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Personal protective equipment for preventing respiratory infections: What have we really learned?

John M. Conly

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The use of personal protective equipment (PPE) for health care workers (HCWs) has evolved from the isolation precautions first implemented years ago for patients with communicable diseases such as smallpox, tuberculosis and diphtheria.[1] The use of PPE (gloves, gowns, masks and eye protection) in combination with single rooms with airflow control represents the usual barrier precautions employed to prevent transmission of pathogenic mircoorganisms to HCWs. The mechanisms of transmission (airborne, droplet, contact, vector or common vehicle) for the microbe in question often mandate the specific combination of barrier precautions chosen.[2]

Reports of SARS among HCWs in hospital outbreaks reported from Canada, China, Hong Kong, Taiwan and Vietnam focused attention on the critical importance of infection-control practices, including the use of PPE, and the role of training and knowledge among HCWs in using PPE and barrier precautions appropriately.[3] Microbes transmitted by the airborne or droplet routes create the greatest anxiety among HCWs. Additional risks for transmission are posed by the emergence of new pathogens with a severe illness profile (e.g., SARS and avian influenza) and immuno- and other highly compromised patients, who may carry greater microbial burdens for prolonged periods. The advent of new technological diagnostic and therapeutic modalities may also lengthen HCWs' exposure to patients carrying highly infective pathogens.

A thorough understanding of the usual routes of transmission of microbes and the conditions under which these routes may change is paramount to prevent the spread of an infection.[2] Contact transmission, the most common route, occurs when microbes are transferred either directly by physical contact between an infected or colonized individual and a new host or indirectly via an intermediate object (a fomite).[2] Droplet transmission involves drops of fluid 5 µm in diameter and larger, produced from the respiratory tract during coughing or sneezing or by medical procedures, propelled within 1 m of the source patient. Airborne transmission refers to dissemination of microbes within droplet nuclei (particles < 5 µm in diameter), which result from the evaporation of larger droplets or exist within dust particles and remain suspended in the air for long periods. Although most respiratory viruses are transmitted by droplet and contact methods, microbes that can spread via airborne trans-

SARS focused attention on the critical importance of infection-control practices.

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mission include the agents of measles, smallpox, tuberculosis and varicella–zoster.

The SARS outbreaks helped us to recognize the enhanced transmissibility of respiratory pathogens during respiratory procedures that may generate aerosol particles. These procedures have the potential to generate a multitude of large and small droplets, and the procedure itself may propel these droplets well beyond the 1-m radius usually associated with larger droplets. Agreement about aerosol-generating procedures is not universal, but the use of nebulizers, high-flow oxygen, bronchoscopy, non-intubated ventilation (continuous or bilevel positive airway pressure), bag–valve ventilation and uncontrolled intubation are considered higher-risk procedures;[4] they can cause the lines between droplet and airborne transmission to become blurred. What SARS has taught us is that the use of these specialized respiratory procedures can increase the potential for episodic localized airborne transmission and probably expand opportunities for fomite and droplet transmission.

There is compelling evidence that the SARS coronavirus is spread through droplet and contact transmission.[3] Early reports of high infection rates among HCWs and so-called superspreading events were incorrectly judged to indicate a high level of communicability and led to an assumption that the pathogen was airborne.[5,6] Patients with unrecognized SARS, inadequate understanding among HCWs, a lack of compliance with basic infection-control measures and the creation of virus-laden aerosols provide the best explanation for the nosocomial outbreaks of SARS.[5,7,8] Although some HCWs were reported to have become infected with SARS despite the use of PPE, most of these infections occurred during high-risk aerosol- and droplet-generating procedures, accompanied by accounts of suboptimal compliance with protocols for the donning or removal of PPE, PPE reuse, inappropriate double-gloving and gowning (with potential cross-contamination), fatigue and poor knowledge of basic procedures for infection control, which may provide explanations for transmission.[3,8,9]

The report by Zamora and colleagues[10] in this issue of *CMAJ* illustrates the potential for contamination (which represents a potential for contact transmission) with the use of 2 different personal protective systems: a standard procedure with gloves, gowns, masks and eye protection, or one that incorporates a more elaborate powered air-purifying respirator (PAPR). They conducted a well-designed crossover analysis with adequate power to detect significant outcome differences in baseclothing or skin contamination, using a standard protocol in a controlled setting and a suitable surrogate marker for contamination. They found that skin contamination with the surrogate marker occurred with either PPE system; exposed skin contamination occurred more often with standard PPE than with the PAPR system; and PPE donning and removal violations occurred more often with use of the PAPR system.

Both systems have their faults and may create potential risks for contact transmission, either through direct contamination or when donning and removal protocols are breached. Although the study begs the question as to how applicable these results would be in an uncontrolled real-life scenario, it certainly emphasizes the need for handwashing after glove removal, given the high contamination rates of the hands and wrists with the use of either system. They also provide indirect evidence that whatever system is used, the need for trials, drills and adherence to protocol are important elements in the protection of HCWs. Any system or strategy can be expected to meet with success, but execution becomes a critical element in the overall process. The consistent application of appropriate infection-control techniques is essential to the prevention of droplet and contact transmission. This has been demonstrated in many countries around the world,[3] most of which had no access to PAPR systems and many even to N95 respirator masks, but were nevertheless able to focus on adherence to infection-control techniques, which was the key component in controlling the spread of SARS.

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