General Anesthesia

Intubation of SARS patients: infection and perspectives of healthcare workers

[L'intubation de patients atteints du SRAS : infection et perspectives des travailleurs de la santé]

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Purpose: The outbreak of severe acute respiratory syndrome (SARS) in 2003 presented major challenges to the safety of anesthesiologists and other healthcare workers (HCWs). This study determined the incidence of SARS transmission to HCWs who intubated patients and analyzed the concerns of HCWs regarding personal and patient safety.

Methods: Healthcare workers who performed tracheal intubation in 10 Toronto hospitals were identified using the Ontario Public Health database. A questionnaire was used to collect information from the HCWs. To determine if the patterns of personal protection or concerns changed over time, data were analyzed according to whether the intubation occurred during SARS 1 (February 23 to April 21) or SARS 2 (April 22 to July 1).

Results: Thirty-three HCWs who performed 39 intubations on 35 SARS patients were interviewed. Three of 23 HCWs (13%) acquired SARS during SARS 1 whereas none (0/10) acquired SARS during SARS 2. Personal protection increased from SARS 1 to SARS 2 and HCWs' concerns changed over time. During SARS 1, concerns focused on the need for personal protective equipment whereas during SARS 2, concerns focused on the need for strict training and patient care protocols. HCWs perceived that their experiences were ineffectively integrated into risk management protocols.

Conclusions: Protection guidelines failed to completely prevent the transmission of SARS to HCWs. Nine percent of the interviewed HCWs who intubated patients contracted SARS. A Risk Analysis Framework is presented to facilitate the rapid integration of HCWs' experiences into practice guidelines.

Objectif *: L'éclosion du syndrome respiratoire aigu sévère (SRAS) en 2003 a présenté des défis importants à la sécurité des anesthésiologistes et des autres travailleurs de la santé (TS). L'étude a déterminé l'incidence de transmission du SRAS aux TS qui ont intubé des patients et a analysé les préoccupations des TS concernant la sécurité du personnel et des patients.*

Méthode *: Nous avons repéré les TS qui ont réalisé des intubations dans 10 hôpitaux de Toronto grâce à la base de données sur la santé publique de l'Ontario. Un questionnaire a été utilisé pour recueillir les informations des TS. Pour vérifier si les modèles de protection individuelle et les préoccupations avaient changé avec le temps, l'analyse a tenu compte des intubations réalisées pendant les phases I ou II du SRAS : du 23 février au 21 avril ou du 22 avril au premier juillet.*

Résultats *: Nous avons interrogé 33 travailleurs qui ont fait 39 intubations sur 35 patients atteints de SRAS. Pendant la phase I, 3 /23 TS (13 %) ont contracté le SRAS et pendant la phase II, aucun (0/10) n'a été atteint. La protection du personnel s'est améliorée d'une phase à l'autre et les inquiétudes ont changé avec le temps. Pendant la phase I, on se préoccupait davantage de la nécessité d'un équipement de protection individuelle tandis qu'à la phase II, l'attention a été centrée sur la formation rigoureuse et le respect des protocoles de soins. Les TS ont eu l'impression que leurs expériences avaient été mal intégrées aux protocoles de gestion du risque.*

Conclusion *: Les directives sur la protection n'ont pas permis d'empêcher complètement la transmission du SRAS aux TS. Parmi les TS qui ont intubé des patients, 9 % ont contracté le SRAS. Un cadre d'analyse du risque est présenté pour faciliter l'intégration rapide des expériences des TS en directives cliniques.*

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THE outbreak of severe acute respiratory syndrome (SARS) in 2003 resulted in 438 probable or suspected cases and 43 deaths in the Toronto area. During the epidemic, management protocols were developed to reduce the risk of transmission.[1-4] These protocols were based on the consensus opinion of infectious disease experts but were initially guided by minimal clinical data. Procedural lists and protocols were frequently revised during the epidemic, sometimes changing several times over the course of a day. Further, not all hospitals had personal protective systems (PPS), such as Stryker suits (Stryker Corporation, Kalamazoo, MI, USA), which were recommended for the protection of HCWs.[5]

Despite existing safety protocols, 51% of the SARS cases were HCWs of which three died.[6] In several cases, the disease was transmitted to family members of HCWs including children. Intubation occurred in 26% of cases and was considered a high-risk procedure for SARS transmission.[2] Anesthesiologists and other critical care providers were considered to be at particular risk for infection during endotracheal intubation because the primary mode of transmission was thought to be through contact of mucous membranes with infectious respiratory droplets or fomites.[2] Airway management protocols were quickly developed by infection control experts who often lacked expertise in the management of airway problems, and experts in airway management who lacked expertise in infection control. Furthermore, some protocols were proposed by caregivers that had no experience treating SARS patients. Healthcare workers who were directly involved in patient care had limited opportunities to inform policy makers about appropriate protocols and/or refine treatment guidelines.

The purpose of this study was to: 1) determine the incidence of infection in HCWs who intubated SARS patients; 2) identify the self-protection measures used by HCWs during intubation; and 3) solicit recommendations from HCWs who might assist with the management of future pandemics. Based on the responses, a risk management framework was developed to facilitate the rapid integration of HCW experiences into treatment guidelines for the management of future outbreaks of highly infectious diseases.

Methods

The study protocol was approved by the Public Health Department of Ontario as part of a provincial investigation into the SARS outbreak. The Institutional Ethics Review Board of Sunnybrook and Women's College Health Sciences Centre approved the questionnaire and research protocol.

Patients who were intubated because of SARS were identified by researchers from the hospital section of the Toronto SARS investigation team using medical records from the Ontario Ministry of Health and Long Term Care, local public health units and hospitals. The HCWs who performed the intubations were identified from the medical records.

Study design and questionnaire

Verbal consent was obtained from respondents with the understanding that they could withdraw from the study at any time. Healthcare workers were interviewed individually and were assured of confidentiality. Each interview was conducted by two investigators and one of the investigators transcribed the information from all interviews.

The interview protocol consisted of three sections (Appendix I, available as Additional Material at www.cja-jca.org), including patient information, HCW information, and HCW recommendations for future outbreaks. The pre-SARS physical status of the patients was classified according to the presence of systemic disease and its impact on daily activity using the American Society of Anesthesiologists' (ASA) classification of physical status.[7] A clinical assessment of the airway anatomy (Mallampati score) was used to predict the view of the larynx during direct larygoscopy.[8] The Cormack-Lehane score categorized the actual view of the glottic opening during laryngoscopy.[9] The motor activity assessment score (MAAS) was used to estimate the level of patient sedation during the intubation procedure.[10]

Responses to the questionnaire were recorded throughout the interviews using Microsoft Access database software. The use of semi-structured interviews allowed HCWs to provide detailed information about the procedure. Responses to the opinion and recommendation sections were entered as free text. Subsequently, data were entered into NUD*IST qualitative software program (QSR International, Melbourne, Australia) for coding and analysis. The qualitative data from open-ended questions were iteratively grouped to identify common themes. These themes directed the development of a conceptual model for risk management during an infectious disease outbreak.

Data analysis was undertaken in two phases. The text data were first reviewed in the NUD*IST program and entered into groups pertaining to type of recommendation. Analysis of these groups revealed that most of the HCW comments were observations rather than recommendations. Next, an analysis was undertaken to identify potential changes in the nature

TABLE I SARS infection of HCWs, ASA classification (pre-SARS) and airway assessment scores

	ASA physical status (pre-SARS)*		*Mallampati airway assessment score*		*Cormack-Lehane score*	
Score	SARS yes	SARS no	SARS yes	SARS no	SARS yes	SARS *no*
1	0	21	1	25	1	29
2	0	7	0	8	1	6
3	2	6	2	1	0	0
4	1	1	0	2	1	1

ASA = American Society of Anesthesiologists; SARS = severe acute respiratory syndrome; HCWs = healthcare workers. *One HCW who did not acquire SARS during SARS 1 could not recall the ASA score.

TABLE II SARS infections of HCWs in relation to ASA score and airway assessment scores for patients during SARS 1 and SARS 2

	*ASA physical status (pre-SARS)**		*Mallampati airway assessment score*		*Cormack-Lehane score*	
Score	*SARS 1*	*SARS 2*	SARS 1	*SARS 2*	*SARS 1*	*SARS 2*
1	10	11	15	11	16	14
2	4	3	5	3	6	1
3	7	1	3	0	0	0
4	1	1	0	2	1	1

ASA = American Society of Anesthesiologists; SARS = severe acute respiratory syndrome;
HCWs = healthcare workers. *One HCW who did not acquire SARS during SARS 1 could not recall the patient's ASA score.

TABLE III Urgency and management of intubation during SARS 1 and SARS 2 and incidence of SARS in HCWs in relation to management strategies

	Urgency of intubation		*Sedation during intubation?*		*Paralysis during intubation?*	
	*Emergent**	*Non-emergent*	*Yes*	*No*	*Yes*	*No*
SARS Yes	3	0	3	0	2†	1
SARS No	11	25	35	1	27‡	9
SARS 1	10	13	22	1	15	8
SARS 2	4	12	16	0	14	2

SARS = Severe acute respiratory syndrome; HCWs = healthcare workers. *Impending respiratory arrest; †both patients treated with succinylcholine; ‡15 patients treated with succinylcholine and 12 with rocuronium.

and incidence of HCW observations and recommendations during SARS 1 and SARS 2.

Analysis of data

The experiences of HCWs who did and did not develop SARS were compared for intubations performed during SARS 1 (February 23 to April 21, 2003) and SARS 2 (April 22 to July 1, 2003). Differences between the groups were analyzed using a Chi-squared test and a significant difference was considered to exist at $P < 0.05$.

Results

Patient and caregiver identification

The database identified 59 HCWs who performed at least one intubation of a SARS patient. Ten of the 59 HCWs failed to respond to multiple attempts to contact them, either by telephone or in person. Of the 49 HCWs who were contacted, 33 consented to be interviewed. The most common reason for declining the invitation to participate in the study was involvement in other SARS studies that consumed substantial amounts of time. The interviews were conducted during a six-month interval from August 1, 2003 to January 31, 2004.

The 33 participating HCWs performed 39 intubations of 35 SARS patients. The intubations were performed in ten Toronto hospitals; four were fully affiliated University teaching hospitals and six were community-based hospitals. Approximately 59% (23/39) of the intubations occurred during the SARS 1 and 41% (16/39) during SARS 2.

The 33 HCWs interviewed included 22 anesthesiologists, five respiratory therapists, three specialists in internal medicine, and three physicians from other specialties. Seven HCWs had less than five years of

TABLE IV SARS infection of HCWs in relation to the techniques and the number of attempts at intubation

	Intubation method			*# of attempts*	
	Direct	*Fibreoptic*	*Tracheostomy*	*1*	*2+*
SARS acquired	2	1	0	1	2
No SARS acquired	35	0	1	28	8
SARS 1	22	1	0	15	8
SARS 2	15	0	1	14	2

SARS = severe acute respiratory syndrome; HCWs = healthcare workers.

TABLE V The incidence of SARS infection of HCWs and the MAAS during the intubation

	*MAAS**						
	1	*2*	*3*	*4*	*5*	*6*	*Average*
SARS acquired	0	1	0	1	0	1	4
No SARS acquired	1	15	11	6	0	1	2.6
SARS 1	1	11	2	6	0	2	3.0
SARS 2	0	5	9	1	0	0	2.7

SARS = severe acute respiratory syndrome; HCWs = healthcare workers; MAAS = motor activity assessment scores. *One HCW in SARS 1 and one HCW in SARS 2 could not recall the MAAS.

clinical post-graduate experience; five had six to ten years; nine had 11 to 15 years and 12 had greater than 15 years. Three of the 33 HCWs, including two anesthesiologists, acquired SARS. All SARS infections occurred during SARS 1.

The mean age of the 35 patients was 58.4 yr (range 33–86). Nineteen patients were female and 16 were male. Table I summarizes the number of infected HCWs in relation to the ASA physical status of the patient prior to SARS and Mallampati and Cormack-Lehane scores. Table II summarizes the transmission during SARS 1 and SARS 2 as it relates to the ASA physical status, Mallampati score and Cormack-Lehane score of the patients.

Preintubation therapy

A variety of techniques were used prior to the intubation. For HCWs who acquired SARS, two of their patients were treated with bilevel positive airway pressure (Bi-PAP™; Respironics, Inc., Carlsbad, CA, USA), and the third patient received high-flow oxygen from a facemask. For the HCWs who did not acquire SARS, 29 of their patients received high-flow oxygen and seven were treated with Bi-PAP. During SARS 1, eight of 23 patients were treated with Bi-PAP, whereas only one of 16 patients was treated with Bi-PAP during SARS 2 ($P < 0.05$).

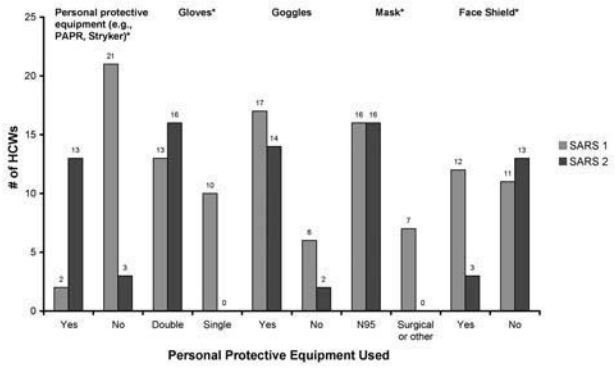

FIGURE 1 Healthcare workers personal protection during severe acute respiratory syndrome (SARS) 1 and SARS 2. The use of personal protective equipment, gloves, masks and face shields increased during SARS 2 compared to SARS 1 ($P < 0.05$).

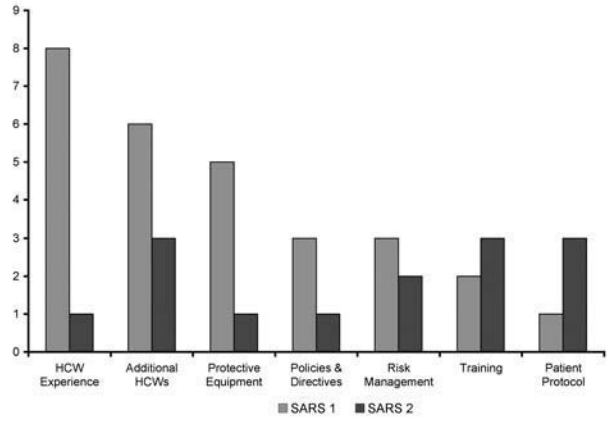

FIGURE 2 The number of recommendations by healthcare workers (HCWs) during severe acute respiratory syndrome (SARS) 1 and SARS 2. During SARS 1, HCWs' recommendations focused on the need for highly experienced personnel, the need for additional personnel and use of protective equipment. Recommendations by HCWs during SARS 2 were primarily focused on the need for better education for medical staff about the importance of adhering to strict protocols, rather than specific recommendations about the use of protective equipment.

Drugs administered

Table III outlines the urgency of intubation and the use of sedative and paralytic drugs. Emergent intubations were more likely to be associated with the transmission of SARS ($P < 0.05$). Notably, no patient was treated with antisialogue drugs despite recommendations to do so. There was no statistical difference in

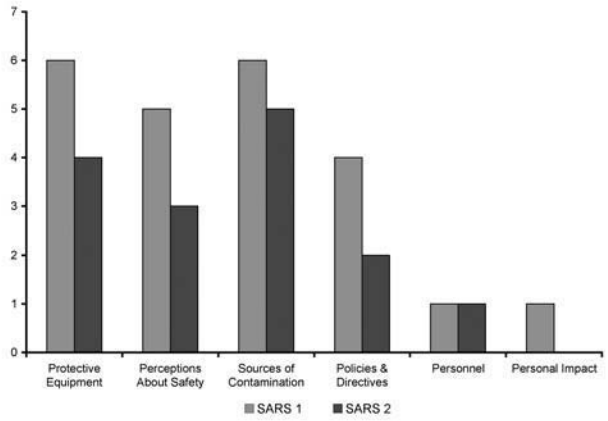

FIGURE 3 The frequency and type of observations reported by healthcare workers during severe acute respiratory syndrome (SARS) 1 and SARS 2. During SARS 1, observations focused on human actions including a doctor leaving the room with surgical cap still on, failure to wash, lack of negative ventilation rooms. During SARS 2, most observations related to both equipment and personnel factors such as battery failure on Stryker hood during disrobing, concern that Stryker suits suck in room air, and improper use of masks by nurses and physicians. Fewer observations about policy and guidelines were observed during SARS 2.

the urgency of intubation between SARS 1 and SARS 2 or the likelihood that HCWs used sedative or paralyzing agents.

Intubation

Table IV summarizes the incidence of SARS infection, and techniques used for intubation and the number of attempts. Two of the three intubations that resulted in SARS transmission required two or more attempts. The average number of HCWs present in the patient's room during intubation was 3.6 (range 2–9). The numbers of HCWs present in the room during the three intubations associated with SARS transmission were three, five and seven. There was a trend towards higher MAAS for patients during SARS 1 compared to SARS 2 ($P = 0.05$, Table V).

Healthcare worker protection

The protective equipment used by HCWs during intubation is summarized in Table VI and Figure 1. None of the infected HCWs wore PPS or double gloves. Two wore a N95 mask (Tecnol Medical Products, Inc, Fort Worth, TX, USA) and one wore both goggles and a face shield. During SARS 1, HCWs were less likely to wear PPS, double gloves, a N95 mask, and a face shield compared to SARS 2 ($P < 0.05$). The use of goggles was comparable between the two periods (Figure 1).

Recommendations and observations

Respondents were asked to provide recommendations for the future management of SARS patients. The responses were categorized as either recommendations or observations (Appendices II and III, available as Additional Material at www.cja-jca.org). Figure 2 illustrates how HCWs' recommendations changed over the two periods of the outbreak. During SARS 1, HCWs' recommendations focused on the need for highly experienced personnel**,** the need for additional personnel, and the use of personal protective equipment. Recommendations from HCWs during SARS 2 were focused on the need for greater awareness by the medical staff regarding the importance of adhering to strict protocols.

The frequency of common observations is summarized in Figure 3. During SARS 1, respondents frequently identified human error, such as a doctor leaving the room wearing a surgical cap or a failure to wash hands. During SARS 2, the observations related to both equipment and personnel factors such as the failure of a battery on a Stryker hood during disrobing, concerns that Stryker suits suck in room air, and the improper use of surgical masks by nurses and physicians.

Development of a risk management framework

A data-derived risk management tool was then developed to facilitate the development of guidelines based on HCWs' responses. The framework consisted of three broad categories or "breakpoints" in the system

TABLE VI Incidence of SARS infection of HCWs and personal protective equipment (body substance precautions) and personal protective system (PAPR hood or Stryker suit)

	PPS		*Gloves*		*Goggles*		*Mask*			*Face shield*	
	PAPR[1]	*Stryker*	*No*	*2*	*1*	*Y*	*N*	*N95*	*PCM* 2000[2]	Surgical	Y	N
SARS acquired	0	0	3	0	3	1	2	2	0	1	1	2
No SARS acquired	4	11	21	29	7	30	6	29	5	2	14	22

SARS = severe acute respiratory syndrome; HCWs = healthcare workers; PPS = personal protective system; Y = yes, N = no.
1. Powered air purifying respirator.
2. N95-equivalent mask, manufactured by Tecnol Medical Products, Inc., Fort Worth, TX, USA.

TABLE VII

Category	*Breakpoint*	*Problem*	*Recommendations*
Process	Protocols	Hazardous airway management protocol	Early intervention is required (i.e., intubate sooner rather than later)
			Revise the airway management algorithm to emphasize instructions for paralysis of infectious patients (back-up techniques required)
			Minimize aerosolization (dispersion of patient secretions in a fine mist in the air) by turning off ventilator during self extubation or tracheostomy, not using topical lidocaine or Bi-Pap™; also be aware or aerosolization from oxygen masks
		Inconsistent infectious disease	Ensure all HCWs are fit-tested for preferred masks even in absence of infectious disease outbreak
	Education	Many HCWs did not adhere to the protocols and engaged in high-risk behaviour	Increase education regarding transmission potential to foster better adherence to protocols
			Incorporate team-based simulation education
	New knowledge	Unknown factors result in conflicting recommendations	Review airway management protocol (always paralyze vs never paralyze)
			Review Stryker suit guidelines. Reported problems include: Can't communicate through the suit or listen with stethoscope (some people put stethoscope up stryker suit): suits offer "perceived comfort" that is not scientifically founded
			Review human resource protocol (increase number of HCWs to facilitate intubation or minimize number to decrease risk)
	Communication strategy	Unclear, inconsistent instruction from MOH, hospital and department	Clear, consistent, timely instructions from the MOH, hospital and department (HCWs should not be receiving new information from the media)
		Lack of two-way communication	Foster two-way communication (i.e., HCWs' concerns need to be heard)
			Develop a formal procedure for escalating HCW concerns
People	Experience	Most of the intubators who contracted SARS were inexperienced (e.g., residents)	An experienced HCW should perform the intubation of an infectious patient
	Availability	Staff that transport the patient also press elevator buttons, touch doorknobs, etc.	Extra staff are required during patient transportation (e.g., to press elevator buttons)
		Long wait times exist for necessary equipment/drugs during the intubation	Extra staff are required outside the room during the intubation with additional drugs and equipment in case they are required
Tools and infrastructure	Patient equipment	Problems classified under other headings	New methods of airway management available (e.g., videolaryngoscope)
	HCW equipment	Inserting the *iv* with double gloves and protective suits is difficult	Insert *iv* early and leave it in throughout the course of the disease
		Adequate equipment is not always available on wards	Where possible, intubate in ICU for maximum access to equipment
	Hospital infrastructure	Transport time from ward to ICU is too long and potentially hazardous	Ensure that infectious disease ward is in close proximity to ICU
		SARS patients were left waiting out in the open in the ER	Add isolation rooms in the emergency department
		Not all hospitals have negative pressure rooms on their ICUs	Ensure all ICUs are equipped with negative pressure rooms

Data consistent across interviews

Some differing opinions

HCW - = healthcare workers; MOH = Ministry of Health; ICU = intensive care unit.

which potentially increased the risk of infection. These potential areas of weakness or vulnerability were categorized as: 1) process breakpoints; 2) people breakpoints; and 3) technology/infrastructure breakpoints. Table VII outlines the framework and experience-based recommendations from which the framework was derived.

Discussion

Existing safety protocols and practice guidelines failed to protect all HCWs from SARS transmission during the 2003 outbreak.[11–13] Anesthesiologists were at particular risk as 9% of the interviewed HCWs who performed an intubation contracted SARS. All SARS infections occurred during SARS 1 and the pattern of self-protection changed over time as the use of personal protective equipment increased during SARS 2. Since 26% of SARS patients required intubation, clearly the number of HCWs would rapidly decline if a similar trend occurred during a future outbreak.[2] This unique dataset provides compelling evidence that aggressive measures are required to protect HCWs from viral transmission.

This report was subject to the considerable limitations of a questionnaire-based study and possible bias of the HCWs who agreed to participate. The sample size was small and possibly, not all HCWs who performed an intubation were identified in the initial chart review. Confounding factors and recall bias do not permit firm conclusions to be drawn regarding a causal link between increased personal protection strategies and the reduced number of infections during SARS 2. Nevertheless, it was apparent that HCWs developed their own self-protection strategies which were often stricter and sometimes inconsistent with policies outlined by the Ontario Ministry of Health or hospitals.

The first provincial guidelines for intubation were published one month after the onset of SARS 1.[14–16] These guidelines focused on both the intubation procedures ("intubate while the patient is sedated and paralyzed if medical condition permits") and personnel requirements ("the most experienced staff member should perform the intubation with a maximum of two to three persons present"). The time course suggests a lag in gathering local knowledge and providing feedback to practitioners. Responses from the HCWs suggest that the process underlying the development of guidelines was suboptimal as it did not incorporate the experiences of front-line staff, and guidelines were inconsistently implemented.

The challenges of developing effective guidelines in an acute situation cannot be underestimated. Discussions between the authors and experts that developed the guidelines highlighted several difficulties. The guidelines took weeks to develop from the time risk was identified due to: a) the absence of data; b) the high stress environment; c) an inability to hold face to face meetings in healthcare settings; d) difficulty in guaranteeing a supply of protective equipment after it was recommended; e) difficulty in coping with the competing risks of HCWs and patients; and f) an understandable lack of consensus on what the important issues were and how to deal with them.

In an editorial by Nicolle, the "chaotic" process of developing and distributing guidelines was eloquently described.[17] Proposed solutions include the need to develop a mechanism for rapid development, communication and implementation of guidelines for infection control measures. A risk management strategy must be developed to rapidly translate the experience of frontline HCWs into treatment protocols for high risk situations. Responses from the HCWs in this study identified three key breakpoints or potential areas of vulnerability that must be addressed when developing such guidelines: 1) process; 2) people; and 3) technology/infrastructure.

In summary, consensus-based guidelines failed to prevent the transmission of SARS during SARS 1. Healthcare workers perceived that their experiences and advice were ineffectively integrated into risk management protocols. The data-derived risk analysis framework presented in this report may be useful to facilitate the integration of HCWs' experiences into treatment guidelines during future epidemics.

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