

Appropriate use of personal protective equipment among health care workers in Singapore, China, and Japan hospitals during the SARS outbreak

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ABSTRACT

Several countries in Asia were affected by the outbreak Severe Acute Respiratory Syndrome (SARS) from late 2002 to 2003. The use of personal protective equipment (PPE) by health care workers (HCWs) was one of the major lines of defense against infection. The objectives of this study were: (1) to study usage of PPE among 3 groups of HCWs viz. doctors, nurses, and clerical staff in Singapore, China and Japan; (2) to determine if the appropriate PPE were used by the different groups; and (3) to examine the factors that may determine inappropriate use. A self-administered questionnaire survey of HCWs in various health care settings in Singapore (n=15,025), China (n=3,000) and Japan (n=9,978) was conducted during May to July 2003. This study found that 27% - 76%, 86% - 90%, and 68% - 70% of the HCWs in Singapore, China and Japan; respectively either agree or strongly agree that paper and/or surgical mask was protective against SARS. This study also highlights the importance of not only emphasizing the right respirators to be used but also the need to implement a PPE programme for all levels of HCWs.

Keywords: Respirators, Health care workers, SARS, Singapore, Japan, China

INTRODUCTION

Severe Acute Respiratory Syndrome (SARS), a viral respiratory illness caused by the coronavirus, SARS-CoV, is possibly the first globally significant occupational disease to emerge in the 21st century. Corona viruses are single-stranded-RNA viruses causing disease in humans and animals. Other identified corona viruses have also been known to cause the common cold in humans. Most studies of SARS cases in which transmission occurred from a single point of exposure have reported an incubation period between 2 and 10 days (Peiris, 2003). SARS is an occupational disease with which the world is beginning to come to grips, and a grim reminder that health care work is potentially hazardous (Koh, 2003). Health care workers (HCWs) in direct contact with patients, especially involving aerosol-generating procedures, were at highest risk (WHO, 2003a). In some cases, transmission to HCWs occurred even when they were wearing masks, eye protection, gowns, and gloves.

The primary mode of transmission appears to be through direct or indirect contact of mucous membrane (eyes, nose, or mouth) with infectious respiratory droplets or fomites (WHO, 2003a). Outbreaks involving large numbers of SARS patients have been linked to the use of aerosol-generating procedures such as endotracheal intubation, bronchoscopy, and treatment using aerosolized medication (Peiris, 2003). The role of fecal-oral route is unknown but may be important. Person-to-person spread by infected droplets is the most important mode of transmission. When the infected person coughs, droplets containing the virus are released into the surroundings and infect those around this sick person. This explains the spread of SARS to health care workers, their family members and friends which has been reported in many studies (Hus, 2003; Abdullah, 2003).

For other occupational exposures, engineering measures (e.g. enclosure, local exhaust ventilation, substitution, etc.) could be adopted more easily. But the most important means of protecting HCWs against SARS is by equipping them with personal protective equipment (PPE). Therefore the correct choice and use of PPE are paramount.

The World Health Organisation (WHO) issued a guidance dated 24 April 2003 entitled 'Hospital Infection Control Guidance for Severe Acute Respiratory Syndrome (SARS)' (WHO, 2003b). This guideline was meant for all hospitals worldwide. How closely is the WHO guidance being followed by HCWs in different countries and what is their understanding of the protective nature of PPE? It was with the above in mind that the study was conducted with the objectives of (i) determining the use of PPE among 3 groups of HCWs viz. doctors, nurses, and clerical staff; (ii) determining if the correct PPE was being worn by each group and (iii) examining the factors associated with incorrect knowledge on the usage of PPE among HCWs in Singapore, China and Japan during the SARS period.

METHODS

This paper reports the results from a subset of a larger study involving a self-administered questionnaire survey of HCWs in various health care settings in Singapore (n=15,025), China (n=3,000) and Japan (n=9,978) which was conducted during May to July 2003. Only doctors, nurses and clerical staff were selected for subsequent analysis. The six-page questionnaire was first formulated in English. The Chinese and Japanese versions of the questionnaires were translated by experts in the relevant languages who were also HCWs.

The questions were on occupational and socio-demographic data, perception of risk of infection and preventive measures, and the impact of the SARS outbreak on personal and work life. The responses were recorded on a 6-point Likert scale (1 = strongly disagree, 6 = strongly agree) with scores of 1 to 3 taken as indicative of negative response, and 4 to 6 as a positive response. Ethical approval was obtained from the Institutional Review Boards of the respective institutions in the different countries.

In Singapore, the health care settings included three SARS affected tertiary hospitals, a non-affected hospital for women and children, two community hospitals, two dental centers (one of which was located within a SARS affected hospital), and nine primary care clinics belonging to one of two health

care clusters locally. The two dental centers are excluded in the present report. Only doctors, nurses and clerical staff (those least likely to be exposed to SARS) were included.

Since the SARS outbreak was very serious in Beijing and Tai Yuan, the capital city of Shan Xi province, and as they represent the various socioeconomic status in China, these cities were selected to study the representative sample of the psychological response in the health care workers of north China. Five hospitals (including two Traditional Chinese Medicine (TCM) hospitals) were selected that would accurately represent the different characteristics of medical care in China (general hospital, TCM hospital, military hospital, and specialized hospital). The staff working in the five hospitals (Provincial, District and Community) between June and July 2003 were included in this study after they agreed to participate in this study. Staff were excluded if they were not willing to complete the questionnaire survey.

The survey in Japan was conducted in seven tertiary hospitals distributed throughout Japan. Of these, four are university-attached, two are municipal and one is private. One of the municipal hospitals was specifically designated to accommodate SARS patients and the rest have similar potential to encounter SARS patients. On hindsight, Japan was spared from the epidemic but the entire country was then at high alert and various countermeasures were devised and implemented in hospitals. As a general rule, all staff working at the respective hospitals, regardless of profession or section, were asked to answer the anonymous questionnaire.

Data analysis were performed using SPSS Version 12 (SPSS Inc, Chicago, USA) for the data analysis. The questions began with a stem such as "I believe that the following measures are useful in protecting me from contracting SARS..." Individuals who agreed that paper and/or surgical masks were effective were grouped together as "agreed" for all subsequent analysis. In addition to univariate descriptive statistics, multiple logistic regression were used to determine the significant factors that were associated with the view that usage of paper/surgical masks was protective against SARS.

Logistic regression analysis was used to evaluate significant factors predicting a positive response for paper and/or surgical masks being effective against SARS, adjusting for significant possible risk factors. Odds ratios and 95% confidence intervals (CI) were calculated, using the lowest risk group as the referent. The following variables were entered into the multiple logistic regression models: age, length of service, job title, nature of work, and area of work.

RESULTS

Overall, 10,236 (70% response), 2,792 (93% response) and 7,282 (73% response) valid questionnaires were returned in Singapore, China and Japan; respectively. 873 doctors, 4,404 nurses, and 921 clerical staff in Singapore, 859 doctors, 1,033 nurses, and 128 clerical staff in China and 1,282 doctors, 3,588 nurses, and 763 clerical staff in Japan were studied.

We studied the knowledge of effectiveness of PPE by doctors, nurses and clerical staff by country. The types of PPE were grouped under respiratory and others, and within each group the PPE is ranked in descending order starting with the most effective. The responses for the other PPE (N95 mask, goggles, PAPR, gowns, hair cover, gloves, shoe cover) were fairly homogenous among the three groups of occupations in all 3 countries (Data is available in Tables I-III).

The responses on Likert scale were subsequently merged into 3 corresponding categories – "Agree", "Undecided" and "Disagree".

The mean age of the HCWs and their mean length of experience were fairly similar for the 3 countries (data not shown). All individuals who agreed that paper and/or surgical masks were effective were grouped together as "agreed" for further analysis. Tables IV, V and VI summarize the significant factors ($p < 0.005$) that were associated with individuals who agreed that paper and/or surgical masks were adequate protection against SARS. The risks of using a less effective level of respiratory protection were significantly lowest among doctors, followed by nurses and clerical staff for Singapore and China (Tables VI and V). But there was no significant difference in the risk of using a less effective level of respiratory protection for doctors, nurses and clerical staff in Japan (Table VI). Interestingly, doctors and nurses in Japan seem to be less persuaded of the effectiveness of other PPE than doctors in the other countries. In

Singapore, individuals who (regularly) came into contact with SARS patients were significantly more likely to wear the appropriate respiratory protection compared to those who did not (Table IV). This relationship was not observed in the China and Japan HCWs (Tables V and VI). Using "administrative staff" as the reference group, Singapore HCWs working in surgical, medical and intensive care units were more likely to wear the appropriate respiratory protection. However, there was no significant difference for those individuals in the other areas viz. A&E Unit, radiographic services, laboratory services and others compared to administrative personnel. There were no significant associations between the area of work and usage of a less effective level of respiratory protection for HCWs of China and Japan (Tables V and VI).

Table I. Knowledge of Effectiveness of Personal Protective Equipment (PPE) by Doctors, Nurses and Clerical Staff in Singapore

	Doctors (n=873)			Nurses (n=4,404)			Clerical Staff (n=291)		
	Disagree	Undecided	Agree	Disagree	Undecided	Agree	Disagree	Undecided	Agree
N95 mask	2 0.2%	35 3.9%	866 95.9%	16 0.4	91 2.1	4340 97.6	15 1.8	47 5.4	807 92.9
Surgical Mask	511 58.3%	172 19.6%	194 22.1%	1703 41.4	644 15.7	1769 42.9	92 6.1	112 12.5	628 75.5
Paper Mask	723 82.7%	80 9.2%	68 7.8%	2419 60.7	451 11.2	1181 29.2	291 37.7	134 17.4	346 44.9
Goggles	28 3.1%	122 13.8%	737 83.1%	58 1.3	245 5.7	4058 93.1	49 6.7	115 15.7	571 77.7
Gloves	5 0.6%	25 2.9%	852 96.6%	18 0.4	89 2.0	4287 97.6	25 3.3	75 9.9	659 86.8
Gowns	17 1.9%	89 10.1%	776 88%	46 0.8	165 3.7	4206 95.4	28 3.8	84 11.4	626 84.8
Hair cover	71 8.1%	230 26.5%	568 65.3%	129 3.0%	464 11.0	3611 85.9	36 5.1	126 17.6	552 77.3
Shoe cover	106 12.5%	309 36.6%	431 51%	230 5.9	803 20.7	2850 73.4	52 7.7	162 24.1	459 68.2

DISCUSSION

In the prevention of occupational disease, controlling the hazard at source is always the foremost guiding principle, although this is realistically very difficult to apply. HCWs come into contact with varied groups of people from all walks of life. Of course, health care institutions do set up other safeguards, for example, temperature screening for all individuals coming into the hospital, special protocols for managing febrile patients, isolation wards, respiratory isolation and barrier precautions (Ho, 2003; Dwosh, 2003; Fisher 2003). But ultimately, the last line of defense is the appropriate use of personal protective devices, especially that of effective respiratory protection.

Table II. Knowledge of Effectiveness of Personal Protective Equipment (PPE) by Doctors, Nurses and Clerical Staff in China

	Doctors (n=873)			Nurses (n=4,404)			Clerical Staff (n=291)		
	Disagree	Undecided	Agree	Disagree	Undecided	Agree	Disagree	Undecided	Agree
N95 mask	19 2.40%	107 13.60%	660 84.00%	16 1.70%	82 9.10%	809 89.20%	0 0.00%	12 25.00%	36 75.00%
Surgical Mask	77 10.00%	142 18.50%	552 71.60%	86 9.40%	130 14.20%	699 76.40%	4 8.70%	18 39.10%	24 52.10%
Paper Mask	214 29.60%	182 25.20%	327 45.30%	278 34.70%	178 22.20%	345 43.10%	12 25.50%	17 36.20%	18 38.30%
Goggles	8 4.10%	24 12.30%	163 83.60%	3 1.40%	24 11.20%	188 87.50%	0 0.00%	0 0.00%	8 100.00%
Gloves	13 1.60%	82 10.10%	719 59.00%	7 0.70%	58 5.90%	916 93.40%	1 2.00%	4 7.80%	46 90.20%
Gowns	44 6.00%	171 23.10%	537 72.30%	34 4.10%	135 16.50%	650 79.40%	1 2.20%	6 13.20%	38 84.40%
Hair cover	23 2.90%	115 14.50%	654 82.60%	21 2.30%	95 10.40%	797 87.30%	1 2.20%	8 21.80%	36 44.40%
Shoe cover	15 1.90%	100 12.30%	699 85.90%	8 0.80%	79 3.40%	894 91.10%	2 3.90%	7 13.70%	42 82.30%

The questions asked on usage of PPE began with a stem "I believe that the following measures are useful in protecting me from contracting SARS..." The range of PPE available to HCWs which we studied is listed in supplementary Table I. The responses for the other PPE (N95 mask, goggles, PAPR, gowns, hair cover, gloves, shoe cover) were fairly homogenous among the three groups of occupations in all the 3 countries (supplementary Tables I-III).

With regard to respiratory protections (viz. paper mask and surgical mask) the responses were more varied. Doctors in Singapore were more knowledgeable about respiratory protection than the nurses and the nurses more than the clerical staff. However, this pattern was not observed among the doctors and nurses in China and Japan. In these countries, knowledge about respiratory protection was fairly similar for both the doctors and nurses. This observation may be a reflection of the education levels of the health care workers in China and Japan. Although respiratory protection knowledge may differ among the countries, what was disturbing was that 22% - 76%, 52% - 76%, and 36% - 38% of the HCWs in Singapore, China and Japan; respectively either agreed or strongly agreed that surgical masks were protective against SARS (Table I-III).

Possible explanations for this observation could be (i) at the early stages of the SARS outbreak, the nature of the virus and its mode of transmission were unclear and therefore the importance of usage of PPE may also not have been clear; (ii) HCWs may have their own interpretation of what level of protection was considered 'adequate'; (iii) hospitals may have other preventive measures, e.g., compulsory temperature screening for all visitors and patients. These measures may have given the confidence that things were under control. These reasons have earlier been discussed in depth in a paper

that examines the use of PPE among HCWs in Singapore (Chia, 2005). Although the paper was in relation to Singapore HCWs, the reasons would probably be applicable to the Chinese and Japanese HCWs too.

Table III. Knowledge of Effectiveness of Personal Protective Equipment (PPE) by Doctors, Nurses and Clerical Staff in Japan

	Doctors (n=873)			Nurses (n=4,404)			Clerical Staff (n=291)		
	Disagree	Undecided	Agree	Disagree	Undecided	Agree	Disagree	Undecided	Agree
N95 mask	47 3.7%	333 26.9%	860 69.4%	141 4.7%	803 26.7%	2063 68.6%	23 3.3%	176 25.8%	482 70.8%
Surgical Mask	222 17.8%	577 46.2%	448 35.9%	548 18.4%	1313 44.1%	1115 37.5%	102 14.9%	324 47.2%	260 37.9%
Paper Mask	431 34.8%	589 47.5%	219 17.6%	907 30.5%	1483 49.8%	586 19.7%	211 30.6%	349 50.6%	129 18.8%
Goggles	214 17.2%	604 48.6%	425 34.2%	447 15.0%	1381 46.2%	1155 38.8%	123 17.9%	309 45.0%	256 37.2%
Gloves	121 9.1%	538 40.6%	666 50.2%	185 5.8%	1036 32.8%	1938 61.3%	79 12.1%	298 45.5%	295 45.0%
Gowns	175 13.3%	612 46.4%	530 40.3%	263 8.4%	1261 40.4%	1600 51.2%	121 18.7%	344 53.1%	182 28.1%
Hair cover	209 15.9%	661 50.2%	448 34.0%	370 11.9%	1432 46.1%	1301 41.9%	120 18.6%	340 52.7%	165 25.6%
Shoe cover	223 17.0%	707 53.9%	383 29.2%	446 14.6%	1545 50.8%	1052 34.6%	124 19.4%	357 22.7%	160 24.9%

The US Centers for Disease Control and Prevention report recommended “a respirator that is at least as protective as an N-95 respirator approved by the National Institute for Occupational Safety and Health (NIOSH)” for protection against SARS as early as 6 May 2003 (CDC, 2003). Likewise, WHO issued a statement dated 24 April 2003 regarding respiratory protection that said “This should where feasible be provided at P100/FFP3, or P99/FFP2 filter level (99.97% and 99% efficiency respectively). N95 filters (95% filter efficiency) also provide high levels of protection and could be worn where no acceptable higher protection alternatives are available for example staff working in triage areas, prior to isolation. Ideally, the masks used should be fit tested using an appropriate ‘fit test kit’ in accordance with the manufacturing instructions. Disposable masks should not be reused.” (WHO, 2003b). Both these guidelines were issued via the respective institutions’ websites and were freely accessible to all.

Of the HCWs who reported working with SARS patients, 23.6% of the doctors and 42.3% of the nurses in Singapore and 82.8% of the doctors and 87.1% of the nurses in China felt that paper and/or surgical masks were adequate protection against SARS (data not shown). Paper masks have been reported to be ineffective in protection against SARS while the protective factor of surgical masks was much lower than that of N95 (Seto, 2003; Loeb, 2004). In spite of this at least 23% and 80% of HCWs in Singapore and China, respectively still thought that paper and/or surgical mask were protective. A sizable percentage of this group of HCWs were from Medicine, Intensive Care Units, Accident and Emergency

Units and Radiographic services – all of which are high risk areas for possible SARS patients. The fact that these HCWs were not adequately protected certainly put them at higher risk of infection compared to those with necessary respiratory protection.

Table IV. Significant Factors Predicting a Response that Agree that Paper and/or Surgical Masks Were Protective against SARS in Singapore

	Odds Ratios (OR)*	95% confidence intervals
Age (years)	1.013	1.003 – 1.024
Length of service (years)	0.984	0.974 – 0.994
Job title		
Clerical staff	1	
Doctor	0.127	0.090 - 0.181
Nurses	0.330	0.238 – 0.459
Nature of work		
Not in contact with SARS patients	1	
Contact with SARS patients	0.673	0.587- 0.771
Area of work		
Administrative	1	
Surgical	0.570	0.385 – 0.845
Medical	0.635	0.431 – 0.934
Intensive Care Unit	0.378	0.249 – 0.574
Accidents & Emergency	0.837	0.514 – 1.364
Radiographic services	0.622	0.316 – 1.224
Laboratory services	1.542	0.727 – 3.267
Others	0.726	0.498 – 1.059

* OR derived using multiple logistic regression model adjusting for age, length of service, job title, nature of work, and area of work; where applicable.

HCWs caring for patients with SARS or other types of infectious diseases which can be transmitted from direct patient contact or contact with large respiratory droplets in the close vicinity of an infected patient should be properly trained in the correct use and removal of PPE. This 3-country study has clearly shown that there are still deficiencies in the knowledge of the right types of respiratory protection among HCWs despite clear instructions given by recognized international health institutions. There have been reports of clusters of SARS cases among protected HCWs (Ofner, 2003). Some of the reasons cited for these cases were that “no formal respiratory protection programme existed”, “individual workers had not been fit tested”, “mask did not fit well” and “lacked a clear understanding of how best to remove PPE without contaminating themselves” (Ofner, 2003). The authors felt that given the many other tasks that the infection control nurses had to do it should not be the responsibility of the infection control nurses, as is the practice of some hospitals, to take charge of educating the HCWs in the hospital, sourcing for the right protective equipment, and ensuring that PPE is worn correctly and maintained. The authors are of the opinion that the use of PPE is a highly specialized discipline which requires a dedicated team of health care professionals who are trained in this job, prior to an outbreak of diseases. We have learnt the hard way during the recent SARS outbreak. If HCWs had been trained earlier in the use of PPE, especially regarding correct respiratory protection, perhaps there would have been less HCWs getting infected with SARS in the course of their work.

Table V. Significant Factors Predicting a Response that Agree that Paper and/or Surgical Masks Were Protective against SARS in China

	Odds Ratio (OR)*	95% confidence interval
Age (years)	1.048	0.984 – 1.115
Length of service (years)	0.951	0.895 – 1.010
Job title		
Clerical staff	1	
Doctor	0.464	0.112 – 1.926
Nurses	0.631	0.153 – 2.608
Nature of work		
Not in contact with SARS patients	1	
Contact with SARS patients	0.783	0.527- 1.164
Area of work		
Administrative	1	
Surgical	1.412	0.326 – 6.110
Medical	1.365	0.320 - 5.822
Intensive Care Unit	0.659	0.147 - 2.944
Accidents & Emergency	1.584	0.352 – 7.115
Radiographic services	0.898	0.161 – 5.013
Laboratory services	3.552	0.296 – 42.625
Others	1.178	0.280 – 4.945

* OR derived using multiple logistic regression model adjusting for age, length of service, job title and nature of work; where applicable.

In the authors' opinion, the most effective way of organizing the team is through the occupational health service (OHS) unit which is an integral part of any workplace which is committed to looking after the safety and health of its workforce. The OHS unit should ideally consist of an occupational physician, an occupational health nurse, a safety officer and an occupational hygienist. The OHS team would be in the best position to train and advise HCWs on the use of appropriate PPE, audit its usage and correct those who are using it wrongly.

Emerging infectious diseases are here to stay. In addition to the relentless pursue of identifying and studying these emanating infectious agents, surely, the relevant bodies must also put in place a steadfast program to protect the health of HCWs. The time is now for health care service providers to deploy a programme that will ensure the protection of HCWs against any known or emerging infectious agents. They cannot wait till another 'SARS' or an infectious disease outbreak occurs before starting another preventive exercise. We have learnt the lessons with the lives of many HCWs in the recent SARS outbreak. Lessons learnt must be translated to action now before another infectious pandemic strikes. As can be seen from this study, a variety of factors determine appropriate use of personal protective equipment by HCWs in the face of a major SARS outbreak. This report highlights the importance of not only emphasizing the right respirators to be used but also the need to implement a PPE programme for all levels of HCWs. The authors believe this would be best implemented by an occupational health service unit in hospitals.

Table VI. Significant Factors Predicting a Response that Agree that Paper and/or Surgical Masks Were Protective against SARS in Japan

	Odds Ratios (OR)*	95% confidence intervals
Age (years)	1.006	0.988 – 1.020
Length of service (years)	0.996	0.979 – 1.013
Job title		
Clerical staff	1	
Doctor	1.075	0.741 – 1.58
Nurses	1.046	0.730 – 1.499
Nature of work		
Not in <i>possible</i> contact with SARS patients	1	
<i>Possible</i> contact with SARS patients	1.012	0.886- 1.155
Area of work		
Administrative	1	
Surgical	0.851	0.565 – 1.282
Medical	0.899	0.597 – 1.352
Intensive Care Unit	0.679	0.423 – 1.090
Accidents & Emergency	0.887	0.499 – 1.575
Radiographic services	0.873	0.500 – 1.523
Laboratory services	0.690	0.364 – 1.310
Others	1.132	0.735 – 1.743

* OR derived using multiple logistic regression model adjusting for age, length of service, job title and nature of work; where applicable.

CONCLUSIONS

This study found that 27% - 76%, 86% - 90%, and 68% - 70% of the HCWs in Singapore, China and Japan; respectively either agree or strongly agree that paper and/or surgical mask was protective against SARS. This study also highlights the importance of not only emphasizing the right respirators to be used but also the need to implement a PPE programme for all levels of HCWs.

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