

High-risk procedures: How to play safe during the SARS-CoV-2 epidemic

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Since December 2019, a novel coronavirus (CoV) was recognized in a cluster of patients with community-acquired pneumoniae in Wuhan, Hubei Province. The genome of the novel coronavirus was found to be highly similar to the SARS-CoV that caused SARS in 2003, the novel CoV has been designated as SARS-CoV-2. As of 27 February 2020, 82178 cases of SARS-CoV-2 infections have been confirmed across 28 countries with more than 95% cases occurring in mainland China. Notably, >3000 healthcare workers (HCW) have been reported to be infected with several tens of deaths. Thus, there is an urgent need to revisit the lessons that we have learnt from review of the “high-risk procedures” that have been linked to transmission of SARS to HCWs (Table 1). It should be noted that much of the evidence relating to high-risk procedures is still anecdotal. The key points for minimizing the risk of SARS transmission are: (1) the early involvement of senior and experienced staff careful using an anticipatory approach and a risk management approach; (2) the procedure-related plan should cover steps before, during and after the procedure, (3) consideration should be given to source control and effective measures implemented to reduce the dissemination of virus-containing bio-aerosols from the patient; (4) the used equipment should be cleaned carefully and personnel should remove PPE carefully in a designated area, and should take a shower for decontamination. Too complicated procedures, which are difficult to follow and perform, may bring in new problems which may itself be a weak point in the transmission of infection. We should be vigilant in the 3 “C” in infection control practices: caution, compliance and competence. Unless these “C”s are meticulously executed, the guidelines and PPE will not take their desired effect.

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Table 1. Summary of studies reporting or evaluating the infection risk associated with patient care procedures that generate droplets and aerosols.

First author	Location and event dates	Nature of study	Aerosol-generating procedure(s) performed on SARS patient(s)	Relevant findings	PPE	Other additional infection control measures	Other potential contributory factors suggested by authors for SARS transmission to HCWs
Park et al. (39)	8 healthcare facilities in the; Mar to Jun 2003	A retrospective description of 110 HCWs with exposure to 6 SARS patients	One to 5 HCWs reported exposure to aerosolized medication, resuscitation, airway manipulation and bronchoscopy	No SARS transmission	Standard** or masks higher than N95	None	-
Varia et al. (7)	A hospital in Toronto, Canada; 7 Mar to 15 Apr 2003	Descriptive epidemiology for a cluster of 128 probable and suspected cases of SARS	Aerosolized medication	On 7 Mar 2003, nosocomial transmission started in the hospital when case A received nebulised salbutamol in the observation area of the emergency department. SARS was transmitted to two other patients (cases B and C) in	Not specified and probably none	None	-

				the same area. The beds of cases B and C were 1.5 m and 5 m away from the index. Cases A to C were cared for by the same nurse.			
Ditto	Ditto		Events surrounding intubation of case B	4 HCWs including 1 physician and 3 nurses who were present at the intubation were infected.	Contact and droplet precautions (surgical mask, gown and gloves) for the intubating doctor and presumably for the 3 nurses.	Placement in an isolation room	(1) Absence of protective eyewear; (2) Other unrecognized minor breaches in infection control
Lee et al. (4)	A hospital in Hong Kong; 11-15 March 2003	Descriptive study of a major cluster of suspected SARS cases	Aerosolized medication (the index patient received aerosolized albuterol four times daily for a total of 7 days from 6 to 12 Mar 2003)	SARS developed in 138 patients, 60 being HCWs, all associated with the index ward.	Not specified and probably none	None	The use of a jet nebulizer on the index patient was suspected to have aggravated the spread of the disease by droplets.
Wong et al. (8)	Ditto	Retrospective cohort study of a cluster of SARS among	Ditto	66 medical students (of whom 16 with SARS) who reported visiting the index	None	None	(1) SARS likely spread through contact and droplets in most

		medical students exposed to the index patient		ward during the study period. Findings were: (1) efficient transmission before nebuliser use; (2) proximity to the index case associated with transmission; (3) no significant association between SARS and presence in ward when nebuliser was in use.			instances; (2) Role of contaminated fomites and small aerosols could not be excluded.
Ofner et al. (6)	A hospital in Toronto, Canada; 15-21 April 2003	A descriptive study of a cluster of SARS among HCWs	NIPPV, intubation, HFOV	A cluster of 2 probable and 7 suspected SARS among HCWs with exposure to a single index case.	Standard**	(1) Careful hand hygiene; (2) intubation performed in a negative pressure room. Room air exhausted to outside after HEPA filtration.	(1) Frothy secretions during intubation later obstructing ventilator tubing requiring disconnection and drainage; (2) one nurse reported mask leakage (3) N95 masks not NIOSH-approved;

							(4) no N95 mask fit testing; (5) no clear understanding on how to avoid contamination while removing the PPE.
Cheung et al. (12)	A hospital in Hong Kong; 9 March to 28 April 2003	A descriptive study aimed to evaluate the infection risk among 105 HCWs with direct contact with 20 patients receiving NIPPV	NIPPV	Zero SARS transmission to HCWs. No HCWs had SARS symptoms. SARS-coronavirus serology negative in 103 HCWs tested.	Surgical or N95 mask, protective eye wear, full-face shields, caps, gown with full sleeve coverage, gloves, shoe covers and additional use of PAPR*	(1) Strict enforcement of infection control measures; (2) installation of exhaust ventilation fans to achieve negative pressure and air changes at >12/h; (3) addition of a viral-bacterial filter to NIPPV exhaust port.	
Fowler et al. (15)	A hospital in Toronto, Canada; 1-22 Apr	Retrospective cohort study of 122 critical care HCWs	Intubation, NIPPV and HFOV	Ten exposed HCWs developed SARS. Direct participation in intubation was a	All worn gloves, gowns, N95/PCM 2000 masks, and	All patients were placed in negative pressure	

	2003	with exposure to 9 SARS patients		risk factor for SARS (RR, 13.3; 95% CI, 2.9 to 59.0; P=0.003). The risks of developing SARS for nurses caring for SARS patients on NIPPV (RR 2.3, 95% CI 0.3 to 21.9; P=0.5) or HFOV (RR 0.7, 95% CI 0.1 to 4.9; P=0.6) were not significantly different from those for nurses caring for SARS patients on conventional mechanical ventilation.	hairnets. Use of eye or face shield was variable.	isolation rooms.	
Loeb et al. (19)	A hospital in Toronto, Canada; March 2003	A retrospective cohort study of 43 nurses in two critical care units with SARS patients	Multiple including nebuliser treatment, intubation, manipulation of NIPPV mask, suctioning before and after intubation, bronchoscopy.	8 nurses infected. None of 11 nurses who did not enter patient's room became ill. A statistically significant higher risk was found for 3 patient care activities: intubation	Highly variable. Three infected HCWs did not use mask including 2 with no PPE at all.	None	Inconsistent use of PPE

				(RR 4.3; 95% CI 1.6-11.1), suctioning before intubation (RR 4.3; 95% CI 1.6-11.1) and manipulation of oxygen mask (RR 9.0, 95% CI 1.3-64.9)			
Lau et al. (18)	5 hospitals in Hong Kong; March to May 2003	Case-control study of 72 infected HCWs and 144 matched controls	“High-risk procedures”, a composite variable including intubation, suction and cardiopulmonary resuscitation	Exposure to “high-risk procedures” was not a risk factor for SARS infection (OR 1.22, 95% CI 0.45 to 3.14; P = 0.8). The major risk factors included (1) perceived inadequate PPE supply (adjusted OR 4.3; P=0.003); (2) inconsistent use of PPE (adjusted OR 5.1; P=0.02); and (3) inadequate infection control training (OR 13.6, P=0.002)	Variable. 27.8% reported inconsistent use of ≥1 PPE compared to 7.9% for controls.	Not specified	

Christian et al. (21)	A hospital in Toronto, Canada; May 2003	Descriptive study of possible SARS transmission among HCWs with exposure to a single index patient during cardio-pulmonary resuscitation	Intubation (performed quickly without difficulty; suctioning not required)	9 HCWs had exposures. One using standard PPE set had probable SARS. One under investigation. Remaining did not meet case definitions for probable or possible SARS.	Standard set including gowns, gloves, goggles with or without faceshield, shoe covers, hair covers and NIOSH-approved N95 mask for 6 HCWs and N95 mask plus T4 Personal Protection System for 3 HCWs.	HCWs were instructed to leave the room and remove their PPE immediately after procedure.	(1) Unrecognized breach in contact and droplet precautions; (2) no fit testing of N95 mask; (3) a high airborne viral load.
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*PAPR = Powered Air Purifying Respirator, or Air-Mate (3M Corporation; ST. Paul, MN)

**Standard PPE is defined as gloves, N95 mask, full-length gown, and eye protection with goggles and/or a face shield.

Abbreviations: CI=confidence interval; HEPA = high efficiency particulate air filtration; HFOV = high-frequency oscillatory ventilation; OR=Odds ratio; RR = relative risk; NA = not applicable