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ORIGINAL ARTICLE

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Substantial differences in preparedness for emergency infection control measures among major hospitals in Japan: lessons from SARS

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Abstract Emergency infection control measures are essential in hospitals. Although Japan was spared from the 2003 epidemic of severe acute respiratory syndrome (SARS), hospitals were placed on high alert. The actual preparedness level of hospitals can be determined by examining individual perceptions among the hospital healthcare workers (HCWs). The objective of this study was to assess the level of preparedness of emergency infection control measures in Japan and to quantify the differences in preparedness across institutions and disciplines. From July to September 2003, a questionnaire survey concerning the perceptions of risks and countermeasures and knowledge about SARS was distributed at seven tertiary hospitals. Disciplines were categorized as emergency room (ER)/intensive care unit (ICU), surgical, medical, and "others". Of the 9978 questionnaires administered, 6929 valid responses were received and analyzed. After adjusting for age, sex, and job category, specific institutional measures (I-scores) were found to be more indicative of the level of preparedness across institutions and disciplines than were measures of overall effectiveness (E-scores) or knowledge of preventive measures (K-scores). In particular, the difference in I-scores was much more substantial across institutions than across disciplines. Across disciplines, surgical ranked lower than ER/ICU or medical. In conclusion, substantial differences in emergency infection control measures, as perceived by HCWs, exists among hospitals in Japan, with the differences across institutions exceeding those across disciplines. To achieve a higher level of preparedness for infectious diseases, institutions should designate and implement effective emergency infection control measures.

Key words Infection control · Occupational health · SARS · Questionnaires

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Introduction

Epidemics of emerging and re-emerging infectious disease may cause health crises in hospitals. Due to the high risk of exposure of healthcare workers (HCWs) to known and unknown infectious agents, and the modes of transmission of the latter, health crises may first occur among critical care staff. For example, during the global outbreak of severe acute respiratory syndrome (SARS) in 2002–2003, 21% of a total of 8096 probable cases involved HCWs.[1] During the early stages of the SARS epidemic in Toronto, 60% of infected HCWs were critical care staff members in area hospitals.[2] To prevent the spread of nosocomial infection, effective emergency infection control measures, involving the full spectrum of HCWs including critical care staff, need to be implemented at the institutional level.

During the SARS epidemic, hospitals in affected areas emphasized training and the issuing of guidelines on emergency infection control measures.[3–5] Hospitals in Japan were also at a stage of high alert, but because Japan was ultimately spared from the SARS epidemic, the efficacy of such institutional measures remained untested. However, the potential for future outbreaks of emerging and re-emerging infectious diseases is considerable. Hence, not only is the practice of infection control measures critical for every hospital,[6] but their actual state of preparedness, as perceived and achieved by their HCWs, carries important implications for global health.

Our study had two aims: (i) to assess the perception of risk, knowledge of preventive measures, and the perceptions of emergency infection control measures for SARS among HCWs in Japan; and (ii) to compare the levels of

these factors across institutions and disciplines. As regards the first aim, we have shown in a previous report that individual perception is likely to be influenced by institutional measures.[7] The present study was more concerned with our second aim, and in this study, we analyzed data at the collective (i.e., institutional and disciplinary) level. It should be noted that most institutional infection control measures in Japan at the time of the SARS epidemic were voluntary,[8,9] and differences could have existed which entailed strengths and weaknesses in the state of preparedness. The objective of this study was, therefore, to assess the levels of preparedness in emergency infection control measures related to SARS, with particular focus on differences across institutions and disciplines.

Subjects, materials, and methods

Study population

The study population consisted of 9978 HCWs working at seven tertiary-level hospitals throughout Japan. A questionnaire was administered to each of these HCWs between July and September 2003. Overall, 7463 HCWs responded to the questionnaire (crude response rate, 74.8%). After excluding missing/invalid responses to questions on sex, age, job category, or discipline, 6929 responses were analyzed (valid response rate, 69.0%; Table 1). The HCWs' disciplines were divided into four categories: emergency room (ER)/intensive care unit (ICU), surgical, medical, and "others". The ER/ICU category was equivalent to critical care, and the category "others" included radiographical services, laboratory services, administrative, and primary care.

Institutions were categorized as universities (A, C, D, and E in Tables 1–5); municipal institutions (F and G in Tables 1–5); and private (B in Tables 1–5).

Questionnaire

The questionnaire included 3 items regarding the perception of specific institutional measures (Institutional score), 1 item on the overall effectiveness of institutional measures (Effectiveness score), and 15 items on knowledge of preventive measures (Knowledge score; Appendix Table). For each question, the responses were scored as "strongly disagree" (–3), "disagree" (–2), "probably disagree" (–1), "probably agree" (+1), "agree" (+2), "strongly agree" (+3), and "not applicable" (0), and these were used to calculate the I- and E-scores. The K-score was calculated by assigning 1 point for correct ("probably agree," "agree," "strongly agree") and 0 points for incorrect ("probably disagree," "disagree," "strongly disagree") responses, except for items regarding "paper mask" and "gauze mask," for which the reverse was true.

Specifically, the I-score was the sum of the scores for three questions regarding "clear policies and protocols," "specialist available," and "adequate training," divided by 9 (full score of 3 for 3 questions), yielding possible scores of –1 to 1. The E-score was the score for "effectiveness," divided by 3 (full score of 3 for 1 question), for possible scores of –1 to 1. The K-score was the sum of correct responses to the 15 questions regarding the effectiveness of various preventive measures divided by 15 (full score of 1 for 15 questions), for possible scores of 0 to 1. The correct response was based on WHO guidelines [10] and other findings. The range of I- and E-scores between –1 and +1 reflected negative and positive perceptions, and accounted for the gradient in responses (probably agree/disagree, agree/disagree, strongly agree/disagree). In contrast, K-scores ranging between 0 and +1 corresponded to the proportion of correct knowledge, and accounted for binary responses (correct response/incorrect response). The K-score thus reflected the mean rate of correct knowledge among respondents by institution and discipline. The I- and E-scores are, therefore, directly comparable, whereas the K-score is not comparable with the other scores. Cronbach's α was 0.87 for the K-score and 0.76 for the I-score, which indicated a high degree of internal consistency for each score.[7]

Statistical analysis

The χ^2 test was used to evaluate differences in the proportions of respondents by institutions and disciplines. Analysis of variance was used to evaluate differences in the unadjusted scores, and analysis of covariance was used to evaluate the differences in mean scores by institutions and disciplines (after adjusting for age, sex, and job category), as well as to calculate the adjusted mean scores. The adjusted mean scores were then categorized into quartiles. Bonferroni's *t*-test was used for pairwise comparisons of adjusted mean scores, while correcting for multiple comparisons.

All data were analyzed using SPSS, version 11.5J for Windows (SPSS, Chicago, IL, USA).

Results

The crude means and standard errors (SE) for the I-, E-, and K-scores by institutions and disciplines are shown in Table 1. There were significant differences in the mean values of the three scores among institutions and disciplines ($P < 0.001$ to $P = 0.005$ for each of the three items). The range of each crude score was wider across institutions (–0.16 [B] to 0.49 [G] for the I-score; –0.33 [B] to 0.06 [G] for the E-score, and 0.63 [A] to 0.77 [G] for the K-score) than across disciplines (–0.04 [others] to 0.18 [ER/ICU] for the I-score, –0.22 [surgical] to –0.13 [ER/ICU] for the E-score, and 0.64 [others] to 0.72 [ER/ICU] for the K-score). For the crude unadjusted scores, institution G scored the highest among the institutions, and ER/ICU scored the highest among disciplines.

Tables 2 to 4 show the mean and SE values for the I-, E-, and K-scores, respectively, by institutions and

Table 1. Demographic characteristics of respondents and institutional (I-), effectiveness (E-), and knowledge (K-) scores by institutions and disciplines

	Institution[a]							Discipline				Total *n*(%)
	A *n*(%)	B *n*(%)	C *n*(%)	D *n*(%)	E *n* (%)	F *n*(%)	G *n*(%)	ER/ICU *n*(%)	Surgical *n*(%)	Medical *n*(%)	Others *n*(%)	
Total	1227 (17.7)	730 (10.5)	862 (12.4)	1810 (26.1)	1029 (14.9)	808 (11.7)	463 (6.7)	469 (6.8)	1918 (27.7)	1708 (24.7)	2834 (40.9)	6929 (100.0)
Age, years												
<35	668 (54.4)	523 (71.6)	424 (49.2)	1008 (55.7)	544 (52.9)	406 (50.2)	214 (46.2)	319 (68.0)	1166 (60.8)	1069 (62.6)	1233 (43.5)	3787 (54.7)
≥35	559 (45.6)	207 (28.4)	438 (50.8)	802 (44.3)	485 (47.1)	402 (49.8)	249 (53.8)	150 (32.0)	752 (39.2)	639 (37.4)	1601 (56.5)	3142 (45.3)
Mean ± SD	34.9 ± 12.0	31.3 ± 9.6	36.7 ± 10.7	35.8 ± 11.3	35.7 ± 11.0	37.1 ± 11.2	37.4 ± 10.2	32.4 ± 9.1	33.7 ± 10.6	33.3 ± 10.1	33.6 ± 11.8	35.5 ± 11.2
Sex												
Female	885 (72.1)	545 (74.7)	561 (65.1)	1118 (61.8)	744 (72.3)	626 (77.5)	355 (76.7)	393 (83.8)	1396 (72.8)	1245 (72.9)	1800 (63.5)	4834 (69.8)
Male	342 (27.9)	185 (25.3)	301 (34.9)	692 (38.2)	285 (27.7)	182 (22.5)	108 (23.3)	76 (16.2)	522 (27.2)	463 (27.1)	1034 (36.5)	2095 (30.2)
Job category												
Physicians	165 (13.4)	93 (12.7)	229 (26.6)	499 (27.6)	177 (17.2)	90 (11.1)	54 (11.7)	47 (10.0)	552 (28.8)	539 (31.6)	169 (6.0)	1307 (18.9)
Nurses	617 (50.3)	339 (46.4)	355 (41.2)	588 (32.5)	568 (55.2)	394 (48.8)	261 (56.4)	376 (80.2)	1192 (62.1)	1011 (59.2)	543 (19.2)	3122 (45.1)
Others[b]	445 (36.3)	298 (40.8)	278 (32.3)	723 (39.9)	284 (27.6)	324 (40.1)	148 (32.0)	46 (9.8)	174 (9.1)	158 (9.3)	2122 (74.9)	2500 (36.1)
Discipline												
ER/ICU	69 (5.6)	40 (5.5)	54 (6.3)	94 (5.2)	69 (6.7)	77 (9.5)	66 (14.3)	–	–	–	–	469 (6.8)
Surgical	413 (33.7)	150 (20.5)	268 (31.1)	508 (28.1)	274 (26.6)	214 (26.5)	91 (19.7)	–	–	–	–	1918 (27.7)
Medical	262 (21.4)	211 (28.9)	213 (24.7)	438 (24.2)	312 (30.3)	154 (19.1)	118 (25.5)	–	–	–	–	1708 (24.7)
Others[c]	483 (39.4)	329 (45.1)	327 (37.9)	770 (42.5)	374 (36.3)	363 (44.9)	188 (40.6)	–	–	–	–	2834 (40.9)
Perception of institutional measures												
Institutional (I-) score, unadjusted (–1 through 1 point)												
Mean	–0.144	–0.155	–0.102	–0.015	0.144	0.147	0.485	0.180	–0.013	0.087	–0.043	0.012
Effectiveness (E-) score, unadjusted (–1 through 1 point)												
Mean	–0.239	–0.326	–0.249	–0.237	–0.216	–0.077	0.063	–0.134	–0.221	–0.197	–0.214	–0.206
Knowledge of preventive measures												
Knowledge (K-) score, unadjusted (0 through 1 point)												
Mean	0.632	0.668	0.636	0.633	0.699	0.689	0.765	0.718	0.660	0.682	0.642	0.662

See text and appendix for definitions of variables

$P < 0.01$ for each item (P values are based on the χ^2 test for differences in proportions and on analysis of variance (ANOVA) for differences in means across institutions and disciplines

[a] A, C, D, and E are universities, F and G are municipal institutions, and B is a private institution

[b] "Others" includes nursing assistants, social workers, pharmacists, clinical and radiologic technologists, physical therapists, occupational therapists, speech therapists, managerial staff, clerks, educational and research staff, building maintenance staff, cleaners, nutritionists, and licensed cooks

[c] "Others" includes radiographical services, laboratory services, administrative, and primary care

Table 2. Institutional (I-) score by institutions and disciplines

	Institution							
	A	B	C	D	E	F	G	Total
Discipline								
ER/ICU	–0.285 (0.053)	–0.213 (0.070)	0.059 (0.060)	0.323 (0.045)	0.193 (0.053)	0.353 (0.050)	0.585 (0.054)	0.145 (0.021)
Surgical	–0.110 (0.022)	–0.159 (0.036)	–0.091 (0.027)	0.003 (0.020)	0.134 (0.027)	0.118 (0.030)	0.496 (0.046)	0.056 (0.012)
Medical	–0.021 (0.027)	–0.076 (0.030)	–0.034 (0.030)	0.140 (0.022)	0.166 (0.025)	0.288 (0.030)	0.563 (0.041)	0.146 (0.012)
Others	–0.244 (0.020)	–0.166 (0.024)	–0.168 (0.025)	–0.115 (0.016)	0.106 (0.023)	0.014 (0.023)	0.333 (0.032)	–0.034 (0.009)
Total	–0.165 (0.017)	–0.154 (0.022)	–0.059 (0.019)	0.088 (0.014)	0.150 (0.017)	0.193 (0.018)	0.494 (0.022)	0.012 (0.006)

mean (SE)
highest Q
upper-middle Q
lower-middle Q
lowest Q

Mean I-score and SE were calculated by using ANCOVA, adjusting for age (≧35 years), sex (female), and job category (physician). Each mean I-score was categorized into quartiles (Q): lowest (<25%ile, I-score < –0.158); lower-middle (25–<50%ile, –0.158 ≤ I-score < 0.060); upper-middle (50–<75%ile, 0.060 ≤ I-score < 0.314); highest (75–100%ile, 0.314 ≤ I-score). Possible score, –1 through 1 point

Bonferroni's *t*-test of I-score among institutions and disciplines

Institutions	A	B	C	D	E	F	G
A		NS	*	*	*	*	*
B			*	*	*	*	*
C				*	*	*	*
D					NS	*	*
E						NS	*
F							*
Disciplines	**ER/ICU**	**Surgical**	**Medical**	**Others**			
ER/ICU		*	NS	*			
Surgical			*	*			
Medical				*			

*$P < 0.05$; NS, not significant

Table 3. Effectiveness (E-) score by institutions and disciplines

	Institution							
	A	B	C	D	E	F	G	Total
Discipline								
ER/ICU	–0.270 (0.059)	–0.499 (0.078)	–0.215 (0.067)	–0.166 (0.051)	–0.115 (0.059)	0.027 (0.056)	0.152 (0.060)	–0.155 (0.023)
Surgical	–0.205 (0.024)	–0.282 (0.040)	–0.258 (0.030)	–0.215 (0.022)	–0.257 (0.030)	–0.123 (0.034)	0.048 (0.051)	–0.185 (0.013)
Medical	–0.180 (0.030	–0.247 (0.034)	–0.213 (0.034)	–0.189 (0.024)	–0.256 (0.028)	–0.052 (0.040)	0.070 (0.045)	–0.152 (0.013)
Others	–0.309 (0.023)	–0.365 (0.027)	–0.262 (0.027)	–0.270 (0.018)	–0.176 (0.026)	–0.100 (0.026)	0.009 (0.036)	–0.210 (0.011)
Total	–0.241 (0.019)	–0.348 (0.024)	–0.237 (0.021)	–0.210 (0.016)	–0.201 (0.019)	–0.062 (0.020)	0.070 (0.025)	–0.206 (0.006)

mean (SE)
highest Q
upper-middle Q
lower-middle Q
lowest Q

Mean E-score and SE were calculated by using ANCOVA adjusting for age (≧35 years), sex (female), and job category (physician). Each mean E-score was categorized into quartiles (Q): lowest (<25%ile, E-score < –0.261); lower-middle (25–< 50%ile, –0.261 ≤ E-score < –0.209); upper-middle (50–<75%ile, –0.209 ≤ E-score < –0.104); highest (75–100%ile, –0.104 ≤ E-score). Possible score: –1 through 1 point

Bonferroni's *t*-test of E-score among institutions and disciplines

Institutions	A	B	C	D	E	F	G
A		*	NS	NS	NS	*	*
B			*	*	*	*	*
C				NS	NS	*	*
D					NS	*	*
E						*	*
F							*
Disciplines	**ER/ICU**	**Surgical**	**Medical**	**Others**			
ER/ICU		NS	NS	NS			
Surgical			NS	NS			
Medical				*			

*$P < 0.05$; NS, not significant

Table 4. Knowledge (K-) score by institutions and disciplines

	Institution							
	A	B	C	D	E	F	G	Total
Discipline								
ER/ICU	0.665 (0.025)	0.673 (0.033)	0.741 (0.028)	0.663 (0.021)	0.721 (0.025)	0.752 (0.023)	0.809 (0.025)	0.718 (0.010)
Surgical	0.661 (0.010)	0.612 (0.017)	0.633 (0.013)	0.635 (0.009)	0.694 (0.012)	0.693 (0.014)	0.767 (0.022)	0.671 (0.006)
Medical	0.651 (0.013)	0.685 (0.014)	0.656 (0.014)	0.651 (0.010)	0.714 (0.012)	0.715 (0.017)	0.783 (0.019)	0.693 (0.006)
Others	0.592 (0.010)	0.682 (0.011)	0.610 (0.011)	0.620 (0.008)	0.684 (0.011)	0.660 (0.011)	0.734 (0.015)	0.654 (0.004)
Total	0.642 (0.008)	0.663 (0.010)	0.660 (0.009)	0.642 (0.007)	0.703 (0.008)	0.705 (0.008)	0.773 (0.010)	0.662 (0.003)

mean (SE)
highest Q
upper-middle Q
lower-middle Q
lowest Q

Mean K-score and SE were calculated by using ANCOVA adjusting for age (≧35 years), sex (female), and job category (physician). Each mean K-score was categorized into quartiles (Q): lowest (<25%ile, K-score < –0.261); lower-middle (25–< 50%ile, –0.261 ≤ K-score < –0.209); upper-middle (50–<75%ile, –0.209 ≤ K-score < –0.104); highest (75–100%ile, –0.104 ≤ K-score). Possible score: –1 through 1 point

Bonferroni's *t*-test of K-score among institutions and disciplines

Institutions	A	B	C	D	E	F	G
A		NS	NS	NS	*	*	*
B			NS	NS	*	*	*
C				NS	*	*	*
D					*	*	*
E						NS	*
F							*
Disciplines	ER/ICU	Surgical	Medical	Others			
ER/ICU		*	NS	*			
Surgical			*	NS			
Medical				*			

*$P < 0.05$; NS, not significant

Table 5. Ranks[a] of I-, E-, and K-scores by institutions and disciplines according to statistically significant differences in values

	Institution							Discipline			
	A	B	C	D	E	F	G	ER/ICU	Surgical	Medical	Others
I-score	4 (6)	4 (6)	3 (5)	2	2	2	1	1	2 (3)	1	3 (4)
E-score	3	4 (7)	3	3	3	2	1	1	1	1	2 (4)
K-score	3 (4)	3 (4)	3 (4)	3 (4)	2	2	1	1	2 (3)	1	2 (3)
Rank sum	10 (13)	11 (17)	9 (12)	8	7	6	3	3	5 (7)	3	7 (11)
Total rank[b]	6	7	5	4	3	2	1	1	2	1	3

Numbers in parentheses show ranks adjusted for equal ranks
[a] Ranks are based on the values of the I-, E-, and K-scores shown in Tables 2–4
[b] Based on the rank sum

disciplines, after adjusting for age, sex, and job category. Overall, there were statistically significant differences in the mean values of each of these three scores across institutions ($P < 0.001$) and disciplines ($P < 0.001$ to $P = 0.005$).

When we categorized the mean I-scores for the seven institutions into quartiles, we found that A was in the lowest quartile; B and C were in the lower-middle quartile; D, E, and F were in the upper-middle quartile; and G was in the highest quartile, with a 0.66-point difference from institution A (–0.17) to institution G (0.49; Table 2). Similarly, when we categorized the four disciplines, we found that "others" and "surgical" were in the lower-middle quartile, while "medical" and "ER/ICU" were in upper-middle quartile, with a 0.18-point difference between others (–0.03) and medical (0.15). Thus, in effect, the difference in mean I-score was larger and more significant across institutions than across disciplines. In addition, pairwise comparisons showed that institution G had a higher mean I-score than the other institutions, and that, across disciplines, "medical" and "ER/ICU" had the highest mean I-scores and "others" had a particularly low mean I-score (Table 2 and Table 5)

Table 2 also shows the differences across institutions according to each discipline, when institutions and disciplines were combined. For the "ER/ICU" discipline, the mean scores differed by 0.87 points across institutions, from –0.29 for institution A to 0.59 for institution G. For the "surgical" discipline, the mean scores differed by 0.66 points across institutions, from –0.16 for institution B to 0.50 for institution G. The difference across institutions in the mean I-score was largest for the "ER/ICU" discipline.

When the seven institutions were categorized into quartiles for their mean E-score, we found that B was in the lowest quartile; A, C, and D were in the lower-middle quartile; E was in the upper-middle quartile; and F and G were in the highest quartile, with a 0.42-point difference in mean E-score across institutions, from –0.35 for institution B to 0.07 for institution G (Table 3). Categorization of the four disciplines showed that "others" was in the lower-middle quartile, whereas "medical," "surgical," and "ER/ICU" were in the upper-middle quartile, with a 0.06-point difference between others (–0.21) and medical (–0.15). In effect, the difference in mean E-score was larger and more significant across institutions than across disciplines. In addition, pairwise comparisons showed that institutions G and F had higher mean E-scores than the other institutions, whereas the discipline "others" had a significantly lower mean E-score than the discipline "medical" (Table 3 and Table 5).

Table 3 also shows the differences across institutions according to each discipline, when institutions and disciplines were combined. For the "ER/ICU" discipline, the mean scores differed by 0.65 points across institutions, from –0.50 for institution B to 0.15 for institution G. The difference across institutions in the mean E-score was largest for the "ER/ICU" discipline.

We also categorized the seven institutions into quartiles for their mean K-scores (Table 4). We found that institutions A and D were in the lowest quartile, B and C were in the lower-middle quartile, E and F were in the upper-middle quartile, and G was in the highest quartile, with a 0.13-point difference in mean K-scores across institutions, from 0.64 for institutions A and D to 0.77 for institution G. The four disciplines were similarly categorized, with "others" and "surgical" being in the lower-middle quartile, while "medical" and "ER/ICU" were in the upper-middle quartile, with a 0.06-point difference between others (0.65) and ER/ICU (0.72). In effect, the difference in mean K-scores was larger and more significant across institutions than across disciplines. In addition, pairwise comparisons showed that institutions G, followed by F and E, had higher mean K-scores than the other institutions, whereas the disciplines "others" and "surgical" had significantly lower mean K-scores than "ER/ICU" and "medical" (Table 4 and Table 5).

Table 4 also shows the differences across institutions according to each discipline, when institutions and disciplines were combined. For the "surgical" discipline, the mean scores differed by 0.16 points across institutions, from 0.61 for institution B to 0.77 for institution G. Although the difference across institutions in mean K-scores was largest for the "surgical" discipline, these differences were smaller than those in the other scores.

The grand mean K-score was 0.66, indicating that the overall correct knowledge level of preventive measures was 66%. Taking statistically significant differences in K-scores into account, we found that institution G had the highest knowledge level (77%), followed by institutions E and F (70%–71%), and institutions A through D (64%–66%). Similarly, when sorted by discipline, the ER/ICU and medical categories had the highest knowledge level (69%–72%), followed by surgical and others (65%–67%).

The rank by each of the three scores (I, E, and K) was compared with the total rank of the three scores combined for both institutions and disciplines (Table 5). We found that, for both institutions and disciplines, the I-rank correlated best with the total rank. The E-rank correlated with the total rank, but was correlated to a lesser extent for institutions, and was correlated least for disciplines. The K-rank was correlated least for institutions but was correlated well for disciplines. Regardless of the score used, institution G ranked higher than the others, followed by F, whereas institution B ranked lowest. Similarly, for disciplines, ER/ICU and medical ranked highest, followed by surgical and "others".

Discussion

A distinctive feature of the present analysis was that the data for individual HCWs were grouped at both institutional and disciplinary levels. In particular, the collective perception of HCWs at each hospital was deemed to be a natural output of the study, which could be used for comparative purposes, and a preliminary analysis was fed back to each facility (unpublished data).

Most notably, the differences across institutions were consistently wider than those across disciplines. This suggested that the state of preparedness at the institutional level was more strongly associated with the perceived efficacy of the policies and measures at that institution than with the perception shared among HCWs belonging to common disciplines. Furthermore, the three score-ranks of institutions and disciplines showed consistent trends. Higher-ranking institutions (G and F) and disciplines (ER/ICU and medical) for a particular score tended to show higher ranks for other scores. This suggested that particular institutions/disciplines could excel (or alternatively, lag behind) in various aspects of preparedness, as perceived by the HCWs.

Among the three scores, the I-score was most reflective of the total rank for institutions and disciplines, as well as being the most efficient measure of differences among institutions and disciplines. The grand mean I-score (+0.01) was narrowly positive; three institutions (A, B, and C) had negative scores and the other four had positive scores. Among the four disciplines, medical, ER/ICU, and surgical had positive I-scores, and others had a negative I-score. Thus, the collective state of preparedness was clearly distin-

guished by the I-score. It is plausible to assume that lower scores, and negative scores in particular, reflect poor institutional policy and countermeasures, as was observed in institutions A, B, and C, and the discipline "others".

The grand mean E-score (–0.21) was negative, and all institutions except for A had negative scores, as did all four disciplines. Hence, the perception of the overall effectiveness of institutional measures (E-score) was more negative than the combined perception of three actual institutional measures (I-score). A possible explanation is that the Japanese system for emergency infection control has not been tested, which may have caused the lack of confidence among HCWs in the effectiveness of institutional measures. In fact, the positive response rates for effectiveness of institutional measures differed substantially between HCWs in Singapore (96%), where the institutional preventive measures were tested and found to be effective, and Japan (31%), where the institutional preventive measures were untested.[11]

Although the difference in knowledge levels was not substantial, certain combinations of discipline and institution had higher-than-expected knowledge levels. For example, ER/ICU HCWs at institution C had a score of 74%, medical HCWs at institution B had a score of 69%, and "other" HCWs at institution B had a score of 68%. Indeed, if HCWs had acquired knowledge on a personal, as opposed to an institutional and/or disciplinary basis, the K-scores would be more randomly distributed across institutions and disciplines. In this survey, 91% of all respondents answered positively to the question "learn as much as you can about SARS" (data not shown). Thus, the individual acquisition of knowledge may have contributed to a narrowing of the differences among institutions/disciplines.

Among disciplines, the three scores for ER/ICU and medical HCWs were higher than those for surgical and "other" HCWs. We expected that the ER/ICU HCWs would have higher scores, because staff engaged in critical care disciplines would have a higher risk of exposure to infectious agents, due to both the specific procedures they perform (e.g., endotracheal intubation, which increases the risk of SARS infection 13-fold)[12] and their exposure to severely ill patients.[13] Under such circumstances, the implementation of emergency infection control measures is imperative, especially for ER/ICU workers.

When institutions and disciplines were combined, the differences in I- and E-scores across institutions were more apparent for ER/ICU HCWs than for the other disciplines. This was due to the lower scores for ER/ICU HCWs at institutions A and B. It was noteworthy that, for most institutions, the ER/ICU discipline scored the highest. Therefore, in the less-prepared hospitals (e.g., A and B), the implementation of emergency infection control measures should be stressed, especially among critical care staff.

Although inferences are limited relative to the type of institution, we found that institutions G and F ranked highest on all three scores. These two institutions are municipal hospitals, and one (F) has been designated to accommodate SARS patients if there is an outbreak. It should be noted, however, that G, a municipal hospital not designated for the treatment of SARS, excelled in all three indicators. Many researchers have emphasized the importance of policy and administrative support at the institutional level for effective infection control measures. Administrative support has been shown to enhance compliance with both universal precautions[14–16] and hand-washing.[17,18] In our analysis, there was a significant difference in the positive response rate for "clear policies and protocols" across institutions, from 92% for institution G to 48% for institution A (data not shown), suggesting that institutional policies contribute to improving the efficacy of emergency infection control measures, as perceived by HCWs.

There are several limitations to our study. First, the cross-sectional nature of the study prevents the determination of cause and effect. Second, there may have been responder bias, in that only workers with a strong interest in SARS may have been motivated to respond. This idea is negated, however, by the quite high response rate to our questionnaire. Third, there may have been a selection bias, in that the number of institutions surveyed was small, although we made an effort to select major hospitals distributed throughout Japan. Fourth, the K-score may not accurately reflect knowledge of preventive measures. HCWs who had accurate knowledge of preventive measures may have answered incorrectly to some items, due to conflicting information, e.g., alcohol rubs and shoe-covers were considered optimal in some guidelines. However, such information was limited, and, hence, its effect should not have been strong. Fifth, we evaluated the differences across institutions and disciplines from the viewpoint of HCWs, but we did not consider the organizational factors associated with this difference. This is also a very important point for each institution to promote their level of preparedness. Such evaluations constitute a separate theme, warranting another study, which will be conducted in the near future.

In conclusion, we found substantial and consistent differences in emergency infection control measures for SARS, as perceived by HCWs, among major health care institutions in Japan. This institutional difference exceeded that across disciplines. Due to the potential for future epidemics of emerging and re-emerging infectious diseases, institutions should aim at higher levels of preparedness, by designating and implementing effective emergency infectious control measures.

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Appendix. Excerpts from administered questionnaire

Institutional (I)[a] **score:** total score of following 3 items divided by 9 (possible score: –1 through +1 point)
1. "Were clear policies and protocols instituted for everyone to follow?" (Clear policies and protocols)
2. "Do you have someone to turn to when you have a problem in using the PPE?" (Specialist available)
3. "Was adequate training provided to you in the use of masks?" (Adequate training)

Effectiveness (E)[a] **score:** total score of following item divided by 3 (possible score: –1 through +1 point)
"Do you feel that implementation of protective measures at work is generally effective?" (Effectiveness)

Knowledge (K)[a] **score:** total of correct responses[b] for following 15 items divided by 15 (possible score: 0 through +1 point)
"Do you believe the following measures are useful in protecting you from contracting SARS?"
1. Area isolation
2. Hand washing
3. Alcohol rubs
4. Prominent notices
5. N95 mask
6. Gloves
7. Gowns
8. Surgical mask
9. Temperature checks
10. Hair covering
11. Paper mask
12. Goggles
13. Gauze mask
14. Shoe covering
15. Limiting visitors

For points assigned for I and E scores, each item was measured on a scale of responses ("strongly disagree " [–3], "disagree" [–2], "probably disagree" [–1], "not applicable" [0], "probably agree" [1], "agree" [2], and "strongly agree"[3])
[a] Abbreviation used in text
[b] The correct responses for the 15 items were positive ("probably agree," "agree," and "strongly agree") for all except "paper mask" and "gauze mask," which required negative responses ("probably disagree," "disagree," and "strongly disagree").

References

1. WHO. Summary of probable SARS cases with onset of illness from 1 November 2002 to 31 July 2003. http://www.who.int/csr/sars/country/table2004_04_21/en/
2. Svoboda T, Henry B, Shulman L, Kennedy E, Rea E, Ng W, et al. Public health measures to control the spread of the svere aute rspiratory syndrome during the outbreak in Toronto. N Engl J Med 2004;350:2352–61.
3. Watts J. China makes preparations for possible new SARS outbreak. Lancet 2003;362:1294.
4. Pang X, Zhu Z, Xu F, Guo J, Gong X, Liu D, et al. Evaluation of control measures implemented in the severe acute respiratory syndrome outbreak in Beijing, 2003. JAMA 2003;290:3215–21.
5. Singh K, Hsu LY, Villacian JS, Habib A, Fisher D, Tambyah PA, et al. Severe Acute Respiratory Syndrome: lessons from Singapore. Emerg Infect Dis 2003;9:1294–8.
6. WHO, Western Pacific Region. Practical guidelines for infection control in health care facilities. http://www.wpro.who.int/sars/docs/practicalguidelines/chapter1.pdf
7. Imai T, Takahashi K, Hoshuyama T, Hasegawa N, Lim MK, Koh D, et al. SARS risk perceptions among healthcare workers, Japan. Emerg Infect Dis 2005;11:404–10.
8. Kaminota M. Prepare for the return of SARS in this winter (in Japanese). Koshu Eisei 2003;67:826–30.
9. Nakashima H. Prevention and therapy for SARS virus infection (in Japanese). BIO Clinica 2003;18:983–8.
10. WHO. Hospital infection control guidance for severe acute respiratory syndrome (SARS). http://www.who.int/csr/sars/infectioncontrol/en/
11. Koh D, Takahashi K, Lim MK, Imai T, Chia SE, Qian F, et al. SARS risk perception and preventive measures, Singapore and Japan. Emerg Infect Dis 2005;11:641–2.
12. Fowler RA, Guest CB, Lapinsky SE, Sibbald WJ, Louie M, Tang P, et al. Transmission of severe acute respiratory syndrome during intubation and mechanical ventilation. Am J Respir Crit Care Med 2004;169:1198–202.
13. Peiris JS, Chu CM, Cheng VC, Chan KS, Hung IF, Poon LL, et al. Clinical progression and viral load in community outbreak of coronavirus-associated SARS pneumonia: a prospective study. Lancet 2003;361:1767–72.
14. Grosch JW, Gershon RR, Murphy LR, Dejoy DM. Safety climate dimensions associated with occupational exposure to blood-borne pathogens in nurses. Am J Ind Med 1999 Sep; (Suppl 1):125–7.
15. Gershon RR, Karkashian CD, Vlahov D, Kummer L, Kasting C, Green-Mckenzie J, et al. Compliance with universal precautions in correctional health care facilities. J Occup Environ Med 1999;41:181–9.
16. Michalsen A, Delclos GL, Felknor SA, Davidson AL, Johnson PC, Vesley D, et al. Compliance with universal precautions among physicians. J Occup Environ Med 1997;39:130–7.
17. Rosenthal VD, McCormick RD, Guzman S, Villamayor C, Orellane PW. Effect of education and performance feedback on handwashing: the benefit of administrative support in Argentinean hospitals. Am J Infect Control 2003;31:85–92.
18. Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauran V, Touveneau S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Lancet 2000;356:1307–12.