptoms of infection exist i.e. diarrhoea or vomiting (seek advice from the ICT).	15	3.2000	3.8889	3.6429	.193
13. Conduct maintenance work in a manner that eases cleaning.	14	3.3333	3.4444	3.4000	.598
– ***Transport Requirement***					
14. Health & safety signage used	15	3.4444	3.4667	3.4667	1.000
15. Contain construction waste before transport in tightly covered containers.	15	3.5556	3.4000	3.4000	.146
16. Transport clean and sterile equipment to storage areas via route that minimises contamination.	15	3.5556	3.4000	3.4000	.678
– ***Administrative Requirement***					
17. Inform Charge Nurse before commencement of maintenance work.	15	4.0000	3.8889	3.9333	.414
18. Ensure in –house and contractors work to same clear guidelines	15	3.8333	3.7778	3.8000	.799
19. Maintain and review infection control policies and procedures.	15	3.6667	3.5556	3.6000	.595
20. Before commencement of maintenance work, obtain infection control permit, and assess patients for risk of maintenance-associated HAIs.	15	3.1667	3.8889	3.6000	.028*
21. Put in place safe working system for maintenance staff in infection prevention.	15	3.8333	3.3333	3.5333	.066*
D. Risk Assessment					
22. Involve all stakeholders in risks identification and response (i.e. the ICT).	15	3.5000	3.7778	3.6667	.280
23. Educate staff and set clear lines of individual responsibility in managing the risk of maintenance-related infections.	15	3.5000	3.4444	3.4667	.837
24. Process for reporting, managing, and analysing complaints and incidents in infection control.	15	3.5000	3.3333	3.4000	.533

Results are statistically significant at $p < 0.05$ level
(HMM - Healthcare maintenance manager; ICM – Infection control member

Under 'liaison and communication', the Delphi participants achieved high-level consensus on five performance measures (refer to IIC). The Delphi participants agreed about the establishment of early consultation and authorization from the IC department on IC issues. As well as seeking professional advice, it is also agreed that HM workers liaise with individuals in charge of the work areas i.e. consultants, doctors, nurses, and domestic staff regarding cleaning during and on completion of maintenance work. Because most hospitals now contract-out HM work, communication channels are also needed between in-house and contracted maintenance staff on IC issues. Other important performance measures include safe record keeping, mandatory codes of conduct, as well as contractors taking responsibility for any unsafe equipment or practice posing the risk of HAIs.

Table IIC: Liaison and communication and service level agreement

E. Liaison and Communication with ICT	***N***	**Mean HMM**	**Mean ICM**	**Combined Mean**	**Mann-Whitney U test (*p*)**
25. Early consultation & authorization from the Infection Control Team before commencement of any maintenance work posing the risk of HAIs.	15	4.000	4.0000	4.0000	1.000
26. Seek the advice of the Infection Control Team (ICT) on such matters concerning infections.	15	3.8333	4.0000	3.9333	.221
27. Liaise with person in charge of area where maintenance is to be carried.	15	3.8333	3.6667	3.7333	.490
28. A system for maintenance staff to liaise with domestic staff regarding cleaning during and on completion of work	15	3.3333	3.6667	3.5333	.221
29. Set communication channel between maintenance staff and contracted staff.	15	3.1667	3.4444	3.3333	.465
F. **Service Level Agreement** – ***Contract Requirements***					
30. Contractor should have safe record keeping, and adhere to mandatory code of conduct in infection control.	15	3.8333	3.6667	3.7333	.490
31. Contractor should have arrangement to response to emergency calls.	15	3.6667	3.4444	3.5333	.586
32. Contractor should have procedure to supervise maintenance work and variables i.e. spares etc.	15	3.5000	3.2222	3.3333	.280
33. Select contractors on their strong technical, resource, managerial, and communication capabilities.	15	3.5000	3.1250	3.2857	.139
– ***Contracted Staff Requirements***					
34. Contractors have to take responsibility for any unsafe equipment, or practice posing risk of infection.	15	3.8333	3.7143	3.7692	.626

Results are statistically significant at $p < 0.05$ level
(HMM - Healthcare maintenance manager; ICM – Infection control member

The CSF referred to as staff education was divided into two sections: staff training and staff development. As shown in Table IID, five important performance measures were agreed under staff education. The Delphi participants agreed on the training of HM staff on statutory and technical guidance on IC. Besides the employment of skilled and competent maintenance staff, it is also agreed that site induction be provided to HM staff on IC. Under staff development, the Delphi participants agreed on the representation of the HM unit in infection prevention and control, risk/governance committee. The continuous development of HM staff on risk assessment and management is also accepted as important performance measure to control HAIs in hospitals. Out of the six performance measures categorised under 'customer satisfaction', only three achieved high-level consensus (refer to Table IID). The Delphi participants agreed about the measurement of the number of maintenance works that fail to meet the required standards in IC. The other two important performance measures concern the review and analysis of complaints, as well as the speed of the HM unit to response to work request with potential risk of HAIs.

In the second Delphi round, there were 17 performance measures that only one group of Delphi participant achieved high-level consensus. Of the 14 performance measures on which HM managers alone achieved consensus, six were retained in the second round of the Delphi exercise. Conversely, on the remaining three performance measures, high-level consensus was achieved by IC members alone. The three performance measures were retained in the second round of the Delphi exercise. All the performance measures in round two of the Delphi exercise with low-level consensus were re-submitted to the Delphi participants for re-rating.

Table IID: Staff education and customer satisfaction

G. **Staff Education** – ***Staff Training***	***N***	**Mean HMM**	**Mean ICM**	**Combined Mean**	**Mann-Whitney U test (*p*)**
35. Provide all maintenance staff with information on statutory and technical guidance on infection control.	15	3.6667	3.5556	3.6000	.678
36. Employ skilled and competent staff to ensure safe and efficient maintenance operations.	14	3.8333	3.2500	3.5000	0.91*
37. Conduct site induction on infection control within few weeks of employment.	15	3.5000	3.2222	3.3333	.426
– ***Staff Development***					
38. The maintenance department should be represented in infection prevention & control, risk/governance committees.	15	3.6667	3.6667	3.6667	.761
39. Educate maintenance staff on the assessment and management of risk in maintenance-associated hospital-acquired infections (HAIs).	14	3.6000	3.3333	3.4286	.352
H. Customer Satisfaction					
40. Measure the number of completed maintenance jobs that failed to meet the required standard in infection control.	14	3.3333	3.6250	3.5000	.298
41. System to review, analyse complaints against maintenance services, and recommend improvement	15	3.5000	3.4444	3.4667	.838
42. Measure the speed to response to maintenance request	15	3.6667	3.2222	3.4000	.188

Results are statistically significant at $p < 0.05$ level
(HMM - Healthcare maintenance manager; ICM – Infection control member

The results of Delphi round 3

In the third round of the Delphi exercise, there were 15 participants - the same participants as in round two of the Delphi exercise. Of the 25 performance measures contained in the third round Delphi instrument, 20 were re-introduced from the second round of the Delphi exercise. The remaining five performance measures were re-introduced from the first round of Delphi exercise. As pointed out earlier, some round one Delphi instruments were submitted late, after the commencement of the second round of the Delphi exercise. Of the 25 performance measures contained in the third round Delphi instrument, consensus was achieved on 11. As shown in Table III, the results of the round three Delphi exercise are presented in four section according to the CSFs in HM in IC. Out of the three performance measures contained under 'maintenance resource availability', two were newly introduced from round one. As shown in Table IIIA, the only performance measure that the Delphi participants achieved high-level consensus was newly introduced from round one. This is about the use of risk assessment to direct resources to maintenance activities posing the risk of HAIs. The Delphi participants did not agree about the involvement of the HM unit and IC department in the purchase of maintenance materials and products. They also failed to achieve high-level consensus about the matching of monthly expenditure against maintenance budget in IC.

Out of the five performance measures under maintenance strategies, four were re-introduced from the second round of the Delphi exercise. Of these five performance measures, high-level consensus was achieved on three. An important performance measure under this category is about the development of a water safety plan to identify, manage, and control the risk of waterborne infections in maintenance. As shown in Table IIIA, the grouped mean score for HM managers and IC members was 3.9167. Two other important performance measures were agreed under maintenance strategies. The first is about the HM unit keeping account of the effectiveness of all critical maintenance equipment/assets that may cause HAIs. In round three, the combined mean score for HM managers and IC managers increased from 3.2667 to 3.4000 (0.1333). The Delphi participants also achieved high-level consensus on the application of a computer-based maintenance system (i.e. reliability-centred maintenance) to coordinate maintenance work in IC. Although the mean

score for IC members went up by 0.1111, they only attained medium-level consensus. In contrast, the mean score for HM managers went up by 0.7222, and they were able to achieve high-level consensus. The Mann-Whitney U test shows a significant difference (p = .007) between the HM managers and IC members. Despite the difference between HM managers and IC members, the Delphi participants achieved a combined mean of 3.4000. The performance measure on the daily check of all critical maintenance systems posing the risk of HAIs did not achieve high-level consensus amongst the Delphi participants.

Table III: Round Three CSFs and Performance Measures in HM in IC
Table IIIA: Maintenance resource availability and strategies

CSFs and Performance Measures **A. Maintenance Res. Availability**	***N***	**Mean HMM**	**Mean ICM**	**Comb. Mean (R3)**	**Mann-Whitney U test (*P*) R3**	**Consensus / retention**	**Comb. Mean R2**	**Mann-Whitney U test (*P*) R2**	**Difference in Mean (R3 –R2)**
1. Use risk assessment in maintenance-associated HAIs to direct maintenance resources to highest risk activities.	11	3.4000	3.5000	3.4545	1.000	**High/R**	-		-
2. Involve the HMU and IC department in the purchase of maintenance materials and products	12	3.2000	3.2857	3.2500	.926	Medium/ NRT			-
3. Conduct monthly review of expenditure against budget in IC.	15	2.6000	2.5556	2.6000	.678	Medium/ NRT	2.6000	.678	0
B. Maintenance Strategies									
4. The development of a water safety plan (reviewed annually) by maintenance and infection control teams, to identify, manage and control risks of waterborne infections associated with maintenance activities.	15	4.0000	3.8571	3.9167	.398	**High/RT**	-		-
5. Keep account of the effectiveness of all critical maintenance equipment/assets that may cause HAI.	15	3.5000	3.3333	3.4000	.533	**High/RT**	3.2667	.107	0.1333
6. Use a computer-based maintenance system (i.e. reliability-centred maintenance) to coordinate all maintenance work.	15	3.8333	3.1111	3.4000	.007*	**High/RT**	3.2667	.006	0.1333
7. Daily check of all critical maintenance systems posing the risk of HAIs	15	3.5000	3.1111	3.2667	.221	Medium/ NRT	3.2667	.029	0
8. Categorize hospital assets, and maintenance equipment into significant and non-significant items in infection control	15	2.8333	3.0000	2.9333	.500	Medium/ NRT	2.9333	.697	0

Results are statistically significant at $p < 0.05$ level
(HMM - Healthcare Maintenance Managers; ICM – Infection Control Member; R – Delphi Rounds, RT – Retained, NRT – Not Retained)

The CSF called infection control practices was divided into three categories; it contained seven performance measures (refer to Table IIIB). The two performance measures presented under cleaning requirements were from the second round of the Delphi exercise. None of the aforementioned performance measures achieved high-level consensus. The Delphi participants did not consider the washing and sanitisation of drainage equipment and temporal hand-washing facilities important in IC. Under transport requirements, the performance measure on the re-direction of pedestrian traffic from maintenance work areas did not also achieve consensus. Although the level of consensus increased slightly in round

three, the two groups of Delphi participants only arrived at a medium level of consensus. The combined mean score increased from 2.8667 in round two to 3.2000 in round three (+ 0.3333). There were three performance measures under administrative requirements. Two of these performance measures were newly introduced in round three of the Delphi exercise. One of the newly introduced performance measures on the development of a work culture that supports the prioritization of maintenance work in IC achieved high-level consensus. The second performance measure on the development of a construction HAI plan to manage the activities of contracted staff in IC did not achieve high-level consensus. The pre-employment health check and immunization program for maintenance staff that was re-introduced from round two of the Delphi exercise achieved high-level consensus. The level of consensus for both groups of Delphi participants increased from 3.2667 to 3.4286.

There was only one performance measure under the CSFs called risk assessment. This was about the application of a recognised risk assessment tool to minimise the level of risk of maintenance-associated HAIs. In round three of the Delphi exercise, the mean score for HM managers fell from 3.3333 to 3.0000 (- 0.3333). On the other hand, the mean score for IC members increased from 3.2222 to 3.3333 (+1111). However, with a combined mean score of 3.2000 (medium level-consensus), the performance measure was not added to the lists of key performance measures.

Table IIIB: Infection control practices and risk assessment

C. Infection Control Practices – ***Cleaning Requirement***	***N***	**Mean HMM**	**Mean ICM**	**Comb. Mean (R3)**	**Mann-Whitney U test (*P*) R3**	**Consensus/ retention**	**Comb. Mean R2**	**Mann-Whitney U test (*P*) R2**	**Difference in Mean (R3 –R2)**
9. Wash and sanitize drainage equipment after use.	15	3.5000	3.0000	3.2000	.255	Medium/ NRT	3.2143	.400	- 0.0143
10. Provide temporal hand washing facilities for maintenance staff working in high risk patient areas.	15	3.3333	3.1111	3.2000	.569	Medium/ NRT	3.0000	.486	0.2
– ***Transport Requirements***									
11. Redirect pedestrian traffic from work area.	15	3.1667	3.0667	3.2000	.572	Medium/ NRT	2.8667	.673	0.3333
– ***Administrative Requirements***									
12. Develop a work culture that supports prioritization of maintenance work in infection control.	12	3.4000	3.7143	3.5833	.558	High/RT			-
13. Pre-employment health check and immunization program for all in-house and contracted maintenance staff.	14	3.5000	3.3750	3.4286	.652	High/RT	3.2667	.699	0.1619
14. Have an agreed HAI plan to control all contract works on site. Review plan annually to see level of compliance and provide annual improvement action plan based on previous year's findings.	13	3.0000	3.0000	3.0000	1.000	Medium/ NRT	-		-
D. Risk Assessment									
15. Use a recognised risk assessment tool (i.e. infection control risk assessment – ICRA) to match the level of risk associated with maintenance work.	15	3.0000	3.3333	3.2000	.286	Medium/ NRT	3.2000	.943	0

Results are statistically significant at $p < 0.05$ level
(HMM - Healthcare Maintenance Managers; ICM – Infection Control Member; R – Delphi Rounds, RT – Retained, NRT – Not Retained)

As shown in Table IIIC, under the CSF called liaison and communication, there was only one performance measure. This concerned 'holding regular meetings between HM managers, IC, and clinical representatives to ensure maintenance work complements clinical care'. As the combined mean score for both groups of Delphi participants went up from 3.2000 in round two to 3.3333, the performance measure was included in the list of key performance measures in HM in IC. Under the CSF called service level agreement (SLA), there were three performance measures. The Delphi participants agreed that taking into account changes in assets and legislation when renewing contracts with external providers is important in IC. In terms of consensus, the mean score for HM managers increased from 3.1667 to 3.8666 (+ 0.6666) in round three. The mean score for IC members also increased, from 3.1111 to 3.2222 (medium-level consensus) in round three. As shown in Table IIIC, there was a significant difference (P = .025) in the level of agreement between HM managers and IC members on this performance measure. Despite this difference, the combined mean score for the two groups of Delphi participants increased from 3.1333 to 3.4667 (+0.3334) in round three of the Delphi exercise. The mandatory induction and training of contracted staff on IC also achieved high-level consensus. As shown in Table III, between rounds two and three of the Delphi exercise, the combined mean score for HM managers and IC members increased from 3.2143 to 3.7143 (+ 0.5). Therefore, the performance measure is considered important in IC and included in the lists of key performance measures. On the other performance measure requiring the HM unit to have customer satisfaction surveys as part of the SLA did not achieve high-level consensus.

Table IIIC: Liaison and communication and service level agreement

E. Liaison Communication with ICT	***N***	**Mean HMM**	**Mean ICM**	**Comb. Mean (R3)**	**Mann-Whitney U test (*P*) R3**	**Consensus/ retention**	**Comb. Mean R2**	**Mann-Whitney U test (*P*) R2**	**Difference in Mean (R3 –R2)**
16. Regularly meet with infection control and clinical representatives to ensure maintenance processes complement clinical care.	15	3.3333	3.3333	3.3333	.894	**High/RT**	3.2000	.601	0.1333
F*. Service Level Agreement – *Contract Requirements									
17. Take into account changes in assets and legislation when renewing contracts.	15	3.8333	3.2222	3.4667	.025*	High/RT	3.1333	.840	0.3334
18. Customer satisfaction surveys should be part of Service Level Agreement with contractors.	15	3.0000	2.8889	2.9333	.673	Medium/ NRT	2.8667	.840	0.0444
– ***Contracted Staff Requirements***									
19. Contracted workers must attend all mandatory induction and training on infection control.	15	3.8333	3.6250	3.7143	.653	**High/RT**	3.2143	.328	0.5

Results are statistically significant at $p < 0.05$ level
(HMM - Healthcare Maintenance Managers; ICM – Infection Control Member; R – Delphi Rounds, RT – Retained, NRT – Not Retained)

The CSF called staff education contained three performance measures. The Delphi participants achieved high-level consensus on the annual review of staff training, HM staff team briefings and appraisal schemes in IC. However, they did not achieve consensus about equal access and improve working lives for HM staff. The Delphi participants did not achieve

high-level consensus in all three performance measures categorised under customer satisfaction. The first had to do with the measurement of the number of maintenance products that fail to conform to request'. The mean score for IC members stayed the same for the two Delphi rounds. As shown in Table IIID, the combined mean score for both groups of Delphi participants increased slightly (+ 0.0666) between the Delphi rounds. Nevertheless, in round three, the combined mean for the Delphi participants was only 3.1333. Therefore, the performance measure was not included in the list of key performance measures. The other two performance measures that did not achieve consensus include the 'visual display of response to complaints' and 'making available complaints boxes and leaflets for people to raise issues about the quality of maintenance work'.

Table IIID: Staff education and customer satisfaction

G. **Staff Education** – ***Staff Training***	***N***	**Mean HMM**	**Mean ICM**	**Comb. Mean (R3)**	**Mann-Whitney U test (*P*) R3**	**Consensus/ retention**	**Comb. Mean R2**	**Mann-Whitney U test (*P*) R2**	**Difference in Mean (R3 –R2)**
20. Conduct annual review of staff training.	15	3.5000	3.3333	3.4000	.533	High/RT	3.2667	.785	0.1333
– ***Staff Development***									
21. Maintenance staff team briefings and appraisal schemes in infection control.	15	3.5000	3.1250	3.2857	.270	High/RT	3.2143	.524	0.0714
22. Equal access, and improve working lives for staff.	15	3.3333	2.7778	3.0000	.107	Medium/ NRT	3.0000	.486	0
H. Customer Satisfaction									
23. Measure the number of maintenance products that do not conform to request.	15	3.3333	3.0000	3.1333	.224	Medium/ NRT	3.0667	.724	.0666
24. Ensure visual display of response to complaints.	15	3.1667	2.8889	3.0000	.324	Medium/ NRT	3.0000	1.000	0
25. Make available complaint boxes/ leaflets to enable people to raise issues related to quality of maintenance services.	15	2.8333	2.8667	2.8667	.673	Medium/ NRT	2.8000	.422	.0667

Results are statistically significant at $p < 0.05$ level
(HMM - Healthcare Maintenance Managers; ICM – Infection Control Member; R – Delphi Rounds, RT – Retained, NRT – Not Retained)

Out of the 25 performance measures in the third round of the Delphi exercise, high-level consensus was achieved on 11. In the third round of the Delphi exercise, there were also performance measures with high-level consensus in only one group of Delphi participant. There were eight performance measures on which only HM managers achieved high-level consensus. However, only two of these performance measures were retained as key performance measures. Neither of the two performance measures on which only IC members achieved high-level consensus were considered as key performance measures in the third round of the Delphi exercise.

Discussion and Conclusion

Between round 2 and 3, the Delphi participants identified 53 important performance measures in HM in IC. One of the most important performance measures in HM in IC relates to the prevention of airborne dust from spreading in the healthcare built environment. Dust contamination in hospital wards (especially in high risks wards) is an important factor in the transmission of maintenance-associated HAIs in hospitals. The hands of healthcare workers remain one of the main routes for the transmission of HAIs in healthcare settings (NAO, 2004). According to the Department of Health (DH), poor hand hygiene practices have been linked to infection rates in hospitals (NAO, 2009). Where advised, maintenance staff should protect themselves by using personal protective equipment (i.e. overalls and facemasks). They should also report injuries, especially those related to sharps, and take measures to cover wounds or sores. In the event of symptoms of an infection, i.e. diarrhoea or vomiting maintenance staff should report it to or seek the advice of the ICT. New recruits in the HM unit working in close proximity to patients should undergo pre-employment health checks, and be immunized according to the same standards applied to clinical staff.

Establishing close collaboration between the HM staff and members of the ICT (infection control team) is probably one of the most important CSFs in HM in IC. In fact, the HM unit needs to consult the IC department on all maintenance activities (refurbishment, alteration, maintenance of premises/equipment, etc.) with implications for IC. The consultation process must start early enough to give the ICT time to assess and respond to IC issues. Basing their judgment on sound evidence, the ICT may either recommend that certain measures be put in place before the commencement of the maintenance project, decide to set up a special committee to assess and monitor the impact of any maintenance project from start to completion. In the worst-case scenario, the ICT should be allowed to delay or not approve a maintenance project on IC grounds.

Despite the benefits of the HM unit working close with IC department, the two groups appear to function as separate entities, with the HM unit requesting help from the IC department only on an ad hoc basis. A survey conducted by the NAO (2004) found that 17% of NHS Trusts did not always consult the IC department on issues regarding theatre ventilation or air conditioning/air pressure control systems. A further 22% did not consult the IC department when reviewing plans for alterations and additions to clinical buildings. In this research study, HM managers disagreed significantly with IC members on obtaining infection control permits before the start of maintenance work with implication for HAIs. HM units that fail to liaise and establish clear lines of communication with the ICT are more likely to perform poorly in IC. Communication between the IC members and HM staff (in-house and contracted) is central to good infection control practices.

One of the least developed CSF in HM in IC is customer satisfaction. The word ‘customer’ here refers to anyone (patients, doctors, nurses, etc.) using a healthcare establishment. As in most public organisations, the issue of customer satisfaction has not been addressed sufficiently in the NHS. The business agenda of most privately owned firms is different from that of publicly funded organisations. While private firms strive to make profit, publicly funded organisations do not. HM managers need to put measures in place to listen to the views of its customers. By giving an ‘ear’ to its customers, the HM unit will be in a better position to identify areas for further improvement in IC.

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