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Impacts of facility service procurement methods on perceived performance of hospital engineering services

Introduction

Medical and healthcare services in modern hospitals cannot be adequately delivered without the support of hospital engineering services (HES), such as electricity supply, lighting, cold and hot water supply, drainage, supply of medical gases, air-conditioning and mechanical ventilation, fire services, vertical transportation, etc. Besides the physical facilities, HES include operation, maintenance and repair services as well as professional services pertaining to improvement and upgrading works and maintenance and asset management. To healthcare services providers, these services, though essential, are support services outside their core business. Outsourcing for non-core services from specialized services providers, which has become a common means of facility management (FM) for enhancing cost effectiveness of operations of organizations (Kakabadse and Kakabadse, 2000; Heikkila and Cordon, 2002; Efficiency Unit, 2003; Booty, 2009), has also been increasingly used for procurement of operation and maintenance works for building services systems in the private sector of Hong Kong (Yik and Lai, 2005).

Because failures in support services provision in hospitals could result in far more dramatic negative consequences than in other general types of buildings (Ventovuori, 2006), managements of hospitals would tend to be more cautious in deciding whether or not to outsource for non-core services. Whereas full outsourcing of FM services for hospitals can be successful (Powell, 2002), hospitals with high occupancy levels require the availability of internal work sources for corrective maintenance (Rees 1997; 1998). Facility managers,

therefore, have to strike a proper balance between in-house provision and outsourcing of FM services (Shohet and Lavy, 2004), and may need to be equipped with adequate tools to support decision making (Lavy and Shohet, 2007).

In Hong Kong, the organization responsible for running public hospitals, clinics and the related facilities is the Hospital Authority (HA). Under HA, there are two categories of hospitals, namely Schedule 1 hospitals which were government hospitals, and Schedule 2 hospitals which were subvented hospitals, before the two groups of hospitals came under the common umbrella of HA since its establishment in 1990 (Hospital Authority, 2008). Based on the geographic distribution of these hospitals, they are grouped into clusters, and each cluster may comprise both Schedule 1 and Schedule 2 hospitals.

The Electrical and Mechanical Services Department (EMSD) of the Hong Kong Government used to provide operation, maintenance, repair and professional services for HES in Schedule 1 hospitals (Wan, 1999). At present, these works are rendered by the Electrical and Mechanical Services Trading Fund (EMSTF), which is EMSD's trading arm providing services to various customer departments within the government as well as other organisations, such as HA (Electrical and Mechanical Services Department, 2008). HA and EMSD have established a cooperative partnership relation since 1996, which led to the adoption of Service Level Agreements (SLAs) to define the performance targets and mutually agreed repair and maintenance time and cost rates for HES works in HA's hospitals (Wan, 1999). Schedule 1 hospitals in different hospital clusters are covered by separate SLAs. Unlike Schedule 1 hospitals, HES works in Schedule 2 hospitals are organized in-house, by HA's own FM staff.

Consequent upon HA's continuous endeavour to improve cost effectiveness, some non-core services, such as domestic house keeping and patient transportation, have already been outsourced since 1993 (Wan, 1999), but no change has been made so far to the arrangements for provision of HES (Schedule 1 hospitals by EMSTF and Schedule 2 hospitals by in-house staff). Arguably, HA may be regarded as having been outsourcing for HES for Schedule 1 hospitals, using the first of the four contractual and management arrangements described by Atkin and Brooks (2005), which involves passing to a single organization, here the EMSTF, the full responsibility for managing and providing a whole range of bundled services (Ventovuori, 2006). However, it remained uncertain whether the present arrangements are the most effective.

With a view to enhancing the cost effectiveness of HES delivery in its hospitals, HA has initiated a review of the methods for procurement of HES, including the potential of outsourcing HES from private sector services providers. This entailed a study to be carried out to examine the likely benefits and risks of outsourcing HES works, to inform decision making. As far as outsourcing HES is concerned, the works to be outsourced would be limited to the operation, maintenance and repair services, which may include also first line attendance during contingent situations, and professional services pertaining to improvement and upgrading works and maintenance and asset management.

A crucial part of the study was to ascertain the quality of HES delivery under the current procurement arrangements, as proper assessment of the potential cost saving due to a change in the procurement strategy must take into consideration any associated impacts on the quality of the service (Amaratunga and Baldry, 2003), which is especially important to healthcare facilities. HES in HA's hospitals comprise 16 trades, as shown in Table 1.

Maintenance and repair services for more specialized biomedical equipments, including various kinds of medical, pathological and laboratory equipments, fall outside the scope of HES and are handled separately. Currently, operation, maintenance and repair services for some HES trades have already been outsourced from private sector services providers, both by EMSTF for Schedule 1 hospitals and directly by individual Schedule 2 hospitals.

Table 1 List of HES trades and current procurement modes (in-house or outsourced) for operation, maintenance and repair services

List of HES	**Procurement mode** (Note 1)	
	Sch. 1 hospitals	Sch. 2 hospitals
For Wards or Operating Theatres (OT)		
1. Electricity supply and lighting systems	EMSTF (in-house)	In-house
2. Steam and hot water systems	EMSTF (in-house)	In-house (outsourced for Hospital D)
3. Heating, ventilating and air-conditioning system	EMSTF (in-house); with CCMS outsourced (Note 2)	In-house; with CCMS outsourced (Note 2)
4. Medical gases system	Outsourced	Outsourced
5. Fire fighting and alarm installation	Outsourced	Outsourced
6. Communal aerial broadcasting and distribution	EMSTF (in-house)	In-house
7. Security installation	Outsourced (for burglar alarm system)	Outsourced (for burglar alarm system)
8. Nurse call and bedhead trunking system	EMSTF (in-house)	In-house
9. Pneumatic tube system	EMSTF (in-house)	In-house
For OT specific		
10. Laminar OT ceilings & pendants	EMSTF (in-house)	In-house
Ancillaries		
11. Pathological incinerator	EMSTF (in-house)	In-house
12. Lifts and/or escalators	Outsourced	Outsourced
13. Cold rooms, hot rooms, mortuary chambers	EMSTF (in-house)	In-house
14. Hydrotherapy pool system	EMSTF (in-house)	In-house
15. Town gas installation	Outsourced	Outsourced
16. Potable or non-potable flushing and drainage pump systems	EMSTF (in-house)	In-house

Note 1: The in-house/outsourcing arrangement remarked was drawn from interviews with responsible staff in the hospitals. The extents of outsourcing slightly vary between the hospitals.
Note 2: CCMS denotes Central Control and Monitoring System.

Similar to outsourcing building services maintenance works in the commercial sector, the reasons for outsourcing maintenance and repair services for those trades of HES include (Yik and Lai, 2005):

(a) The trade of HES involves proprietary products; and/or

(b) It is a regulatory requirement that the required maintenance work shall be undertaken by qualified/registered contractors.

This variety of procurement methods concurrently in use allowed a comparison to be made between the performance of the HES procured through the different methods, including through HA's in-house organization and through SLAs with EMSTF, and under each of the two arrangements, with the works undertaken by hospitals' or EMSTF's own staff or by outside contractors. Given that both Schedule 1 and Schedule 2 hospitals are under the same management framework at HA Head Office and at cluster levels while inadequate HES performance would be intolerable in healthcare settings, it was considered reasonable to expect that:

Hypothesis 1: the performance standard of HES of the same kind should be more or less the same, irrespective of the procurement method used.

If the above hypothesis can be shown to be valid, comparison of the cost effectiveness of the different procurement methods may focus simply on the associated costs which, as a matter of course, should include the management costs for ensuring the same performance standards would be achieved. This helps reduce the problem from a two dimensional problem involving quality of services and costs to a more manageable problem that involves simply the costs.

It is also reasonable to expect that the performance standard of different kinds of HES may differ from one another, given that some trades of HES are more complicated and some are by nature more robust than the others. However, if hypothesis 1 is true, then one should find that:

Hypothesis 2: the ranking order of different trades of HES with respect to their performance as perceived by the users should be consistent among different hospitals.

Therefore, rebuttal of hypothesis 2 will also refute hypothesis 1 and thus hypothesis 2 should be subject to test. However, confirming its validity does not mean hypothesis 1 is validated, as making this assertion commits the fallacy of denying the antecedent (Cheung, 2001).

Research methodology

Since the performance standard of HES is multi-faceted, its measurement entails the use of different methods. The quantitative methods being used are laid down in the SLAs (for Schedule 1 hospitals), which include minimum standards on availability of the systems for providing services, response time to fault calls, duration of fault rectification and turn-over time to request for technical advice. The same set of target performance criteria apply equally to Schedule 2 hospitals, which are to be met by the in-house FM teams. Review of sample periodic performance review reports showed that the performance standards are generally met both in Schedule 1 and Schedule 2 hospitals.

However, no assessment had been made of how well the HES are facilitating the users. The study, therefore, included a questionnaire survey of users' perception about the performance of HES under the present procurement arrangements, so as to find out if the different procurement methods in use had significant impacts on the performance of HES. In the survey, the staff members working in hospitals, including medical doctors, nurses, allied

health workers, healthcare related support staff and administrative staff, were regarded as users of HES, and thus the target respondents of the survey.

Scale of users' perception about HES performance

Given that the purpose of the questionnaire survey was to obtain users' perception about the performance of the HES that they had been using, the questionnaire must include a means to allow the respondents to indicate their perception. Among the various means commonly used in empirical research (Flynn et al, 1990; Babbie, 1998; Florza 2002), one that can yield indices that are interval measures linearly related to the performance of the HES as perceived by the users is preferred. With a linear measure of the respondents' perception, mean performance scores can be computed and used as indices of the collective perception of the respondents as well as for ranking the perceived performance of different trades of HES. Furthermore, standard deviations, *t*-statistics and uncertainties can be evaluated to test the significance of the mean performance scores.

In perception surveys, scales with numeric indices arranged in ascending or descending order, such as the Likert and semantic scales (Flynn et al, 1990; Babbie, 1998; Florza 2002), are extensively used. For example, such scales had been used in surveys of service quality of building maintenance providers (Sui et al, 2001), perception of importance and performance of indoor environmental quality of residential buildings (Lai and Yik, 2009) and perceived importance of motives for individual hospitals to join a multi-hospital organization and the performance of such organizations with respect to the motives (Yavas and Romanova, 2005). Similarly, respondents were requested to indicate their perceived performance of the HES in a numeric scale of 5 to 1 in the present survey.

To make it easier for the respondents to unveil their perceived performance of the HES, the numbers in this 5-point scale were also attached to labels that denote different levels of performance, namely Excellent (5), Very Good (4), Good (3), Fair (2) and Poor (1), which resembles a semantic differential scale (Babbie, 1998). 'Good' performance was put at the middle of the scale because this level of performance was expected to be the norm in hospitals, and at each side, there are two levels of performance that are worse or better than 'Good' for the respondents to choose. Strictly speaking, however, whether the different levels of performance, as conveyed by the labels, would bear equal separation distances in the scale of perceived performance as suggested by their respective numbers in the scale would become uncertain. The numbers, therefore, could become just ordinal measures of perceived performance, similar to measurement of utility in economics (Cheung, 2001).

For the purpose of ranking the perceived performance of different trades of HES in the present study, the ordinal measures would suffice. The ranking orders compiled on this basis had been compared with those compiled with reference to the mean scores and no significant differences were found (see later descriptions). However, means and standard deviations of the scores were employed in statistical tests, which involved the assumption that the scale used to measure perceived performance was not departing significantly from a linear scale.

Questionnaire design

The final version of the questionnaire devised for the survey comprises 4 sections. Section 1 was for the respondent to indicate his/her job title/grade, affiliated hospital and ward/facility, the function of the ward/facility and the duration that the respondent had worked in the

ward/facility. For encouraging expression of genuine assessments and opinions, the respondents were not asked to disclose their identities.

Section 2 includes a table that shows a list of trades of HES (same as those shown in Table 1) and, next to the name of each HES trade, the numbers 5, 4, 3, 2 & 1 and a check box. The respondent was requested to unveil his/her perception about the performance of each listed trade of HES by circling the appropriate numeric performance score based on the aforementioned 5-point scale. If a specific trade of HES was not a provision in his/her workplace, the respondent was requested to tick the check box.

There are four questions in Section 3 that inquire into the responsibility and experience of the respondent pertaining to the HES in his/her workplace. Among the questions, one asks the respondent to tell which three trades of HES he/she would regard as performing most satisfactorily and in which aspects; and another one about the aspects of HES performance that the respondent most often found unsatisfactory. The answers to these questions provided a handle to check the consistency of these answers with the performance scores in the preceding section given by each respondent.

The last section invites the respondent to give his/her other comments and/or opinions about HES provisions in his/her workplace for drawing the attention of HA. The respondent was free to express any comment/opinion that he/she may have in this section.

Survey implementation

Five hospitals, labelled here as Hospitals A to E as shown in Table 2, were selected as the target hospitals for the survey according to the criteria below in order to provide a representative cross-section of hospitals under HA.

1. There must be both Schedule 1 and Schedule 2 hospitals in the sample;
2. There must be both acute and non-acute hospitals in the sample; and
3. No more than one hospital should be selected from each hospital cluster.

Table 2 Schedule group and staff establishment in the five target hospitals and the target sizes of respondent groups

Hospital		A	B	C	D	E	Total	% (Note 1)	Survey target %
Schedule Type		1 Acute	1 Acute	1 Non-acute	2 Acute	2 Acute			
Staff categories:									
	Medical	427	536	60	296	431	1750	11	10
	Nursing	1290	1735	513	1057	1285	5879	36	30
	Allied health	353	487	51	256	337	1484	9	10
	Others (Note 2)	1708	1935	568	1220	1572	7003	43	50 (Note 2)
	Total	3777	4693	1192	2829	3625	16116	100	100
	% (Note 1)	23	29	7	18	22	100		

Note 1: Percentage of total number of staff in the category / hospital out of the total number of staff in the five hospitals.
Note 2: Include healthcare related support staff (20%) and administrative staff (30%).

In the interest of shortening the duration of the study, rather than conducting a pilot run to provide a reference for deciding the required sample size for the survey, it was decided to invite a sufficiently large number of target respondents in the five hospitals to respond to the survey right away. For a target statistical power of 0.8 and a significance level of 0.05, the required sample size for small effect is 271 (Florza 2002). Assuming a response rate of about 20%, the total number of questionnaires that had to be distributed should be no less than 1,355. On this basis, it was decided to issue a total of 1,500 questionnaires to the five target hospitals. How representative was the collected sample could then be checked and, if needed,

more questionnaires could be distributed to ensure a sufficiently representative sample would be obtained (this will be discussed later in the section on analysis of the results).

Three hundred (300) copies of the questionnaire were issued to the hospital management of each of the five target hospitals, and through them to the target respondents. A request was also made to the management of each target hospital that the questionnaires should be distributed to different categories of hospital staff according to the target percentages as shown in the last column in Table 2. The respondents were requested to return their completed questionnaires direct to the study team, through the use of the pre-paid envelope attached to the questionnaire.

Questionnaire survey results

Response rate

Out of the 1,500 questionnaires distributed to the staff in the five hospitals, a total of 444 questionnaire returns were finally received, representing an overall response rate of about 30%, which exceeded the original estimate. Table 3 summarizes the number of questionnaire returns received from the staff of the five hospitals, the respective response rates to this questionnaire survey, the number of respondents in different HA staff categories and their duration of work in their current workplace.

Although the percentage of respondents from the doctors category fell significantly below the target (2% vs. 10%), the percentages of respondents from the other staff categories were not far from the targets. The less than expected response rate from doctors was not considered to

be a significant problem because the HES that were being investigated do not include medical equipments operated solely by doctors. Most of the HES, such as air-conditioning and lighting installations, are for maintaining a suitable indoor environment inside various premises in hospitals, and staff category should have little, if any, influence on the judgement of their performance. For other HES, such as medical gases systems, nurses would be present while these systems are being used and thus would be able to tell how well the systems were performing.

Table 3 Number of questionnaires issued and returned, the response rates, number of respondents in different staff categories and distribution of years of work in current workplace of the respondents

Hospital	A	B	C	D	E	n/a	Total
No. of questionnaires issued	300	300	300	300	300		1500
No. of questionnaires returned	78	44	63	130	124	5	444
% of total no. of returns	17.6%	9.9%	14.2%	29.3%	27.9%	1.1%	100%
Response rate	26.0%	14.7%	21.0%	43.3%	41.3%	-	29.6%
No. of respondents							
Doctors	0	0	0	3	6	0	9 (2%)
Nurses	5	10	29	43	42	0	129 (29%)
Allied health workers	13	4	11	23	7	0	58 (13%)
Healthcare related support staff	18	8	12	41	53	5	137 (31%)
Administrative staff	39	22	11	19	14	0	105 (24%)
Unknown	3	0	0	1	2	0	6 (1%)
Duration of work in current workplace (yr)							
0 - 5	26	12	32	41	44	2	157
>5 - 10	19	11	17	38	33	1	119
>10 - 15	32	9	10	23	34	1	109
>15 - 20	0	10	3	21	11	0	45
>20 - 25	0	1	0	1	1	0	3
>25 - 30	0	1	0	1	1	0	3
>30 - 35	0	0	0	2	0	0	2
>35 - 40	0	0	0	2	0	0	2
Max. no. of years	15	28	20	40	30	15	40
Min. no. of years	0.25	0.5	0.5	0.2	0	2	0
Average no. of years	8.4	11.8	6.4	10.3	8.5	9.0	9.1

Among the 440 respondents who indicated the duration that they had been working in their current workplace, the average duration was 9.1 years. There were only 4 and 12 respondents who had been working in their workplace for less than half and one year, respectively, and no abnormalities were found in their responses. Therefore, the respondents were collectively regarded as sufficiently knowledgeable and experienced about the HES in their respective workplace to give credible evaluation of the performance of the HES.

Perceived performance of HES

Statistics compiled from the performance scores given by the respondents on the HES in their workplace in each of the five hospitals are summarized in Table A in the Appendix. These include, for each HES trade:

1. the number of scores collected (n);
2. the maximum and minimum scores (*Max* & *Min*);
3. the mean score (m);
4. the standard deviation of the scores (sd);
5. the uncertainty in the mean score (u);
6. the rank of the HES trade among the 16 HES trades according to their mean scores (R_m);
7. the percentages of the scores that are less than 3 ($\%n_{<3}$), equal to 3 ($\%n_{=3}$) and greater than 3 ($\%n_{>3}$);
8. the difference between the percentages of scores that are greater than and less than 3 ($\%n_{<3>}$; $\%n_{<3>} = \%n_{>3} - \%n_{<3}$);
9. the rank of the HES trade among the 16 HES trades according to the latter percentage difference ($\%n_{<3>}$; denoted as R_n); and
10. the difference between R_m and R_n (denoted as d) and the square of this value (d^2).

The uncertainty in the mean score (u) was calculated using equation (1) (McClave *et al.*, 2005), where the value of $t_{\alpha/2}$ is dependent on ($n - 1$) while the significance level (α) was taken as 0.05.

$$u = t_{\alpha/2}\frac{sd}{\sqrt{n}} \quad (1)$$

The mean score (m) in conjunction with the uncertainty in the mean score (u) allow us to tell that the population mean (the mean score of the population), μ, would lie, to a confidence level of 95% (= 100(1 – α)%), within the region as shown in equation (2). A small number of available scores (n) will lead to a high uncertainty in the mean score (u) as not only its square root is the denominator term in equation (1), it will also give rise to a larger $t_{\alpha/2}$ value.

$$\mu = m \pm u \quad (2)$$

As discussed earlier, the mean score (m) is meaningful provided only that the performance scores given by the respondents are interval measures. If the scores are simply an ordinal measure of perceived performance, the ranking orders of the 16 trades of HES established with reference to their mean scores (R_m; Table A) may not truly reflect their relative performance in the eyes of the respondents. Nonetheless, even though the performance scores given by the respondents are indeed ordinal measures only, a trade of HES may still be regarded as being judged by the respondents as having been performing better than another trade if there are more number of respondents who had rated that HES trade at a score of above 3 and there are less who had rated it at a score of below 3, as compared to the latter trade of HES. Therefore, the difference between the percentages of scores that are greater than and less than 3 ($\%n_{<3>}$) for individual HES trades can be used as the reference for ranking the perceived performance of the 16 trades of HES (R_n; Table A).

The Spearman's test for rank correlation (McClave *et al.*, 2005) was used to unveil if the ranks R_m and R_n for the 16 HES trades are statistically similar or different. This involved calculation of the Spearman's rank correlation coefficient, r_s, as follows:

$$r_s = 1 - \frac{6\sum d_i^2}{N(N^2-1)} \quad (3)$$

Where

d_i = the difference between the ranks R_m and R_n of the i^{th} HES trade (Table A).

N = 16, the number of trades of HES under study.

The value of r_s always falls between −1 and +1, with +1 indicating perfect positive correlation and −1 indicating perfect negative correlation; its value will approach zero the less the correlation. For N = 16, at significance level (α) of 0.05, the rejection criterion, $r_{s,\alpha/2}$, is 0.425 (McClave *et al.*, 2005), i.e. the hypothesis that there is no significant correlation between the ranks R_m and R_n can be rejected if:

$$|r_s| > r_{s,\alpha/2} = 0.425 \quad (4)$$

The Spearman's rank correlation coefficients calculated from the ranks R_m and R_n for individual hospitals, the three Schedule 1 hospitals as a group, the two Schedule 2 hospitals as a group and for all the five hospitals range from 0.97 to 0.99 (Table A), which show that there are insignificant differences between the sets of ranks for the 16 HES trades. This

shows also that the mean scores are a reliable collective measure of the perceived performance of the respective HES trades and, therefore, further analysis of the perceived performance of the HES was based entirely on the mean scores and other statistics compiled from the scores.

As shown in Table A in the Appendix, there are some HES trades for which only small numbers of respondents had given their performance scores, which include:

HES No. 10 – laminar OT ceilings & pendants

HES No. 11 – pathological incinerator

HES No. 13 – cold rooms, hot rooms, mortuary chambers

HES No. 14 – hydrotherapy pool system

This is mainly because these are specialized facilities that appear only in limited locations and only a few hospital staff would use these facilities in their work. However, rather than expanding the sample size to reduce the uncertainties in the mean scores for these trades, the uncertainties of the sample mean scores for individual trades of HES were borne in mind in further comparisons and analyses. Some other observations that can be made from the results summarized in Table A include:

1. HES No. 1 – electrical and lighting systems were regarded by the respondents in individual hospitals as one of the three best performing HES, and the best one across the five hospitals (mean score = 3.76 ± 0.08).

2. HES No. 3 – heating, ventilating and air-conditioning (HVAC) systems were regarded by the respondents as the least satisfactory in performance in three out of the five hospitals and the least satisfactory across all the five hospitals (mean score = 2.64 ± 0.09).

3. HES No. 12 – lifts and/or escalators were perceived as one of the two HES trades that were least satisfactory in performance among the two Schedule 2 hospitals, especially Hospital E (mean score = 2.29 ± 0.18). However, it was known that the less than satisfactory performance of the lifts in Hospital E was, at least partly, due to insufficient lift provision in the hospital, rather than due to entirely unsatisfactory maintenance.

Most satisfactory and least satisfactory HES

Each respondent was asked to indicate up to 3 HES trades that he/she thought have been performing most satisfactorily. The respondents were also asked to indicate up to 3 aspects of HES performance that they most often found unsatisfactory. The numbers of respondents who had given commendations and criticisms on the performance of the HES, together with the mean performance scores for these HES, are summarized in Table B in the Appendix for a comparison.

Inspection of the data in Table B shows that for a trade of HES that was given a high mean performance score, the number of respondents who had given commendations on its performance is generally much larger than the number of respondents who had criticized its performance. Conversely, a trade of HES that was given a low mean performance score is

generally associated with a low number of commendations and a high number of criticisms. This shows that the responses of the respondents are generally consistent.

Consistency in perceived performance among hospitals

Whether the performances of the various trades of HES as perceived by respondents in different hospitals are consistent across hospitals were tested according to the method described below (Aron *et al.*, 2005), which involved the assumption that the scale used to measure perceived performance was an interval measure.

For a trade of HES for which performance scores had been given by n_1 respondents in one hospital and by n_2 respondents in another hospital, with the corresponding mean scores and standard deviations of the scores being m_1, m_2, sd_1 & sd_2 respectively, the statistic (t) that can tell whether or not the two groups of respondents had dissimilar opinions on the performance of that HES trade was calculated as follows:

$$t = \frac{m_1 - m_2}{sd_D} \tag{5}$$

Where

$$sd_D^2 = sd_{m1}^2 + sd_{m2}^2 \tag{6}$$

$$sd_{m1}^2 = sd_P^2 / n_1 \tag{7}$$

$$sd_{m2}^2 = sd_P^2 / n_2 \tag{8}$$

$$sd_P^2 = \frac{(n_1 - 1)}{(n_1 - 1) + (n_2 - 1)} sd_1^2 + \frac{(n_2 - 1)}{(n_1 - 1) + (n_2 - 1)} sd_2^2 \tag{9}$$

If $|t| < t_{\alpha/2}$, the hypothesis that the two groups of respondents had different judgements on the performance of the trade of HES under concern can be rejected. The value of $t_{\alpha/2}$ is dependent on $(n_1 + n_2 - 2)$, the total degree of freedom of the two sets of scores, and on the value of α, which was taken as 0.05.

For each HES trade, the scores given by respondents in the three Schedule 1 hospitals were pair-wise compared in turn; likewise between the two Schedule 2 hospitals and then between the Schedule 1 and Schedule 2 hospitals, according to the abovementioned method. Table C in the Appendix summarizes the results of this series of tests.

This set of test results shows that the performances of various trades of HES as perceived by the respondents in different hospitals are largely similar, although there are cases where perceived performances of the same trade of HES were statistically shown to be dissimilar between hospitals. However, such dissimilarity occurs only between hospitals of the same category (Schedule 1 or Schedule 2) which, therefore, would not be due to the use of different procurement strategies, while none of the HES trade had attracted dissimilar performance perception both between Schedule 1 hospitals and between Schedule 2 hospitals.

Discounting those HES trades for which performance scores were obtained from small numbers of respondents (HES No. 10, 11, 13 & 14), the cases that show significant differences in performance between the Schedule 1 and Schedule 2 hospitals include:

HES No. 1 – electrical supply and lighting systems

HES No. 12 – lifts and/or escalators

HES No. 15 – town gas installations

The largest difference is on lifts and/or escalators (HES No. 12), which was due to unsatisfactory performance of this HES trade in Hospital E and as explained above, this should have been given rise mainly by inadequate provision in the first place. Whereas electrical supply and lighting systems are a highly important HES trade, the actual difference in the mean performance scores of Schedule 1 and Schedule 2 hospitals is 0.219 only. The difference in the mean performance scores of town gas installations is larger (0.518), but this is just a relatively minor HES trade.

Therefore, it may be concluded that, generally speaking, there is no strong evidence to show that there are large differences in the performance of HES between the two categories of hospitals, although the procurement arrangements are different, i.e. through SLAs with EMSTF for Schedule 1 hospitals and through in-house organization for Schedule 2 hospitals.

As to the impact of outsourcing facility services from private services providers on the performance of the HES, the conclusion that no significant difference could be observed has the support of the following observations:

1. Operation and maintenance (O&M) of electrical & lighting systems (HES No. 1) and HVAC systems (HES No. 3) are both done by the in-house staff of EMSTF (Schedule 1) or the hospitals (Schedule 2) but the mean performance scores of these two trades of HES across the five hospitals are significantly different (3.76 vs. 2.64), being the highest and lowest mean performance scores among the 16 trades of HES.

2. Across the five hospitals, electrical & lighting systems (HES No. 1) and medical gases systems (HES No. 4) are respectively the best and second best performing HES trades (mean performance score = 3.76 and 3.59) but O&M works for the former are undertaken by in-house staff of EMSTF or the hospitals concerned whilst O&M works for the latter are outsourced for both the Schedule 1 and Schedule 2 hospitals.

3. Among the Schedule 1 hospitals, lifts and/or escalators (HES No. 12) and potable or non-potable flushing and drainage pump systems (HES No. 16) are of similar (low) ranking with respect to their mean performance scores (Rank: 13 vs. 14; mean performance score: 3.12 vs. 2.93). However, O&M works for the former are outsourced whilst those for the latter are undertaken by EMSTF staff in-house.

Impact of the nature of HES on perceived performance

The statistical analysis results presented and the arguments put forward in the preceding section are in support of hypothesis 1. However, as pointed out earlier, rebuttal of hypothesis 2 will refute hypothesis 1. Therefore, it is necessary to test if hypothesis 2 can be refuted. The test for such purpose is based on the premise that the differences in the nature of different trades of HES will lead to different degrees of propensity to failure and difficulties in

rectification of system and component failures. And, given that hypothesis 1 is true, the ranking orders of the different trades of HES, prioritized according to the mean performance scores given by the respondents, should be consistent between the Schedule 1 and Schedule 2 hospitals, despite that different procurement arrangements are being used for the O&M works between these two groups of hospitals.

The Spearman's test for rank correlation (equation 3) was, once again, used for this test but, in this test:

d_i = the difference between the ranks of the i^{th} HES trade compiled from the mean performance scores given by respondents in the Schedule 1 and Schedule 2 hospitals (Table A).

The Spearman's rank correlation coefficient calculated from the ranks R_m (Table A) is +0.561 which is greater than 0.425. Therefore, hypothesis 2 cannot be rejected and, therefore, hypothesis 1 is not refuted.

Conclusion

The statistical analyses on the survey results show that despite that there are differences in the arrangements for procurement of operation and maintenance (O&M) services for the HES in the hospitals studied, including from EMSTF or by hospitals' in-house teams and between in-house and outsourcing the O&M works, there are no strong evidences to show that these different arrangements have affected the performance of the HES, as perceived by the end-users. The key drivers for this insensitivity in performance to procurement methods

include the unified standards applied to monitor performance and the low tolerance for unsatisfactory performance of the HES.

Apparently, the key factor that affects the performance of HES is the nature of the HES, such as the probability of failure of components in the system and the complexity of remedial works for rectifying the failures. It follows that the perception that there would be negative impacts on the performance of HES if the O&M works for them are outsourced is not necessarily true. In making the decision to outsource for O&M works for the HES, focus could be put on if there are cost savings compared to the cost under the present procurement arrangement, taking into account the costs for performance assessment and monitoring (Lai and Yik, 2007), which are crucial to ensuring the expected performance standards are met.

This result underpinned the later parts of the study that involved estimation of the potential risk and cost saving achievable by outsourcing the HES from private sector services providers. The mean perceived performance scores for the 16 trades of HES found in this study may also be taken as benchmarks for comparison of HES performance in the same and other hospitals in future, especially when changes have been made to the procurement strategy.

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Appendix

Table A Perceived performance of HES in the five hospitals

Hospital A (Schedule 1)

HES No.	*n*	*Max*	*Min*	*m*	*sd*	*u*	R_m	$\%n_{>3}$	$\%n_{=3}$	$\%n_{<3}$	$\%n_{<3>}$	R_n	*d*	d^2
1	73	5	1	3.79	0.87	0.2	3	63	32.9	4.11	58.9	3	0	0
2	64	5	2	3.59	0.79	0.2	5	50	45.3	4.69	45.3	6	-1	1
3	72	5	1	2.42	0.83	0.2	16	9.72	30.6	59.7	-50	16	0	0
4	48	5	2	3.58	0.79	0.23	6	52.1	41.7	6.25	45.8	5	1	1
5	70	5	2	3.41	0.69	0.17	7	41.4	52.9	5.71	35.7	7	0	0
6	59	5	1	3.17	0.85	0.22	11	32.2	50.8	16.9	15.3	11	0	0
7	72	5	1	3.25	0.8	0.19	10	31.9	55.6	12.5	19.4	10	0	0
8	46	5	1	3.3	0.79	0.23	9	34.8	56.5	8.7	26.1	8	1	1
9	48	4	1	2.73	0.89	0.26	15	18.8	45.8	35.4	-16.7	14	1	1
10	9	5	2	3.33	0.87	0.67	8	33.3	55.6	11.1	22.2	9	-1	1
11	4	3	2	2.75	0.5	0.8	14	0	75	25	-25	15	-1	1
12	61	5	1	3.02	0.99	0.25	13	31.1	37.7	31.1	0	13	0	0
13	8	5	3	3.63	0.74	0.62	4	50	50	0	50	4	0	0
14	7	5	3	3.86	0.69	0.64	2	71.4	28.6	0	71.4	1	1	1
15	10	5	3	4.1	0.88	0.63	1	70	30	0	70	2	-1	1
16	67	5	1	3.09	1.03	0.25	12	32.8	40.3	26.9	5.97	12	0	0
													Σd^2	8
													r_s	0.988

Hospital B (Schedule 1)

HES No.	*n*	*Max*	*Min*	*m*	*sd*	*u*	R_m	$\%n_{>3}$	$\%n_{=3}$	$\%n_{<3}$	$\%n_{<3>}$	R_n	*d*	d^2
1	41	5	3	3.93	0.52	0.16	3	81	19	0	81	2	1	1
2	41	5	2	3.2	0.75	0.24	12.5	34.1	48.8	17.1	17.1	12	0.5	0.25
3	42	5	1	2.57	0.91	0.29	16	14.3	35.7	50	-35.7	16	0	0
4	34	5	3	3.82	0.63	0.22	4	70.6	29.4	0	70.6	3	1	1
5	42	5	2	3.48	0.71	0.22	8	45.2	50	4.76	40.5	7	1	1
6	30	5	2	3.2	0.71	0.27	12.5	30	56.7	13.3	16.7	13	-0.5	0.25
7	40	5	2	3.4	0.74	0.24	9	45	45	10	35	8	1	1
8	27	5	1	3.22	0.85	0.34	11	37	48.1	14.8	22.2	10	1	1
9	11	5	2	3	1	0.67	15	27.3	36.4	36.4	-9.09	15	0	0
10	6	5	3	4	0.63	0.66	1.5	83.3	16.7	0	83.3	1	0	0
11	2	5	3	4	1.41	12.7	1.5	50	50	0	50	4	-3	9
12	33	5	1	3.24	0.87	0.31	10	36.4	48.5	15.2	21.2	11	-1	1
13	7	5	2	3.57	0.98	0.9	6	57.1	28.6	14.3	42.9	6	0	0
14	6	5	3	3.67	0.82	0.86	5	50	50	0	50	4	1	1
15	6	5	3	3.5	0.84	0.88	7	33.3	66.7	0	33.3	9	-2	4
16	35	5	1	3.06	0.76	0.26	14	22.9	60	17.1	5.71	14	0	0
													Σd^2	20.5
													r_s	0.97

See notes at end of table.

Table A Perceived performance of HES (Cont'd)

Hospital C (Schedule 1)

HES No.	*n*	*Max*	*Min*	*m*	*sd*	*u*	R_m	$\%n_{>3}$	$\%n_{=3}$	$\%n_{<3}$	$\%n_{<3>}$	R_n	*d*	d^2
1	60	5	3	3.95	0.72	0.19	1	71.7	28.3	0	71.7	1	0	0
2	43	5	2	3.16	0.84	0.26	8.5	39.5	34.9	25.6	14	7	1.5	2.25
3	60	5	1	2.77	0.98	0.25	11	21.7	40	38.3	-16.7	11	0	0
4	12	5	2	3.83	0.94	0.6	2	66.7	25	8.33	58.3	2	0	0
5	60	5	1	2.97	1.06	0.27	10	33.3	30	36.7	-3.33	10	0	0
6	37	5	1	3.24	0.86	0.29	6	40.5	45.9	13.5	27	4	2	4
7	56	5	2	3.29	0.91	0.24	4	41.1	37.5	21.4	19.6	5	-1	1
8	24	5	2	3.25	0.9	0.38	5	37.5	41.7	20.8	16.7	6	-1	1
9	5	5	2	3.2	1.1	1.36	7	20	60	20	0	9	-2	4
10	0	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
11	0	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
12	56	5	1	3.16	1.02	0.27	8.5	42.9	26.8	30.4	12.5	8	0.5	0.25
13	0	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
14	0	0	0	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
15	15	5	2	3.67	0.9	0.5	3	66.7	20	13.3	53.3	3	0	0
16	57	5	1	2.67	1.01	0.27	12	21.1	31.6	47.4	-26.3	12	0	0
													Σd^2	12.5
													r_s	0.982

All Schedule 1 hospitals

HES No.	*n*	*Max*	*Min*	*m*	*sd*	*u*	R_m	$\%n_{>3}$	$\%n_{=3}$	$\%n_{<3}$	$\%n_{<3>}$	R_n	*d*	d^2
1	174	5	1	3.88	0.75	0.11	1	70.3	28	1.71	68.6	1	0	0
2	148	5	2	3.36	0.82	0.13	7	42.6	43.2	14.2	28.4	7	0	0
3	174	5	1	2.57	0.91	0.14	16	14.9	35.1	50	-35.1	16	0	0
4	94	5	2	3.7	0.76	0.16	4	60.6	35.1	4.26	56.4	3	1	1
5	172	5	1	3.27	0.87	0.13	9.5	39.5	44.2	16.3	23.3	8	1	1
6	126	5	1	3.2	0.82	0.14	11	34.1	50.8	15.1	19	11	0	0
7	168	5	1	3.3	0.82	0.12	8	38.1	47	14.9	23.2	9	-1	1
8	97	5	1	3.27	0.82	0.17	9.5	36.1	50.5	13.4	22.7	10	0	0
9	64	5	1	2.81	0.92	0.23	15	20.3	45.3	34.4	-14.1	15	0	0
10	15	5	2	3.6	0.83	0.46	5.5	53.3	40	6.67	46.7	5	0	0
11	6	5	2	3.17	0.98	1.03	12	16.7	66.7	16.7	0	13	-1	1
12	150	5	1	3.12	0.98	0.16	13	36.7	36	27.3	9.33	12	1	1
13	15	5	2	3.6	0.83	0.46	5.5	53.3	40	6.67	46.7	5	0	0
14	13	5	3	3.77	0.73	0.44	2.5	61.5	38.5	0	61.5	2	1	1
15	31	5	2	3.77	0.88	0.32	2.5	61.3	32.3	6.45	54.8	4	-2	4
16	159	5	1	2.93	0.98	0.15	14	26.4	41.5	32.1	-5.66	14	0	0
													Σd^2	10
													r_s	0.985

See notes at end of table.

Table A Perceived performance of HES (Cont'd)

Hospital D (Schedule 2)

HES No.	*n*	*Max*	*Min*	*m*	*sd*	*u*	R_m	$\%n_{>3}$	$\%n_{=3}$	$\%n_{<3}$	$\%n_{<3>}$	R_n	*d*	d^2
1	111	5	1	3.61	0.81	0.15	1	52.3	43.2	4.5	47.7	1	0	0
2	97	5	1	3.33	0.85	0.17	6	38.1	48.5	13.4	24.7	7	-1	1
3	111	5	1	2.64	0.85	0.16	16	13.5	45.0	41.4	-27.9	16	0	0
4	77	5	1	3.44	0.73	0.17	2	44.2	50.6	5.2	39.0	2	0	0
5	111	5	2	3.27	0.82	0.15	8	36.0	47.7	16.2	19.8	8	0	0
6	81	5	1	3.1	0.9	0.2	10	35.8	37.0	27.2	8.6	10	0	0
7	110	5	1	3.03	0.86	0.16	11.5	28.2	48.2	23.6	4.5	12	0	0
8	70	5	1	3.03	0.92	0.22	11.5	35.7	34.3	30.0	5.7	11	0	0
9	43	5	2	3	0.79	0.24	13	25.6	46.5	27.9	-2.3	14	-1	1
10	11	5	3	3.36	0.67	0.45	4.5	27.3	72.7	0.0	27.3	4	0	0
11	8	5	3	3.38	0.74	0.62	3	25.0	75.0	0.0	25.0	6	-3	9
12	104	5	1	2.71	0.96	0.19	15	19.2	46.2	34.6	-15.4	15	0	0
13	14	5	2	3.36	0.74	0.43	4.5	35.7	57.1	7.1	28.6	3	2	4
14	10	5	3	3.2	0.63	0.45	9	10.0	90.0	0.0	10.0	9	0	0
15	19	5	2	3.32	0.67	0.32	7	31.6	63.2	5.3	26.3	5	2	4
16	111	5	1	2.97	0.81	0.15	14	22.5	53.2	24.3	-1.8	13	1	1
													Σd^2	20
													r_s	0.971

Hospital E (Schedule 2)

HES No.	*n*	*Max*	*Min*	*m*	*sd*	*u*	R_m	$\%n_{>3}$	$\%n_{=3}$	$\%n_{<3}$	$\%n_{<3>}$	R_n	*d*	d^2
1	116	5	2	3.71	0.8	0.15	2	64.7	27.6	7.76	56.9	2	0	0
2	106	5	1	3.25	0.8	0.15	6	41.5	41.5	17	24.5	6	0	0
3	117	5	1	2.75	0.92	0.17	14	19.7	43.6	36.8	-17.1	15	-1	1
4	72	5	2	3.61	0.72	0.17	3	52.8	44.4	2.78	50	3	0	0
5	116	5	2	3.46	0.71	0.13	4	46.6	46.6	6.9	39.7	4	0	0
6	88	5	1	2.99	0.93	0.2	11	30.7	45.5	23.9	6.82	10	1	1
7	102	5	1	3.28	0.81	0.16	5	42.2	41.2	16.7	25.5	5	0	0
8	66	5	2	3.18	0.84	0.21	8	36.4	40.9	22.7	13.6	8	0	0
9	6	4	3	3.83	0.41	0.43	1	83.3	16.7	0	83.3	1	0	0
10	22	4	2	3.09	0.68	0.3	9	27.3	54.5	18.2	9.09	9	0	0
11	0	0	0	n/a	n/a	n/a	n/a	0	n/a	0	0	12	n/a	n/a
12	106	4	1	2.29	0.94	0.18	15	9.43	34	56.6	-47.2	16	-1	1
13	18	3	2	2.83	0.38	0.19	13	0	83.3	16.7	-16.7	14	-1	1
14	11	4	2	2.91	0.7	0.47	12	18.2	54.5	27.3	-9.09	13	-1	1
15	20	5	2	3.2	0.62	0.29	7	20	75	5	15	7	0	0
16	112	5	1	3.04	0.86	0.16	10	32.1	42	25.9	6.25	11	-1	1
													Σd^2	6
													r_s	0.991

See notes at end of table.

Table A Perceived performance of HES (Cont'd)

All Schedule 2 hospitals

HES No.	*n*	*Max*	*Min*	*m*	*sd*	*u*	R_m	$\%n_{>3}$	$\%n_{=3}$	$\%n_{<3}$	$\%n_{<3>}$	R_n	*d*	d^2
1	227	5	1	3.66	0.81	0.1	1	58.6	35.2	6.17	52.4	1	0	0
2	203	5	1	3.29	0.82	0.11	5	39.9	44.8	15.3	24.6	5	0	0
3	228	5	1	2.7	0.89	0.11	15	16.7	44.3	39	-22.4	15	0	0
4	149	5	1	3.52	0.73	0.12	2	48.3	47.7	4.03	44.3	2	0	0
5	227	5	2	3.37	0.77	0.1	4	41.4	47.1	11.5	30	3	1	1
6	169	5	1	3.04	0.92	0.14	13	33.1	41.4	25.4	7.69	11	2	4
7	212	5	1	3.15	0.85	0.11	8	34.9	44.8	20.3	14.6	8	0	0
8	136	5	1	3.1	0.88	0.15	9.5	36	37.5	26.5	9.56	9	0.5	0.25
9	49	5	2	3.1	0.8	0.23	9.5	32.7	42.9	24.5	8.16	10	-0.5	0.25
10	33	5	2	3.18	0.68	0.24	7	27.3	60.6	12.1	15.2	7	0	0
11	8	5	3	3.38	0.74	0.62	3	25	75	0	25	4	-1	1
12	210	5	1	2.5	0.97	0.13	16	14.3	40	45.7	-31.4	16	0	0
13	32	5	2	3.06	0.62	0.22	11	15.6	71.9	12.5	3.13	12	-1	1
14	21	5	2	3.05	0.67	0.3	12	14.3	71.4	14.3	0	14	-2	4
15	39	5	2	3.26	0.64	0.21	6	25.6	69.2	5.13	20.5	6	0	0
16	223	5	1	3.01	0.84	0.11	14	27.4	47.5	25.1	2.24	13	1	1
													Σd^2	12.5
													r_s	0.982

All Schedule 1 & 2 hospitals

HES No.	*n*	*Max*	*Min*	*m*	*sd*	*u*	R_m	$\%n_{>3}$	$\%n_{=3}$	$\%n_{<3}$	$\%n_{<3>}$	R_n	*d*	d^2
1	401	5	1	3.76	0.79	0.08	1	63.7	32.1	4.23	59.5	1	0	0
2	351	5	1	3.32	0.82	0.09	5.5	41	44.2	14.8	26.2	5	0.5	0.25
3	402	5	1	2.64	0.9	0.09	16	15.9	40.3	43.8	-27.9	16	0	0
4	243	5	1	3.59	0.75	0.09	2	53.1	42.8	4.12	49	2	0	0
5	399	5	1	3.33	0.81	0.08	4	40.6	45.9	13.5	27.1	4	0	0
6	295	5	1	3.11	0.88	0.1	12	33.6	45.4	21	12.5	12	0	0
7	380	5	1	3.22	0.84	0.08	10	36.3	45.8	17.9	18.4	8	2	4
8	233	5	1	3.17	0.86	0.11	11	36.1	42.9	21	15	10	1	1
9	113	5	1	2.94	0.88	0.16	14	25.7	44.2	30.1	-4.42	14	0	0
10	48	5	2	3.31	0.75	0.22	7	35.4	54.2	10.4	25	6	1	1
11	14	5	2	3.29	0.83	0.48	8	21.4	71.4	7.14	14.3	11	-3	9
12	360	5	1	2.76	1.02	0.11	15	23.6	38.3	38.1	-14.4	15	0	0
13	47	5	2	3.23	0.73	0.21	9	27.7	61.7	10.6	17	9	0	0
14	34	5	2	3.32	0.77	0.27	5.5	32.4	58.8	8.82	23.5	7	-1.5	2.25
15	70	5	2	3.49	0.79	0.19	3	41.4	52.9	5.71	35.7	3	0	0
16	382	5	1	2.98	0.9	0.09	13	27	45	28	-1.05	13	0	0
													Σd^2	17.5
													r_s	0.974

Notes for Table A:

1. See Table 1 for the names of the HES corresponding to the HES No. shown in the table.
2. *n* = the number of scores collected
3. *Max* & *Min* = the maximum and minimum scores
4. *m* = the mean score
5. *sd* = the standard deviation of the scores
6. *u* = the uncertainty in the mean score
7. R_m = the rank of the HES trade among the 16 HES trades according to their mean scores
8. $\%n_{<3}$, $\%n_{=3}$ & $\%n_{>3}$ are respectively the percentages of the scores that are less than, equal to and greater than 3; and $\%n_{<3>} = \%n_{>3} - \%n_{<3}$
9. R_n = the rank of the HES trade among the 16 HES trades according to $\%n_{<3>}$
10. For each HES, $d = R_m - R_n$
11. r_s = Spearman's rank correlation coefficient that reflects the correlation between R_m and R_n

Table B Mean performance scores (PS) of the HES and numbers of respondents giving commendations (GP) and criticisms (PP) on the HES

	Hospital A			Hospital B			Hospital C			Hospital D			Hospital E		
HES No.	PS	GP	PP	PS	GP	PP	PS	GP	PP	PS	GP	PP	PS	GP	PP
1	3.79	50	5	3.9	28	3	3.95	48	4	3.61	80	8	3.71	66	7
2	3.59	17	6	3.2	5	4	3.16	5	6	3.33	17	6	3.25	22	10
3	2.42	7	51	2.57	6	31	2.77	13	32	2.64	15	56	2.75	17	46
4	3.58	29	1	3.82	21	0	3.83	3	0	3.44	27	4	3.61	32	1
5	3.41	15	10	3.48	11	2	2.97	6	15	3.27	25	14	3.46	25	2
6	3.17	6	2	3.2	3	2	3.24	5	2	3.1	4	3	2.99	7	10
7	3.25	8	3	3.4	7	1	3.29	11	5	3.03	24	7	3.28	18	2
8	3.3	6	4	3.22	4	2	3.25	4	0	3.03	15	8	3.18	9	4
9	2.73	5	19	3	0	4	3.2	1	0	3	2	0	3.83	0	0
10	3.33	0	0	4	1	0	n/a	0	0	3.36	1	0	3.09	2	3
11	2.75	0	0	4	0	0	n/a	0	0	3.38	0	0	n/a	0	0
12	3.02	9	5	3.24	2	3	3.16	12	9	2.71	11	16	2.29	10	41
13	3.63	0	1	3.57	2	1	n/a	0	0	3.36	3	0	2.83	2	1
14	3.86	0	0	3.67	2	0	n/a	0	0	3.2	4	0	2.91	2	0
15	4.1	2	1	3.5	1	0	3.67	6	0	3.32	4	0	3.2	3	0
16	3.09	9	9	3.06	3	4	2.67	6	22	2.97	21	14	3.04	10	12

Note: See Table 1 for the names of the HES corresponding to the HES No. shown in the table.

Table C Results of tests on similarity of perceived performance of HES in the five hospitals

HES No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Hospital A vs. Hospital B (Schedule 1)																
m_1-m_2	-0.13	0.399	-0.15	-0.24	-0.06	-0.03	-0.15	0.082	-0.27	-0.67	-1.25	-0.23	0.054	0.19	0.6	0.032
t	-0.89	2.571	-0.92	-1.47	-0.45	-0.17	-0.97	0.419	-0.89	-1.61	-1.74	-1.1	0.121	0.456	1.348	0.164
$t_{0.025}$	1.96	1.984	1.96	1.99	1.96	1.989	1.96	1.995	2.004	2.161	2.776	1.987	2.161	2.201	2.145	1.984
S/D*	S	D	S	S	S	S	S	S	S	S	S	S	S	S	S	S
Hospital A vs. Hospital C (Schedule 1)																
m_1-m_2	-0.16	0.431	-0.35	-0.25	0.448	-0.07	-0.04	0.054	-0.47	n/a	n/a	-0.14	n/a	n/a	0.433	0.423
t	-1.11	2.69	-2.21	-0.94	2.894	-0.41	-0.24	0.262	-1.1	n/a	n/a	-0.77	n/a	n/a	1.192	2.308
$t_{0.025}$	1.96	1.96	1.96	2.004	1.96	1.987	1.96	1.997	2.009	n/a	n/a	1.96	n/a	n/a	2.069	1.96
S/D*	S	D	D	S	D	S	S	S	S	n/a	n/a	S	n/a	n/a	S	D
Hospital B vs. Hospital C (Schedule 1)																
m_1-m_2	-0.02	0.032	-0.2	-0.01	0.51	-0.04	0.114	-0.03	-0.2	n/a	n/a	0.082	n/a	n/a	-0.17	0.39
t	-0.18	0.185	-1.02	-0.04	2.724	-0.22	0.654	-0.11	-0.36	n/a	n/a	0.384	n/a	n/a	-0.39	1.972
$t_{0.025}$	1.986	1.99	1.984	2.021	1.984	1.997	1.987	2.014	2.145	n/a	n/a	1.989	n/a	n/a	2.093	1.987
S/D*	S	S	S	S	D	S	S	S	S	n/a	n/a	S	n/a	n/a	S	S
Hospital D vs. Hospital E (Schedule 2)																
m_1-m_2	-0.09	0.085	-0.11	-0.17	-0.19	0.11	-0.26	-0.15	-0.83	0.273	n/a	0.419	0.524	0.291	0.116	-0.07
t	-0.88	0.729	-0.96	-1.42	-1.83	0.781	-2.23	-1.02	-2.53	1.085	n/a	3.2	2.583	0.995	0.562	-0.64
$t_{0.025}$	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	2.014	2.043	n/a	1.96	2.043	2.093	2.03	1.96
S/D*	S	S	S	S	S	S	D	S	D	S	n/a	D	D	S	S	S
Schedule 1 hospitals vs. Schedule 2 hospitals																
m_1-m_2	0.219	0.072	-0.12	0.179	-0.09	0.157	0.147	0.165	-0.29	0.418	-0.21	0.62	0.538	0.722	0.518	-0.08
t	2.777	0.815	-1.36	1.827	-1.12	1.523	1.698	1.45	-1.75	1.84	-0.45	5.966	2.487	2.961	2.847	-0.84
$t_{0.025}$	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	1.96	2.014	2.179	1.96	2.014	2.043	1.997	1.96
S/D*	D	S	S	S	S	S	S	S	S	S	S	D	D	D	D	S

Note: See Table 1 for the names of the HES corresponding to the HES No. shown in the table.

* S denotes the test result ($|t| < t_{0.025}$) that shows the two groups of respondents had the same perception on the performance of the HES whilst D denotes the result ($|t| > t_{0.025}$) that shows different perceptions.