Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Public Health (2006) **120**, 8–14

ELSEVIER

PUBLIC HEALTH

JOURNAL OF THE ROYAL INSTITUTE OF PUBLIC HEALTH

www.elsevierhealth.com/journals/pubh

MINI-SYMPOSUIM

The 2003 SARS outbreak and its impact on infection control practices

Karen Shaw*

Health Protection Agency, South East Regional Office, 6th Floor New Court, 48 Carey Street, London WC2A 2JE, UK

Available online 16 November 2005

KEYWORDS
Severe Acute Respiratory;
Syndrome;
Healthcare workers;
Infection control

Summary Severe Acute Respiratory Syndrome (SARS) emerged recently as a new infectious disease that was transmitted efficiently in the healthcare setting and particularly affected healthcare workers (HCWs), patients and visitors. The efficiency of transmission within healthcare facilities was recognised following significant hospital outbreaks of SARS in Canada, China, Hong Kong, Singapore, Taiwan and Vietnam.

The causative agent of SARS was identified as a novel coronavirus, the SARS coronavirus. This was largely spread by direct or indirect contact with large respiratory droplets, although airborne transmission has also been reported. High infection rates among HCWs led initially to the theory that SARS was highly contagious and the concept of 'super-spreading events'. Such events illustrated that lack of infection control (IC) measures or failure to comply with IC precautions could lead to large-scale hospital outbreaks. SARS was eventually contained by the stringent application of IC measures that limited exposure of HCWs to potentially infectious individuals. As the 'global village' becomes smaller and other microbial threats to health emerge, or re-emerge, there is an urgent need to develop a global strategy for infection control in hospitals.

This paper provides an overview of the main IC practices employed during the 2003 SARS outbreak, including management measures, dedicated SARS hospitals, personal protective equipment, isolation, handwashing, environmental decontamination, education and training. The psychological and psychosocial impact on HCWs during the outbreak are also discussed. Requirements for IC programmes in the post-SARS period are proposed based on the major lessons learnt from the SARS outbreak.

Introduction

Severe acute respiratory syndrome (SARS) has emerged recently as a new acute respiratory illness that spread rapidly across the world resulting in 8096 cases and 774 deaths.[1] During the 2003

* Corresponding author. Tel.: +44 20 74920431; fax: +44 20 74920481.
E-mail address: karen.shaw@hpa.org.uk.

0033-3506/$ - see front matter © 2005 The Royal Institute of Public Health. Published by Elsevier Ltd. All rights reserved.
doi:10.1016/j.puhe.2005.10.002

outbreak SARS was transmitted efficiently among healthcare workers (HCWs), patients and hospital visitors. Documented hospital outbreaks of SARS occurred in Canada, China, Hong Kong, Singapore, Taiwan and Vietnam and highlighted the weak infection control (IC) infrastructure present in healthcare facilities in resource rich and resource poor areas.[2-7] The morbidity and mortality seen in HCWs as a result of SARS focused attention on IC practices, including the use of personal protective equipment (PPE), and the role of education and training in the prevention of SARS. Indeed, one of the major lessons learnt from the SARS outbreak was that IC practices and programmes need strengthening globally.

This paper summarises the main IC practices employed during the 2003 SARS outbreak and suggests requirements for IC programmes in the post-SARS period. The content of this paper is based upon personal observation and experience before, during and after the SARS epidemic, a review of the scientific literature, attending conferences and meetings and discussions with colleagues directly involved in efforts to contain SARS.

IC practices within the laboratory environment are also an important issue particularly as a number of laboratory-related incidents occurred following containment of the initial outbreak. However, they are not discussed in this paper.

Transmission

Before discussing the role of IC as a component of the public health response to the containment of SARS, it is necessary to have an understanding of how SARS is transmitted.

The causative agent of SARS was identified as a novel coronavirus, the SARS coronavirus (SARS-CoV) .[8,9] Epidemiological data indicate that the virus is largely spread by direct or indirect contact with respiratory droplets, airborne transmission has also been reported.[10,11] Initially, as a result of early reports of high infection rates among HCWs, SARS was thought to be highly contagious. This was reinforced with the reporting of 'super-spreading events'.[2,5,12-15] The concept of super-spreading events has been proposed to explain incidents where a SARS patient infects many more persons than would be expected. Such events contributed to large-scale nosocomial outbreaks and have been attributed to the lack of stringent IC measures in hospitals. However, this does not fully explain these events and further research is required to understand the underlying risk factors. Aerosol-generating procedures have been associated with increased risk of transmission through the aerosolisation of virus-containing particles.[16] In addition patients with unrecognised SARS, particularly those with atypical presentations were the source of a number of nosocomial outbreaks.[13,15]

As the outbreak evolved SARS was shown to be only moderately transmissible with an estimated basic reproductive number of approximately three.[17,18] The basic reproductive number refers to the average number of secondary cases generated by one primary case in a susceptible population. For SARS this is much lower than for influenza, and unlike influenza and other viral respiratory diseases, SARS-CoV has a long incubation period (up to 14 days), with the viral load peaking during the second week of illness and appearing to be highest in patients with more severe disease.[2] This may explain why transmission has not been identified in asymptomatic patients or after symptoms have resolved, and why transmission mainly occurs in hospitals.

Infection control practices during the SARS outbreak

The World Health Organization (WHO) coordinated the global response to SARS and together with a number of technical partners including the Global Outbreak Alert and Response Network (GOARN) provided support, including field teams, to health authorities to combat SARS.[19] WHO also established a number of virtual networks which linked clinicians, epidemiologists, microbiologists, virologists, public health experts, IC practitioners and others enabling the rapid exchange of data and information.[19] These discussion groups, particularly those of the clinical network, helped fashion the IC guidance provided by WHO on its website. Many countries and regions employed WHO or other IC guidelines directly, or modified them to suit local circumstances.[20]

Early in the course of the epidemic hospital outbreaks of SARS occurred in Canada, China, Hong Kong, Singapore, Taiwan, and Vietnam.[2-7] A total of 1706 cases of SARS occurred among HCWs and their distribution varied by country.[1] Major IC measures implemented in hospitals to control the outbreak included the following.

Management measures

These were implemented to prevent further transmission of infection on the wards as well as in the

outpatient setting and, to provide reassurance to healthcare workers and the wider community. Management measures included: closure of hospitals; written policies for SARS IC practices; triage screening; restriction of hospital visitors; limiting non-essential contact between HCWs and patients; closure of emergency departments (ED); and the use of masks by HCWs, patients and hospital visitors.[5,21–25] However, despite IC policies being made available during the SARS outbreak, direct observation indicated that they were not applied consistently.[22,26]

Dedicated SARS hospitals

In a number of areas that had major outbreaks of SARS, one or more hospitals were designated to manage SARS patients exclusively.[22,27] Early on in the outbreak this led to the inadvertent spread of SARS as patients discharged to provide beds for incoming suspect and probable SARS cases were themselves incubating SARS and acted as 'Trojan horses' carrying SARS-CoV with them and starting nosocomial outbreaks elsewhere. It is unclear whether the designation of a SARS hospital is an effective method of controlling the spread of the SARS-CoV. However, among the lessons learnt from this was that patients should be isolated rather than transferred to other hospitals.

Personal protective equipment

During the SARS outbreak experts were divided on the adequacy of IC measures, types of PPE that should be used and the need for protective eyewear. There were reports that masks, fit testing and fit checking practices varied and did not always take place.[28] However, subsequent evidence has shown that the use of a mask, either surgical or an N95 respirator (or equivalent), was protective compared to no mask.[28] It was also reported from Toronto that SARS was less likely to develop if a mask was used consistently with each patient contact.[29] This is supported by evidence from Hong Kong which suggests that HCWs who used complete precautionary measures were less likely to become infected than those who omitted even one precautionary measure.[30] However, there is evidence that some HCWs were infected with SARS following exposure to aerosol- and droplet-generating procedures despite wearing full PPE (that is N95 mask (or equivalent), gown, eye protection and gloves).[6,16,19,31] A number of reasons were proposed for this including incomplete compliance with infection control guidance such as removing PPE unsafely, reuse of single use PPE, not having masks correctly fitted prior to use and not using eye protection. In contrast, a retrospective study reported that 70% (72/102) of HCWs in the United States who cared for SARS patients did not use eye protection.[32] Furthermore, no documented transmission of SARS-CoV was reported, even among those who had been within 3 feet of a confirmed case.

Although it is generally agreed that the widespread use of PPE was effective in controlling the spread of SARS in the hospital environment, the costs were prohibitive. In Singapore where routine use of PPE was instituted early in the epidemic, it is estimated that in the first 6 weeks of the epidemic US$700 000 was spent on PPE alone.[33] Furthermore, inappropriate use of PPE and respirators resulted in shortages and guidelines had to be developed to prioritise those who should use respirators and where they should be worn.[22,33] This demonstrates the importance of planning and preparedness, particularly with regard to supplies of essential equipment.

Isolation

Isolation refers to the separation and restricted movement of ill persons who have a contagious disease in order to prevent its transmission to others.[34] Isolation measures typically occur in a hospital setting and may be applied to individuals or larger groups to interrupt disease transmission. During the SARS outbreak rapid identification and isolation of SARS patients together with rapid identification and management of contacts proved to be highly effective in interrupting transmission. However, isolation practices varied both between and within countries. This was most likely due to important variations in resources and IC practices.

WHO recommended that probable SARS patients be placed in a negative pressure room, isolated in a single room or cohorted in areas with independent air circulation.[35] In response to this a number of countries and areas designated certain hospitals or wards for SARS patients only. Others constructed new isolation wards and rooms or carried out extensive engineering modifications to existing structures.[22,36–38] Those lacking such facilities and resources responded with innovative solutions. Three examples were: hospital staff attempting to create negative-pressure relative to hallways by using fans and windows opening to the exterior; the development of guidelines to enable the re-use of respirators; and the erection of glass walls in

hallways to create anterooms to patients' rooms.[7,22]

Physical space separation

There is evidence indicating that the risk of developing SARS was related to proximity to a case.[2,5,39,40] In one study a 'Hierarchy of Risk' was developed which showed that the risk of infection increased with proximity of contact, and that in the absence of aerosol-generating procedures, exposures <1 m from a case of SARS (with or without contact) were those that posed the highest risk.[2] These results suggest that physical separation of SARS patients from HCWs, hospital visitors and other patients should reduce the transmission of SARS. Indeed, in many of the areas with a large number of SARS cases several different measures were implemented in order to do this. These included the rapid identification and isolation of possible SARS patients waiting in Emergency Departments; isolating potential SARS patients either individually or in cohorts; designating lifts for use by potential SARS cases only; and, using anterooms for the donning and removal of PPE.[3,7,22,23]

Handwashing

Despite a number of studies demonstrating that handwashing is effective in reducing the transmission of pathogens, it is recognised that compliance among HCWs is poor.[41,42] Although there have not been any formal evaluations of the impact of handwashing on SARS-CoV transmission, recent evidence indicates that HCWs who washed their hands while caring for SARS patients were less likely to develop SARS compared to those that did not.[30]

Environmental decontamination

SARS-CoV is present in all body fluids making precautions with waste disposal essential. There is also evidence of probable survival on inanimate hospital surfaces for up to 72 h.[11] The cleaning and disinfection of environmental surfaces in hospitals employing commonly used disinfectants is believed to be effective against SARS-CoV.[11] There is little research evidence, however, regarding the effectiveness of this practice in reducing hospital transmission of SARS.

Education and training

The SARS outbreak has highlighted the importance of educating and training all HCWs in complying with all IC recommendations. Not understanding IC training was associated with an increased risk of SARS infection.[28] Lack of 'surge capacity' in hospitals, particularly those with large numbers of infected HCWs, led to some of the following measures: cross-training of staff in IC and the recognition of potential SARS cases; reduction in nurse-patient and doctor-patient ratios; and, the implementation of shorter shifts and shorter working weeks.[43,44] One of the positive effects of this education and training was that it resulted in positive behavioural changes regarding IC practices. The challenge is ensuring that these behavioural changes are maintained.

Psychological and psychosocial impact

As a result of concern about transmission and the uncertainties associated with SARS, HCWs experienced anxiety, stress and poor morale. Other negative effects of the SARS outbreak among HCWs included: fear of infection; financial loss; stigmatisation; changes to personal and family lifestyle; caring for colleagues as patients; staff refusing to care for or assist with the triaging of SARS cases; concern for family and personal safety; and, masks interfering with work, family and social relationships.[25,45,46]Taken together these factors would have contributed to increased stress levels, a heightened sense of social isolation and a reduction in effectiveness of healthcare provision, at a time when meticulous attention to detail was most needed.[47,48]

Despite the reported negative effects of SARS on HCWs, a number of positive aspects were also identified. These included: an increased awareness of IC; identifying the SARS outbreak as a positive learning experience; an increased sense of togetherness and cooperation; and a greater appreciation of life and work.[45,46]

Infection control in the post-SARS period

Although it is widely acknowledged that hospital IC and prevention is an important issue, it is usually given a low priority and focuses mainly on physicians and nurses rather than all HCWs. Many basic IC measures are not universally applied and there are inequalities in the distribution of staff and resources, both between and within countries. However, common components have been identified which should be considered for inclusion in IC strategies in the post-SARS period.

At the national level there should be an IC programme, which would provide healthcare facilities with appropriate direction, guidance and support in preventing the spread of infection in healthcare facilities. This will ensure consistency of approach.[49] In those areas without existing legislation to make IC and prevention interventions mandatory, public health officials should promote meetings with policy makers to lobby for legislation to mandate that each hospital should have an IC committee (ICC) with a specified core membership and an appropriate IC infrastructure, including resources. Functions of the hospital ICC should include outbreak investigation, surveillance, reviewing local epidemiological data, educating staff, patients and visitors, developing and promoting local guidelines and estimating resource needs. The ICC should be multidisciplinary and include nursing, medical, laboratory, public health, pharmacy, occupational health, hospital management and engineering representatives.

IC guidelines should be developed, revised and updated regularly and compliance monitored and reinforced as part of an IC strategy.[50] Most will require HCWs to comply with hand hygiene which is the single most effective IC measure, they should also emphasise the safe donning, removal and disposal of PPE.[51] It is recognised that HCWs work within a wide range of financial, technological and human resource constraints and that policies should be adapted for local use employing locally available infrastructure. The design of health care facilities is therefore important and should support HCWs in their implementation of IC procedures. IC practitioners should be consulted when designing new hospitals and when other hospital buildings are being redesigned or renovated.[52]

Prompt diagnosis is critical for any effective IC programme. This requires reliable and effective methods of surveillance with early detection of outbreaks and contact tracing in both the healthcare setting as well as in the community. As clinical diagnosis may not always be sufficiently reliable, rapid isolation and strict IC practices will need to be applied. Also, given that the clustering of fever and respiratory tract illness in HCWs was a feature of SARS, clusters of infection among staff members should be recognised and investigated.

Training of all HCWs in proper IC practices should begin during the initial years of their professional training and be regularly updated.[53] All staff in a health care facility should receive routine training and reinforcement regarding IC practices as well as targeted training when required for instance in outbreak situations or after the introduction of a new policy or intervention. This will provide 'surge capacity,' as well as increased preparedness to deal with unexpected outbreaks.

Attendance at regional and international training courses and meetings should be promoted in order to gain knowledge and establish links. Efforts should be made to collaborate with existing networks as well as establish and link national, regional and global networks in order to conduct research, coordinate activities, standardise practices, support educational activities and identify innovative IC measures.

Advances in technology mean that most countries have access to computer technology and the Internet. These can greatly assist in IC programmes in a variety of ways including surveillance, communication, and distance learning. Appropriate internal and external communication channels are essential. ICCs will therefore need to assess communication needs and capacity, and establish protocols to communicate data and information that will need to be reported during an outbreak or similar major hospital-based incident.

Quality improvement strategies, including the use of evaluation, audit and research, should be built-in to IC programmes. In addition, major outbreak plans should be developed, tested and regularly updated.

A window of opportunity

For many years IC has been considered a low priority and as a result was addressed in a limited and fragmented manner. Recent events such as the SARS, Ebola and avian influenza outbreaks and the continuing rise of healthcare associated infections, such as methicillin-resistant *Staphylococcus aureus* (MRSA), have challenged the international public health community to apply the lessons learnt from IC practices during the 2003 SARS outbreak on a global basis. Indeed, international experts and policy makers have gathered at regional consultations supported by WHO and recommended that a global strategy be developed for IC practices in order to establish international minimum standards.[49]

In the wake of SARS, IC has been provided with a window of opportunity to revolutionise the way it is viewed and ensure that in future it is considered as a high priority. SARS has clearly demonstrated that IC is not only about implementing and following guidelines or knowing how to don and remove PPE. It is also about surveillance, surge capacity, information provision, consistent application of IC

measures and an appropriate and adequate public health infrastructure. Many of the IC measures implemented during SARS are yet to be formally evaluated. Nevertheless, the literature clearly demonstrates that failure to implement appropriate IC procedures and apply them consistently was an important factor in the hospital transmission of SARS. It is now upto IC practitioners to harness momentum generated by SARS into actions that will improve local, national and global infection control infrastructure.

Acknowledgements

I gratefully acknowledge all WHO colleagues who I worked with during the SARS outbreak and the avian influenza outbreak. In particular I would like to thank colleagues in the Western Pacific Regional Office, the China office, Headquarters, Geneva and South East Asia Regional Office. I would like to thank Professor Barry Cookson for his comments on the manuscript.

References

1. World Health Organization. *Summary of probable SARS cases with onset of illness from; 1 November 2002 to 31 July 2003*. Available from: http://www.who.int/csr/sars/country/table2004_04_21/en/index.html.
2. Varia M, Wilson S, Sarwal S, McGeer A, Gournis E, Galanis E, et al. Hospital outbreak investigation team. Investigation of a nosocomial outbreak of severe acute respiratory syndrome (SARS) in Toronto, Canada. *Can Med Assoc J* 2003;**169**:285–92.
3. Zhao Z, Zhang F, Xu M, Huang K, Zhong W, Cai W, et al. Description and clinical treatment of an early outbreak of severe acute respiratory syndrome (SARS) in Guangzhou, PR China. *J Med Microbiol* 2003;**52**:715–20.
4. Ho AS, Sung JJ, Chan-Yeung M. An outbreak of severe acute respiratory syndrome among hospital workers in a community hospital in Hong Kong. *Ann Intern Med* 2003;**139**:564–7.
5. Gopalakrishna G, Choo P, Leo YS, Tay BK, Lim YT, Khan AS, et al. SARS transmission and hospital containment. *Emerg Infect Dis* 2004;**10**:395–400.
6. Twu SJ, Chen TJ, Chen CJ, Olsen SJ, Lee LT, Fisk T, et al. Control measures for severe acute respiratory syndrome (SARS) in Taiwan. *Emerg Infect Dis* 2003;**9**:718–20.
7. Le DH, Bloom SA, Nguyen QH, Maloney SA, Le QM, Leitmeyer KC, et al. Lack of SARS transmission among public hospital workers, Vietnam. *Emerg Infect Dis* 2004;**10**:265–8.
8. Drosten C, Gunther S, Preiser W, van der Werf S, Brodt HR, Becker S, et al. Identification of a novel coronavirus in patients with severe acute respiratory syndrome. *N Engl J Med* 2003;**348**:1967–76 [Epub 2003 Apr 10].
9. Peiris JS, Lai ST, Poon LL, Guan Y, Yam LY, Lim W, et al. Coronavirus as a possible cause of severe acute respiratory syndrome. *Lancet* 2003;**361**:1319–25.
10. Yu IT, Li Y, Wong TW, Tam W, Chan AT, Lee JH, et al. Evidence of airborne transmission of the severe acute respiratory syndrome virus. *N Engl J Med* 2004;**350**:1731–9.
11. World Health Organization. Consensus document on the epidemiology of severe acute respiratory syndrome (SARS). Available from: http://www.who.int/csr/sars/en/WHOconsensus.pdf.
12. Tsang KW, Ho PL, Ooi GC, Yee WK, Wang T, Chan-Yeung M, et al. A cluster of cases of severe acute respiratory syndrome in Hong Kong. *N Engl J Med* 2003;**348**:1977–85 [Epub 2003 Mar 31].
13. Shen Z, Ning F, Zhou W, He X, Lin C, Chin DP, et al. Superspreading SARS events, Beijing, 2003. *Emerg Infect Dis* 2004;**10**:256–60.
14. Centers for Disease Control and Prevention (CDC). Severe acute respiratory syndrome—Taiwan, 2003. *MMWR Morb Mortal Wkly Rep* 2003;**52**:461–36.
15. Chow KY, Lee CE, Ling ML, Heng DM, Yap SG. Outbreak of severe acute respiratory syndrome in a tertiary hospital in Singapore, linked to an index patient with atypical presentation: epidemiological study. *Br Med J* 2004;**328**:195 [Epub 2004 Jan 15].
16. Ofner M, Lem M, Sarwal S, Vearncombe M, Simor A. Cluster of severe acute respiratory syndrome cases among protected health care workers—Toronto, April 2003. *Can Commun Dis Rep* 2003;**29**:93–7.
17. Riley S, Fraser C, Donnelly CA, Ghani AC, Abu-Raddad LJ, Hedley AJ, et al. Transmission dynamics of the etiological agent of SARS in Hong Kong: impact of public health interventions. *Science* 2003;**300**:1961–6 [Epub 2003 May 23].
18. Lipsitch M, Cohen T, Cooper B, Robins JM, Ma S, James L, et al. Transmission dynamics and control of severe acute respiratory syndrome. *Science* 2003;**300**:1966–70 [Epub 2003 May 23].
19. Mackenzie JS, Drury P, Ellis A, Grein T, Leitmeyer KC, Mardel S, et al. The WHO response to SARS and preparations for the future. In: Knobler S, Mahmoud A, Lemon S, Mack A, Sivitz L, Oberholtzer K, editors. *Learning from SARS: preparing for the next disease outbreak—workshop summary*. Washington, DC: Institute of Medicine, The National Academies Press; 2004. Available from: www.nap.edu/openbook.php?.
20. Li TS, Buckley TA, Yap FH, Sung JJ, Joynt GM. Severe acute respiratory syndrome (SARS): infection control. *Lancet* 2003;**361**:1386.
21. Tsai MC, Arnold JL, Chuang CC, Chi CH, Liu CC, Yang YJ. Impact of an outbreak of severe acute respiratory syndrome on a hospital in Taiwan, ROC. *Emerg Med J* 2004;**21**:311–6.
22. Ho PL, Tang XP, Seto WH. SARS: hospital infection control and admission strategies. *Respirology* 2003;**8**(supplement):S41–S5.
23. Lee N, Sung JJ. Nosocomial transmission of SARS. *Curr Infect Dis Rep* 2003;**5**:473–6.
24. Lee NE, Siriarayapon P, Tappero J, Chen KT, Shuey D, Limpakarnjanarat K, et al. SARS mobile response team investigators. Infection control practices for SARS in lao people's democratic republic, Taiwan, and Thailand: experience from mobile SARS containment teams, 2003. *Am J Infect Control* 2004;**32**:377–83.
25. Svoboda T, Henry B, Shulman L, Kennedy E, Rea E, Ng W, et al. Public health measures to control the spread of the severe acute respiratory syndrome during the outbreak in Toronto. *N Engl J Med* 2004;**350**:2352–61.
26. Maunder R, Hunter J, Vincent L, Bennett J, Peladeau N, Leszcz M, et al. The immediate psychological and occupational impact of the SARS outbreak in a teaching hospital. *Can Med Assoc J* 2003;**168**:1245–51.

27. Centers for Disease Control and Prevention (CDC). Severe acute respiratory syndrome—Singapore, 2003. *MMWR Morb Mortal Wkly Rep* 2003;**52**:405–11.
28. Lau JT, Fung KS, Wong TW, Kim JH, Wong E, Chung S, et al. SARS transmission among hospital workers in Hong Kong. *Emerg Infect Dis* 2004;**10**:280–6.
29. Loeb M, McGeer A, Henry B, Ofner M, Rose D, Hlywka T, et al. SARS among critical care nurses, Toronto. *Emerg Infect Dis* 2004;**10**:251–5.
30. Seto WH, Tsang D, Yung RW, Ching TY, Ng TK, Ho M, et al. Advisors of Expert SARS group of Hospital Authority. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). *Lancet* 2003;**361**:1519–20.
31. Mukhopadhyay A, Tambyah PA, Singh KS, Lim TK, Lee KH. SARS in a hospital visitor and her intensivist. *J Hosp Infect* 2004;**56**:249–50.
32. Park BJ, Peck AJ, Kuehnert MJ, Newbern C, Smelser C, Comer JA, et al. Lack of SARS transmission among healthcare workers, United States. *Emerg Infect Dis* 2004;**10**:244–8.
33. Tambyah PA. Severe acute respiratory syndrome from the trenches, at a Singapore university hospital. *Lancet Infect Dis* 2004;**4**:690–6.
34. Cetron M, Maloney S, Koppaka R, Simone P. Isolation and quarantine: containment strategies for SARS 2003. In: Knobler S, Mahmoud A, Lemon S, Mack A, Sivitz L, Oberholtzer K, editors. *Learning from SARS: preparing for the next disease outbreak—workshop Summary*. Washington, DC: Institute of Medicine of The National Academies, The National Academies Press; 2004. Available from: http://www.nap.edu/openbook.php?chapselect=yo&page=71&record_id=10915.
35. World Health Organization. *Hospital infection control guidance for severe acute respiratory syndrome (SARS)*. Available from: http://www.who.int/csr/sars/infection-control/en/.
36. Seow E. SARS: experience from the emergency department, Tan Tock Seng Hospital, Singapore. *Emerg Med J* 2003;**20**:501–4.
37. McDonald LC, Simor AE, Su IJ, Maloney S, Ofner M, Chen KT, et al. SARS in healthcare facilities, Toronto and Taiwan. *Emerg Infect Dis* 2004;**10**:777–81.
38. Esswein EJ, Kiefer M, Wallingford K, Burr G, Lee LJ, Wang JD, et al. Environmental and occupational health response to SARS, Taiwan, 2003. *Emerg Infect Dis* 2004;**10**:1187–94.
39. Wong TW, Lee CK, Tam W, Lau JT, Yu TS, Lui SF, et al. Cluster of SARS among medical students exposed to single patient, Hong Kong. *Emerg Infect Dis* 2004;**10**:269–76.
40. Gamage B, Moore D, Copes R, Yassi A, Bryce E, The BC interdisciplinary respiratory protection study group. Protecting health care workers from SARS and other respiratory pathogens: a review of the infection control literature. *Am J Infect Control* 2005;**33**:114–21.
41. Jarvis WR. Handwashing—the Semmelweis lesson forgotten? *Lancet* 1994;**344**:1311–2.
42. Pittet D, Mourouga P, Perneger TV. Compliance with handwashing in a teaching hospital. Infection control program. *Ann Intern Med* 1999;**130**:126–30.
43. Tiwari A, Chan S, Wong A, Tai J, Cheng K, Chan J, et al. Nursing task force on anti-SARS of queen mary hospital. Severe acute respiratory syndrome (SARS) in Hong Kong: patients' experiences. *Nurs Outlook* 2003;**51**:212–9.
44. Loutfy MR, Wallington T, Rutledge T, Mederski B, Rose K, Kwolek S, et al. Hospital preparedness and SARS. *Emerg Infect Dis* 2004;**10**:771–6.
45. Straus SE, Wilson K, Rambaldini G, Rath D, Lin Y, Gold WL, et al. Severe acute respiratory syndrome and its impact on professionalism: qualitative study of physicians' behaviour during an emerging healthcare crisis. *Br Med J* 2004;**329**:83 [Epub 2004 Jun 2].
46. Nickell LA, Crighton EJ, Tracy CS, Al-Enazy H, Bolaji Y, Hanjrah S, et al. Psychosocial effects of SARS on hospital staff: survey of a large tertiary care institution. *Can Med Assoc J* 2004;**170**:793–8.
47. Maunder R. The experience of the 2003 SARS outbreak as a traumatic stress among frontline healthcare workers in Toronto: lessons learned. *Philos Trans R Soc Lond B Biol Sci* 2004;**359**:1117–25.
48. Gershon RR, Karkashian CD, Grosch JW, Murphy LR, Escamilla-Cejudo A, Flanagan PA, et al. Hospital safety climate and its relationship with safe work practices and workplace exposure incidents. *Am J Infect Control* 2000;**28**:211–21.
49. Pittet D, Allegranzi B, Sax H, Bertinato L, Concia E, Cookson B, et al. Considerations for a WHO European strategy on health-care-associated infection, surveillance, and control. *Lancet Infect Dis* 2005;**5**:242–50.
50. Sehulster L, Chinn RY. Guidelines for environmental infection control in health-care facilities. Recommendations of CDC and the healthcare infection control practices advisory committee (HICPAC). *MMWR Recomm Rep* 2003;**52**(RR-10):1–42.
51. Pittet D, Hugonnet S, Harbarth S, Mourouga P, Sauvan V, Touveneau S, et al. Effectiveness of a hospital-wide programme to improve compliance with hand hygiene. Infection control programme. *Lancet* 2000;**356**:1307–12.
52. Cheng SM, Streifel AJ. Infection control considerations during construction activities: land excavation and demolition. *Am J Infect Control* 2001;**29**:321–8.
53. Jeffe DB, Mutha S, L'Ecuyer PB, Kim LE, Singal RB, Evanoff BA, et al. Healthcare workers' attitudes and compliance with universal precautions: gender, occupation, and specialty differences. *Infect Control Hosp Epidemiol* 1997;**18**:710–2.