
Protecting the Faces of Health Care Workers:

Knowledge Gaps and Research Priorities for Effective Protection
Against Occupationally-Acquired Respiratory Infectious Diseases



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Protecting the Faces of Health Care Workers

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Protecting the Faces of Health Care Workers

EXECUTIVE SUMMARY

On March 12, 2003, the World Health Organization (WHO) announced a global outbreak of an atypical pneumonia that was quickly named Severe Acute Respiratory Syndrome (SARS) and shortly thereafter determined to be caused by a novel coronavirus. The virus spread internationally along travel routes and caused the well-documented nosocomial outbreaks in the Greater Toronto Area, China, Hong Kong, Vietnam and Singapore. Contact, droplet and airborne precautions were reportedly instituted in affected hospitals; however, they were apparently incomplete, intermittently applied or only partially effective. The Canadian outbreak resulted in 438 cases, 51% of these were health care workers (HCWs) with three related deaths.

The objective of this report is to summarize our findings from an analysis of the key domains, as pertinent to improving the effectiveness of facial protective equipment (FPE) in preventing occupational-associated respiratory disease transmission in healthcare workers. The report includes: 1) a review of the scientific literature dealing with bioaerosols, filtration and how this influences the design and performance of FPE; 2) a review of the scientific literature of the organizational, environmental and individual factors that influence the effectiveness of occupational health and safety in general, and infection control procedures, in particular 3) an analysis of these factors as identified through a series of 15 focus group discussions involving front-line healthcare workers and; 4) a framework for assigning priorities for further research and a list of priorities derived from the gaps identified in the literature review and the priorities of front-line healthcare workers.

Summary of Evidence Available from the Scientific Literature

A. Epidemiology and Transmission

SARS was a disease largely spread by respiratory droplets. The lack of spread within the community and the recent information on relatively low R_0 values for SARS coronavirus (SARS CoV) indicate that SARS is less contagious than influenza and other similar respiratory infections. It is important to emphasize that the consistent application of basic infection control precautions terminated outbreaks in Vietnam, China and Singapore. Large outbreaks occurred early in the emergence of the disease when the causative agent was not recognized and infection control procedures not in place. The literature makes it fairly clear that failure to implement appropriate barrier precautions was responsible for most nosocomial transmission. As such, attention to understanding why there was a failure to implement appropriate precautions, and how best to promote compliance in future, is an important topic for study.

Although largely spread by the droplet route, there is indirect evidence that the generation of aerosols and the lack of control of aerosols at source was an important factor in hospital

dissemination. The relative lack of transmission within the community also suggests that sneezing and coughing may not generate highly infectious aerosols in contrast to hospital-based mechanical procedures. The relative role of aerosol transmission in disease scenarios traditionally thought to be spread by the droplet route is unknown, as is our understanding of the role of mucosal contamination and autoinoculation in acquisition of infection.

As patients with SARS did not appear to transmit disease unless they had symptoms, recognizing the disease in patients presenting to hospital was probably one of the most important factors in limiting spread. Once the disease was recognized, all the outbreaks in 2003 were able to be contained, using a variety of different infection control strategies. The development of new laboratory tests for the SARS CoV provides optimism that identifying SARS patients will become easier in the future. This is an area of important research that is already ongoing, and will lead to greater protection of healthcare workers against SARS. However, specific clinical diagnosis of disease can never be relied upon to protect against emerging diseases.

B. Risk Assessment:

In hospitals, the risk of disease transmission appeared to vary widely, but several factors were quickly identified as being important determinants of risk. Patients were only able to transmit disease if they were symptomatic and the patients with the most severe illness seemed to pose a greater risk. Working in close proximity to a patient resulted in a higher risk of disease transmission to healthcare workers. Added to the individual risk of the source patient were the risks associated with the hospital environment in terms of whether the patient wore a mask in hospital, was nursed in isolation and the state of the hospital ventilation system. Further, whether the patient underwent aerosol generating procedures also influenced the risk of disease acquisition for an individual healthcare worker. Therefore, for healthcare workers who do not work in an area of a hospital where patients who acutely ill and who may require one of the above procedures, the risk of acquiring SARS is also quite low.

C. Risk Management:

1. Controlling aerosols at source

The occupational health literature has extensively documented that controlling hazards at the source is the most effective means of protecting workers. The only consistent form of source control applied during the SARS outbreaks was having patients wear a surgical mask, a simple and likely effective method of limiting SARS CoV exposures, but which was not formally evaluated for its effectiveness. Many other potential forms of source control exist such the installation of filters on the exhaust port of nebulizer masks, and fitting anaesthesia machines, pulmonary function machines, ventilators, and manual ventilation units with filters. The effectiveness of these measures remain to be studied.

2. Isolation and ventilation

The extent to which isolation of SARS patients within an institution is useful in reducing risk of transmission is not known but this practice could be defended on general infection control grounds – as it is wise to minimize the number of potential exposures. The available evidence also suggests that procedures likely to generate high concentrations of aerosols should be performed only in designated areas where a higher level of protective measures can be employed.

Inadequate hospital ventilation systems in the general patient area were identified as an important determinant of “superspreading” of SARS in one hospital in Hong Kong, likely in combination with aerosol-generating procedures. This observation is similar to that of a recent study of nosocomial-transmitted tuberculosis in Canadian HCWs that also found ventilation systems outside of isolation rooms was an important determinant of infection. While there has been much interest in the importance of having SARS patients nursed in negative pressure rooms, more research is needed to identify if there is any added benefit of negative pressure rooms beyond that of isolation and adequate ventilation throughout the hospital.

3. Environmental decontamination

Studies have shown that SARS CoV is easily killed with standard disinfectants. It is also known that SARS can survive for several days on surfaces, and for longer periods in stool, especially stool from patients with diarrhoea. Recommendations regarding surface decontamination and hand-washing thus appear to be well-grounded for SARS, in that the virus appears to be better able to survive outside the human body than most other common respiratory viruses. The practical importance of these findings and the role that fomite transmission of SARS plays in spreading the disease in hospitals is not known.

4. Personal Protective Equipment

While there is an extensive literature on the performance of personal protective equipment (PPE), especially respirators with regards to particle penetration of some bioaerosols, how this performance translates into protecting healthcare workers from infectious diseases is not clear. Two observational studies have shown that using any mask regularly is more protective than not using a mask regularly. N95 masks have been shown to reduce exposures to airborne particles to a greater extent than surgical masks. However it is still unclear whether N95 masks offer significantly better protection from acquiring disease than surgical masks. Small studies have shown that wearing gowns, gloves, goggles and caps were protective in univariate analyses, but not in final models. It is not clear if the lack of these effects is due only to small sample sizes and confounding effects or to true limited effectiveness. It is also not clear how some HCWs contracted SARS while working with what should have been adequate PPE during aerosol-generating procedures. It will be important to study whether the failures to protect HCWs in these circumstances were due to failure in efficacy of controls, or in the effectiveness in their use. Failures in efficacy would imply that better PPE (i.e. N95 masks, PAPRs) may be needed to adequately protect HCWs from SARS in these circumstances. However failure in effectiveness in the use of PPE would imply that less complicated infection control guidelines, which focus on the key protective factors, combined with the appropriate safety climate and incentives for compliance may ultimately be more successful in reducing infections. Further we have found that there is relatively little information on how important the trans-ocular route is for disease transmission and how existing eye protection reduces this risk to healthcare workers.

5. Fit Testing

Review of the scientific literature prior to the advent of SARS provides clear evidence that fit-tested N95 masks provide an extra degree of protection to exposure to organisms *transmitted by the airborne route*, primarily tuberculosis. It is equally as clear that any leak in the seal negates the additional benefit this type of respirator provides. Thus it is important that HCWs know how to verify that there are leaks around their masks. Fit-testing minimizes the chance of leakage. However, the relative importance of fit-testing as opposed to fit-checking is unclear. The information from a study

by Huff using a nebulized solution containing Tc^{-99m} suggests that fit-testing does have a valuable role to play in reducing the risk of exposure to aerosolized droplets.

The educational value of the fit-testing exercise cannot be dissected from the actual fit-testing benefit, nor should it be. The limited studies demonstrating the importance of a HCW conducting a fit-check each and every time to ensure a good seal, suggests that fit-testing annually is less important than on-going assessment of the ability of HCWs to achieve an effective seal through fit-checking. As noted above, with respect to N95 versus surgical masks, fit-testing reduces exposure to infectious particles but whether it reduces the risk of infection is unknown. Whether fit-testing is needed in a given institution should be based on an assessment of the potential risks of infectious exposures to air-borne organisms in the facility.

D. Adherence to infection control guidelines

Current research suggests that individual factors are less important than organizational and environmental factors in affecting the level of compliance with use of PPE, and specifically facial protection. The literature also indicates that the theoretical or laboratory derived protectiveness of different types of PPE needs to be carefully evaluated with field studies, as compliance in the workplace is usually much less than in idealized research settings. The available evidence supports the view that users as well as infection control and occupational health experts need to be consulted *before* required workplace practices are established and PPE is selected. Once the PPE and work practice requirements are set, workers do need to be trained, but the available evidence indicates that knowledge deficit is not a major barrier to compliance. Non-compliant staff generally know they are non-compliant. This suggests that a focus on training content or methods to increase knowledge may not yield much change in compliance.

Even in circumstances where the key factors in protecting healthcare workers are known, the challenge of changing workplace behaviour will remain. A number of interventions such as educational outreach visits, posted reminders, interactive educational meetings and other multifaceted approaches have been shown to be very successful in changing the behaviour of physicians around the use of clinical practice guidelines. However, research on knowledge translation in the workplace setting pertaining to infection control guidelines is lacking.

Feedback to workers on their adherence to precautions has been identified as an important factor in facilitating compliance with infection control practices. However, the type of feedback that is most effective in achieving compliance is not known and the optimal timing of feedback and the optimum feedback frequency are also not known. Time and equipment to permit worker adherence to infection control guidelines must be available.

Most of the reviewed studies were observational in nature. Many of the research questions raised here need to be investigated as controlled intervention studies in “real-world” situations.

Summary of Key Factors Identified by Healthcare Workers in Focus Groups

A. Organizational factors

The healthcare workers who participated in focus groups spent the greatest amount of time discussing organizational factors. Foremost among their concerns were the lack of consistency with safety instructions and the frequently changing directives which were commonplace during the SARS outbreaks. This was a source of much anxiety for healthcare workers both in BC and Ontario. Coupled with this was the diversity of views on the role of regulatory agencies, such as the Ministry of Labour and the Workers Compensation Board. Many workers saw the measures imposed as being somewhat Draconian, while others saw some measures, such as the requirement for fit-testing as long overdue.

Workplace attitudes towards safety were also seen as important. Paramount to this were the attitudes and actions of management and the perceived importance of occupational health and safety, both of which were important determinants of the safety climate within hospitals.

Healthcare workers also expressed support for the development of evidence-based and practical infection control policies that includes representation from front-line workers. Ensuring adequate resources for infection control was also seen as a priority. In order to improve worker adherence to infection control guidelines, focus group participants felt that better enforcement of infection control guidelines was needed, but should not rely on nurses needing to “police” other professionals. Participants also saw the need for more accommodation of worker concerns and infection control guidelines for patients and visitors.

Safety training, in terms of infection control training was also discussed at length. Focus group members expressed their views that repeated training was needed and that better tracking methods in order to monitor who has been trained and who requires training should be developed. Workers felt that the appropriateness of the “train-the-trainer” model needs to be evaluated in terms of the existing time constraints on front-line workers. It was also felt that hospitals need to develop specific policies to address issues for part-time staff, physicians, residents and students.

Communication about safety within healthcare organizations was seen as having a key role in protecting HCWs, especially during the SARS outbreaks. Face-to-face “town-hall” meetings were seen as necessary in order to build worker confidence in hospital infection control policies during SARS. A variety of communication media were seen to be more effective than any single strategy and workers identified a need for communication strategies to be adapted for the large, multi-centred organizations which have developed in recent years. Similarly, recent organizational changes have resulted in fewer front-line managers, formerly responsible for much of the communication with other HCWs. Communication between employees, units and especially between occupational health and infection control was seen as being important in creating safe workplaces.

Focus group participants discussed fit-testing at length but the value of it was not universally accepted, as different institutions used different methods and workers often saw these inconsistencies as sources of concern for the whole process. The participants also identified the need to address the increased amount of worker fatigue which existed when HCWs work

with full PPE. They also felt that the effect of casualization and out-sourcing of the workforce needed to be evaluated in terms of their effect on worker health and safety.

B. Environmental factors:

Environmental factors were the least discussed issues in the focus groups. The topics that were discussed included the role of isolation rooms for patients with suspected communicable diseases, the availability of anterooms for HCWs to change into PPE and the use and availability of negative-pressure rooms. Participants also discussed the importance of environmental decontamination, primarily hand-washing, and the well-documented problems with the availability of specific PPE during SARS, especially with respect to N95 masks and face shields or goggles.

C. Individual factors:

Knowledge of infection control procedures and the rationale behind them was seen as being important, but not sufficient to ensure proper infection control procedures. Attitudes such as professionalism and belief in effectiveness of infection control guidelines, as modified by past experiences were identified as having important influences on worker adherence to procedures. The additional burden on healthcare workers that wearing full personal protective equipment imposed was also seen as being a key determinant. The increased time constraints, increased workload and discomfort associated with wearing PPE were felt to be important barriers to worker adherence to recommendations. The peer environment, especially the compliance of other occupational groups (including physicians) and the feedback from peers were also identified as important factors which could exert positive or negative influence on individual worker actions. Attitudes of family members, in particular the fear that family members expressed towards contracting SARS, also influenced the actions of healthcare workers on the job.

Priorities for Further Research

Taking into account the evidence from the literature review, the priorities identified through the focus group analysis and a proposed framework for assigning research priorities, the following areas for further research were identified:

#1. Improving workplace health and safety through organizational factors: i.e. how best to bring about meaningful knowledge translation.

- a) How can the safety climate of HC institutions be improved? What approaches best facilitate an organizational culture that promotes safety?
- b) What are the best mechanisms to provide communication to front-line workers in order to ensure appropriate infection control practices?
- c) What are the best mechanisms to provide feed-back to front-line HCWs in order to ensure infection control measures are practical and feasible while still enhancing safety?
- d) What are the best ways to train HCWs on appropriate use of personal protection equipment?
- e) How have changes to the healthcare workforce in terms of increased casualization and increase out-sourcing of services affected workplace health and safety?

- f) What key components of an occupational health program are needed to improve or maintain worker health and safety in healthcare facilities?

#2. Epidemiology and transmission of SARS:

- a) How do respiratory droplets produced by aerosolizing procedures differ from those produced by more “natural” methods such as coughing or sneezing, in terms of their size, their spread and their infectivity? This question is key because it addresses the issue of the hierarchy of precautionary measures.
- b) Do infectious organisms survive on barrier equipment and clothing and for how long? This has implications for this area for environmental decontamination, reuse of barriers versus the use of disposals and the potential importance of auto-inoculation through contaminated PPE.
- c) How able are respiratory tract pathogens to cause disease through the trans-ocular route?

#3. Risk reduction through engineering controls and personal protective equipment:

- a) What is the relative effect of engineering controls to maximize particle fall out or decrease viability of organisms e.g. temperature, air exchange, relative humidity? There may be simple yet effective measures to decrease these aerosols that could have significant impact on reducing the risk of exposure.
- b) What design criteria are required to minimize generation and dispersal of infectious aerosols in medical equipment such as anaesthesia machines, and ventilators? This question addresses the relative effectiveness of decreasing aerosols at source.
- c) What is the added benefit of nursing high risk patients in a negative pressure atmosphere over physical isolation and adequate ventilation throughout hospitals? There has been a great emphasis on hospitals improving access to this technology, yet evidence to support their use is lacking
- d) What is the effectiveness of facial protection against bioaerosols? (In conjunction with question 2.c), above, answers to this question will clarify the relative importance of full facial protection, versus eye-protection, versus nose and mouth protection.)
- e) What is the relative importance of fit-testing versus fit-checking of respirators? The reasons for selecting this as a priority is less an issue of burden of disease but more an issue of stakeholder interest, the implications for where resources are expended and the potential extrapolation of this knowledge to other airborne illnesses.

Protecting the Faces of Health Care Workers

CHAPTER 1: INTRODUCTION

On March 12, 2003, the World Health Organization (WHO) announced a global outbreak of an atypical pneumonia that was quickly named Severe Acute Respiratory Syndrome (SARS) and shortly thereafter determined to be caused by a novel coronavirus. The virus spread internationally along travel routes and caused the well-documented nosocomial outbreaks in the Greater Toronto Area, China, Hong Kong, Vietnam and Singapore. Droplet and airborne precautions were reportedly instituted in affected hospitals; however, they were apparently incomplete, intermittently applied or only partially effective. The Canadian outbreak resulted in 438 cases, with 51% of these being health care workers (HCWs). Three HCWs died from SARS-related causes.

The recent events regarding SARS, particularly the morbidity and mortality in Canadian HCWs, focused attention on the adequacy of facial protection in preventing airborne and droplet-spread transmission of infectious agents. Facial protection traditionally consisted of a mask, and in some circumstances, protective eyewear. During the SARS outbreak, widely divergent opinions on the adequacy of facial protection emerged, ranging from the view that N95 masks* (originally used in industrial applications and advocated for airborne diseases such as tuberculosis) were unnecessary for agents mainly spread via droplets, to the belief that a higher level of protection (e.g. powered air purifying respirators, a.k.a. PAPRs) was required under certain circumstances. The “science” behind respirator selection and use was also a contentious issue as the need for fit testing was questioned and there was confusion regarding the approval criteria for N95 masks. Similarly, there were conflicting views regarding protective eyewear and expert opinion varied as to the need for safety glasses versus splash goggles or face shields. Clearly, there was a need to evaluate the adequacy of facial protection to ensure that HCWs are protected in future outbreaks, not only for SARS, but also against a variety of new and emerging respiratory pathogens.

In light of these observations, The Change Foundation issued a request for applications in September 2003 for a grant to undertake a review of the relevant literature on facial protection that would also address the concerns of front-line healthcare workers. A research team in Vancouver was assembled and wrote a proposal which was accepted in October 2003. The project was conducted over the period from November 1, 2003 to March 31, 2004.

This report was written by a unique interdisciplinary collaboration of researchers based in Vancouver, BC, with a strong track record of relevant research in this subject matter. The team

* The terms “mask” and “respirator” are used interchangeably in this report, which reflects their usage in healthcare. However, the authors recognize that the two words have very different meanings in the occupational health and occupational hygiene fields, as described later in the report.

included experts in the health of healthcare workers – with researchers from both occupational medicine and occupational hygiene; nationally and internationally renowned infection control experts and specialists in public health and epidemiology. We also had clinicians and a representative of frontline care providers. The members of our research team are listed on page 3.

The objective of this document is to summarize our findings in an analysis of the key domains identified by The Change Foundation as pertinent to improving the effectiveness of facial protective equipment (FPE). This includes: 1) a review of the scientific literature dealing with bioaerosols, filtration and how this influences the design and performance of FPE; 2) a review of the scientific literature of the organizational, environmental and individual factors that influence the effectiveness of occupational health and safety in general, and infection control procedures, in particular 3) an analysis of these factors as identified through a series of 15 focus group discussions involving front-line healthcare workers and; 4) the identification of a framework for assigning priorities for further research and a list of identified priorities derived from the gaps identified in the literature review and the priorities of front-line healthcare workers.

It was not our goal to define what specific policies are needed to protect workers from infectious diseases such as SARS, but to identify what is already known about SARS and other respiratory tract nosocomial infections with regards to worker safety and to identify areas where further research should be directed.

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Protecting the Faces of Health Care Workers

CHAPTER 2: LITERATURE REVIEW

Methodology

This literature review was directed at understanding what scientific knowledge already exists with respect to the efficacy of facial protective equipment in preventing the transmission of respiratory infections, and the effectiveness of protective measures when used in the real world. The following describes the methodology used for this section of the project.

The research team developed a list of key words to be used in searching several databases for articles published in the last 15 years that relate to infection control practices, occupational health and safety issues, organizational behaviour and other issues of importance in protecting workers against respiratory infections in healthcare settings. Literature searches were conducted using Medline, EMBASE, CINAHL (Cumulated Index of Nursing and Allied Health Literature), Web of Science and OSHROM. Citations were divided into two broad categories, 1) the applied and basic science of bioaerosols and how various types of protective equipment perform in preventing the transmission of respiratory tract pathogens and 2) the organizational, environmental and individual factors which influence the effectiveness of infection control procedures, in general and the use of facial protective equipment in healthcare settings. We have retained these two categories for purposes of discussion here.

These initial searches produced lists of 462 citations and 379 citations, respectively. The research proposal expected that the committee would design a data abstraction form, collect data from each article and summarize the data using a weighting formula based on the number of studies and the study design used. This methodology, which is similar to that of the Cochrane Reviews for clinical trials, was found to be unworkable in practice for this project given the time-frame of this project. The topic areas were too broad, the study designs too varied and the numbers of citations were too many, to be summarized in this manner.

Instead, a series of research topics were then developed by the research team for each of the two broad categories “basic science and efficacy” and “factors influencing effectiveness”. The titles we found that related to these categories were next reviewed to eliminate citations which did not directly relate to the objectives of the study. This resulted in the literature review list being shortened to include 316 and 267 citations. The research topics were then divided between the research committee members to write summaries, using articles on these lists as reference materials. Secondary reference materials, derived from these primary references, were also added to the source reference list. The drafts from each group were merged, then the compiled version reviewed by the team as a whole, and the summary of the evidence, the gaps in the evidence and the recommendations for further research were then determined with consensus from the research team.

Part I: Literature Review of the Basic Science and Efficacy of Facial Protection

This section is divided into two parts. Part A discusses the science of air-borne particles and the evolution of respirators and summarizes the advantages and disadvantages of respirators in the health care setting. Part B summarizes current scientific knowledge on performance data of respiratory protective devices and addresses issues surrounding the application of the science to the healthcare setting.

Section A: The Science of Air-borne Transmission and Use of Respirators

What is an aerosol? Where do airborne droplets or droplet nuclei fit in?

During every breath the respiratory system takes in a mixture of solid particles, liquid droplets, vapours and gases. Collectively, these suspended particles and their carrier gases are known as aerosols. Aerosols made up of solid particles are called “dusts” or “fumes”, while aerosols made up of liquid particles are called “fogs”, “mists” or “sprays”. Droplets are ejected from the respiratory tract during coughing, shouting, sneezing, talking, and normal breathing. The size and number of droplets produced is dependant on which of these methods generated the particles. These droplets may contain contagious material such as bacteria or viruses, including the SARS coronavirus.

The infectious agent as a particle

A number of scientific studies have shown that a NIOSH-certified respirator such as the N95 effectively filters aerosols, containing microbes such as *Mycobacterium tuberculosis*. Brousseau et al. [1], Qian et al. [2] and Lee et al. [3] demonstrated that biological particles including those contained in droplet nuclei, will be deposited in airways and filters in the same manner as non-biological particles, and that the most important characteristics of these particles are aerodynamic diameter and shape. The biological state does not appear to influence the way in which particles are collected and retained by a filter [1]. All particles, whether they are liquids, solids or microorganisms, can be filtered by a particulate filter. The efficiency of the filtration is dependant on particle size, shape, and electrostatic and hygroscopic interactions.

How long do respiratory droplets remain airborne and where are they deposited?

Typically, a person breathes between 10 to 20 m³ (10,000 to 20,000 litres) of air daily. Where air-borne particles are deposited within the airways is primarily a function of particle size [4] [5] [6] [7] [8]. Larger droplets (generally greater than about the 50 to 100 µm size range), settle more quickly than smaller particles, and exposure to these is typically the result of direct contact with the skin surface including mucous membranes of the eyes, nose and mouth or onto inanimate surfaces in the immediate vicinity of the infectious patient. These larger droplets are normally not inhaled into the lungs since they are trapped by cilia and mucous in the nose and mouth. However, they can be deposited in the pharynx if the HCW is in close proximity to the infectious patient.

Small particles and droplets less than 10 µm in size are likely to remain in the air long enough to be swept around by air currents and may be inhaled by a susceptible host within the same room. Therefore, when working in close proximity to a patient, one can be exposed to respiratory droplets following a cough, sneeze or a high velocity exhalation or during endotracheal intubation, bronchoscopy or similar invasive procedures.

Droplet nuclei are at the lower end of the spectrum for droplet diameter and can travel considerable distances in the air and may be readily inhaled into the lung. Droplet nuclei are typically smaller than 5 µm, and exhibit a settling velocity in still air of about 1 metre per hour.

Inhaled particles greater than about 3 µm will deposit in the upper respiratory tract and particles less than 2 µm will be deposited in the alveolar regions. Particles near 0.3 µm will have the least deposition (about 14%) while either larger or smaller particles will deposit with much higher efficiency, often approaching 100% deposition. From the perspective of infectious disease spread by the airborne route, particles deemed “inhalable” fall in the size range of 0.1 to 10 µm in diameter. The effects of the high relative humidity in the respiratory tract can result in the relative size of particles increasing in aerodynamic diameter which, in turn, can affect the site of deposition in the respiratory tract [9]. For inhaled infectious particles, the location of receptors in the respiratory tract for particular pathogens also influences their ability to cause disease [168].

Table 2.1 and Figure 2.1 summarize the size of respiratory droplets and how it relates to the time they remain aloft and their potential to transmit disease [10].

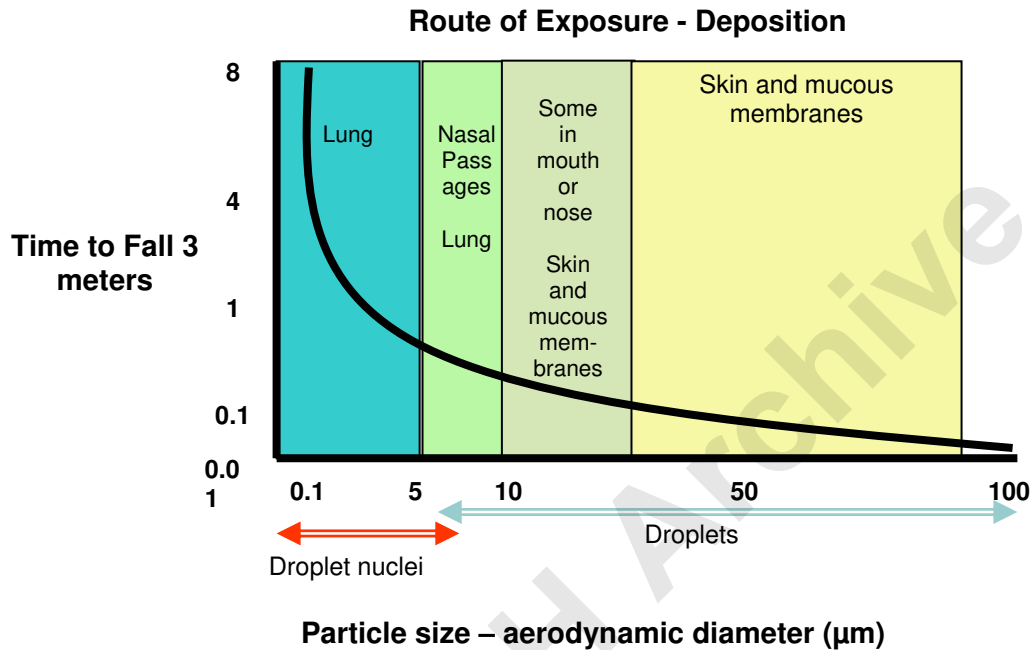
Table 2.1:

Behaviour of infectious aerosols in still air and route of exposure

Diameter in µm	Time to fall 3 metres	Route of exposure
100	10 sec	Direct contact with skin or mucous membranes
40	1 min	Direct contact
20	4 min	Direct contact
10	17 min	Direct contact Some deposition in mouth or nose
6 - 10	Several hours	Deposition in nasal passages
0.06 to 6	Many hours	Deposition into lungs

Small particles (< 6 µm) do not settle out at an appreciable rate, but spread so that as distance (r) from the source increases, the relative concentration of particles in air decreases in proportion to r^3 [11]. This equation does not consider the effects of droplet evaporation or convective disturbances. Thus as the distance from the source doubles, the aerosol concentration declines 8-fold.

Figure 2.1



Size of particles produced by the human respiratory tract

It should be noted that although there may be nearly 2 million particles extruded from a sneeze compared to fewer than 100,000 from a cough, more infective droplets may be released in a cough because of the deeper origin of particles in the lungs [10]. A further complicating matter is the effect of relative humidity on the infectious droplets. The size of aerosolized droplets ejected by a patient is likely to be reduced very quickly in air of low relative humidity (e.g., below about 20 – 40%) and high temperature (above 20^o - 25^oC). While a droplet of pure water will evaporate fully if relative humidity is less than 100%, a droplet that contains soluble material, such as sodium chloride, will reach an equilibrium state based on the mass of the sodium chloride contained in the droplet and the relative humidity of ambient air. Since respiratory secretions contain an isotonic concentration of sodium chloride, it cannot be assumed that smaller respiratory droplets, potentially containing microorganisms, will fully evaporate in ambient air. However, if the relative humidity is low enough (less than approximately 40%), then even a particle containing soluble material will evaporate completely, leaving behind a residue particle consisting of the dried solute and any other solid matter

that was contained in the original droplet, possibly including microorganisms. If these biological agents are not damaged by the drying process, they can potentially infect a susceptible host.

Duguid [12] in a study conducted in 1946, reported on the size distribution of aerosols produced from the nose and mouth during various activities (Table 2.2) collected under experimental conditions. According to the results, the size of the expelled particulate determines the fate of the particle in air. This study also reported on the composite size distribution of particulate captured on slit samplers as seen in Tables 2.2 and 2.3.

Table 2.2

The percent size distribution of the larger droplets as a function of expiratory activity.

Diameter in um	Sneezes	Coughs with mouth closed	Coughs with mouth open	Speaking loudly
0-5	0 (0%)	0 (0%)	0 (0%)	0 (0%)
5-10	36 (1.2%)	24 (0.8%)	8 (2.7%)	20 (0.7%)
10-15	94 (3.1%)	119 (3.9%)	39 (1.3%)	84 (2.8%)
15-20	267 (8.9%)	337 (11.2%)	127 (4.2%)	200 (6.7%)
20-25	312 (10.4%)	346 (11.5%)	189 (6.3%)	224 (7.5%)
25-50	807 (26.9%)	767 (25.6%)	577 (19.2%)	597 (19.9%)
50-75	593 (19.8%)	468 (15.6%)	593 (19.8%)	531 (17.7%)
75-100	260 (8.7%)	285 (9.5%)	341 (11.4%)	352 (11.7%)
100-125	144 (4.8%)	160 (5.3%)	231 (7.7%)	260 (8.7%)
125-150	105 (3.5%)	125 (4.2%)	202 (6.7%)	214 (7.1%)
150-200	115 (3.8%)	115 (3.8%)	253 (8.4%)	179 (5.9%)
200-250	82 (2.7%)	96 (3.2%)	165 (5.5%)	99 (3.3%)
250-500	118 (3.9%)	113 (3.8%)	213 (7.1%)	197 (6.6%)
500-1000	59 (1.9%)	40 (1.3%)	52 (1.7%)	41 (1.4%)
1000-2000	8 (0.3%)	5 (0.2%)	10 (0.3%)	2 (0.07%)
Total	3000 (100%)	3000 (100%)	3000 (100%)	3000 (100%)

Table 2.3

Composite size-distribution table for the droplets expelled during sneezing, coughing and speaking.

Droplet diameter in μm	One sneeze	One cough with mouth closed	Counting loudly "1 to 100"
< 1	Remain airborne		
1-2	26,000 (2.6%)	50 (10%)	1 (0.4%)
2-4	160,000 (16%)	290 (5.8%)	13 (5.2%)
4-8	350,000 (35%)	970 (19.4%)	52 (20.8%)
8-16	280,000 (28%)	1,600 (32.5%)	78 (31.2%)
16-24	97,000 (9.7%)	870 (17.4%)	40 (16%)
24-32	37,000 (3.7%)	420 (8.4%)	24 (9.6%)
32-40	17,000 (1.7%)	240 (4.8%)	12 (4.8%)
40-50	9,000 (0.9%)	110 (2.2%)	6 (2.4%)
50-75	10,000 (10%)	140 (2.8%)	7 (2.8%)
75-100	4,500 (0.45%)	85 (1.7%)	5 (2%)
	Fall at once to ground		
100-125	2,500 (0.25%)	48 (0.96%)	4 (1.6%)
125-150	1,800 (0.18%)	38 (0.76%)	3 (1.2%)
150-200	2,000 (0.2%)	35 (0.7%)	2 (0.8%)
200-250	1,400 (0.14%)	29 (0.58%)	1 (0.4%)
250-500	2,100 (0.21%)	34 (0.68%)	3 (1.2%)
500-1000	1,000 (0.1%)	12 (0.24%)	1 (0.4%)
1000-2000	140 (0.014%)	2 (0.04%)	0 (0%)
Approximate Total	1,000,000 (100%)	5,000 (100%)	250 (100%)

The lack of very small particulate was likely an artefact of the methodology available at the time of Duguid's study [12]. A more recent study by Papineni and Rosenthal [13] reported on the production of respiratory particles produced by five normal subjects using an optical particle counter and electron microscopy. They found substantial variability person to person, by collection method, as well as by method of exhalation. Table 2.4 reports their findings in two size fractions, less than and greater than 1 μm particulate diameter.

Table 2.4.

Mean droplet concentration (per L of air) in exhaled breath for five subjects

Droplet diameter (μm)	Coughing	Mouth breathing	Nose breathing	Talking
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
< 1	83 (63)	12.5 (10.7)	4.7 (4.1)	19.2 (9.5)
> 1	13.4 (13.2)	1.9 (2.3)	0.7 (0.67)	3.3 (1.2)

The lack of larger particulate was also an artefact of the methodology employed, preventing a comparison between the two studies, although clearly both studies found coughing to be associated with the greatest dissemination of particulate. Papineni and Rosenthal examined the exhaled breath of three subjects by electron microscopy and found 36% of the exhaled particulate was < 1 μm in diameter, 64% was > 1 μm in diameter [13].

In a study published this year, Fennelly [14] developed a specially constructed chamber to become the first study ever to report the size ranges of infectious particulate disseminated by patients with active tuberculosis. Although it has been long known that *M. tuberculosis* is disseminated through droplet nuclei, the organism had never before been cultured from the respiratory exhalations of patients in a clinical setting. Of particular interest is the wide variability between patients of the size ranges of the infectious particulate. This study used an Andersen multiple stage impactor to determine the size ranges of the infectious particulate. During sputum-induction procedures, the mode infectious particulate size was 1.1-2.2 μm (49% of total) while 90% of the sample recovered was between 0.65 and 3.3 μm . In a patient coughing naturally (not induced) the mode size was 2.1 – 3.3 μm , and 100% of particulate was larger than 1.1 μm aerodynamic diameter.

Principles of filtration as it applies to respirator particulate filters

Over the last 50 years, filtration of aerosol particles by fibrous filters has been extensively studied and the relationships between particle size and filtration efficiency as well as mechanisms of filtration firmly established. Aerosol particles, whether solid or liquid attach firmly to their contact surface and fibrous filters are designed to maximize the chance that these particles adhere to the filter material while allowing gases to continue through the filter. Five basic mechanisms dictate how a particle is captured by the filter material: inertial impaction, interception, diffusion caused by Brownian motion, gravitational settling and electrostatic attraction. Mechanical filters rely upon the first four methods for particle capture. Electrostatic filters use electrostatically charged filter fibres or electrets to increase the particle capture and often can use a much looser weave of filter fibres as a result. This loose

weave has a much lower resistance per unit area of filter medium and is typically not pleated [15] [16] [17].

The most important parameter for characterizing how a particle will deposit is particle size. An increase in particle size will cause increased filtration by the interception and inertial impaction mechanisms whereas a decrease in particle size (below 0.3 μm) will enhance collection by Brownian diffusion. As a consequence, there is an intermediate particle size region where two or more mechanisms are simultaneously operating yet none is dominating. This is the region where the potential for particle penetration through the filter is at the maximum and the efficiency of the filter a minimum [17]. The fibrous filters found in most respirators have minimum filter efficiency in the vicinity of 0.3 μm . The 0.3 μm particle is referred to as the most penetrating particle size or MPPS and is the basis for respirator testing (worst-case testing) and certification pursuant to International Standard Organization EN149:2001, NIOSH 42 CFR Part 84 and Australian Standard AS1716.

What is a respirator?

A respirator is a personal protective device that is worn on the face, covers at least the nose and mouth, and is used to reduce the wearer's risk of inhaling hazardous airborne gases, vapours and particulate matter or aerosols. Note that the term "mask", as in surgical mask, is used to refer to a device that is worn by a person to minimize the spread of airborne contaminants from that person's respiratory tract and to protect other persons from exposure. As such, surgical masks are therefore not recognized by regulators as an approved design for respiratory protection, even though they may offer some degree of protection.

Aerosols containing bacteria, viruses, fungi and other biological material (bioaerosols) are filtered in a similar manner as non-biological particulate material. Brousseau et al. [1] affirmed that the most important parameters for aerosol filtration, whether biological or non-biological, are the physical characteristics of the aerosol such as aerodynamic diameter and shape.

The main types of respirators are classified as follows [15] [18]:

1. **Air-purifying respirators** – remove contaminants from the air
 - a) particulate respirators – filter out aerosols;
 - b) chemical cartridge/canister respirators – filter out chemical vapours and gases
2. **Air-supplying respirators** – provides the wearer with a source of air other than the surrounding air
 - a) airline respirators – supplied by breathable air via a hose from a remote source; and
 - b) self-contained breathing apparatus (SCBA) – uses its own compressed air supply.

The discussion here will be confined to the first group, particulate respirators, which can be further divided into:

1. **Disposable filtering face piece respirators** (fabric type with 2 straps), where the entire respirator is discarded when it becomes unsuitable for further use due to excessive breathing resistance, unhygienic condition, or physical damage;

2. **Reusable or elastomeric respirators**, either half face or full face, where the facepiece can be cleaned and reused but the filter cartridges are discarded and replaced when they become unsuitable for further use, and
3. **Powered air-purifying respirators (PAPRs)**, where a battery-powered blower moves the air through the filters to the face.

Assigned protection factors – APFs

The level of protection afforded by particular class of respirators is based on its assigned protection factor (APF). An APF is a measure of the anticipated level of workplace respiratory protection that would be provided by a properly functioning respirator or class of respirators to properly fitted and trained users [15,18,19]. The APF is a special application of the general protection factor (PF) concept. The PF is the ratio of the amount of contaminant to which a person would be exposed without a respirator, to the amount of contaminant to which a person is exposed with a respirator. This is determined by comparing the amount of contaminant inside the facepiece, C_i to the amount of contaminant outside the respirator, C_o , such that

$$PF = C_o/C_i$$

Since C_o is equal/greater than C_i the protection factor is always equal or greater than unity.

APFs are used as a regulatory requirement used in establishing what type of respirator to use in a given situation. It is calculated assuming by multiplying the APF by the 8-hour exposure limit for a particular contaminant to which the worker may be exposed. For example a respirator with an APF of 10 will allow the worker to work in an atmosphere up to 1000 ppm where the 8-hour exposure limit for the contaminant is 100 ppm (i.e., $10 \times 100 = 1000$).

This regulatory mechanism has not been applied to bioaerosols, since no exposure limits have been established for any disease-causing microorganisms. Nevertheless, it is assumed that the higher the APF, the greater the level of protection for the worker. Thus a device with an assigned protection factor of 10 allows for penetration through the filter medium up to 10%; an APF of 25 allows penetration up to 2.5% and an APF of 1000 allows penetration up to 0.1%. The actual risk of disease transmission associated with these APFs is unknown and likely varies markedly depending on the organism of interest and the clinical situation. From a practical perspective, a properly fit-tested particulate face piece respirator or elastomeric half face piece respirator commonly provides protection factors from several dozen to several hundred-fold levels of protection when assessed by quantitative fit testing techniques. The APFs for different types of respirators are shown in Table 2.5.

Table 2.5

Assigned Protection factors [18].

Respirator Class	Respirator style			
	Half face-piece	Full face-piece	Helmet/hood	Loose-fitting face-piece/ visor
Air-purifying	10	100	-	-
Powered air-purifying	50	1000	1000	25
Supplied-air (continuous flow)	50	1000	-	-
Self contained breathing apparatus (SCBA)	-	10,000	-	-

Fit testing – assessing respirator face seal leakage

All facial seal dependent respirators – those with elastomeric perimeters that are specifically designed to form a seal with the skin of the face – are required to be fit tested in order to check for evidence of leakage at the facial seal. This is a requirement for all North American, United Kingdom, European, New Zealand and Australian jurisdictions when a worker is required to wear such a device for protection against airborne contaminants in over-exposure conditions. Over-exposure conditions exist when a worker is working in an environment where the 8-hour occupational exposure limit (OEL) for a particular contaminant could be exceeded.

The primary role of fit testing is to ensure that the wearer has selected a respirator brand, model and size that properly seals with his or her face [20]. Fit tests are designed so that the filter penetration of the test substance is negligible and that any entry of the test agent is solely the result of any existing leaks along the facial seal. Fit tests are also useful for training wearers in proper donning procedures including how to conduct a fit check (negative or positive pressure tests). A fit check should be carried out every time the wearer dons the device.

Determining face piece fit involves qualitative or quantitative fit testing. Qualitative fit-testing relies on the wearer's subjective response to taste, odour, or irritation. Quantitative fit-testing involves methods that measure pressure differentials or particulate concentrations inside versus outside the face-piece. The various fit test methods, both qualitative and quantitative, are described in the 2002 edition of CSA Standard Z94.4 [18].

In a recent study on N95 performance [21], it was shown that if no fit testing was conducted, one could experience considerable leakage. The average exposure experienced by the 25-person panel in this study was measured at 33% of ambient level – which is below the performance requirements for the N95, set at equal or less than 10% leakage. When the panel was fit tested, the average exposure was reduced to 3% of ambient. Another study by Coffey et al.[22], demonstrated that fit testing screens out poorly fitting respirators. For example, if an initial screening of the various brands available on the market, the employer would not be aware that the brand originally chosen would provide relatively poor fit when compared to another brand. Researchers observed large variability for filtration effectiveness among the 21 models tested, and that some models were far more effective than others. Without fit testing, the 95th percentile penetration ranged from 6 to 88% among the 25 subjects.

Coffey et al [23], using a panel of 25 subjects (men and women) chosen to represent face lengths from 93.5 mm to 133.5 mm and lip lengths of 34.5 mm to 61.5 mm, examined eighteen different brands of N95 filtering-facepiece respirators. This study is representative of the wider range of face sizes that would be found in the health care field (e.g. encompassing almost 95% of the U.S. working population). The respirators were evaluated both qualitatively and quantitatively without fit testing in order to judge how the different brands of respirators would function “off the shelf”. Without fit testing, the 5th percentile simulated workplace performance (SWPF) values ranged from 1.3 (virtually no protection) to 48. Only three of the eighteen respirators had a 5th percentile SWPF greater than 10 (the nominal protection factor expected of a N95 mask). There remained a large variation between models in the percentage of people passing the various fit-test methods (Bitrex, saccharin, PortaCount, generated aerosol). One model of the eighteen had a high pass rate for all methods. The respirators returned different results for different test agents. Passing the Bitrex fit-test method resulted in 12 of the 18 models providing adequate protection, Passing the PortaCount Plus fit-test resulted in 12 of 13 models providing adequate protection, while six respirators were unable to pass with any subject.

Lee et al. [3] conducted quantitative fit tests with respect to TB exposure on a number of different brands of respirators. Fit-test pass-rates increased significantly when a well-fitting brand was chosen for the test subjects. Initial screening of the various brands indicated great variability in filter penetrations. They selected two brands because: a) their medium/regular models fit the greatest proportion of subjects, b) they provided the highest fit factors, and c) the greatest proportions of employees rated them as comfortable to wear. The latter is an important consideration for an effective respirator program. Among 1860 individuals who were fit tested, 99.6% were successfully fit testing with one or the other brand.

Qualitative fit testing involves exposing the subject to a substance which can be either smelled, tasted, or is irritating to the upper respiratory tract. Assessing fit on a particulate filter respirator has traditionally been based on the saccharin test. Several years ago Bitrex® (denatorium benzoate) was introduced as an alternate substance to saccharin. McKay & Davies [24] assessed the relative effectiveness of the two test agents and found Bitrex more effective. All study subjects correctly detected Bitrex in an induced leak test (sensitivity 100%). Nine of the 26 subjects were unable to detect saccharin in the presence of the induced leak. The authors claim that Bitrex is a better test agent for qualitative fit tests and helps to minimize false negative fit tests.

An overview of respirator performance and certification process

Filter media typically consists of fibres made from fibreglass, cellulose or more commonly today, plastic polymers such as polypropylene. Particles can be captured by a number of mechanical methods including: interception, inertial compaction, sedimentational or gravitational settling, Brownian diffusion and by a non-mechanical method – electrostatic attraction [15, 17, 25, 26].

Designing a respirator involves balancing filtration efficiency versus worker comfort. Filtration effectiveness increases with filter thickness and density when the primary method of filtration is based on mechanical methods, as is the case for filter material used up until the mid-1990's [27, 28, 29]. A thicker, denser filter will cause an increase in the effort required to inhale or exhale through the filter material thereby reducing worker comfort because of increased breathing resistance. This limitation imposed by the filter design and material of the day was lifted recently with the introduction of plastic polymers microfibrils as the building material for the filter.

In June 1995, the National Institute for Occupational Safety and Health (NIOSH), the agency responsible for certification of respiratory protective devices in the US (and recognized by Canadian and other jurisdictions and agencies) issued new regulations for certifying non-powered particulate respirators under federal statute – the Code of Federal Regulations, specifically 42 CFR Part 84. The new regulations replaced the older 30 CFR Part 11 regulations in force at the time.

The impetus for change was in response to the recognition in the mid-1980s that workers in health care and correctional facilities were exposed to airborne TB without adequate respiratory protection. Specifically, the older 30 CFR Part 11 dust/mist/fume type particulate respirators were not found effective as filtration devices for airborne biological agents. Furthermore, the traditional use of surgical masks in the health care setting was seriously challenged by a number of organizations including the Centers for Disease Control and Prevention [30], NIOSH [20] and the Occupational Safety & Health Administration (OSHA). The CDC revised its guidelines for respiratory protection in healthcare workers in 1994 to include the recommendation that respirators used to protect healthcare workers from TB have a minimum of 95% efficiency for 1 μm when tested at 50 L/min airflow [30]. At the time only high efficiency particulate-(HEPA) rated respirators could meet these criteria. Dust/mist/fume-type respirators had not been tested at the time in accordance with the new CDC criteria. Tests conducted at a later date on the filtration effectiveness of 30 CFR Part 11 versus 42 CFR Part 84, [31] clearly indicate most 30 CFR Part 11 dust/mist devices failed to meet the new test criteria, particularly at the higher flow rates (85 L/min).

Under 42 CFR Part 84, a new filter classification system was created that distinguishes nine classes of filters based on three filtration efficiencies and three series of filter degradation resistance. The three efficiency levels are 95, 99 and 100% (99.97% actual) tested at the NIOSH-prescribed test flow rate of 85 L/min, a flow rate considered a moderate workload for human subjects. A “95”, “99” and “100” rated respirator is allowed particle penetration of 5, 1 or 0.03%, respectively. The test particulate used was in the size range that is considered the most penetrating particle size (MPPS) – generally considered as particle in the 0.1 to 0.3 μm range [32]. The 0.3 μm particle forms the basis for testing filters.

Filtration efficiency depends on particle size. An increase in particle size will cause increased filtration by the interception and inertial impaction mechanisms, whereas a decrease in particle size will enhance collection by Brownian diffusion. As a consequence, there is an intermediate particle size region where two or more mechanisms are simultaneously operating yet none is dominating. This is the region where the potential for particle penetration through the filter is at the maximum and the efficiency of the filter a minimum [17]. For fibrous filters, such as found in most respirators, the minimum filter efficiency is generally known to occur in the vicinity of 0.3 μm . This is the basis of the widely used dioctyl phthalate (DOP) or sodium chloride tests for high efficiency particulate filters (HEPA) and 42 CFR Part 84 particulate filter devices (95/99/100 series), which make use of monodisperse 0.3 μm diameter DOP or NaCl particles for testing the filter.

Chen & Huang have shown that if a polypropylene filter is electrically neutralized, the filter efficiency is reduced by a factor of 36 to 68% [33] [34]. Other studies have shown that decreasing the electrostatic charge on the filters by using an isopropanol wash, penetration of N95 respirators increased from an average of 2% to as high as 43.5% [34]. The authors also demonstrated that penetration of N99 respirators went from an average of 0.23% to as high as 53.3%; penetration of P100 respirators went from an average of 0.001% to as high as 3.92%. These studies reinforce the fact that such respirators rely heavily upon electrostatic attraction, and if exposed to industrial aerosols, such as oily mists or certain other chemicals, the efficiency of these respirators can fall dramatically. That is the reason that “N” designated respirators cannot be used in work environments where one could be exposed to oil mists. In that case, a “P” type respirator must be selected, as

noted below. This is of little consequence to the health care setting. “N” type devices are suitable for most health care applications.

Temperature and relative humidity have historically been shown to have an effect on respirator efficiencies [27]. However, recent testing of newer electrostatic respirators suggests that the effects of relative humidity on filtration efficiency are no longer very significant, most likely due to technological advancements in the filter media [35]. Polypropylene, the basis for most 42 CFR Part 84 respirator filter media, is a highly hydrophobic material – the fibres do not absorb water.

With respect to TB exposure, NIOSH has approved all filter media of respirators certified as 42 CFR Part 84 compliant for use against TB exposure, since the filters are more efficient at the 1 µm size than at the most penetrating particle size (0.3 µm) size. Since individual viruses are smaller than the most penetrating particle size, they will be effectively filtered by all 42 CFR Part 84 compliant respirators. Polypropylene filter media have also proved to be highly effective in filtering particles in the size range typically associated with viruses and fungal spores. Of greatest concern are viruses carried on droplets near the most penetrating particle size, as they have a higher probability of penetrating a respirator than an individual virus.

However, most viruses which cause respiratory and gastrointestinal disease in humans, must be contained in large droplets (>5 µm) in order to survive outside the body and transmit disease from person-to-person. This includes such common respiratory pathogens as influenza, respiratory syncytial virus (RSV) parainfluenza viruses, the common coronaviruses and others. The notable exceptions are measles, varicella zoster virus (chickenpox) and smallpox which apparently can survive in small diameter droplets or droplet nuclei and can be transmitted by air over long distances [36].

Typically disposable particulate respirators are constructed from a filter material in the shape of a formed cup or loosely in the shape commonly called the “duck-bill”. Approved half face-piece devices are designed to sit on the bony framework of the face – over the jawbone and cheekbones. Approved half face-piece respirators are designed to form a secure seal where the device meets the skin of the face in accordance with performance criteria established by NIOSH. Approved devices are supplied with two straps; typically, one is designed to be placed over the back-top of the head, the other around the neck. This is to ensure the device is pulled both up and down over the jawbone and cheekbones to facilitate the seal with the face.

The skin-to-respirator seal is important since the space within the respirator is under negative pressure during inhalation. As a consequence, air-purifying respirators are classified as “negative-pressure” devices unlike respirators that are supplied by either ambient-pressure air (PAPRs) or high pressure air (airline or SCBA). The latter are classified as “positive-pressure” devices. Accordingly, positive pressure devices provide the wearer with a higher level of protection than negative-pressure devices when the respirator is not able to form a seal with the face. Loose fitting PAPRs are not positive pressure according to the respirator classification system.

Half face piece respirators – both filtering face-piece type such as the N95s as well as elastomeric devices – are assigned protection factors of 10 (see Table 5).

Performance of surgical masks and air-purifying particulate filter respirators

Surgical masks were developed to prevent the wearer's exhaled secretions from contaminating the operative field [37]. However, these devices also have been used for decades, in the health care industry and by the general public, as protective devices to prevent exposure to various respiratory pathogens. Surgical masks are constructed of a filter material and cut basically in the shape of a rectangle. The device is placed over the nose and mouth and held in place by straps placed behind the ears or around the head but more usually around the back of the head and neck. The device fits fairly loosely and a tight seal is not feasible where the outside edge of the mask meets the skin of the face. Most users in health care industry tend to wear surgical masks rather loosely; considerable gaps are usually observed at the peripheral edges of the surgical mask along the cheeks, around the bridge of the nose and along the bottom edge of the mask below the chin.

Standard surgical masks are considered a Class II device by the US federal Food and Drug Administration (FDA) which require pre-market sales approval. This means that to obtain approval as an item for sale, the manufacturer must demonstrate to the satisfaction of the FDA that the new device is substantially equivalent to similar masks currently on the market [19]. There is no specific requirement to prove that the existing masks are effective and there is no standard test or set of data required supporting the assertion of equivalence. Nor does the FDA conduct or sponsor testing of surgical masks.

Concerns surrounding health care worker exposure to TB gave greater prominence to the use of surgical masks as protective devices for healthcare workers [38]. Moreover, several studies conducted in the early 1990s showed that air leakage occurs both around and through surgical masks. Chen et al.[39] demonstrated that surgical masks are highly variable when challenge tested with 1 μm particles, with results ranging from 5 – 100% penetration. In another study, Chen and Willeke [40] observed 40 – 60% penetration for one model of surgical mask over the particle size range of 0.3 – 1.0 μm and 80 to 85% penetration for the other brand tested over the particle size range of 0.3 to 2.0 μm range. Weber et al. [28], assessed eight brands of surgical masks and found penetration ranging from 20 – 100% for particles in the 0.1 to 4.0 μm aerodynamic diameter range. These and related studies led the CDC in 1990 to recommend the use of NIOSH-approved respirators as superior protective devices against TB aerosols.

Wake et al. [41] conducted a filter penetration study on a wide variety of devices available in the UK. Single strap dust masks (non-UK, non-NIOSH approved) typically sold in hardware stores, proved highly ineffective when challenged with microbiological aerosols of *Bacillus subtilis* subsp. *globigii*, *Micrococcus luteus* and *Pseudomonas alcaligenes* allowing penetration up to 100%. Surgical masks allowed penetration up to 83% of the bioaerosol. Surgical masks made with polypropylene fibres, offered better protection, ranging from 0.9 to 25% penetration. Dust/mist and Dust/mist/fume (approved by the UK and equivalent to 30 CFR Part 11 filters) allowed penetration from less than 0.01 to 0.9%. Filtering facepiece (N95 equivalent – FFP3 approved) proved the most effective in filtering the bioaerosols, allowed penetration from 0.02 to 0.4%.

Another study by Brosseau et al.[1] found filter penetration highest and most variable for the surgical masks when compared to NIOSH-approved respirators. Geometric mean penetration of the filter material was about 22% for surgical masks versus that of 0.02% geometric mean penetration for respirator-type HEPA filters when challenged by both non-biological (0.55 μm latex spheres) and biological test particulates (*Mycobacterium abscessus* and *Pseudomonas fluorescens* aerosols). *M. abscessus* is in the range of the most penetrating particle size – 0.3 μm aerodynamic diameter.

With respect to testing the efficacy of surgical masks, a number of manufacturers, routinely conduct biological testing on their products such as the Viral Filtration Efficiency (VFE) or Bacterial Filtration Efficiency (BFE) tests. The BFE and VFE tests typically aerosolize solutions of bacteria or viruses into 3.0 µm particles, which are far easier to filter than if 0.3 µm droplets were used. Occasionally, the investigator may run the droplets go through a drying chamber, so that droplets evaporate and only individual viruses or bacteria are challenging the filter. There is no requirement for manufacturers to run these types of tests, but they are still very commonly done; the filtration efficiencies reported from BFE and VFE tests are very high (nearly always >99.999%), so they make the devices appear far more effective than they may actually be. This is an issue of concern for anaesthesia and respiratory breathing system filters, pulmonary function filters, and heat-moisture exchanging filters, as there is no requirement for NaCl or DOP challenges to determine filtering capabilities. Manufacturers typically report results of BFE and VFE tests (typically >99.999% efficiency), and these devices are considered “bacterial” or “viral” filters. However, there are presently breathing system filters and pulmonary function filters that claim to be >99.999% efficient at removing bacteria or viruses, but which may show 70% or less efficiency when challenged with NaCl or DOP tests at 0.3 µm [166] . These filters are routinely used to filter microorganisms at the source, such as on anaesthesia machines, pulmonary function machines, ventilators, and manual ventilation unit. The lack of meaningful standards for these devices, along with the use of BFE and VFE test data, has created an environment in which health care workers think they are far more protected than they actually are.

However, even with the use of highly efficient, modern filter media, exhaled air may escape or enter unfiltered around the edges of the mask [37, 42] . Surgical masks cannot be fit tested. To illustrate the ineffectiveness of facial seal of the surgical mask, Tuomi [43] conducted particle penetrations studies on several brands of surgical masks. One test involved normal positioning of the surgical mask on the test head/breathing machine; the other test involved tape-sealing the edges of the surgical mask to the test head. The overall filtration efficiency of the non-taped versus taped mask measured 33% and 67%, respectively across most of the particle size range (0.2 to 10.0 µm) with a greater difference noted for the larger particle sizes (above 2 µm).

Powered air-purifying respirators

A powered air purifying respirators or PAPR is basically an air-purifying respirator in which a blower pulls ambient air through air-purifying filters (housed in cassettes or canisters), and then supplies purified air to the facepiece [15] [18]. This is accomplished by the addition of a battery-operated blower. Certain models of PAPRs do not provide a seal with the face.

PAPRs can be fitted to the following facepieces:

- tight-fitting or face-seal dependent
 - half face-piece type
 - full face-piece type
- non-tight-fitting or non-face-seal dependent
 - loose fitting helmet/hood
 - loose fitting face-piece/visor
 - full-body suit.

The PAPR used predominantly used in the healthcare industry is the loose fitting facepiece/visor type which carries an assigned protection factor (APF) of 25. Facial seal dependent or tight fitting PAPRs provide a higher level of protection than their loose-fitting counterparts and are assigned a protection

factor (APF) of 1000. Tight fitting PAPRs also allow fit-testing. Loose fitting PAPRs cannot be fit tested.

All types of NIOSH-certified PAPRs meet the CDC requirements for protection against tuberculosis when fitted with a HEPA filter. At this time, there are no certified 42 CFR Part 84 filters, including filters rated at 95, 99 or 99.97% efficiencies, available for PAPRs. Only 30 CFR Part 11 NIOSH-certified HEPA filters are currently approved for use with PAPRs. HEPA filters are highly effective and equivalent to an N100 filter.

Loose fitting PAPRs provide a viable alternative in the health care industry where a worker, who is required to wear respirator, cannot achieve a proper fit as determined by a failed fit test, or is fully bearded. Note that a loose-fitting PAPR provides a higher level of protection than a tight-fitting half facepiece respirator (filtering facepiece-type, or elastomeric facepiece fitted with particulate filters) – refer to Table 2.6 for a comparison of protection factors for the various devices available.

PAPR-like devices

A recent study by Derrick and Gomersall [44] found the Stryker® and the Stackhouse FreedomAire® powered-air supplying surgical helmets offer very little protection against airborne 0.02 to 1.0 µm diameter particles. It should be noted, however, that these devices are not sold as “respirators” and are not NIOSH approved. They are designed to be used for protection against droplets and splashes and to minimize contamination of a sterile field. In comparison with protection factors obtained with N100s, the protection factors ranged from 3.5 to 4.5 for the Stryker and 2.5 to 3.0 with the Stackhouse.

Respiratory protection – selecting the appropriate device

Prior to the last decade, many health care practitioners were inexperienced with respiratory protective devices. They saw them only as devices designed for general industry. In fact, in hospital settings the word “respirator” is more likely to suggest a device for providing respiratory support to a patient than a device for protecting the health care worker. Many in the health care industry view surgical masks as providing respiratory protection for the wearer. This belief continued as recently as the SARS outbreak in March 2003.

The selection of a respirator for protecting the health care worker from exposure to pathogenic bioaerosols, should follow fundamental occupational hygiene principles based on the risk management paradigm – risk identification, risk evaluation and implementation of risk control measures. The decision framework used for airborne chemical toxicants as prescribed by NIOSH in its 1987 document entitled *Respirator Decision Logic* [45] has been suggested as an appropriate model [46]. That is, one specifies an acceptable risk of infection (analogous to setting an occupational exposure limit for a chemical) and estimates exposure intensity and duration based on the pathogenesis of – and infectious dose for – the organism based on establishing virulence, infectivity, potential for transmission by inhalation, viability of the organism when present in respiratory droplets of various sizes, and population susceptibilities.

Where it is established the organism presents a risk to human health through respiratory tract exposure, protection should be considered. A respirator would be selected with an average penetration value sufficient to reduce exposure to meet the acceptable risk criterion established through the risk assessment process. For example a N95 may provide an adequate level of

protection for pathogenic agent “A” but a N100 is required for agent “B” since it is assessed as presenting a higher risk of infectivity and/or virulence. Table 2.6 summarizes the factors to consider when choosing respiratory protection for healthcare workers.

For example, a N95-rated respirator is considered an appropriate device by CDC and NIOSH for protection against bioaerosols containing *Mycobacterium tuberculosis* since, in part, N95s are worst-case challenged tested to aerosols with aerodynamic diameters averaging 0.3 μm . A single tubercle bacillus measures around 0.8 μm [31] and this study found that 42 CFR Part 84 rated respirators offer much greater efficiency than their 30 CFR Part 11 predecessors, particularly at higher flow rates (moderately high respiratory flows – 85 L/min).

No government or other agency has yet specified an acceptable occupational risk of a *Mycobacterium tuberculosis* infection, the organism most often studied in relation to occupational risk of infection. The same is true for other pathogenic agents, although the scientific literature presents a number of articles that describe in detail risk models [5,9,46-48]. Infectivity data, is available for the Coxsackie A-21 virus where the aerosol infectious dose for tissue culture has been established as 28 times the TCID₅₀ (50% tissue culture infectious dose)[11].

Barnhart et al. [49] has shown that, for tuberculosis in health care settings, based on the estimated aerosol infectious dose from Nicas, [5] and analysis of TB skin-test conversion rates, the use of respiratory protection is estimated to reduce the risk of skin-test conversion by the following proportions:

- surgical mask – 2.5 fold reduction
- disposable dust/mist/fume (30 CFR Part 11) respirators – 17.5 fold
- disposable HEPA respirators – 17.5 fold
- elastomeric HEPA respirators – 45.5 fold
- HEPA-fitted PAPR – 238 fold reduction

Note that the no. 42 CFR Part 84 devices were not available at the time of this study, as they only became commercially available in July of 1998.

The authors based their risk assessment on 130 TB patients who produced an average of 0.25 infectious quanta per hour but with marked variation, ranging from 0 to 60 infectious quanta per hour. An infectious quantum is the number of infectious droplets required to cause infection in a prescribed number of susceptible individuals [50].

Lee et al. also estimated the risk of TB infection using data from their fit test studies and the cumulative risk of infection estimated on a Poisson probability model in a manner that incorporated the rate of successful fit tests of the various brands of respirators for which quantitative fit-tests were conducted [3]. Cumulative infection rates were calculated for *M. tuberculosis* infection risks as follows:

- With no respirator use
 - low risk scenario produced 1-yr and 5-yr cumulative risks of 0.0133 and 0.0648, respectively
 - high risk scenario produced 1-yr and 5-yr cumulative risks of 0.0522 and 0.235, respectively.

- With a respirator with a pass rate of 95%
 - low risk scenario produced 1-yr and 5-yr cumulative risks of 0.0007 and 0.0036, respectively
 - high risk scenario produced 1-yr and 5-yr cumulative risks of 0.0029 and 0.0141, respectively.¹

Table 2.6:

Advantages and disadvantages of various types of respirators as it applies to health care workers.

Type of Respirator	Advantages	Disadvantages/Limitations
Air-purifying Particulate Non-powered Half face “Filtering face piece-type” e.g., N95 “disposable”	<ul style="list-style-type: none"> - Disposable - Small size - Light weight - Simple design – easily understood by wearer - Can be reused (short-term) - Unrestrictive mobility - Inexpensive over short-term - Requires no cleaning - Requires no maintenance - APF of 10 - Easy to breathe through (low breathing resistance) - Allows good peripheral vision - Can be fit tested - Allows easy communication - Non-threatening to patient - Units without exhalation valves allows use in sterile field - Meets CDC criteria for protection against TB and other bioaerosols 	<ul style="list-style-type: none"> - Negative pressure device increases inward leakage - Facial hair or scars or certain face types will interfere with facial seal - Higher costs over long term (vs. non-disposables) - Reusable for short-term periods only - Units with exhalation valve allow contamination in a sterile field - Difficult to fit check - No eye/face protection

¹ **Note:** 0.0133 signifies 13 infections among 1000 susceptible employees in one year; 0.0648 = 65 among 1000 in 5 years.

Low risk scenario – HCW in room with TB patient; normal procedures

High risk scenario – HCW in same room with TB patient undergoing bronchoscopy.

Table 2.6 (continued)

<p>Air-purifying Particulate Non-powered Half face Elastomeric facepiece- type Particulate filter cartridges</p>	<ul style="list-style-type: none"> - Can be reused (long-term) - Can be cleaned - Unrestrictive mobility - Most models are light weight - Moderate cost over long term - APF of 10 - Most models easy to breathe through (low breathing resistance) - Most models light weight - Low profile models allows good peripheral vision - Easy to fit check - Can be fit tested - Meets CDC criteria for protection against TB and other bioaerosols 	<ul style="list-style-type: none"> - Negative pressure device increases inward leakage - Facial hair or scars or certain face types will interfere with facial seal - Moderate initial cost - Presence of exhalation valves and will allow contamination in a sterile field - Require disinfection between use - Requires routine maintenance - No eye/face protection - Communication more difficult than for disposables - Some models have a slightly higher breathing resistance - Some models are heavy - Some models affect peripheral vision - More threatening to patients (the more industrial it looks, the more intimidating)
<p>Air-purifying Particulate Non-powered Full face Elastomeric face piece- type Particulate filter cartridges</p>	<ul style="list-style-type: none"> - Can be reused - Can be cleaned - Unrestrictive mobility - Provides eye/face protection - Moderate cost over long term - More protective - APF of 100 - Most models provide adequate peripheral vision - Easy to fit check - Can be fit tested - Slightly higher breathing resistance - Meets CDC criteria for protection against TB and other bioaerosols 	<ul style="list-style-type: none"> - Negative pressure device increases inward leakage - Facial hair or scars or certain face types will interfere with facial seal - All units have exhalation valves and will allow contamination in a sterile field - Higher initial cost than half facepiece type - Prescriptive glasses cannot be worn due to interference with facial seal - Requires special prescriptive inserts - heavier and bulkier - Decreased comfort level - Requires routine maintenance - Require disinfection between use - Communication more difficult - Some models provide limited peripheral vision - More threatening to patients

Table 2.6 (continued)

<p>Air-purifying Particulate Powered Loose fitting facial seal e.g Face piece/visor- type Powered Air- Purifying Respirator (PAPR)</p>	<ul style="list-style-type: none"> - Allow persons with beards and those unable to fit standard respirators to be protected - Moderate cost over long term - Unrestrictive mobility - Low breathing resistance - Provides cool air - Comfortable face seal - Allows wearing of prescription glasses - Can be reused - Can be cleaned - More protective than half facepiece devices - APF of 25 - Built-in eye/face protection - Meets CDC criteria for protection against TB and other bioaerosols if fitted with HEPA filter(s) 	<ul style="list-style-type: none"> - allows contamination in a sterile field since exhaled air exists around the fabric dam of the visor - High initial cost - Heavier and bulkier - Decreased comfort level - High level of maintenance - Batteries must be recharged and maintained - Bulky and noisy (motor) - Communication more difficult - Better peripheral vision than helmet/hood PAPR - Require disinfection between use - Cannot be fit checked or fit tested - More threatening to patients
<p>Air-purifying Particulate Powered Tight fitting facial seal e.g. Helmet/hood-type Powered Air- Purifying Respirator (PAPR)</p>	<ul style="list-style-type: none"> - Can be reused - Can be cleaned - Moderate cost over long term - Unrestrictive mobility - Low breathing resistance - Provides cool air - More protective than full facepiece non-powered devices - APF of 1000 - Allows fit checking - Allows fit testing - Built-in eye/face protection - Meets CDC criteria for protection against TB and other bioaerosols if fitted with HEPA filter(s) 	<ul style="list-style-type: none"> - High initial cost - Facial hair or scars or certain face types will interfere with facial seal - Prescriptive glasses cannot be worn due to interference with facial seal - Units with front-mounted exhalation valves will allow contamination in a sterile field - Heavier device - Peripheral vision inferior to loose fitting PAPR - High level of maintenance - Batteries must be recharged and maintained - Bulky and noisy (motor) - Communication more difficult - Require disinfection between use - More threatening to patients

Table 2.6 (continued)

<p>Air-supplying Half face piece or Full face piece e.g Supplied-air respirators</p>	<ul style="list-style-type: none"> - Can be reused - Can be cleaned - moderate cost over long term if air supply readily available - Low breathing resistance - Provides cool air - More protective than full facepiece non-powered devices - APF of 1000 - Allows fit checking - Allows fit testing - Built-in eye/face protection for full facepiece devices - Meets CDC criteria for protection against TB and other bioaerosols 	<ul style="list-style-type: none"> - High initial cost - Facial hair or scars or certain face types will interfere with facial seal - Requires source of quality breathable air - Restricts mobility due to presence of airline - Units with front-mounted exhalation valves will allow contamination in a sterile field - Prescriptive glasses cannot be worn due to interference with facial seal - Communication more difficult - Require disinfection between use - Complex maintenance - More threatening to patients
<p>Air-supplying Full face piece only e.g. self contained breathing apparatus (SCBA)</p>	<ul style="list-style-type: none"> - Highest level of protection - APF of 10,000 	<ul style="list-style-type: none"> - Impractical for health care - Very high costs – initial and long-term - Highly skilled, technically trained staff required

Section B: Application of the Science of Respirator Protection to the Health Care Setting

Have respirators been evaluated under “true” workplace conditions?

As discussed in the previous section, respirators were adapted from industry to healthcare and initial testing was based on industry standards. Questions have been raised as to whether there is a relevant model for health care regarding respirator use. A series of articles (several predating NIOSH and 42 CFR 84 standards) by Brosseau et al. examined the performance of several respirators and surgical masks when challenged with *M. abscessus* aerosols (to mimic TB exposures) [1, 51, 52]. Unlike methods used in many other bacterial challenges, Brosseau ensured that the bacterial aerosol went through a drying process such that the majority of particles were individual bacterium, not large water droplets. The authors concluded that non-biological particles such as polystyrene latex or dioctyl phthalate (DOP) with an aerodynamic particle size similar to the bioaerosol of interest appeared to be an appropriate challenge particle. The investigators also examined the recovery of organisms captured by filters as viable organisms released to the environment after reentrainment from masks. In general, organisms were found to be non-viable when reentrained from masks. Importantly, the authors demonstrated that any facial leakage negated the increase in filtration efficacy gained with N95 masks (the importance of a good facial seal has been discussed in the previous section of this review). These articles confirmed that biological models to assess the efficacy of respirators are possible, and if carefully designed to ensure worst case challenges, may be more representative of actual working conditions than traditional industry models.

A series of articles by Coffey et al [22, 53, 54] examined the role of fit-testing and respirator performance under simulated conditions. The articles discussed the sequential development of a model to assess quantitative fit-testing methods, evaluate the fit-testing methods and examine different test aerosols and their accuracy in assessing fit-testing. Importantly, the investigators used a simulated workplace environment to conduct their studies. Subjects donned a respirator and conducted a user seal check prior to an evaluation of total penetration of particles during a series of manoeuvres. Simulated testing demonstrated that fit-testing gave better protection by screening out poorly fitting respirators.

Lastly, Huff et al. [55] clearly illustrated the importance of wearing of a fit tested particulate face piece respirator in conjunction with the use of simple body substance isolation techniques. The authors tracked the dispersal of radioisotope technetium (Tc^{99m}) during pulmonary function testing. Personnel were evaluated for contamination on clothing, hair, and airways (nose swabs). Laboratory coats and latex glove were the only PPE provided in the first part of the study. In the second part, personnel wore surgical masks, cover gowns and head covering. For the third part, personnel were fitted with dust/mist/fume respirators designed for protection against radionuclides, gowns, and head coverings and had been trained in infection control procedures. The respirator used was of the facepiece type with an elastomeric liner around the periphery of the device to create a good face-seal.

Results for Part 1 and 2 demonstrated levels as high as 11,000 disintegrations/min in the nasal passages of personnel, indicating that surgical masks were ineffective in reducing respiratory tract deposition of technetium. When fit tested respirators were worn, the levels were measured at 50 disintegrations/min or less. One worker, who had not been properly fit tested, had readings exceeding 1000 disintegration/min. This individual was subsequently retrained and retested – a reduction in contamination was subsequently noted, illustrating that the wearing of a fit tested dust/mist/fume face piece respirator significantly reduced exposure levels to aerosols.

The study concluded that proper infection control techniques (e.g. hand hygiene) and wearing the appropriate PPE (head coverings, surgical cover gowns) resulted in a significant reduction in deposition of the radioisotope onto the body and the lab coats worn under the gown. The study clearly demonstrated that fit-testing of N95 respirators significantly reduced exposure levels to the technetium compared to surgical masks. This article is one of few actual work-place evaluations, and it provides a potential model for real-time evaluations while offering a method of sample collection.

Fit-testing versus Fit-Checking

Fundamental to the fit-testing process is the educational component – i.e. teaching the worker to select the correct mask for best facial fit and to perform a fit-check each time a respirator is worn. Hannum et al. examined the effect of three different methods of respirator training on the ability of healthcare workers to pass a qualitative fit test [56]. Employees were divided into three groups: Group A received one-on-one training and were fit tested as part of the training; Group B received classroom instruction and demonstration by infection control nurses in the proper use of respirators but were not fit tested; and Group C received no formal training. Participants then went onto a subsequent qualitative fit test using irritant smoke to check for their ability to correctly adjust the respirator. Location or professional status did not affect fit test pass rate but prior experience wearing respirators did. When the study groups were compared after stratifying for prior experience, there was no difference between Groups A and B but significance difference between the latter two groups and Group C. The authors concluded that fit testing as part of training marginally enhances the ability of HCWs to wear respirators properly and pass a fit-test.

Protecting the Eyes of Health Care Workers

The published literature on the role of eye protection in protecting HCWs from injury and disease is limited. Those studies which have been conducted generally relate to the use of eye protection in the context of dental infection control practice [57,58], in reducing the risk of splashes from blood during operative procedures [59, 60], or the protective effect of goggles in protecting against traumatic [61] or chemical injuries [62, 63, 64]. Significantly, no studies were found that measure actual facial/ocular/nasal exposure to bio-aerosols and how or what types of eye protective equipment are effective in reducing exposures. The literature reviewed does not address putting on and taking off (donning and doffing) of face shields, goggles and safety glasses to prevent auto-inoculation. Nor does it address the efficacy of manufacturers' protocols for care, sterilization, cleaning and storage of the equipment. There are no standards specific to the use of face shields and eye-wear for protection against bioaerosols.

The need for facial protection in healthcare is suggested by studies such as Kouri & Ernest [59] who examined the perceived and actual face shield contamination during vaginal and caesarean delivery. They found that in 50% of caesarean deliveries and 32% of vaginal deliveries, there was measurable contamination of the face shield surface that was not detected by the physician. This occurred 92% of the time for caesarean delivery and 50% of the time for vaginal delivery. Similarly, Leese et al. [65] measured surface contamination of face shields and goggles resulting from manual dumping of medical waste. Twenty-two percent of face shield and goggle samples were found to be contaminated.

Giachino [66] reported on a study of macroscopic contamination of the conjunctiva of orthopaedic surgeons by body fluids. All members of the surgical team at a hospital wore high impact polycarbonate glasses during 60 consecutive orthopaedic surgical procedures. In 37 cases both the

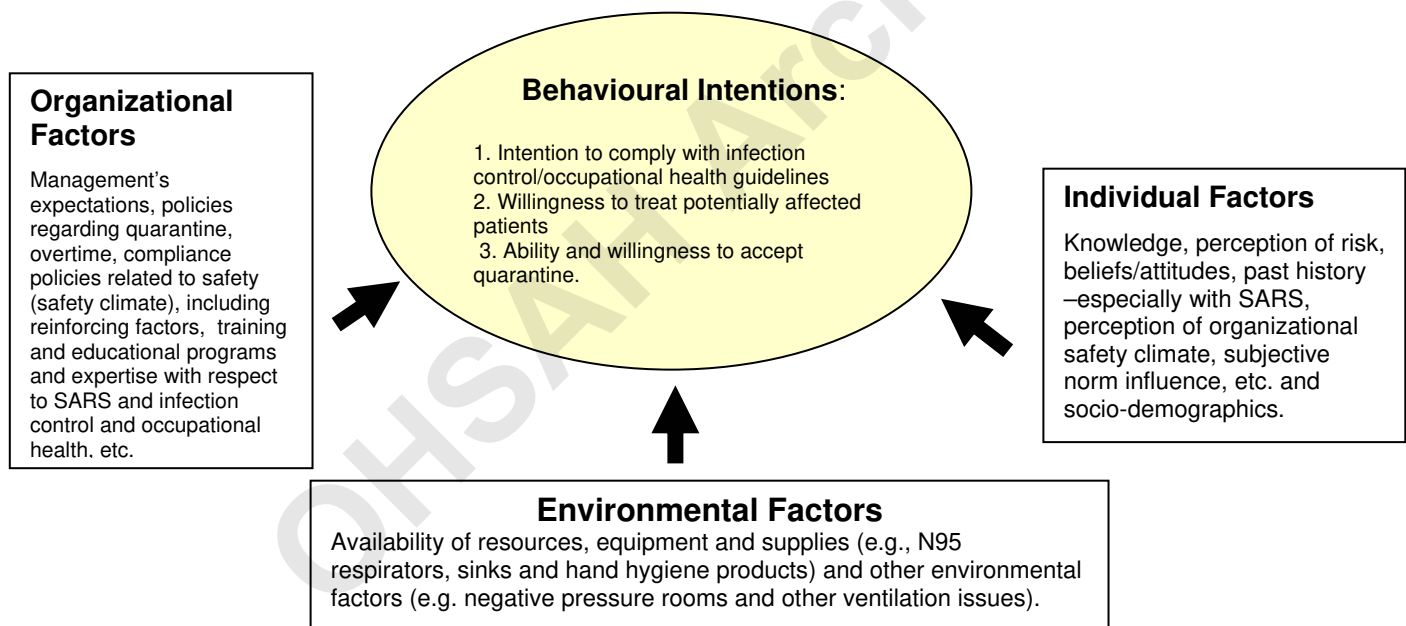
lenses of the surgeon and his assistant were contaminated by body fluids from the patient, resulting in 59 contaminations, but the significance of these results are unclear due to the uncertainty of the ability of blood-borne pathogens to be transmitted through the intra-ocular route.

The few studies which have looked at the effectiveness of eye protection have found mixed results. Davies et al. collected sera from 50 practicing dental surgeons and 50 control subjects matched for age and sex [67]. Questionnaires from the dentists detailed information relating to protective work-wear and other cross-infection control measures employed within the surgery. The sera were examined by complement fixation tests for antibodies to influenza A and B, respiratory syncytial virus and adenovirus. The dental group had a significantly elevated prevalence of antibodies to influenza A and B ($P < 0.001$) and respiratory syncytial virus compared with the controls. Wearing of masks or eye protection did not markedly reduce infection with these viruses among the dentists. The authors conclude that dentists are at occupational risk of infection with respiratory tract viruses, and that mask- or spectacle-wearing afford little protection. Using face masks and eye glasses was not correlated with the prevalence of nasal irritation, runny eyes, and itchy skin symptoms in a group of dental hygienists [68].

Despite this lack of evidence for the efficacy of eye protection, this has been included in formal recommendations to protect HCWs from SARS [69]. Given the documented ability for viruses in the size range of the SARS-CoV to be transmitted via hand to eye contact, this would seem reasonable. However, there is an urgent need to identify the additive benefit of the addition of goggles to other measures designed to reduce exposure to infectious agents among health care workers.

Part II: Effectiveness of Interventions in Protecting Healthcare Workers and Preventing Transmission of Respiratory Infections in Healthcare Settings

In order for infection control guidelines to be successful in protecting healthcare workers (HCWs) and patients from SARS, a good understanding is required of what procedures, and specifically personal protective equipment (PPE), are most effective. In addition, organizational and environmental factors, and worker characteristics, influence the ability and willingness to comply with these procedures. A theoretical model which can account for these factors, stems from the PRECEDE (Predisposing, Reinforcing and Enabling Factors in Educational Diagnosis and Evaluation) model of health promotion as developed by Green and colleagues [70] and as modified by DeJoy [71] for application to self-protective behaviour at work. Predisposing factors can be seen as the **characteristics of the individual** (beliefs, attitudes, values) that facilitate self-protective behaviour. Enabling factors can refer to the **environmental factors** that block or promote self-protective behaviour, including the skills, knowledge, as well as availability and accessibility of PPE and other resources. Reinforcing factors involve the **organizational factors**, such as communication, training, performance feedback, social approval or disapproval from coworkers or management and other safety climate dimensions. These factors can be seen to interact in the following manner:



There are an increasing number of studies highlighting the importance of a multi-dimensional or systems approach to worker health and safety, including considering job/task demands; worker characteristics; and, especially, environmental and organizational factors [72, 73, 74, 75, 76, 77]. It can be concluded from this body of literature that “compliance” cannot be fully understood by examining each of these factors in isolation, but rather how they relate to each other. This critical appraisal of the literature encompasses all three factors, reviewing first, information from the recent SARS outbreak, then from other respiratory pathogens which threaten the well-being of HCWs, then from the general health and safety literature in healthcare, and finally in workplaces generally.

Section A. Organizational Factors

Evidence pertaining to the key organizational factors from the SARS outbreak are still subject to debate, but research into the determinants of general infection control and health and safety in healthcare as well in other workplaces provide a great deal of relevant information.

Organizational factors of importance include both general organizational culture and climate, such as leadership style and institutional mission and goals, as well as specific policies and procedures.

1. Evidence from the recent SARS outbreaks:

Five descriptive [78, 79, 80, 81, 82] and five analytic studies [83, 84, 85, 86, 87] have been published on the hospital-associated outbreaks of SARS in the spring of 2003. Other information sources included letters to the editor, editorials, personal commentaries and a variety of infection control guidelines [69, 88], [89]. Some of these reports analyzed organizational factors in terms of their importance in preventing SARS transmission, but the quality of evidence presented varies markedly.

Lau et al. [87] conducted a case-control study of 72 hospital workers who developed SARS in Hong Kong, along with 144 matched controls. They found that having an inadequate amount of infection control training was associated with a higher risk of SARS infection. Specifically, 50% of healthcare workers who developed SARS had not received any SARS infection control training, versus 28% of the controls. Interestingly, the authors found no significant differences between the cases and controls with respect to performing high-risk procedures, incurring minor PPE problems, or having social contact with SARS-infected individuals. In the final multivariate mode, perceptions of an inadequate PPE supply, infection control training less than 2 hours, and inconsistent use of PPE were significant independent risk factors for SARS infection. The issues related to PPE supply are further discussed in the section on environmental factors below.

Scales et al. [79] described the consequences of a brief, unexpected exposure to a patient with SARS that resulted in 16 intensive care staff being put at risk of exposure. Of these 16 HCWs, 7 developed the disease. Three of those affected were present in the room for more than 4 hours. Further 3 of 5 people who were present during endotracheal intubation developed infections, including one worker who wore gloves, gown and an N95 respirator. The authors discussed the approach to quarantine, emphasizing the desirability of not quarantining more people than necessary but emphasizing that the consequences of missing the diagnosis of SARS for even a relatively brief period can have disastrous consequences therefore a wide net is needed.

The CDC also emphasized the importance of formal respiratory protection programs as well as ensuring that workers understand the correct order to remove PPE [80]. This study noted that many healthcare workers became quite fatigued and recognized that there were momentary lapses where they forgot to put on their goggles, or forgot to change their mask. One editorial suggested that only the most experienced personnel should be involved in high-risk procedures such as intubation [90].

Organizational interventions which were actually applied in the hospital-associated outbreaks of SARS included temperature checks on hospital staff [82], quarantine [82], limiting visitors [82], hospital closures [82], and limiting the number of HCWs present during aerosol-generating

procedures [91]. None of these interventions, have however been tested with respect to their ability to prevent SARS transmission.

The study by Park and his co-workers which retrospectively reviewed HCWs who had been exposed to those American patients with laboratory evidence of SARS-CoV infection provides some interesting observations on compliance with infection control guidelines [92]. 66 HCWs reported exposure to a patient who was coughing and later found to be SARS positive, yet 40% did not use a respirator. Despite being exposed and developing symptoms, 10 of 17 HCWs were not furloughed. However, none of the HCWs became ill and no local disease transmission occurred.

2. Evidence from other nosocomial infection studies and workplace health and safety in healthcare

Specific Policies and Procedures:

Much of the evidence that is most relevant to “protecting the faces of HCWs” comes from studies of other infectious diseases transmitted to HCWs or patients. Studies on the effectiveness of infection control practices for other respiratory viruses have shown that organizational factors can be important determinants of limiting disease transmission. Isolation, or cohorting of patients, restricting visitors and screening admitted patients for respiratory syncytial virus (RSV) have been shown to be more effective in reducing nosocomial spread of RSV, than the use of specific PPE, alone [93, 94, 95]. Outbreaks of parainfluenza virus have been controlled in bone marrow transplant units and neonatal ICUs by application of contact precautions using gowns, gloves, isolation and cohorting of nurses [96, 97, 98].

The most important determinants of successful general nosocomial infection control programs in hospitals have been understood since the mid-1980s when the Study on the Efficacy of Nosocomial Infection Control (SENIC) was published [99, 100]. The following organizational factors were found to be important in determining effective infection control and lower rates of nosocomial-transmitted disease: having one infection control practitioner per 250 acute care beds, having at least one full-time physician interested in infection control, having an intensive surveillance program for nosocomial diseases and having intensive control policies and procedures. However in a recent survey of 172 hospitals in Canada, only about 60% of hospitals had evidence of compliance for each of the SENIC factors. The number of institutions who had all four factors was likely much less [101].

General infection control procedures are focused on protecting patients and the public, while occupational health practitioners are charged with protecting the workforce. While studies have been conducted related to resource requirements for infection control, no similar studies have been conducted regarding resource requirements for occupational health resources. The American Medical Association in 1989 in their publication "Occupational Health Services: A Practical Approach" stated, that “for industries lacking exceptional physical or chemical hazards”, the following guidelines are appropriate: for the 1st 300 employees 1 full-time occupational health nurse (OHN), and an additional OHN for every 750 employees [102]. In regard to occupational physicians they state a full time physician is needed if there are greater than 2,000 employees. It is well recognized that health care does have exceptional hazards, in most, if not all, areas not the least of which relates to occupational infections. While there have been no studies as to the current levels of occupational health resources in Canadian hospitals, it is clear that it is well below the appropriate levels.

Communication, Training and Feedback:

There is considerable literature with respect to adherence to standard precautions (SP) and measures to prevent the spread of TB. Most of the studies are observational and it has been noted that there is a dearth of controlled intervention studies, but the importance of good communication is a major theme that emerges. A study of 451 nurses employed in a large US hospital centre [103] found that organizational factors were the best predictors of adherence to SP. Although the variance in adherence predicted by the model was modest, the factors that predicted adherence to SP included whether compliance was seen as a job hindrance, the availability and accessibility of PPE, and whether feedback on compliance was given. This study, however, did not look specifically at the type of feedback or communication used. Other studies in health care and correctional facilities have had similar findings [104, 105].

There is very little information that directly touches on what formative training and continuing education strategies are most effective in implementing and maintaining good infection control practices, nor on what methods of feedback are best. An intervention that was found to improve compliance with barrier precautions (use of cap, gown, mask, gloves, protective eyewear) was pre-notification of emergency room staff [106] which resulted in an increase in compliance with barrier precautions from 63% to 92%. In another study, an educational intervention consisting of lecture and practice sessions for operating room staff was shown to increase compliance with use of protective eyewear from 54% to 66% and double gloving from 28% to 55% [107]. It was unclear, however, how much of this effect was due to awareness by staff that they were being observed.

In a study conducted to analyze the effect of organizational safety climate in health care (discussed further below) [103] in nurses working in a high-risk environment, job hindrance were found to be the strongest predictor of compliance. This suggests that training programs must focus less on knowledge-based training and more on helping workers overcome or reduce the barriers associated with compliance. Task analysis, critical-incident techniques and focus groups could inform the information base for such training programs.

Most of these studies used self reports as their measure of compliance. This likely overestimates compliance as studies that have used direct observation have found lower compliance. The act of observing staff also may affect compliance with precautions, such that true compliance is likely considerably lower than either observed or self-reported compliance. Compliance has been generally observed to increase over the course of a study, consistent with a Hawthorne effect. However, what appears to be a methodological weakness may also be an indication of what is required to improve compliance with precautions. The presence of an observer may constitute a very 'soft' form of feedback. The optimal form of feedback has not been determined from the literature. It does appear that feedback must be given on an ongoing basis.

A study of Thai health care workers [108] demonstrated higher compliance with glove use and hand washing during a peer feedback intervention (83% compliance vs. 49% compliance at baseline). However, compliance fell to 73% in the post-intervention phase. The authors noted that other techniques, including in-service educational sessions, computer-assisted learning, as well as provision of education and group feedback by researchers also failed to show long-term effectiveness. The authors noted the importance of cultural sensitivity in how feedback is given, but regardless, emphasize that ongoing observation and feedback is needed, as the

effectiveness of programs diminish over time. They suggested that adjunct measures are needed and more research is needed as to how best to maintain a long-term effect.

Safety Climate:

A component of organizational culture is the “safety climate”, which refers to the perceptions that workers share about safety in their organization. The importance of the safety climate is increasingly being recognized in health care, as more emphasis is placed on productivity and performance. Hospital-based healthcare workers are having to work faster and harder than ever, in an environment of higher patient acuity, increased patient turnover, and with less time for training and education [109-113]. To compound the complexity of an analysis of organizational factors in healthcare is the reality that in most health care settings, groups of specialized and interdependent workers interact with each other and with various types of equipment and devices, such that safety performance can decline in a non-linear fashion as total group workload and situational demands increase. Results of several studies suggest that adherence may often be poorest when the risk of exposure is highest [72]. As discussed below, identification and analysis of special compliance requirements and high-risk task situations should be an important feature of a comprehensive infection-control program. Specifically, there is growing evidence to indicate that it is both incorrect and unfair to assume that health care workers have total control over their own compliance behaviour.

Although the precise nature of safety climate requires further clarification, there is general agreement that the safety-related attitudes and actions of management play an important role in creating a good or bad safety climate [1, 14,72]. Zohar established a 40-item measurement model for assessing perceived safety climate in workplaces[115]. Brown and Holmes in attempting factorial validation of Zohar’s 8 climate determinants, concluded that an employee’s previous experience and, specifically, having incurred work-related injury or disease, may influence employees’ perceptions[116], and therefore urged that longitudinal assessments of climate relative to the onset of physical trauma (in our case, SARS) is needed.

Studies of safety program effectiveness in non-health-care settings have repeatedly shown that a positive or supportive safety climate is an important contributing factor to good safety performance [117-119]. Specifically, it is known that as safe behaviours are adopted throughout an organization, increasing pressure is put on non-compliers to “come in line”. As noted by Gershon et al, early research identified management’s involvement in safety programs, safety training and safety communications programs, orderly operations, good housekeeping and an emphasis on the recognition of good performance rather than on punishment or enforcement as important determinants of workplace safety [114].

A number of studies have examined the role of safety climate in health care in general [120] and several studies have examined standard precautions with respect to blood and body fluid exposure, in particular [121]. It has been shown that the safety climate has an important influence on the transfer of training knowledge [122, 123]. White and Berger [121] insist that it is the interactions amongst workers making decisions that is particularly important; direct feedback on the consequences of use/non-use of appropriate procedures; information received from the media, professional literature and other sources; and messages from the organization such as policy and procedure statements, training programs, protective equipment availability and choices, and feedback from supervisors.

Using a 13-item scale to measure safety climate, Gershon et al. [104] found that respondents who perceived a strong commitment to safety at their institution were over 2.5 times more likely

to be compliant than respondents who did not perceive a strong safety climate. Consistent with the general hypothesis of the study, job/task and organizational-level factors were the best predictors of adherence. Using the results from the study, a three-pronged intervention strategy was developed that emphasized: 1). the availability and accessibility of personal protective devices, 2). the reduction of job hindrances and barriers, and 3). improvements in safety performance feedback and related communications.

In a separate analysis of 482 nurses in a high-risk environment [103], job hindrances were found to be the strongest predictor of compliance, and safety climate was the best predictor of job hindrances. Safety performance feedback and availability of personal protective equipment were the strongest predictors of safety climate, together accounting for 30% of the variance.

A later study by the same group of researchers examined the contribution of the pre-disposing, enabling and re-enforcing factors on compliance with standard precautions in 902 nurses at three large acute care hospitals in different regions of the US [124]. They found that all three categories of factors influenced general compliance, but predisposing factors were unimportant for compliance with PPE. Their results indicated that a positive safety climate is most likely to increase compliance in HCWs.

DeJoy et al. [72] offered several recommendations: first, safety should be integrated into the management system of the organization. Second, poor safety performance should not be viewed as simply a behavioural or worker-focused problem. Training efforts, which have focused almost exclusively on front-line health care workers, should also include supervisors and administrators as they are critical when creating supportive safety climates. Third, safety-related communication and performance feedback systems are needed. These must provide opportunity for two-way communication, which is not the case by simply posting notices or conducting training sessions. Participatory strategies including involvement of safety committees and offering performance feedback was suggested. They also note that certain worker groups, most notably physicians, cannot be allowed to be “outside the loop” in terms of regular safety communications and feedback.

An earlier paper by DeJoy [103], also recommended providing workers with as wide a variety of personal protective equipment options and choices as possible, training workers in the proper use of the PPE that is linked to specific job tasks, and attempt to reduce the costs and barriers associated with PPE use. They noted that similar studies that have been conducted with respect to hearing protectors, protective footwear and other types of protective equipment.

Gershon et al. reported the results of another study on hospital safety climate and its relationship with safe work practices and workplace exposure incidents[114]. A 20-item hospital safety climate scale was extracted through factor analysis from a 46 safety climate item survey. This new scale sub-factored into six dimensions: 1) senior management support for safety programs, 2) absence for workplace barriers to safe work practices, 3) cleanliness and orderliness of the worksite, 4) minimal conflict and good communications among staff, 5) frequent safety-related feedback and training by supervisors, and 6) availability of PPE and engineering controls. Senior management support was found to be the especially significant with regard to both compliance and exposure incidents. Worker feedback and training were also significantly related to workplace exposure incidents to blood and body fluids.

Rivers et al. recently published the results of a survey of 742 nurses regarding predictors of nurses' acceptance of an intravenous catheter safety device [125]. They too concluded that a

positive institutional safety climate was more important than individual factors, and recommended high quality training but also an atmosphere of caring about nurse's safety.

Gershon's group recommended that a safety climate survey be administered in hospitals using the safety climate scale, sponsored jointly by the infection control and occupational health and safety committees. They recommended that the survey be anonymous but be distributed to everyone, and preferably distributed at departmental meetings with a pre-addressed in-house envelope. (Non-anonymous but confidential questionnaires would be preferable if there was sufficient trust to allow this.) They recommended the results of the safety climate survey be used in several ways. Firstly, scores on the six dimensions can be ordered from high to low with the dimensions with the lowest score targeted for improvement. Secondly, safety climate can be measured before and then after any major organization-wide safety initiative. Third, the safety climate can be used to compare departments in the hospital, again to identify areas that require special attention. Fourth, this survey could be used to trend improvements in the overall safety program over time and fifth, the safety climate survey can provide management with valuable employee feedback to address barriers [114]. None of the recommendations from any of these studies, however, have been evaluated in terms of their ability to improve worker safety, once applied.

Section B. Environmental Factors

1. Evidence derived from the SARS outbreak

The recently published studies on the hospital-associated outbreaks of SARS in the spring of 2003 have all concluded that direct contact or close exposure to a SARS patient is generally required to transmit the virus, although important exceptions exist [78 - 87]. In some circumstances aerosol-generating procedures have resulted in spread beyond that which is expected by droplet transmission. Further, there is some evidence that fomites on surfaces in hospitals may be able to transmit disease without direct patient contact in some instances. This is also the conclusion of a recent WHO consensus document on the epidemiological features of SARS [126]. Understanding the mode, or modes of transmission is key to designing effective environmental control practices for hospital-acquired infections.

Physical space separation:

During the SARS outbreaks in Singapore, Taiwan, Hong Kong, Hanoi and Toronto [82, 127, 128] a number of different physical space interventions were applied. These included separating triage patients in waiting rooms for emergency wards and other hospital departments; isolating suspected SARS patients in single rooms in emergency departments, general medical wards and intensive care units and using anterooms to separate donning and doffing from patient care activities.

In examining the evidence for the transmission route of SARS, Varia et al found that the risk of developing SARS in Toronto healthcare workers and family members was graded by distance with exposures less than 1 m from a case being highest risk [84]. Risk decreased sequentially with exposures less than 3 m from a case or greater than 3 m and whether they took place with or without cough-inducing, or aerosol-generating procedures. This implies that physical separation of SARS patients from other patients and staff, should have some effect on preventing transmission of SARS. However, this intervention has not been evaluated formally.

Transmission appears to only occur from those who are symptomatic with the disease [126]. Further, three recently-published seroprevalence studies of healthcare workers in the United States, Hong Kong and Viet Nam have shown that asymptomatic infection does not appear to occur [92,129]. Therefore directing infection control measures against those patients who have symptoms compatible with SARS should be an effective means of controlling the outbreak. This was, in fact, the case in all of the outbreaks in 2003. Once the disease was recognized and appropriate infection control measures put into place, the numbers of new infections declined rapidly.

Engineering controls:

Limiting the generation or dissemination of infectious particles from patients can be seen as a means of controlling the source of a hazardous occupational exposure. Early infection control guidelines for SARS [88, 89] suggested placing surgical masks on suspected patients in triage or while being transported in the hospital in order to reduce infectious exposures. Early presentation of patients with symptoms to hospital limits exposure of community to SARS and can be seen as another means of limiting exposures to hospital staff because viral shedding appears to be maximal in the second week of illness[130]. No published studies have evaluated source control as a means of preventing transmission of SARS.

Some procedures, such as intubation, the use of continuous positive pressure ventilation or nebulizer therapy seemed to result in the generation of finer infectious droplets from SARS patients which could travel farther than those generated spontaneously from patients. Such aerosols seem to be responsible for some episodes for spread at distances greater than those commonly found with large droplets and some instances of failure of infection control practices to prevent transmission [80, 81]. Therefore recommendations were made to avoid aerosol-generating procedures, such as nebulizer therapy, and procedures to limit the generation of infectious aerosols during intubation were also developed [91]. Similar recommendations for using closed ventilation systems for intubated patients were also made. Loeb, in a study of ICU nurses in Toronto, did find that assisting with intubations, suctioning before intubations and manipulating oxygen masks on SARS patients were practices which increased the risk of acquiring SARS [85]. The effect of avoiding these procedures have not been evaluated in terms of preventing disease transmission.

SARS infection control guidelines also recommended that patients be cared for in negative pressure rooms with 6 to 9 air exchanges per hour. These recommendations would not likely be effective in reducing SARS transmission, above that of caring for patients in a single room, if indeed, large respiratory droplets are the primary means of transmission. However, in theory, negative pressure would have the added benefit of reducing exposures to finer droplets produced by aerosol-generating procedures. It is worth noting, however, that in Viet Nam, the first affected country to successfully control the spread of SARS, negative pressure rooms were not available in either affected hospital [128].

The importance of having appropriate ventilation systems in place was shown by the “super-spreading” phenomenon seen in Hong Kong, where the index patient in the Prince of Wales Hospital transmitted SARS to 47 healthcare workers. Later studies of the ventilation system revealed that the patient’s cubicle was under positive pressure relative to the rest of the ward and the hallway[86]. Furthermore, this problem with the ventilation system appeared to be more important than the use of nebulizer therapy in determining transmission patterns.

An analysis of a large outbreak in the Amoy Gardens apartment complex in Hong Kong concluded that the aerosolization of SARS from fecal material by flushing toilets allowed spread of disease through the building's ventilation system because of improper seals around floor drains [127, 166]. This again resulted in transmission which ranged farther than could be explained by respiratory droplets.

Other engineer controls such as filtration of exhaust ventilation, ultraviolet germicidal irradiation or increasing ambient air humidity were not included in most SARS infection control guidelines and have not been evaluated.

Environmental decontamination:

Cleaning and disinfecting surfaces was recommended as a means of preventing SARS transmission early in the course of the epidemic. This was supported by the observation that the SARS CoV could survive on plastic surfaces for up to 48 hours [126]. The virus has also been shown to be able to survive up to 2 days in stool and up to 4 days, if the patient was experiencing diarrhoea [126]. Further the hypothesis that the virus could be transmitted by fomites on surfaces was supported by the observation of Ho et al., that three hospital cleaning staff became infected with SARS, despite having only exposures that involved cleaning a room which was previously occupied by a SARS patient [78]. Similarly, one of the infected HCWs in Seto's cohort did not have an exposure to a SARS infected patient, but was classified as probably being exposed outside the hospital [83]. However, environmental decontamination has again, not been formally evaluated as a control measure for SARS.

Hand-washing can also be seen as a similar type of environmental decontamination, which is recommended in all basic infection control guidelines. While Seto et al. did show that HCWs who reported hand-washing during patient care experienced a lower risk of developing SARS in univariate analyses. However, this effect was not seen in the multivariate analysis [83]. No other evaluation of hand-washing has been reported.

Specific personal protective equipment:

Controversy arose over whether surgical masks or N95 respirators were required to protect HCWs from SARS. Both Seto in a study on Hong Kong healthcare workers [83] and Loeb in a study conducted in Toronto [85] found that not consistently wearing either a surgical mask or an N95 mask was associated with developing SARS when compared with consistent use. Seto found no difference in risk of infection whether HCWs were using surgical or N95 masks [83]. It should be noted that one hospital where the source of outbreak was determined to be a patient who was receiving nebulizer therapy, was excluded from this study as "*droplet precautions have never been recognised as an effective infection control measure for such aerosol-generating procedures...*" In addition, aerosolizing events were not included. The authors concluded that precautions against droplets and contact are adequate for prevention of nosocomial SARS where no aerosol-generating procedures are used. The surgical and N95 masks were both effective in the above scenarios. The situation is less clear where aerosol-generating procedures are in use.

Loeb et al., in a retrospective cohort study of 43 nurses in two critical care units with SARS patients examined the risks for disease acquisition and did find a trend towards increased protection from N95 masks compared to surgical masks, but this was not statistically significant [85]. Eight of 32 nurses working with patients became infected. Specifically, 3 of 23 nurses (13%) who consistently wore a mask (either surgical or N95) acquired SARS compared to 5 of 9 nurses (56%) who did not consistently wear a mask ($p=0.02$). The relative risk for infection was

0.22 ($p=0.06$) for nurses who always wore an N95 mask when compared with nurses who did not wear any mask consistently. The relative risk for infection was 0.45 ($p=0.56$) for nurses who always wore a surgical mask when compared with nurses who did not wear any mask consistently, implying no statistically significant difference between wearing a surgical mask and not wearing a mask at all. However the difference in relative risk for SARS infection for nurses who consistently wore N95 masks compared to those who consistently wore surgical masks was also not statistically significant ($p=0.5$). The study is one of the most informative coming from the SARS outbreak itself, but suffers from many limitations. Primarily, the results were not analyzed to correct for possible confounding factors. In addition it did not examine whether fit-testing was performed on those using the N95 masks, did not address the issues of potential autoinoculation when removing gear and suffered from small sample size of the cohort. It is worth noting that in Viet Nam, N95 masks were not available until the third week of the outbreak, a factor which did not seem to prevent their ability to control it [128].

The Seto study also found that regularly wearing gowns was protective in univariate analyses, but that only mask usage was significant in the multivariate analysis [83]. The study by Lau found that inconsistent use of goggles, gowns, gloves and caps was also associated with acquiring SARS in univariate analyses, but were not also significant in multivariate models [87]. 100% of HCW used an N95 or surgical mask and no difference was noted in the use of N95s between cases and controls. Again, small sample sizes may have limited the power of these studies to show the effects of these interventions. No other published studies have evaluated the effectiveness of face shields and/or goggles in their ability to protect HCWs against SARS.

Interestingly, the study by Lau found that HCWs who perceived the amount of personal protective equipment available to be inadequate were at higher risk for developing SARS and this effect remained significant in the multivariate model [87]. The study was conducted in five hospitals in Hong Kong, so the researchers were unable to confirm, which specific items (if any) were inadequately supplied. They note, however, that given the large differences they found (odds ratio >5 , $p < 0.001$), it is likely that PPE shortages were at least partially responsible for many of the SARS infections.

Christian et al. examined a cluster of health care workers after exposure to a patient with SARS during cardiopulmonary resuscitation (CPR) [81]. Three of the six nurses present during the intubation developed respiratory symptoms and it was suspected that they had been exposed. HCWs were interviewed, the healthcare setting inspected and policies and procedures reviewed. The CPR event described took place when protocols for management of patients suspected of having SARS were in place but the use of Stryker T4 Personal Protection Systems was being advocated as an additional protective measure. Nine HCWs were present during the intubation. Six nurses did not wear T4 personal protective equipment while three respiratory technicians and physicians did. In addition, the nurses were exposed to an ambubag that did not have an appropriate filter attached during the initial resuscitation. Three of the six nurses developed symptoms in the week after the procedure, however, only one was found later to have positive serology for the SARS-CoV. It was suggested that T4 PPE was potentially more protective, however, not all the subjects involved in the events underwent serologic testing and the level of exposure for each HCW was likely different, with the nurses likely having higher exposures due to the problem of the unprotected ambu-bag. The patient was not breathing at the time of the intubation that was performed without difficulty, making the generation of small infectious particles less likely. The study did not allow a clear determination of what mode of disease transmission was the most important in this cluster. Importantly, the appropriate removal of equipment was not discussed and it appears that the nurses were not wearing fit-tested respirators.

The authors point out that the delay in some members of the team to respond to the code was due to the time required to put on the T4. This resulted in a second code blue being called and additional HCWs exposed to the index case and suggests that better PPE may conversely result in increased exposures to infections if it is not well suited to the work environment.

2. Evidence derived from other droplet-spread respiratory infections

Other viruses which can cause significant respiratory infections and have been shown to be transmitted in healthcare settings include other coronaviruses, influenza and parainfluenza viruses and respiratory syncytial virus. All of these viruses are transmitted through the spread of large droplets or fomites, similar to the primary means of transmission of SARS CoV. However, there have been no reported instances of spread through smaller respiratory droplets over larger distances due to nebulizer therapy or intubation procedures for these viruses. It is uncertain as to whether this is because it does not occur or because it does occur but the transmitted disease goes unrecognized. Therefore, the evidence related to these viruses may be generally analogous to SARS, except with respect to the “superspreading” instances referred to above.

Other coronaviruses are thought to primarily cause mild disease such as the common cold, accounting for up to one-third of cases. However, outbreaks in susceptible populations such as in neo-natal ICU’s or in elderly people living in long-term care facilities, coronaviruses have been shown to cause significant lower respiratory disease, leading to hypoxia [131,132]. However, no studies evaluating the effectiveness of infection control practices with respect to other coronaviruses have been published.

Outbreaks of nosocomially-transmitted influenza are a common occurrence during the winter months in Canada, causing hundreds of thousands of infections and between 500 and 1500 deaths per year, substantially more than SARS. The primary means of controlling the disease is through vaccination of those members of the population who are at highest risk for disease, as well as those who are in direct contact with this population [133]. The latter group includes healthcare workers, who are often the vehicle through which hospital patients or residents of long-term care facilities become infected [134]. Droplet precautions are recommended for paediatric hospitals and some adult hospitals caring for patients with influenza-like-illness [36], but have not been evaluated in terms of their ability to prevent transmission.

Respiratory syncytial virus (RSV) is another common cause of outbreaks of moderately severe acute respiratory infections in healthcare institutions, primarily in paediatric hospitals. Infections are transmitted through inoculation of the nose or eye, rather than the mouth [135]. Studies on the effectiveness of infection control practices have shown that organizational controls such as isolation or cohorting of patients were more effective than the use of gloves, gowns and masks in reducing nosocomial spread of RSV [93, 94, 95]. Screening all patients with viral respiratory infections for RSV on admission and using contact precautions (isolation without masks, but using gown and gloves) was shown in one study to reduce RSV transmission rates by 39% and save \$6 for every \$1 spent [136]. Two other studies conducted in adult bone-marrow transplant units found similar evidence of effectiveness [137]. Another study, paradoxically, found an association with wearing gowns and an increased risk of nosocomial transmission of RSV [138]. RSV is only able to survive on surfaces for approximately six hours, much less than SARS CoV [139].

Parainfluenza viruses are also thought to be primarily transmitted through large respiratory droplets. They appear to be less viable in the hospital environment than SARS, as they survive for only 10 hours on surfaces [140]. Outbreaks of parainfluenza have been controlled in bone marrow transplant units and neonatal ICUs by application of contact precautions using gowns, gloves, isolation and cohorting of nurses [96-98].

3. Evidence derived from airborne-spread respiratory infections

Measles and varicella zoster are viruses, which can cause respiratory disease and are primarily spread by the airborne route. However, widespread outbreaks are rarely seen in healthcare settings largely because of widespread immunity to both diseases either as a result of successful vaccination programs (for measles) or because of natural infection (varicella). No studies evaluating infection control measures for these viruses, other than vaccination could be found.

An abundance of studies have been published on the prevention of nosocomial transmission of tuberculosis, but the extent to which this information is relevant to SARS is unclear. TB is spread by small droplet nuclei that can travel large distances while remaining aloft after being produced by infected patients. This is unlike the spread through large droplets, by which the SARS coronavirus is generally believed to be transmitted. However, some controls used to prevent nosocomial TB transmission, have the potential to be useful for the control of SARS with respect to the “superspreading” events where smaller infectious droplets are generated.

In the late 1980s and early 1990s it was recognized that infection control practices were not stringent enough to prevent the occurrence of outbreaks of tuberculosis in healthcare facilities [141]. Consequently, more rigorous guidelines to prevent nosocomial transmission of tuberculosis were developed [30, 142]. These have generally been credited with reducing the spread of tuberculosis in healthcare facilities, but it remains unclear which components of the guidelines have had the greatest effect [141].

Physical space separation:

The airborne nature of TB transmission means that simply physically separating TB patients from other patients and healthcare will not prevent transmission, as long as the ventilation systems are not separated. However, some TB control plans recommend the separation of procedure rooms and general care rooms, so that aerosol-generating procedures do not result in an increased burden of infectious agents in patient-care areas [143]. Similarly hospital designs could help to reduce the environmental contamination of SARS-CoV if patients requiring intubation and nebulization therapy could be transferred to separate procedure rooms.

Engineering controls:

Anti-tuberculosis therapy can rapidly reduce the production of infectious particles, thus limiting exposures to healthcare workers. If effective anti-viral therapies could be developed which could reduce the production of infectious viral particles, these could similarly protect hospital workers, even if they do not improve patient outcomes. Other types of source controls such as masking patients or using closed ventilation systems for intubated patients likely have similar effects on reducing the production of infectious particles, but have not been evaluated with respect to preventing transmission of tuberculosis.

Another method of source control is limiting the movement of patients once admitted to hospital with TB. In a hospital with a large HIV unit in Lisbon, Portugal, restricting patient movements was identified as one of a number of infection control measures which were introduced to eliminate risks for nosocomial transmission of multi-drug resistant TB [144].

Ventilation systems, which generate 6 to 10 air exchanges per hour, and exhaust outside the hospital resulting in the creation of negative pressure environments in patient care rooms, have been shown to remove 99.9% of airborne contaminants within 69 minutes [143]. However, in one study of the effectiveness of these systems revealed that 11% of such ventilation systems in three US hospitals were not actually generating negative pressure [145]. Further, 19% of TB patients were not isolated on the first day of admission because the aetiology of their problem was not recognized. Similarly, Canadian researchers have shown that inadequate ventilation systems of general patient rooms can lead to increased risks to TB infection for healthcare workers because of patients with unrecognized infections [141].

Ultraviolet irradiation has been shown to enhance the decontamination of infectious airborne bacteria and viruses [143]. While it has a limited effect on surface contamination, because of poor penetrative ability, and does not work well in instances of high humidity, it could also be of some benefit in terms of decontaminating patient-care rooms where the infectious organism is a droplet-spread virus such as SARS. Filtration of exhaust ventilation of isolation rooms with HEPA filters is standard practice to prevent environmental contamination of tuberculosis, but it has not been evaluated in terms of its ability to actually prevent transmission.

Specific personal protective equipment:

N95 respirators have been required to be provided for HCWs who work in the US since 1994, when the CDC TB transmission prevention guidelines were published. However, studies of actual practice have shown that a range of between 44 and 97% of HCWs use these properly [146]. Thus, it is feasible that the improved efficacy of an N95 mask over a surgical mask may be easily lost, if compliance is poor. No published reports on the effectiveness of face shields and/or goggles, gloves or gowns were found with respect to preventing nosocomial transmission of TB.

Section C. Individual Factors

Several individual factors may affect the compliance of health care workers (HCW) to using personal protective equipment (PPE) for protection against respiratory infectious diseases in healthcare settings. The majority of research done in this area has been exploring HCW compliance with standard precautions (SP). SP were introduced in the 1980s in response to the risk of transmission of blood-borne pathogens to HCWs from patients, in particular HIV. Though the research does not directly examine the compliance of HCW with facial protection, the reasons for non-compliance with SP can be extrapolated to any PPE.

1. Knowledge acquired through training and personal experience

Knowledge of the appropriate use of PPE is necessary but not sufficient for HCWs to adopt safe work practices [147]. The study by Gershon et al. from 1995 [104], found that HCWs surveyed had high levels of knowledge regarding UP practices but that this did not lead to high levels of compliance. Compliance was noted to be more correlated with perception of risk. Use of PPE

only when there is visible blood may demonstrate that HCWs make personal judgements about their own potential risk instead of following a consistent policy [148]. Repeated exposures without consequences may decrease compliance. HCWs may perceive decreased risk if, while caring for patients, they receive repeated exposures to blood and body fluids (BBF) but are never infected. This may lead to a false sense of invulnerability and therefore increase risk taking [124].

It is noteworthy that, at least the more recent studies on compliance with standard precautions indicate that HCWs do not appear to dismiss or underestimate their personal risk of acquiring an occupational infectious disease [149,150,151]; in fact HCWs are more likely to overestimate their risk.

Gershon et al. in their 1999 study found HCWs less than 40 years of age more likely to comply with SP [105]. This may reflect more recent training. HCW surveyed were found to have realistic risk perceptions about exposure to BBF: few were fearful of contagion. Level of experience did not necessarily lead to a lack of understanding of risks involved. Nurses who were educated in a more disease driven infection control model, where precautions were used only when the patient was known to be infected by a given pathogen, were less comfortable in UP model as compared to recent graduates [152].

Students and other HCWs may look to attending physicians as a role model; poor compliance in these senior physicians may lead to lower levels of compliance in their students. Kim et al. had similar findings [107]. Younger physicians, house staff and medical students were found to be more compliant with SP than senior physicians. The increased compliance probably reflects more recent training. Another study found that compliance with methicillin resistant *Staphylococcus aureus* (MRSA) precautions (which included use of gloves and gowns and hand washing) was related to occupational group with physicians showing the lowest compliance (22%) and physiotherapists and occupational therapists having the highest compliance (89%) [153]. Compliance with gown and glove requirements was 65%, and for hand hygiene, 35%. Gershon et al. stated that physicians are “out of the loop” with regard to safety climate within hospitals. Special efforts need to be made to involve them in training, safety programs, and safety committees [105].

Angtuaco et al. [154] found that fewer gastroenterologists than GI endoscopy nurses used face shields for all procedures (14% vs. 21%; $p=0.02$). Overall compliance with use of barrier equipment for both groups was low.

Prieto and Clark interviewed HCWs regarding their attitudes toward use of PPE [155]. Nurses reported confusion at the ward level and uncertainty about the rationale for the uses of PPE recommended in infection control guidelines. They perceived the existing guidelines lack specificity to their practice. They also doubted the effectiveness of isolation precautions to prevent disease transmission and voiced frustration with the lack of adherence by allied professionals. Physicians echoed nurses concerns but also felt that their training inadequately prepared them to implement isolation precautions and relied on the nursing staff to direct them. Jeffe et al. also cited the need to teach medical students the importance of the use of PPE before they become set in their ways [156]. Teaching medical students early in their clinical training about the risk of exposure to BBF and specific prevention measures may be associated with more positive attitudes and better compliance with precautions.

2. Attitudes and Beliefs

Demographics such as gender, education, shift work or occupation have not consistently found to be associated with compliance with infection control procedures [104]. Compliance is more often found to be affected by knowledge, attitudes and perception of risk. Dejoy et al. found that having a positive attitude towards the patients, lower risk-taking tendencies and greater knowledge of modes of transmission leads to greater compliance [124]. If the HCW does not understand the risk status of patients or that a single momentary lapse in compliance can lead to serious results, they may be willing to take unnecessary risks when providing care.

Perceived barriers may be one of the most important factors affecting compliance. Godin et al. found that HCW perception of their ability to adopt the use of PPE into their practice affected their level of compliance [157]. If they believe that the barriers to their adherence to recommended use of PPE cannot be circumvented they will not comply. Actual working conditions resulting in overwork, lack of time with patients and having to deal with emergencies were reported to have significant negative effects on compliance. Godin et al. also found that HCW are influenced by the subjective norm, i.e. the perception of social expectation to adopt a given behaviour [157]. This suggests that if HCW believe that key persons in their work and social environment expect them to be compliant with the use of PPE, they are more likely to do so.

As noted above, organizational issues impact individual attitudes considerably. For example, workload issues are thought to affect HCW willingness to comply with recommendations for PPE use. Workers who feel stressed and overloaded at work are much less likely to be attendant to safety needs and precautions [114]. Helfgott et al. found that sufficient knowledge of how to prevent occupational exposure did not appear to correlate with compliance with UP [147]. The most common reasons why HCW did not comply were time constraints, hindrance of performing a specific task and HCWs presumed lack of risk based on identifying infectious patients. It was also noteworthy that this study also found that level of compliance was inversely proportional to level of experience of the HCW. Reasons for this finding were given as increased level of competence, feelings of invulnerability or just plain laziness.

Dejoy et al. in their 2000 study, cited the importance of easy access to the correct PPE when needed, including protective outer garments, eye shields and facemasks as an influence on compliance [124]. The availability of certain PPE can have a significant effect on the attitudes of HCW towards using them. The greater perceived availability of PPE may lead to stronger beliefs in their effectiveness for prevention amongst HCW. Face protection is often less readily available in health care settings than gloves or sharps containers.

A significant factor that may influence HCW compliance with PPE use is the perception that their use may lead to a decreased quality in the therapeutic relationship between patients and HCW. Nickell et al. found that during the Toronto SARS outbreak HCW found wearing of masks particularly bothersome [158]. A mask made communication difficult, recognizing people difficult and lead to a sense of social isolation. Dejoy et al found that the wearing of PPE places barriers between two people, negatively altering interpersonal dynamics and complicating the performance of tasks and treatment [124]. Respirators cover the face and mouth hampering communication especially for the elderly and those with hearing loss. Use of respirators may lead to increased isolation and fear amongst patients [159]. Prieto and Clark also cited concerns amongst nurses that isolation of patients could lead to depression from lack of social contacts [155]. In trying to avoid these negative consequences, HCW may choose not to comply with PPE recommendation even though they know they should.

Reduction of job related hindrance through analysis and modification of patient care tasks and development of skills based training may increase compliance. HCW have adequate information and knowledge but need to enhance skills at practicing use of PPE [124]. Unfortunately, most studies have found that formal education sessions may have effects on compliance levels, but these improvements are found to be short lived. Improvements in compliance may come from informal point-of use prompts or more formal safety performance feedback, rather than official policy statements.

Previous studies have also showed that health care workers view standard precautions, as adversely affecting job performance and the practitioner-patient relationship [160, 161, 162]. The most common reasons for lack of adherence were insufficient time, interference with job duties and discomfort. In the Willy et al. study, interference with the practitioner-patient relationship and decreased dexterity were the most frequently cited reasons for non-compliance. Osborne determined that mean compliance rates among Australian operating room nurses were 55.6% with always double-gloving during surgical procedures and 92% with always wearing adequate eye protection [163]. The variable that had the most influence on compliance was the perception of barriers to compliance, specifically, that adhering to standard precautions interfered with duties. Nickell et al. found in their study of HCWs during the SARS outbreak in Toronto that the most commonly cited difficulty with complying with precautionary measures, especially masks, was that wearing one for any extended period of time was very uncomfortable [158].

3. The challenge of changing health care worker behaviour

An important consideration in defining an approach to the management of SARS and other emerging infectious diseases is that whatever the evidence that emerges the key challenge of changing behaviour will remain. In recent years much research has been conducted on the components of a successful strategy but much work needs to be done. This is especially true in the context of SARS where the scientific knowledge base will be rapidly evolving simultaneously with the need to implement change. Bero and colleagues have characterized components of interventions that are likely to be successful or unsuccessful, some of which are listed in Table 2.7 [164]. In addition Grol and colleagues [165] have characterized the features that were more likely to be associated with a change in primary care practice. An important finding was that recommendations with a strong evidence-base were more likely to be effective than consensus statements.

Table 2.7

Features that are likely to be associated with success in guideline dissemination
Consistently effective
Educational out reach visits
Reminders
Interactive educational meetings
Multi faceted interventions
Interventions with variable success:
Audit and feed back
Local opinion leaders
Local consensus approach
Patient mediated interventions
Interventions with little or no effect
Educational materials
Didactic educational meetings.

These data indicate that the mere creation of recommendations within a well grounded program in knowledge translation will be unlikely to achieve a safer workplace.

Part III: Summary of Literature Review

Summary of available evidence:

A. Epidemiology and Transmission

SARS is a disease largely spread by respiratory droplets. The lack of spread within the community and the recent information on relatively low R_0 values for SARS coronavirus indicate that SARS is less contagious than influenza and other similar respiratory infections. It is important to emphasize that the consistent application of basic infection control precautions terminated outbreaks in Vietnam, China and Singapore. Large outbreaks occurred early in the emergence of the disease when the causative agent was not recognized and infection control procedures not in place. The literature makes it fairly clear that failure to implement appropriate barrier precautions was responsible for most nosocomial transmission. As such, attention to understanding why there was a failure to implement

appropriate precautions, and how best to promote compliance in future, is an important topic for study.

Although largely spread by the droplet route, review of the literature relating to SARS provides indirect evidence that the generation of aerosols and the lack of control of aerosols at source was an important factor in hospital dissemination. In other Pacific Rim countries, cessation of the outbreak generally occurred without the use of negative pressure rooms, personal respirators, or other sophisticated environmental controls. However, it is important to stress that aerosolizing procedures were less common in these institutions and where they did occur, increased nosocomial transmission was documented. Uncontrolled intubations, with prolonged exposure times and multiple opportunities for breaks in technique and the use of BiPAP or CPAP often for extended periods of time contributed to transmission of the virus to healthcare workers in some settings. The relative lack of transmission within the community also suggests that sneezing and coughing may not generate highly infectious aerosols in contrast to hospital-based mechanical procedures.

The relative role of aerosol transmission in disease scenarios traditionally thought to be spread by the droplet route is unknown, as is our understanding of the role of mucosal contamination and autoinoculation in acquisition of infection. These topics require further investigation and more research is needed, using appropriate infectious agents as models, on the generation and behaviour of respiratory droplets in the hospital environment, especially during procedures such as suctioning, intubation or nebulizer therapy.

As patients with SARS did not appear to transmit disease unless they had symptoms, recognizing the disease in patients presenting to hospital was probably one of the most important factors in limiting spread. Once the disease was recognized, all the outbreaks in 2003 were able to be contained, using a variety of different infection control strategies. The development of new laboratory tests for the SARS CoV provides optimism that identifying SARS patients will become easier in the future, providing they are sufficiently sensitive and specific, and used in the appropriate clinical situation. This is an area of important research that is already ongoing, and will lead to greater protection of healthcare workers against SARS. However, specific clinical diagnosis of disease can never be relied upon to protect against emerging diseases.

B. Risk Assessment:

Risk assessment is a systematic process for describing and quantifying the risk associated with hazardous substances, processes, actions, or events. Risk assessments are frequently performed by hospital staff and others as a guide to determining the need for preventive measures. Information on epidemiology and transmission can provide information for use in risk assessments. Risks can be characterized in many ways, but some gaps remain in our understanding of the risk of transmission in any given situation.

In the case of SARS, much is already known about the risk of disease transmission. It appears that the risk of acquiring SARS in the community was very low. In most cases infection seemed to require close contact with individuals. In hospitals, the risk of disease transmission appeared to vary widely, but several factors were quickly identified as being important determinants of risk. Patients were only able to transmit disease if they were symptomatic and the patients with the most severe illness seemed to be at greater risk for transmitted the disease. Again, working in close proximity to a patient resulted in a higher risk of disease transmission to healthcare

workers. Added to the individual risk of the source patient were the risks associated with the hospital environment in terms of whether the patient wore a mask in hospital, was nursed in an isolation room and the state of the hospital ventilation system. Further, whether the patient received nebulizer therapy, BiPAP, was intubated or underwent another aerosol generating procedure also increased the risk of disease acquisition for an individual healthcare worker. Therefore, for healthcare workers who do not work in an area of a hospital where patients are acutely ill and who may require one of the above procedures is likely, the risk of acquiring SARS is also quite low. As noted, further research is needed to properly characterize the risk of aerosol generating procedures compared to coughing and sneezing alone in terms of the concentration and size distribution of the aerosol, the duration respiratory droplets remain aloft and their potential to cause disease. However, we have already noted a number of criteria by which infection control practitioners or occupation health managers can stratify workers into those who may not need extra protection from SARS or other respiratory pathogens and those who do.

C. Risk Management:

1. Controlling aerosols at source

The occupational health literature has extensively documented that controlling aerosols and droplets at the source is the most effective means of protecting workers from occupational hazards. When infectious patients are subjected to certain procedures such as nebulizing therapy very fine particles (droplet nuclei) may be generated and disseminated into the air of treatment or operating rooms. An effective engineering control is the installation of an HEPA-rated filter on the exhaust port of the nebulizer. Other equipment that should be fitted with an effective filter system when connected to infectious patients include anaesthesia machines, pulmonary function machines, ventilators, and manual ventilation units. Moreover, having an infectious patient wear a surgical mask is a simple and effective method of controlling at source.

2. Isolation and ventilation

Risk of nosocomial transmission of SARS was much greater than community transmission. No good evidence emerged to substantiate the need for quarantine in controlling risk in the community. The extent to which isolation of SARS patients within an institution is useful in reducing risk of transmission is not known but this practice could be defended on general infection control grounds – as it is wise to minimize the number of staff who have *potential* exposure.

It is not clear which procedures (e.g. intubation, CPAP) are, and which are not capable of producing exposures that increase risk of transmission. However, the available evidence on the importance of aerosols for transmission suggests that procedures likely to generate high concentrations of aerosols should be performed only in designated areas where a higher level of protective measures can be employed

Inadequate hospital ventilation systems in the general patient area were identified as an important determinant of “superspreading” of SARS in one hospital in Hong Kong, likely in combination with aerosol-generating procedures. This observation is similar to that of a recent study of nosocomial-transmitted tuberculosis in Canadian HCWs that also found ventilation systems outside of isolation rooms was an important determinant of infection. Inadequate ventilation systems were also implicated in a large outbreak in an apartment complex in Hong

Kong. More research needs to be done on how adequate are existing ventilation systems in healthcare facilities and what can be done to improve them, if needed. While there has been much interest in the importance of having SARS patients nursed in negative pressure rooms, more research is needed to identify the added benefit, if any, of negative pressure rooms beyond that of isolation and adequate ventilation throughout the hospital.

3. Environmental decontamination

Studies have shown that SARS coronavirus is easily killed with standard disinfectants. It is also known that SARS can survive for several days on surfaces, and for longer periods in stool, especially stool from patients with diarrhoea. Recommendations regarding surface decontamination and hand-washing thus appear to be well-grounded for SARS, in that the virus appears to be better able to survive outside the human body than the other common respiratory viruses. It will be important to clarify the ability of the SARS CoV to survive on clothing, human skin and body fluids and to more firmly establish the role that fomite transmission of SARS plays in spreading the disease in hospitals. Finally it will be necessary to study further the effectiveness of environmental control measures, including decontamination procedures.

4. Personal Protective Equipment

While there is extensive literature on the performance of personal protective equipment, especially respirators with regards to particle penetration of some bioaerosols, how this performance translates into protecting healthcare workers from infectious diseases is not clear. Two observational studies have shown that using any mask regularly is more protective than not using a mask. However it is still unclear whether N95 masks offer significantly better protection against infection than surgical masks. Small studies have shown that wearing gowns, gloves, goggles and caps were protective in univariate analyses, but not in final models. It is not clear if the lack of effect is due to the small sample size, confounding effects or true limited effectiveness. It is also not clear, why some HCWs contracted SARS while working with what should have been adequate PPE during aerosol-generating procedures. It will be important to study whether the failures to protect HCWs in these circumstances were due to failure in efficacy of controls, or in the effectiveness in their use. Failures in efficacy would imply that better PPE (i.e. N95 masks, PAPRs) may be needed to adequately protect HCWs from SARS in these circumstances. However failure in effectiveness in the use of PPE would imply that less complicated infection control guidelines, which focus on the key protective factors, combined with the appropriate safety climate and incentives for compliance may ultimately be more successful in reducing infections. Further we have found that there is relatively little information on how important the trans-ocular route is for disease transmission and how existing eye protection reduces this risk to healthcare workers.

It was noted that more research was needed regarding the possibility of re-use of respirators for SARS when sufficient respirators are not available; it is known that the re-use might increase the potential for contamination, however this risk may be balanced against the need to fully provide respiratory protection for healthcare personnel. A long list of guidelines and suggestions have been produced that range from training and fit-testing to ensure proper seal to the need for the reusable elements in PAPRs to be cleaned and disinfected after use, but few of these elements have been studied in terms of their effectiveness in reducing disease transmission.

5. Fit Testing

Review of the scientific literature prior to the advent of SARS provides clear evidence that fit-tested N95 masks provide an extra degree of protection to exposure to organisms *transmitted by the air-borne route*, primarily tuberculosis. It is equally as clear that any leak in the seal negates the additional benefit this type of respirator provides. Thus it is important that HCWs know how to verify that there are leaks around their masks. Fit-testing minimizes the chance of leakage. However, the relative importance of fit-testing as opposed to fit-checking is unclear. The information from a study by Huff using a nebulized solution containing Tc^{-99m} suggests that fit-testing does have a valuable role to play in reducing the risk of exposure to aerosolized droplets.

The educational value of the fit-testing exercise cannot be dissected from the actual fit-testing benefit, nor should it be. The limited studies demonstrating the importance of a HCW conducting a fit-check each and every time to ensure a good seal, suggests that fit-testing annually is less important than on-going assessment of the ability of HCWs to achieve an effective seal through fit-checking. As noted above, with respect to N95 versus surgical masks, fit-testing reduces exposure to infectious particles but whether it reduces the risk of infection is unknown. Whether fit-testing is needed in a given institution should be based on an assessment of the potential risks of infectious exposures to air-borne organisms in the facility.

While studies have demonstrated that fit-testing reduces the risk of exposure to infectious agents by the airborne routine, it is unclear as to whether or not the risk of infection in healthcare workers is reduced, for tuberculosis, or for other respiratory pathogens. The latter is interdependent on multiple host, environmental and agent factors and the current risk of disease acquisition for healthcare workers is very small, making the problem difficult to study. It would seem prudent, however, to minimize risk where-ever possible and therefore the use of fit-testing is supported by this group of investigators. The limited studies demonstrating the importance of fit-checking each and every time to ensure a good seal, suggests that fit-testing annually is less important than on-going assessment of the ability of health care workers to achieve an effective seal through fit-checking.

D. Adherence to infection control guidelines

Current research suggests that individual factors are less important than organizational and environmental factors in affecting the level of compliance with use of PPE, and specifically facial protection. The literature also indicates that theoretical or laboratory derived protectiveness of different types of PPE needs to be carefully evaluated with field studies, as compliance in the workplace is usually much less than in idealized research settings. The available evidence supports the view that users of infection control guidelines, as well as infection control and occupational health experts need to be consulted *before* required workplace practices are established and PPE is selected. Once the PPE and work practice requirements are set, workers do need to be trained, but the available evidence indicates that knowledge deficit is not a major barrier to compliance. Non-compliant staff generally know they are non-compliant. This suggests that a focus on training content or methods to increase knowledge may not yield much change in compliance.

Feedback to workers on their adherence to precautions has been identified as an important factor in facilitating compliance with infection control practices. However, the type of feedback

that is most effective in achieving compliance is not known and the optimal timing of feedback and the optimum feedback frequency are also not known. This is an important area for further research. Implementation of systems that provide workers with feedback on their adherence to precautions does offer an opportunity for individualized supplementary training and continuing education when this is identified as a need. This individualized approach may be more effective and efficient than routine periodic retraining of all workers, however, clear evidence on this point is lacking. Similarly the role of incentives and disincentives in improving compliance requires further study.

Time and equipment to permit compliance must be available, and provision of feedback on compliance seems to be desirable. Further research in this, and all areas in need of study, must be methodologically sound. Most of the reviewed studies were observational in nature, while many of the research questions could be investigated using relatively tightly controlled study designs similar to randomized controlled trials, provided appropriate infectious agents could be developed.

Even in circumstances where the key factors in protecting healthcare workers are known, the challenge of changing workplace behaviour will remain. A number of interventions such as educational outreach visits, posted reminders, interactive educational meetings and other multifaceted approaches have been shown to be very successful in changing the behaviour of physicians around the use of clinical practice guidelines. However, research on knowledge translation in the workplace setting pertaining to infection control guidelines is lacking.

Gaps in the Evidence

Specifically, the following gaps in our knowledge of protecting the “faces” of healthcare workers were identified through our review of the literature.

A. Epidemiology, Transmission and Risk Assessment:

A1 How do respiratory droplets produced by aerosolizing procedures differ from those produced by more “natural” methods such as coughing or sneezing, in terms of their size, their spread and their infectivity?

A2 Studies as to the dispersal of droplets and aerosols in the workplace. These studies are important in examining the role of cleaning; the role of autoinoculation; the need for respirators, filters and ventilation systems.

A3 The relative roles of mucosal contamination (autoinoculation) in disease transmission and how much of PPE effectiveness is related to controlling these exposures.

A4 How able are respiratory tract pathogens able to cause disease through the trans-ocular route?

B. Risk Management:

B1 Minimizing the exposure at the source is a fundamental tenant of occupational health and safety, yet development and assessment of engineering controls in the health care sector are sadly overlooked. In particular research is needed in:

- standards pertaining to minimizing infectious bioaerosols at source
- rigorous and standardized testing for breathing system filters, pulmonary function filters, and heat moisture exchange filters that are commonly used
- design research for anaesthesia machines, ventilators, and other respiratory equipment to minimize aerosol generation
- studies on the relative effect of changes in engineering controls such as the role of increasing relative humidity to maximize particle fall out
- defining added benefit of nursing high risk patients in a negative pressure atmosphere over physical isolation and adequate ventilation throughout hospitals

B2 There is a lack of information concerning the effectiveness of face shields in providing an individual with facial protection. While a few studies have examined the effectiveness for blood and body fluid splashes, no published studies were found that address the effectiveness in providing facial protection against bioaerosols. Design issues for compliance with eyewear protection (e.g. antifogging, comfort) have not been adequately addressed in the healthcare sector.

B3 The relative importance of fit-testing versus fit-checking versus other forms of healthcare worker training on infection control procedures needs further assessment.

C. Compliance with infection control guidelines

C1 How can the safety climate of healthcare institutions be improved in light of other changing factors in the sector such as demands for increased productivity and resource constraints?

C2 What training methods are most appropriate to teach infection control practices to staff from all occupational backgrounds?

C3 What determines individual workers' belief in the effectiveness of infection control procedures and how can this be facilitated to assist worker compliance?

C4 What is the best way to provide feedback on adherence to the required practices and use of PPE?

C5 What are the most appropriate infection control practices, taking into account sufficient time available to comply with the required precautions while meeting other work load requirements?

C6 Can compliance be achieved without being seen as a hindrance to other aspects of the job such as communication with patients and other staff?

C7 Are the required PPE and work practices convenient and comfortable for workers to use?

C8 How can the impairment of communication and social interaction associated with PPE be overcome?

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Protecting the Faces of Health Care Workers

CHAPTER 3: FOCUS GROUP ANALYSIS

Methodology

In order to develop effective occupational health and safety and infection control policies and procedures for healthcare facilities, it is necessary to have a good understanding how frontline healthcare workers assess the importance the various components of these issues. In order to do this, we organized a series of focus groups in order to ascertain what environmental factors, organizational factors and individual factors were the most important determinants of successful infection control procedures, in the opinion of selected groups of healthcare workers. The focus groups were conducted primarily in two cities, Toronto and Vancouver, and have involved seven different classifications of healthcare workers: a) occupational health staff b) infection control practitioners, c) physicians, d) clinical nursing staff, e) allied health professionals (including respiratory therapists, laboratory technicians, radiology technicians, physiotherapists and others), f) support staff and g) hospital managers. An additional mixed group of occupational health and infection control professionals was held in Ottawa.

Participants were recruited in three ways for the 11 focus groups conducted in Ontario. In the first instance, letters were written to the Chief Executive Officers of 13 hospitals, 11 in Toronto, which had admitted SARS patients, and two in Ottawa explaining the study's objective and asking them to identify appropriate participants from their facilities. Secondly, letters were also sent to the Canadian College of Health Services Executives, Greater Toronto Area (GTA) Chapter, the Ontario Society of Medical Technologists, The College of Respiratory Therapists of Ontario, Ontario Medical Association, The Ontario Nurses Association, the Registered Nurses Association of Ontario, and the Occupational Health and Safety workers identified by the Ontario Hospital Association Human Resources database and the Canadian Union for Public Employees (for support staff). Finally, emails were also sent to infection control physicians on The Change Foundation's project steering committee requesting their assistance in forwarding the message to other physicians. All invitation letters requested participants to have direct experiences with SARS. In all, 87 individuals came from 21 different health care institutions, organizations and professional associations to participate in the 11 Ontario focus groups. Two focus groups were conducted in Toronto for each of occupational health staff and hospital administrators, as the response was larger than expected. Two groups of mixed workers from two different facilities were also conducted.

Several different strategies were used to recruit participants in the four focus groups in Vancouver. Nurses, allied health professionals and support staff from the five acute care hospitals in greater Vancouver which had confirmed SARS cases during the outbreak were recruited through their affiliated unions. Infection control practitioners, occupational health staff and clinical managers were recruited through letters sent to staff from the five hospitals

identified by one of the project's steering committee. We were unsuccessful in recruiting physicians to a focus group, therefore, only the physicians group from Ontario is presented here.

Each focus group was approximately 90 minutes in length. Participants discussed three very broad questions relating to the organizational, environmental and individual factors and their importance in infection control and occupation health and safety in healthcare facilities. The discussion questions and the examples provided for each question are attached as Appendix 1. Facilitators read out one question at a time and allowed the group to exhaust its discussion of the subject before moving on to the next question. Facilitators tried not to interfere in the discussion except where clarification was required or if some members of the group were having difficulty entering the conversation. There was also an opportunity for participants to discuss other issues at the end of the session which were not brought up earlier. The discussion questions were developed based on what research has shown to be important (see Part II of the literature review) and were piloted with a mixed group of healthcare workers and modified prior to their use in the first sessions in Ottawa and Toronto.

All focus groups were recorded and transcribed. Three members of the research committee then began coding the transcripts according to the *a priori* specification of variables known or suspected to contribute to the effectiveness of workplace health and safety and infection control programs. Codes were divided into organizational, environmental and individual factors. All three researchers reviewed the same transcript initially and compared their results, so as to standardize coding procedures for subsequent transcripts which were only reviewed by one researcher each. During the subsequent analysis of all the transcripts, researchers tracked the number of times each variable was discussed and compiled quotations which best represented the discussion. New variables were also identified and tracked. Each researcher compiled a one- to two-page summary of each focus group which synthesized the key points of discussion and important suggestions or novel ideas which were raised. These summaries are found in Appendix 2. This narrative summary was written based on the one-page summaries, following a discussion with the three researchers on what codes arose most frequently, what codes were lightly discussed or not at all and which of the new codes identified were raised by more than one group.

Results

Focus group participants:

Table 3.1 shows the demographic and work-related information of participants in 14 of the 15 focus groups. One group of approximately eight participants from Toronto did not have this information available. Of the 97 participants where information was available, 80% came from Ontario and 19% were from BC. Over 85% came from healthcare facilities where SARS patients were admitted and 44% of participants reported having had contact with a SARS patient at least once. 37% of participants had experienced quarantine during the outbreak, either at work, or at home. Participants were mostly female (78%), reflecting the predominantly female composition of the healthcare workforce, especially in the nursing profession, which formed the single largest occupational group (24% of participants). Clinical managers were the next most represented group (12%), followed by occupational health or infection control managers (11%). The other job categories each formed less than 10% of the total number of participants. Only four physicians were able to be recruited, despite several attempts to recruit

more. Two of the mixed groups did have physician participants. The average age of participants was 43.1 years.

Table 3. 1: Characteristics of Focus Group Participants (n=97)

Variable	Respondents to question	Results	
Province	97	British Columbia	18 (19%)
		Ontario	79 (81%)
Sex	94	Male	22(23%)
		Female	73 (78%)
Age	92	43.1 yrs (average; range 26-64)	
Job Category	97	Manager (all)	33 (34%)
		Manager (Clinical)	12 (12%)
		Manager (OH&S, ICP)	11 (11%)
		Registered Nurse	23 (24%)
		Support Staff	9 (9%)
		Medical Technologist	8 (8%)
		Respiratory Therapist	6 (6%)
		Infection Control Practitioner	4 (4%)
		Occupational Health and Safety	5 (5%)
		Physician	4 (4%)
		Administration	1 (1%)
		Pharmacist	1 (1%)
		Physiotherapist	1 (1%)
Quarantine	97	Any quarantine	36 (37%)
		Work quarantine	14 (14%)
		Home quarantine	14 (14%)
Institutional experience with SARS	97	SARS in facility	82 (85%)
		SARS in ward	52 (53%)
		SARS in room	34 (35%)
Contact with SARS patients	97	Contact with any SARS patient	43 (44%)
Total number of contacts	41	6.9 patients (average; range 1-35)	
Total number of days in contact	35	19.5 days (average; range 1-72)	
History of SARS infection	97	In Self	1 (1%)
		In Co-worker	30 (30%)

NB: data from 14 of 15 focus groups

Content Analysis

General comments:

Generally the discussions were free-flowing and the facilitators were not directive in presenting the questions, although this varied somewhat from group to group. Focus groups ranged in size between two and 11 people, with most groups having between eight and 10 participants. The discussions covered the topics mostly from the perspective of what occurred during the SARS outbreaks, but included discussions of factors pre- and post-SARS, as well. The opinions presented here may not reflect the views of the majority of healthcare workers as we did not try to quantify the responses; however the points discussed here were the elements where most groups spent significant amounts of time. These comments sometimes reflect a range of opinion, which may conflict, but which was expressed in these groups. This should give policy makers and researchers a flavour for the feelings that healthcare workers express about these issues.

1. *Organizational factors:*

Lack of consistency with safety instructions and frequently changing directives

This issue was commented on by nearly every group and was a source of much anxiety for healthcare workers both in BC and Ontario. A support worker from Toronto described it this way “...there was so much information. The information changed on more than a daily basis, and even the managers, sometimes, I am sure they were confused. Which directives to take? Which ones not to take? And I don't think there was enough time for even the managers to relate all the information to the workers. We were just being bombarded with new directives, on how to do certain things and things changed so quickly...when you are so busy trying to actually do work, you don't have enough time to go sit at the computer and read word by word on what's being directed to you. (line 112-120, transcript 7).” A clinical manager from Toronto felt this about the changing directives “...there was always that uncertainty of perhaps, there is information which we don't have. And you're telling me this now but will that change tomorrow? ... And I certainly think that that affected the compliance of the staff with following protocols and their own comfort levels...(line 157-166, transcript 5).” It seems likely that the changing recommendations and guidelines undermined the workers' confidence in that any of the guidelines would adequately protect them, thus heightening worker anxiety.

Enforcement by regulatory agencies

Related to this issue was that of how external organizations such as the Ministry of Labour in Ontario and the Workers Compensation Board in BC exerted their authority in healthcare institutions. There was some diversity of opinion around these issues, in that while many workers saw the measures imposed as being somewhat Draconian, others saw some measures, such as the requirement for fit-testing as long overdue. In comparing the role of the Ministry of Labour in healthcare versus other industries one occupational health and safety professional had this to say: “...the Ministry of Labour traditionally does not go into healthcare settings,They go into (other) industries and they say 'Okay, where is your card for your fit-testing performance...' If you don't produce it, the employees can be fined, the employer can also be fined right up to senior management and that does happen. But traditionally, in the healthcare setting, they do not come in. So if they do start coming in, there might be a shift” (line 597-602, transcript 12).

An infection control practitioner, felt that the new levels of enforcement by the Ministry of Labour interfered with rational infection control practice: *“ We couldn’t use those sound principles because we’re told that if it’s a directive, you have to apply it .”*(line 221-222, transcript 9). There were also general feelings that if new health and safety directives were to be successfully applied, they must come with further funding to make them happen. Similarly, an infection control practitioner from Vancouver stated *“ When any sort of organizational body has such power in an entire province to enforce something that suddenly...it needs to be done with more planning and certainly much more communication and collaborative dialogue, instead of just imposing it on the entire province”* (line 277-280, transcript 10).

Workplace attitudes towards safety

Workplace attitudes towards safety were felt to be important for most participants. Generally there was seen to be a lack of commitment to occupational health and safety in healthcare both by workers themselves and by management. Management’s commitment to worker safety is primarily judged by their actions. This was seen during the SARS crisis in terms of whether management was willing to spend money to buy extra PPE and whether they were willing after SARS to hire more infection control and occupational health professionals. It was also seen in their visibility during the crisis. A support staff worker from Toronto characterized it this way *“I think ... more involvement with the president of the hospital. I think that when that person is speaking to you and addressing the issue, you feel like you are in the loop. When you are getting all this second-hand information from everywhere, you wonder what they are hiding.”* (line 290, transcript 7).

In the absence of an outbreak, healthcare often sends mixed messages to its employees. A nurse from Vancouver described this: *“ I know that at Hospital B there is a policy now that if you have flu-like symptoms, if you have the headache and sore throat, you’re not to show up for work. But they’re monitoring all the sick time that we’re using. Some managers... is (are) giving direction to use a LOA (leave of absence), instead of a sick day....It’s talking out of both sides of the mouth.”* (line 903-911, transcript 2)

The lack of safety consciousness among healthcare workers, themselves, was an area where workers felt there also needed to be some improvements. While having good peer support and more follow-up to training in infection control was mentioned as means to achieve this, participants generally felt that there should be more enforcement of compliance with infection control, through better supervision on the wards. They suggested that having consequences in place for non-compliance and also that supervisors should have mechanisms in place to provide feedback of worker performance in terms of infection control.

The recent down-sizing of the workforce and the replacement, in most facilities, of the “head nurse” position, with a “charge nurse” who changes from day to day has made this more complicated. However one allied health professional offered this solution: *“ ...I think what ended up happening with the SARS outbreak in our facility is that there would be infection control individuals, who would come in...the ICU and speak with whichever bedside nurse was managing that particular patient on that day. That individual, that nurse, then became the infection control officer for the rest of the shift and for every other individual.”* (line 256, transcript 4). However, most nurses did not see this as being a sustainable solution (see below, under “safety training.”)

Another way in which management displays its concern for worker safety is through the provision of adequate range of choices and adequate supply of personal protective equipment. One occupational health worker saw this as being an important determinant of infection control success or failure *“You’re seeing a resurgence of MRSA because of how we had to deal with supplies, we had to break some of our rules and tell people they had to wear a gown from patient to patient. They had to wear a mask for 12 hours. That’s not good practice.”* (line 193-196, transcript 12). Although other staff saw the MRSA problem as primarily being one of following proper procedures, and not supply.

The occupational health and safety groups, especially those with experience in other industries felt that their role was generally undervalued in healthcare, although this was not highlighted by the other groups. This is perhaps part of the problem, as described by a participant from a mixed group in Toronto: *“On the joint health and safety committee, staff could go to any member of that committee and have an issue raised, if they didn’t feel that it was being addressed appropriately. But I’m not sure that we probably did that very well, and I’m not even sure if people knew that we had an occupational hygienist, or what their role was in the institution. They are of great value to the organization, but I’m not sure that we always promoted that within the organization.”*(line 196-210, transcript 14).

Evidenced-based and practical infection control policies

Having specific policies and procedures for infection control and sufficient resources available to carry out these policies was also identified as a key factor. One of the driving factors behind this was that workers often felt that infection control policies developed elsewhere, often had little relevance to their workplace, especially if the institution had not experienced SARS. One of the remedies to this disconnect was to involve front line workers in setting infection control guidelines and procedures. Some of the participants in the focus groups came from institutions where they felt that good infection control policies were in place, but where the resources applied to make these policies happen were not available. Most groups mentioned that their institutions did not have an adequate number of infection control practitioners, and some (especially the groups composed of infection control practitioners), cited the SENIC study mentioned in Part II of the literature review as evidence that they did not have enough.

Other participants felt that basic infection control policies and procedures in their institutions were either not well developed or were not enforced. Identified deficiencies included tracking of who receives training in infection control, to ensure that all those who need training actually get it; consistent policies for quarantining individuals; policies regarding the re-use of masks and policies regarding which patients require negative pressure rooms.

Yet, workers also feel that they want to have the option to use more protective equipment than the clinical situation may warrant. It appears in some situations that physicians may do this: *“ I came head to head with a physician over that because after the SARS precautions had been sort of down-graded...and the physician walks in with his, you know, fully garbed and I was saying... we have told all of our team members that they no longer needed to wear all of this ...he’s like, ‘ I’m not taking any chances’ , then I say ‘It’s a consistency (issue), everybody has to follow the standards and believe in them.”* (line 768, transcript 14). Generally, however, physicians were perceived to be less compliant with the use of PPE than other healthcare staff (see below). Front line healthcare workers do not often have this option, as one of the allied health professional from Vancouver mentioned resistance to him wearing a mask in the presence of an MRSA positive patient, despite the fact the patient was coughing. This could

also be seen as management listening to the concerns of HCW and trying to accommodate them where possible.

Many participants described the need to establish a respiratory assessment for “high risk” patients on which workers can rely and that doesn’t lead to unnecessary precautions being taken. Ideally this is done by having the adequate number of infection control practitioners, who are familiar with the acuity of the patients and with best practices regarding staffing issues. The latter theme was seen to be especially important in ensuring that the extra burden of applying complete PPE against air-borne infections is not borne by the staff unnecessarily. If staff are asked to wear this equipment too often when it is not necessary, then it is quite likely that the “new normal” of hyper-vigilance with respect to infectious precautions will be eroded.

The need for greater availability of infection control practitioners was seen by both infection control professions and non-ICP staff. Interestingly, both groups saw the importance of ICPs being visible on the wards, but often differed in how they viewed their current visibility. ICPs generally saw themselves spending most of their time on the wards, whereas other health staff felt they were not visible enough.

Consensus was not found among participants on whether it was preferable to cohort nursing staff when caring for highly infectious patients. Some groups saw this as being beneficial, whereas others saw it as overburdening a small number of workers. One group recommended that these decisions should be left up to ICPs and not be a nursing decision alone. As well, it was felt that institutions need to develop clear policies over which workers should be able to work with these patients and whether issues of personal health or health of a household member or pregnancy are grounds for being able to refuse such work assignments.

Many groups mentioned the lack of infection control guidelines for patients and family members as being a source of frustration.” *Sometimes you have the perception that the hospital is afraid to say no to visitors and that they do their best to accommodate visitors, but sometimes it’s at the mercy of health care. It happened during SARS.”* (line 1127-1129, transcript 15.) *“I think we should go back to what we did have at one point: two visitors at any one time between the hours of 3 and 8. Period. No children under the age of 13. Period.”* (line 1148-1150, transcript 15). *“We need to go back to those restrictions... Yes, I’m sorry you’re ill. I’m sorry you can’t see your family, but we don’t want you taking whatever illness back to your family.”* (line 1154-1156, transcript 15).

Others area where infection control policies were found to be lacking was in incorporating effective procedures for the cleaning of portable equipment in different care settings. Another was in establishing which procedures can be classified as “high-risk” and require the need for extra protective measures. One group suggested that there should be a specific policy to ensure that one person on the “code team” on the hospital should be responsible to ensure that all team members are using the proper PPE.

Safety training

Issues related to training healthcare workers in proper infection control procedures also arose very frequently in the focus groups. Many group felt that existing programs for training in infection control had been inadequate prior to SARS, in that they were often only given to new employees at the time of hiring and no accommodation for ongoing training in infection control existed. However these problems were compounded when SARS struck and healthcare workers were expected to use new procedures and equipment with which they had no

experience. Some workers felt they had no extra training during SARS, at least initially. *"Well there were lots of masks available, but we didn't get instructions on how to use them. Nobody instructed us. We just stuck them on our heads as best we could. There was no person that was designated to teach the staff and it was a bad situation..."*(line 221-224, transcript 1). Others were being trained but by trainers who did not have much confidence in their abilities. One occupational health and safety professional from Toronto stated *"I think for me personally the biggest thing was that I had to educate and train other people on practices that I didn't even know myself yet. You're learning and you're trying to teach at the same time that you're trying to absorb it and process..."* (line 1042-1045, transcript 12)."

In other facilities, health and safety training for SARS was delegated to front-line staff who had more experience in infection control, which led to other problems, as outlined by an allied health professional from Vancouver *"The problem is with primary instructor, it's also the primary caregiver, and so they have to determine what their priorities are going to be teaching all the staff as they're doing their bedside care, or are they going to be taking their focus away from their patient and worrying about all the staff..."* (line 286-289, transcript 4). The lack of flexibility or preparedness to rapidly educate staff during SARS was summarized by a manager from Toronto as *"You cannot educate in a crisis"* (line 558, transcript 6).

With regards to planning for future training, workers suggested that occupational health or infection control keep records of who has received recent training, so they will know who needs to receive more. Some facilities already have similar systems in place, but there was also a recognition that classroom teaching needs to be followed-up on the wards in order to ensure that it is being properly applied. Again, an infection control practitioner from Vancouver *"If you're teaching somebody something that they're not going to apply for a long time or isn't relevant to them at that particular moment, that's not going to be a useful thing to do. You do kind of have to be prepared to grab those teachable moments. And that also again involves being able to be visible, being available"* (line 711 - 716, transcript 10)."

Also the question of where physicians, residents and medical students fit into infection control training seems unclear, as observed by a nurse from Vancouver: *"There's all these little in-services from infection control and they are all gathering the nurse around the nurse's station to tell them how to do this and I never see the doctors gathering around and their residents, gathering round and getting an in-service."* (line 481-484, transcript 2).

Communication about safety within healthcare organizations

The pivotal role that internal communication played in the SARS outbreak was best described by a manager from Toronto: *"I think communication is paramount to having any success in implementing any infection control procedures and I think that in some organizations that was a challenge, because how do you, you know, staff work three shifts, how do you disseminate all of this incredible amount of information simultaneously in a timely way, when we had new directives coming down the pipeline every hour sometimes. That was challenge, I think."* (line 53-58, transcript 5).

Much of the communication issues surrounded the dissemination of the constantly changing directives which were discussed above. However, the best means of communicating these messages varied. Most participants agreed that having visible representatives from the hospital in face-to-face meetings was seen as being very credible, and important in terms of boosting staff morale. As another manager from Toronto put it: *"We had a 'town hall' (meeting) between the two sites so that everyday there was communication of information. The staff really did want*

to see somebody, especially in the areas that were high risk areas - the emergency department, the areas where the SARS unit was. They wanted to see somebody from administration and education actually coming onto their unit because they really kind of felt isolated from the rest of the organization. So that was an important role in communicating with the staff.” (line 117-123, transcript 5).

Despite the lack of a widely disseminated outbreak in Vancouver, some staff did not feel that their institutions communicated with staff very well. An allied health professional from Vancouver stated “*Communication within the institution is one of the major breakdowns in terms of infection control...Changes happen, and we saw that every single day during the SARS outbreak and the standards changed sometimes from hour to hour and it was very difficult to communicate that throughout the facility”* (line 80 - 86, transcript 4).

The amalgamation of hospitals into larger administrative units was seen as a barrier to having good communication, as stated by a manager from Toronto: “*...most of the decisions are being made at Hospital A and then they had to be disseminated down to the campuses, so what happened at my campus was that the information would sometimes come from the media before coming to us. That was very difficult for staff and that led to a lot of talking in the corridors and people getting the wrong information. It’s a big problem in a big institution.”* (line 62-66, transcript 5). It was generally recognized that relying on the media as an information source was not desirable from the point of view of healthcare workers.

Other communication strategies used during the SARS outbreaks included email distributions to staff. There was some variability in how useful this was seen by staff. Many felt that because they did not have the time or the access to email at work, that this was not effective. A support staff worker from Toronto: “*It would have been nice to have been informed of the changes right off...Sometimes that didn’t always happen... (Another speaker) And I can add to that. I personally think the reason that was, is because it was all done by e-mail and a lot of direct people- housekeeping, nursing, anybody that does direct care, do not sit down at a computer before they start their day. I think that it was not the ideal method.”* (line 38-45, transcript 8). Others felt that it was a useful addition to the other forms of communication. Posters and notices were also widely used, especially as reminders, or environmental cues for infection control guidelines, and to inform the public about the situation on arrival in the hospital.

In addition to better communication from the organization to employees, other participants identified communication problems between employees in the hospital. This was described by a member of one of the mixed groups in Toronto. “*Many times the patients arrive and we don’t know that they’ve had a cough or a fever or something where we would have to take precautions, so I think there needs to be better communication between departments.”* (line 381-383, transcript 15).

Good communication between occupational health and infection control was generally seen as being beneficial both during SARS and after. A support staff worker from Toronto stated “*I don’t think you can have a good health and safety program without having infection control included. And if they are not intermingled, then I think the system breaks down”* (line 598-599, transcript 7).

Fit-testing

Participants did spend some time discussing fit-testing, but the value of it was not universally accepted, as different institutions used different methods and workers often saw these

inconsistencies as sources of concern for the whole process. One of the managers from Toronto had this to say: *“We have a few issues around mask fitting. One of the things that were a concern...is it necessary? What’s the benefit? Beyond that it’s even the process and standardization of fit testing, because I think that depending on the company that you hired to do it, the process is not exactly the same....I think there needs to be some work around coordination and standardizing the fit testing process itself.”* (line 448-455, transcript 5).

Even if the fit-testing process was successful, there were no guarantees that the masks available would match those on which the worker had been tested. A physician from Toronto noted: *“I think one of the critical issues during this outbreak as well as any outbreak is not only the availability of N95 masks or higher, but are they available for the ones that you’ve been fit-tested with because right now there’s a choice probably of about half a dozen that you might get tested for and find the one that fits you. But the problem is that during a crunch, we went through probably half a dozen different companies that provided masks so trying to provide one that you’ve been fitted for is difficult.”* (line 247-253, transcript 13).

Other organizational factors

The increased worker fatigue, especially when having to use large amounts of PPE in stressful situations meant that productivity fell dramatically. Thus staffing levels on a per patient basis likely needed to be increased in order to compensate and workers felt this was not adequately addressed. As well, because of the casualization and out-sourcing of the labour force, management needs to recognize that many of their workers work in more than one site, and are often not working full-time at any one institution. This has implications for many of the organizational factors discussed above.

2. Environmental factors:

Participants spend the least amount of time talking about environmental factors, which included the availability of personal protective equipment (PPE).

Physical space separation:

Isolation rooms for patients with suspected communicable diseases

While participants recognized the importance of physical space separation in assisting infection control in hospitals, there appeared to be a great variation in space available. A member of the occupational health/ infection control group in Ottawa *stated “I mean directives came out and said patents presenting to triage with infectious or respiratory symptoms had to be immediately isolated. Well, I mean, they would all be isolated together in the big waiting room, right? Like it couldn’t happen. There weren’t (enough isolation rooms). I mean we have 10 rooms with closed doors on. It’s impossible”* (line 733-739, transcript 9). An allied health professional from Toronto commented *“A lot of our ICUs are open concept with only a select few isolation rooms and there was always an issue of a patient was going sour and we didn’t have an isolation room. What are we going to do? You know, and so we were like hunting everywhere for an isolation room, and then it had to be negative pressure on top of that, so that put us in another bind...”* (line 872-877, transcript 3).

However, it seems that most of the facilities have adapted to the “new normal”, of respiratory precautions hyper-vigilance. A nurse from Toronto describes the current situation: *“...whenever a patient has a temperature, right away the nurses put that patient under fever/pneumonia precautions, so we call infection control and place that room under isolation. If there is a patient in there, we take that patient out so we have to shift the whole floor around and put that patient in a private room.... That will continue and the only person who can take that person off the isolation is the infection control.”* (line 515-522, transcript 1).

Anterooms for HCWs to change into PPE

The same was true for anterooms. A participant from a mixed group in Toronto commented “As far as an anteroom, we don’t have those. They never existed (line 481, transcript 15).” However, many facilities did have anterooms for workers to use, or were developing them.

Negative-pressure rooms

As Ontario hospitals were directed to provide negative pressure rooms for their patients during the SARS outbreak, most facilities had experience with creating them and using them. One manager from Toronto was clearly convinced of their utility: “Initially when this all started, patient who were being admitted were being admitted to negative pressure, ventilated rooms. There were a number of things that were done though to help create negative flow...I think also too, when you look at the period of SARS III, what will make the difference, it definitely is, if we create negative pressure rooms in this area (line 198-208, transcript 6).” Another manager viewed the negative pressure directive as more of a precaution: “I guess, back to negative pressure, its interesting because in regards to SARS, if its not airborne then that wouldn’t have been a necessity, but because as you mentioned earlier, it was the learning process and certainly we all wanted the very best for both our patients and healthcare providers (line 435-439, transcript 6).” However, this participant also recognized that establishing the negative pressure room was not enough. “I feel that unless you do testing of the rooms once you’ve put in the unit, you don’t have a clue what you have and that’s the issue I’ve been fighting...You should even have continuous monitoring to see that negative pressure is maintained (line 446-461, transcript 6).”

Environmental decontamination:

Generally participants felt that most of their facilities had adequate hand-cleansing gels stations, which could compensate for the areas where there might be a lack of hand-washing sinks. A nurse from Toronto *observed “I found that (during) SARS in our institution, it was the first time I worked there that they went around and they actually disinfected and cleaned the doorknobs, the handrails, the pillars. I had never seen it before and they did it twice a day.”* (line 1095 - 1097, transcript 1).

Availability of specific PPE:

Nearly all groups mentioned the supply problems with N95 masks during the SARS outbreak, as described above. There were also supply problems with face-shields and goggles, leading one member of the Ottawa focus group to comment *“The problem with the goggles is that ...you have the choice between something that may work and offer you some protection or something that might work better that nobody is going to use.”* (line 681-684, transcript 9).

3. Individual factors:

Knowledge:

Certainly, the knowledge of infection control procedures and the rationale behind them was found by most groups to be important. A manager from Toronto had this to say *“If we’re going to expect that staff will want to work in a unit with patients infected with SARS or something similar, then we’re going to have to do a lot better by providing cited evidence to support decisions that are being made otherwise...the word of mouth is just not going to work. There needs to be something to back that up.”* (line 608-612, transcript 6). Another support staff worker from Toronto said: *“There were lots of employees, I found just from chatting back and forth, that if there was another outbreak of SARS in the hospital, they would be gone. They would leave because... of all that uncertainty and fear. So I think an education for the employees would make a huge difference. If they knew what they were dealing with and if they knew what precautions to take.”* (line 371-374, transcript 7). However, it was also generally felt that knowledge alone was not sufficient in allowing workers to protect themselves from infectious diseases at work.

Attitudes:

Attitudes such as decreasing compliance when feeling stressed or overworked, and professionalism, which can lead to the HCW placing their safety concerns below those of patients who need help were generally felt to be more important than knowledge. A support staff worker from Vancouver expressed her professionalism this way: *“We work in this field and we know we are going to be exposed to this and we chose this field to work in, so you just have to safeguard and take all the precautions you can. ...It’s different when you have inexperienced workers coming in.”* (line 547-552, transcript 8).

A nurse from Toronto explained it as a mix of both professional ethics and personal empathy for her patients: *“I think in general, the nurses think, oh yeah, I probably can (become infected), but I decided to be a nurse and I’m going to do it because what happens if we all stop? ...What happens to me when that’s me the patient”* (line 897-900, transcript 1).

Beliefs:

Beliefs were also felt to be important by most participants. One nurse from Toronto described how her experience with SARS undermined her belief in the directives which were designed to protect her: *“I volunteered to work on the SARS unit. I only did it because I knew all the nurses and I thought ‘Okay, I’ll do it.’ But about June 5th and you go on the unit and the three doctors who are giving us the education...then one of these doctors became ill. I thought ‘Okay, it’s just Russian roulette here...Nobody felt safe at all.”* (line 760-767, transcript 1).

Yet, generally, the heightened fears of infection with SARS during the outbreak led healthcare workers to be very vigilant for themselves and for their co-workers. An allied health professional from Toronto noted that: *“During the outbreak, really compliance or non-compliance was a non-issue. Everybody just did and there was no question about it. I think the fear of contracting the disease was palpable, very real. Nobody was trying to cut corners.”* (line 590-593, transcript 3). A support staff worker from Toronto stated: *“If SARS were to hit tomorrow and let’s say you have a SARS patient that comes...I would feel a lot more comfortable if I put on a mask, if I put on a respirator, just because I knew that there was a SARS patient in our facility”* (line 340-343, transcript 7).

In some circumstances this fear, led some workers to refuse to work. A physician from Toronto stated that: *“And then you had some people who refused outright. We had one cardiologist at Hospital C who would not come into Hospital D to cardiovert a baby. Absolutely refused to come. And then we had some physicians that just disappeared. They never saw a patient.”* (line 575-578, transcript 13).

Past exposures to disease can lead to decreased compliance when experience shows that barriers are not needed 100% of the time. A support staff from Toronto: *“ I remember when I first started working the hospital, I was ever so careful what I touched and I had my limits. I would never press the elevator button if I didn't have a paper towel in my hand. Now, it's like all those issue they are everyday routine. You don't think about them as much as you used to. I think every once in a while we need to kind of 'wake up' (line 801-805, transcript 7).”* An allied health professional from Toronto also recognized the problem: *“..that's the problem...because you do get, sort of, these people that are put in protective isolation that turn out to be nothing and then after a while people start to ignore the precautions because they think it's going to be another nothing again. So I think it has to be a sort of balance”* (line 349-351, transcript 3).

Impact of PPE on the job:

Time constraints

Participant from the Ottawa focus group: *“I think the staff need to have direction on what is required, but it needs to be realistic, because what we've been told is...that (in) triage, you change your goggles, gloves, mask and gown between every patient and its 100% not feasible. It can't be done. Patients would be dying waiting at the triage desk”* (line 792-796, transcript 9).

Increased workload

An infection control practitioner from Vancouver stated: *“Of course, it is a lot of extra work for the staff- wearing protective eyewear, wearing an N95 mask, which increases your oxygen consumption, wearing gowns, wearing gloves. It can be very hot, very uncomfortable and that continues to be a barrier.”* (line 411-414, transcript 10). A support staff worker from Toronto found that the discomfort dramatically increased her workload *“ I remember going to clean a room and I'm a custodian so I do everything form the ceiling, walls, floor...I had to wear double of everything except the mask, but I had the shield. All I know is by the time I got out of the room, I could squeeze my clothes. I was so dehydrated. You can't just go back and get a drink. It's too time consuming... Because just coming out you have to strip and then you have to regown, double of everything and you have to go back in. And the time that it takes to put all these layers on is just so much that you can't be bothered”* (line 398-405, transcript 7).

Discomfort

Many participants felt that wearing the full protective equipment during SARS was quite uncomfortable, as described by a physician from Toronto: *“The masks weren't very comfortable...Obviously, everybody found the respirators, in particular, cramped or irritating too. You sweat with them, so that's going to affect the compliance.”* (line 390-394, transcript 13). A nurse from Toronto said *“ We had five or six different masks but it was your choice, whatever felt comfortable to you. There were some very strange in their function and they looked funny and they felt funny and they smelt funny. So sometimes in an evening you might wear three different masks because you're trying desperately to get something that is comfortable and doesn't smell like dill pickles and whatever else. They were awful.”*(line 204-209, transcript 1).

Another Toronto nurse said that with regards to the masks *“Our girls complained of rashes and they had to... used (use) a lot of different skin care products.”* (line 1107-1109, transcript 1).

Peer environment

Many workers found that poor compliance with the use of PPE in role models and co-workers, especially physicians to be quite frustrating. A support staff worker from Vancouver explained: *“I think I washed my hands five times every time I came out of a room because you had to wash your hands before you took something else off. So that was one of my big concerns, and the other one- doctors... Doctors not washing their hands. It doesn't matter if it's a SARS patient or who, doctors don't wash their hands. ...Especially when the SARS epidemic was here, people should have been a little bit more diligent in washing their hands and they weren't and that bothered me.”* (line 157-163, transcript 8).

An occupational health and safety manager from Toronto describe another source of frustration: *“People wandering around with gloves and touching elevator buttons. That's what most of our (OH&S) staff get upset about. They feel they are being diligent and donning everything properly and using it when it's appropriate and they see somebody else totally disregarding it.”* (line 946-951, transcript 11).

Peer feedback on compliance with PPE was seen to be effective, if it was applied. But it was often left to the nurses to police others coming in and out of the rooms, a role which they did not feel they wanted to take on. A nurse from Vancouver observed: *“I never see the doctors and their residents gathering around and getting an in-service (on infection control)...And then, when you're the police at the bedside 'Hey, wash your hands!' 'All right..settle down.' And you know what,.. it's the fifth time today that I'm telling somebody to wash their hands.”* (line 482-485, transcript 2).

However, sometimes physicians will use nurses as a source of information about proper infection control, as describe by another nurse from Vancouver *“Some of the doctors..were better. They came and asked me before they went in (to SARS patient's room) and they even said...come with me. And I went. So that was actually the first time, because they usually just go in and out. Some of them were actually a bit concerned”* (line 494-496, transcript 2). Allied health professional from Toronto: *“If someone didn't comply, everybody else helped them comply. 'Cause we had one person that didn't want to comply and it was just like everybody was on the case of that person and they eventually did”* (line 656-659, transcript 3).

Exhaustion/ fatigue

Many participants mentioned fatigue as a major cause of failing to follow proper infection control guidelines. A nurse from Toronto described her experiences: *“I work 12 hour shifts in emergency, rarely got a break, so we were not permitted to have fluids at the desk. None. None in the care area. So we were going for five or six hours with nothing to drink. We were so exhausted. So at the end of your 12 hour shift by six and seven hours you're so exhausted that you're crazy. That is now leading to sloppy practice”* (line 866-877, transcript 1).

Attitudes of others

The attitudes of family members can be an important determinant of increased compliance with infection control guidelines, as described by a support staff worker from Vancouver: " *My son-in-law was angry (that I was working) but you just reassure them that you're taking a shower and you're taking all the precautions. And my boyfriend was the same way. You make sure that you wear that stuff and take all the safety precautions because he didn't want me getting sick. I think we were more at ease, but our family members were definitely upset*" (line 555-559, transcript 8).

Table 3.2 shows a summary of the key points from the focus group analysis.

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Table 3.2 - Summary of Key Factors Identified by Healthcare Workers

1. Organizational factors:

- **Lack of consistency with safety instructions and frequently changing directives**
- **Enforcement by regulatory agencies**
- **Workplace attitudes towards safety**
 - Attitudes and actions of management
 - Safety climate
 - Perceived importance of occupational health and safety
- **Evidence-based and practical infection control policies**
 - Participation of front-line HCWs in development of infection control guidelines
 - Adequate resources for infection control
 - Adequate number of infection control practitioners
 - Better enforcement of infection control guidelines
 - More accommodation of worker concerns
 - Infection control guidelines for patients and visitors
- **Safety training**
 - Repeated safety training
 - Assess the appropriateness of the “train-the-trainer” model
 - Track who has been trained and who needs training
 - Develop policies to deal with part-time staff, physicians, residents and students
- **Communication about safety within healthcare organizations**
 - Face-to-face “town-hall” meetings are necessary to build confidence during a crisis
 - A variety of communication media are likely most effective
 - Communication strategies need to be adapted for large, multi-centred organizations, especially with fewer lower managers
 - Communication between employees, units and especially OH&S and infection control is important in creating safe workplaces
- **Fit-testing**
- **Other organizational factors**
 - Worker fatigue
 - Casualization and out-sourcing of the workforce

2. Environmental factors:

- **Isolation rooms for patients with suspected communicable diseases**
- **Anterooms for HCWs to change into PPE**
- **Negative-pressure rooms**
- **Environmental decontamination**
- **Availability of specific PPE:**
 - Masks
 - Face shields or goggles

3. Individual factors:

- **Knowledge** of infection control procedures and the rationale behind them
- **Attitudes** such as professionalism
- **Beliefs** in effectiveness of infection control guidelines, as modified by past experiences.
- **Impact of PPE on the job**
 - Time constraints
 - Increased workload
 - Discomfort
- **Peer environment**
 - Peer compliance
 - Peer feedback
- **Attitudes of family members**

Conclusion

The content analysis of the 15 focus groups has shown that front line healthcare workers see more organizational factors being important in determining the success of occupational health and safety or infection control programs than factors in the physical environment or individual factors. This supports what has been found from the literature review in Chapter 2. The fact that healthcare workers feel these factors are important does not mean that they necessarily are the most important factors, but it shows that policy makers and researchers must address them if they want to have healthcare worker support in developing their policies and procedures. How these results complement or contrast those of Chapter 2 and how both chapters can be used to developing priorities for research in this area will be the subject of the final chapter of this report.

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Protecting the Faces of Health Care Workers

CHAPTER 4: PRIORITIES FOR FURTHER RESEARCH

Comparing results from the literature review with those from the focus groups

The priorities of healthcare workers as outlined in Chapter 3 included both areas where the literature review found substantial information, and areas where knowledge gaps were identified through the literature review.

The lack of consistency/ changing directives problems and the enforcement issues from the Ministry of Labour in Ontario and the Worker's Compensation Board in BC were themes that were somewhat unique to the SARS outbreaks. Many of the suggestions that emerged in the focus groups conflicted with one another. While many healthcare workers were frustrated by the frequently changing directives, others felt that officials were not forthcoming enough with new information. The differing views on the implementation of rules requiring fit-testing for healthcare workers was particularly noted.

Clearly, if the safety climate within healthcare was better and workers had more confidence in their employers' commitment to worker health and safety, employees would have more confidence in the messages and directives they received during a crisis situation such as SARS. The relatively low profile of occupational health and safety within healthcare is perhaps best reflected in the observation that very few focus groups, aside from those containing health and safety professionals, seemed to be aware of occupational health and safety professionals at all. Tasks such as fit-testing of respirators often fell to infection control practitioners, not to occupational health and safety professionals (although this appears to vary from facility to facility) as it would have in other industries. Certainly more research on what levels or standards are needed to promote effectiveness in occupational health, similar to the SENIC studies for infection control, is needed.

Another suggestion that emerged from the focus groups was to involve experienced and credible front-line healthcare workers in formulating the infection control guidelines and occupational health directives. In most cases these guidelines are developed only by experts who are very well versed in the science behind the guidelines, but may be less informed on how to best translate the science into practice. Allowing some form of adaptation of guidelines by local policy makers may help in this regards, but it is also likely that allowing significant variation in guidelines from facility to facility would increase the uncertainty in their reliability. Similarly, the suggestion to allow workers to use more personal protective equipment than a clinical situation may warrant, could lead to a lack of confidence in the guidelines in general. It is difficult to balance many of these issues and operational research in these areas could greatly inform the discussion.

The suggestion to develop stronger infection control guidelines for patients and visitors is also an area where policies could be developed immediately. The most recent Health Canada guidelines on SARS do include references to visitors and patients, but their description is scanty and mechanisms for ensuring compliance are not developed in most institutions.

The importance of training in infection control is obvious, but the literature review and the focus groups agreed that one-off didactic sessions are unlikely to be the key to ensuring that workers practice appropriate infection control. Again there was inconsistency in how workers viewed the “train the trainers” model for infection control training, and the decision to use this versus other models may be based on trying to balance the concerns of front-line workers who already feel over-burdened and other methods. Certainly, finding innovative ways to ensure that physicians, residents, part-time staff and students receive annual and ongoing infection control training and feedback should be seen as a priority. Nurses do not want to be, nor should they be, seen as the “infection control police” for other health professions.

Equally, the importance of good communication within healthcare organizations is self-evident. The strategies that provide the most effective communication within organizations are not clear and are an area in which research can inform greatly. No single strategy seems likely to meet the communication needs of any organization; therefore it is more a question of what mix of strategies works best for which messages.

Participants did spend significant time discussing fit-testing, but the value of it was not universally accepted, as different institutions used different methods and workers often saw these inconsistencies as sources of concern for the whole process. The fact that prior to SARS, fit-testing had not been a requirement in healthcare facilities likely contributed to this perception. The questions raised by workers during the focus groups regarding fit-testing appeared to be addressed by the literature (see literature review section of this report). As noted, fit-testing is helpful in reducing exposures, but whether this is attributable to the training that accompanies fit-testing or because fit-testing by an expert leads to improved seal between face and respirator, is unclear. This has been identified as an area in need of further research.

Other organizational factors that should be addressed with more research would be the role of how workforce changes such as the increase use of casual workers and outsourcing of some basic services such as cleaning and laundry affect the health and safety of all workers.

The low visibility of occupational health and safety in healthcare is perhaps also reflected in the relatively low priority that focus group participants gave to environmental controls. In general occupation hygiene, engineering controls are seen as being the preferred starting point in reducing risk of injury or illness in workers, but this has received relatively little attention in healthcare in relation to the use of personal protective equipment. Negative pressure rooms were discussed at length by the focus groups but the added benefit of negative pressure, above that for isolation with adequate ventilation systems throughout the facility was already identified as an area requiring further research. Certainly policy changes to include infection control considerations, such as physical space separation, ventilation systems and environmental decontamination issues when designing new facilities or renovating old ones, could already be considered by policy makers at this point.

How specific knowledge, attitudes and beliefs around infection control and occupational health can be improved in individuals, is largely mediated through the organizational factors identified above. The full PPE required for use with SARS patients was found to cumbersome, uncomfortable and imposed additional time-constraints and workload on healthcare workers.

However, part of these findings could have been influenced by the fact that many people were being introduced to the use of this equipment during a crisis when normal coping strategies may not have been functioning. In hospitals where N95 masks had been introduced for general use in the past, it seemed that there were fewer complaints from the staff with their use. Trying to define precisely who needs to use this equipment and when, and what amount of protection is afforded by it, were identified as priorities from the literature review. Another research priority from the point of view of healthcare workers would be in designing protective equipment that provided the most protection and least discomfort.

The importance of peer feedback and peer compliance had been previously identified in the literature review as being key determinants of safety training success. Certainly the attitudes of family members and society in general to the SARS outbreaks greatly influenced healthcare workers in their attitudes to practicing infection control during SARS and this probably should be addressed in terms of infection control policies on deciding which healthcare workers should be working in high risk areas.

Priorities for Further Research

The following criteria were used in identifying research priorities

1. Degree to which the knowledge gained from exploring the “gap” would reduce risk to health care workers (i.e. how big is the gap in our knowledge and does additional knowledge provide any significant benefit to protecting HCWs)
2. Ease with which a research study could be designed and answered
3. Whether research is currently underway in this area
4. Cost and feasibility of the proposed research and/or of the intervention
5. Stakeholder interest

We have divided the priorities into three groups of research, with the following order of priority:

#1. Improving the workplace health and safety through organizational factors: i.e. how best to bring about meaningful knowledge translation.

- a) How can the safety climate of infection prevention and occupational health of HC institutions be improved? What approaches best facilitate an organizational culture that promotes safety?
- b) What are the best mechanisms to provide communication to front-line workers in order to ensure appropriate infection control practices?
- c) What are the best mechanisms to provide feed-back to front-line HCWs in order to ensure infection control measures are practical and feasible while still enhancing safety?
- d) What are the best ways to train HCWs on appropriate use of personal protection equipment?
- e) What are the health and safety effects of the recent changes to the healthcare workforce, in terms of increased casualization and increased out-sourcing of services?
- f) What key components of an infection prevention and occupational health program are needed to improve or maintain worker health and safety in healthcare facilities?

#2. Epidemiology and transmission of respiratory pathogens:

- a) How do respiratory droplets produced by aerosolizing procedures differ from those produced by more “natural” methods such as coughing or sneezing, in terms of their size, their spread and their infectivity? . This question is key because it addresses the issue of the hierarchy of precautionary measures – i.e. are the same level of precautions required for situations that do not generate aerosols by mechanical means?
- b) Do infectious organisms survive on barrier equipment and clothing and for how long? The implications for this are for environmental decontamination, reuse of barriers versus the use of disposals and to assess the potential importance of auto-inoculation through contaminated PPE.
- c) How able are respiratory tract pathogens able to cause disease through the trans-ocular route?

#3. Risk reduction through engineering controls and personal protective equipment:

- a) What is the relative effect of engineering controls to maximize particle fall out or decrease viability of organisms e.g. temperature, air exchange, relative humidity?
- b) There may be simple yet effective measures to decrease these aerosols that could have significant impact on reducing the risk of exposure.
- c) What design criteria are required to minimize generation and dispersal of infectious aerosols in medical equipment such as anaesthesia machines, and ventilators? This question addresses the relative importance of decreasing aerosols at source – is it effective in practice?
- d) What is the added benefit of nursing high risk patients in a negative pressure atmosphere over physical isolation and adequate ventilation throughout hospitals? There has been a great emphasis place on hospitals improving access to this technology, yet evidence to support their use is lacking
- e) What is the effectiveness of facial protection against bioaerosols?
- f) (In conjunction with question 2.c) above, answers to this question will clarify the relative importance of full facial protection, versus eye-protection, versus nose and mouth protection.)
- g) What is the relative importance of fit-testing versus fit-checking of respirators? The reasons for selecting this as a priority is less an issue of burden of disease but because of stakeholder interest, the implications for where resources are expended and the potential extrapolation of this data to other airborne illnesses.

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Protecting the Faces of Health Care Workers

APPENDIX 1 – FOCUS GROUP DISCUSSION QUESTIONS

This focus group will discuss four broad questions related to different factors which influence the success or failure of infection control and workplace health and safety in health care facilities. Each question will be given a fixed amount of time to discuss. The entire exercise should take less than ninety minutes.

1. Organizational factors:

Some examples of workplace organization and hospital culture include:

- How your place of work is organized to function on a day-to-day basis
- Committees, protocols and programs in place that address infection control and occupational health and safety
- Communication within the institution
- Perception that employers adequately respond to concerns of its employees
- Perceived commitment of administration to infection control and workplace health and safety and availability of training programs

“How do workplace organization and the hospital culture influence a) the implementation of sound infection control practices, in general b) the use of facial protective equipment, in particular and c) occupational health and safety initiatives?”

2. Environmental factors:

Some examples of the physical environment include:

- Availability of negative pressure rooms, hand-washing sinks and appropriate space to allow separation of patients who may have contagious diseases
- Availability of surgical masks, N95 masks, gowns, facial shields, goggles etc.

“How have these factors affected your ability to practice safe infection control and, in turn, did you feel comfortable that the environment you worked in was safe?”

3. Individual factors:

Ultimately it is the individual who makes the decision whether to use or not to use a particular piece of protective equipment or to follow (or not) an established protocol. Examples of factors which vary from person to person in the same workplace include:

- Perceived likelihood of catching the disease and the severity of the disease
- Personal knowledge about infection control guidelines
- Confidence in the effectiveness of infection control guidelines
- Family life circumstances
- Ease or difficulty of incorporating infection control into daily work.
- Preference for particular types of protective equipment

“What individual factors have influenced you in practicing safe infection control and occupational health?”

4. Other factors:

“Are there other factors, not already discussed which you feel are important in determining the success or failure of infection control procedures or occupational health and safety initiatives?”

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Protecting the Faces of Health Care Workers

APPENDIX 2 – FOCUS GROUP SUMMARIES

1. NURSES – TORONTO – November 25, 2003

9 participants

Key Points:

- **Impact of frequently changing directives:** During the SARS outbreak there were directives coming from the Ministry that were frequently changing, translated into institutional directives that were frequently changing – raising fears among HCW, particularly when directed to discontinue use of PPE.
- **Communication from organization to Health Care Workers:** Related to frequently changing directives, communication was recognized to be a problem, with there being difficulty for HCW in finding out what the current guidelines were.
- **Fit-testing:** With the institutional requirement for fit-testing, participants voiced concerns that the supply of the particular mask with which they'd been tested was not always available – with accompanying fear of incomplete protection when using a different mask.

Suggestions:

- During an outbreak, there should be a coordinator or responsible person who could coordinate the dissemination of information to HCW
- Infection control practitioners need to be more visible at education sessions for HCW
- The number of infection control practitioners needs to be increased
- The management/organization needs to listen to the concerns of HCW and accommodate them where possible

2. NURSES - VANCOUVER - December 12, 2003

7 participants

Key Points:

- **Necessity of advanced planning for emergencies:** Facilities do not have the resources to deal with emergency situations.
- **Delivering safe care in emergency situations:** Staff take on themselves the complexities of trying to deliver safe care in emergency situations. Many examples were cited where nurses wanted to rush in to assist a patient in crisis and the difficulty of doing this with proper protection on.
- **Consistency of policy and practice:** Nurses strongly perceived an inconsistency in policy and in the application of policy throughout a individual facility and in the community. Examples include when to wear and how to use PPE and when quarantine is required,
- **Development of infection control guidelines for patient behaviours and compliance by patients:** There are perceived to be no policies directing infected patients behaviours. If an infected patient was not bed ridden, their access to the facility was not constrained leading to concerns that they could be spreading infections to staff, visitors and other patients.
- **Contracted out staff:** The nurses have been told not to give direction to contracted out staff. This presents an ethical and practical dilemma for nurses when they see a staff person not complying with safe infection control practices. Further, the style of cleaning where one individual does one task and another individual does a separate task is counter to trying to minimize exposure to infectious agents.
- **Minimization of staff concerns:** Staff felt that their concerns were minimized and suggestions for practice were overruled. For example, when one nurse wrote that staff should use a mask when caring for a MRSA patient because she was producing sputum and was coughing a lot, the Infection Control Nurse (ICN) just overruled her without discussion. According to the ICN, a mask was to be used only during suctioning.
- **Compliance with infection control practices:** Nurses don't want to be the infection control police but often find themselves in this position.
- **Development of protocols for pressurization of rooms:** It was reported that there was a lot of problems with practices surrounding the negative pressure rooms -- who turned on the pressure, alarms, who monitors the pressure in different situations (when more than one room was being used).
- **Leave management programs and use of sick leave:** Management is concerned about how much sick time is used by staff but this should be balanced by the need to keep workers with infectious diseases away from the workplace.

Suggestions:

- Assignment of staff to SARS patients should be informed by Infection Control professionals who are familiar with the acuity of the patients and with best practices regarding staffing issues. Nurses question the practice of assigning the same staff to SARS patients versus sharing responsibilities.
- There should be criteria for identifying conditions that make staff vulnerable when caring for highly infectious patients -- pregnancy, undergoing chemotherapy or having a partner undergoing chemotherapy, etc.
- An emergency plan should be developed to minimize dealing with emergent issues on the fly.
- Basic infection control policies and procedures were either not developed or were not enforced. There needs to be consistent policies and procedures that are enforced and monitored. These include:
 - Methods for monitoring and enforcing compliance
 - Consistent policies for quarantining individuals
 - policies regarding the re-use of masks
 - Tracking of training to ensure that all those who need training actually get it.
 - policies regarding negative pressure rooms.

3. ALLIED HEALTH PROFESSIONALS – TORONTO – November 25, 2003

7 participants

Key Points:

- **Leadership, communication, coordination and the involvement of front line workers** in decision making are key factors in gaining the trust of health care workers and making them feel they are working in a safe environment. The feeling of safety is much more than the provision of personal protective equipment. The more management was visible on the floor, and the more workers were engaged in discussion and understood the development of policies, the higher degree of confidence in safety measures was felt.
- The identification of patients as high risk unnecessarily leads to compliance fatigue. Resorting to a perceived type of "universal respiratory precautions" is not productive.
- There is a stark difference between ICU and ER. ICU workers generally knew what they were dealing with (although not at first). ER workers don't know what to expect when they approach a patient. There are fewer resources such as isolation/negative pressure room in the ERs. Some feel these conditions lead to laxness on the part of ER workers.
- There was no agreement on the identification of high risk procedures and how to deal with them or how to clean portable equipment in different work settings.

Suggestions:

- Involve front line workers in policy setting.
- Establish a respiratory assessment for high risk patients on which workers can rely and that doesn't lead to unnecessary precautions being taken.
- Establish effective procedures for the cleaning of portable equipment in different care settings.
- Establish protocols for high risk procedures -- when, where, how and by whom procedures should be done.
- Establish with certainty the mode of transmission and the efficacy of PPE.
- Evaluate experience after an outbreak to assess the effectiveness of policies and practice and make improvements

4. ALLIED HEALTH PROFESSIONALS – Vancouver – December 12, 2003

5 participants

Key Points:

- There is a great desire for standardized infection control policies and procedures that are enforced by individuals specifically assigned this task as part of, not in addition to, their regular duties.
- Within the need for standardization, professionals want to be given the ability to make choices about the appropriate use of personal protective equipment when their assessment shows a need for its use. Infection control professionals should support the judgment of professionals who have direct contact with infectious patients on a daily basis. For example, choosing to use a mask with an MRSA patient who is productive should not be discouraged.

Suggestions:

- When dealing with an infectious disease that little is known about but that clearly can result in serious illness and/or death, maximum precautions should be taken at first followed up by a tapering off of precautions as more is known about appropriate guidelines.
- Standardize infection control policies and procedures and allow staff to use their judgement in certain situations.
- Especially where there are shortages of PPE supplies, those in high risk situations should be given the equipment in priority.
- Medical surveillance programs should be reinstated.
- Training programs should be delivered at times convenient for all staff who need to attend. They should be delivered by staff as part of their job not in addition to their job.
- Training needs to happen more than once in order to ensure that staff remember how and when to use PPE and proper infection control procedures and techniques. The site should be prepared for disease outbreaks and not scrambling when they occur. Procedures, repeated enough, will become routine.
- Assessment protocols on admittance should be developed to ensure that no one who needs to be isolated is missed and there is minimal isolation of those who do not need it.
- Wearing PPE for long periods can lead to exhaustion. Where this occurs, there should be time for a break before proceeding to the next task.
- Especially in emergency situations with an infectious individual, there should be a member of the response team that is charged to consider infection control issues and who could be the individual who helps people dress and undress appropriately. As procedures become more routine, this may become

unnecessary.

- Emergency departments should all have isolation rooms.
- Multitasking should be considered in situations where it is appropriate to limit the number of individuals needing to don PPE to do certain routine tasks.
- Storage and availability of PPE must be considered to avoid having to spend time looking for equipment.
- The availability of the appropriate PPE on carts presents a problem that need to be addressed.

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5. MANAGERS – TORONTO Group 1 - November 26, 2003

10 participants

Key Points:

- Communication that is timely, ongoing, consistent, and reaches all staff is paramount to having any success in implementing a good infection control program. This is a great challenge in health care due to shift work and the size of facilities. Mixed messages led to staff feeling very insecure about directives and policies.
- The lack of infection control practice leaders was a factor in the difficulties faced in some institutions to get buy-in from staff on infection control directives. Organizations have since the SARS outbreak hired more infection control professionals but are concerned that lack of funding will result in these individuals being cut.
- Cut back of support staff has raised concerns about the adequacy of cleaning being carried out.
- Casualization of the workforce may be leading to increased potential for exposure as staff move from work site to work site in order to get an adequate number of work hours.
- Emergency situations pose particular problems for staff who have to deal with the balance between providing care in a safe manner and providing care in a timely manner.

Suggestions:

- Consistent and effective screening protocols are necessary to ensure proper identification of potential infectious diseases.
- There is a need for ongoing education outside of periods where there is no outbreak of an infection disease. There needs to be an identification of the content of any program and the most effective way to provide this education.
- There must be an identification of the proper PPE required at different stages in the care continuum, including the use of disposable versus non-disposable equipment.
- There needs to be identification of what is meant by an isolation room, a negative pressure room and the appropriate use of each at different stages in the care continuum.

6. MANAGERS - TORONTO - Group 2 November 26, 2003

7 participants

Key Points:

- Establishing of standard protocols, that are widely and well communicated, with consistent follow-up/enforcement were significant themes for this group. There was support for a comprehensive infection control program developed and implemented by staff who are given clear role definitions and areas of responsibility. Confusion and uncertainty needs to be addressed by the development of evidence based information that forms the basis of standard protocols.
- Guidelines and standards aid in inspiring confidence in staff but also aid in assisting in getting senior management to fund infection control initiatives.
- Staff are more likely to be compliant with protocols when they understand the principles and the evidence supporting the protocols. This group of managers felt that evidence based standards are easier to communicate to staff since managers themselves have more confidence in the information they give out.
- Despite the desire for standards, staff need to be given permission to use their own judgment in cases where they determine a higher level of protection may be warranted.

Suggestions:

- Development of standards for number of negative pressure rooms per patient population and having at least one room per facility.
- Development of a computer program that aids implementation of infection control programs.
- Establish best practice for storage of alcohol based hand wash gels.
- Have an infection control professional on the design team for new or renovated buildings or areas.
- The infection control team should have an individual with engineering expertise.
- Develop a cost effective way to retrofit rooms to provide negative pressure environment.
- Since Infection control practitioners are in short supply, organizations should pool resources to create tools available to everyone in order to minimize wasted time and efforts.
- Establish protocols for wearing or not wearing uniforms to and from work. There is a need to reestablish the practice of changing into uniforms and work shoes, etc. before work and changing back after the end of the shift.
- Working with infectious patients while wearing PPE can be exhausting. Break times must be established to keep staff from burning out.

7. SUPPORT STAFF - TORONTO – December 10, 2003

8 participants

Key Points:

- **Communications to staff about infection control procedures:** There was a tension evident in the discussion between concern over frequently changing directives leading to confusion and uncertainty as to what to do, and the need for rapid dissemination of information so that support workers could be kept up-to-date. Support workers appeared to feel out-of-the-loop with respect to safety information.
- **Distrust of management:** This theme was prevalent, with a fear that they were not being told the entire truth by management, and that they would more highly trust the same information coming from a peer. (Interestingly, it was mentioned that there was trust of the president of the hospital)
- **Fear of infection:** Due to lack of knowledge regarding the mode of transmission, there was fear that their required activities were placing them at risk. This is also related to the two other points above: that they feared they were not being told when they were at risk. Examples included fear of catching SARS from fellow HCW in the cafeteria, or a mail-room staff worried about contact with mail coming down from the floors.
- **Lack of compensation/danger pay:** There was a lot of dissatisfaction with the lack of compensation for support staff who worked in the same physical areas as front-line nursing staff who were compensated. A perceived lack of recognition for their service.

Suggestions:

- Have one person in charge of communication instructions / directing staff every shift regarding new policies (ie: during outbreak)
- Need for increased communication regarding infection control procedures (and changes)
- Every department should have a training program in order to keep up to date on new policies and procedures
- Cleaning staff should not be delivering food after cleaning washrooms
- There should always be a supply of masks and respirators for which employees have been tested on the units at all times
- There should be extra breaks when PPE is required due to discomfort associated with prolonged use of PPE
- There should be clean gowns to put over one's uniform prior to entering the cafeteria (because of fears of catching SARS from other staff)
- An essential core of staff should be trained to take over right away in case of an outbreak (like code teams which respond to cardiac arrests)

- There should be annual in-services and education for IC policies and procedures
- Always have one person in every department who can act as an “IC Steward” who is trusted, who can convey concerns about IC to the organization

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8. SUPPORT STAFF – VANCOUVER – November 12, 2003

3 participants

Key Points:

- **Professional Commitment:** The workers displayed pride in their work, and that they were thorough in cleaning SARS rooms in order to protect others. There was also a sense that they were fully compliant with all infection control procedures when other HCW were not. The theme of “we chose to do this job knowing all the risks involved” was raised on several occasions.
- **Infection control practices of other HCW:** The workers portrayed themselves as the “conscience” of the units by pointing out when others were not complying fully. There was discussion that physicians in particular were not compliant and there was concern that they were spreading infection.
- **Organizational valuing of support staff:** There was the impression that housekeeping staff did not have policies, etc in place to protect them (ie from dirty linen) and that priority was placed on nursing and front-line staff. Along the same lines, communication of their concerns to management was a problem.
- **Changing directives:** Again perceived as a problem.

Suggestions:

- A protocol for the transport of garbage / linen from patient care floors is needed (some concern over practice of popping holes in sealed garbage bags in order to compress)
- There is a need to be frugal with PPE supplies for isolation rooms because otherwise they are wasted unnecessarily which is expensive
- Stricter policies on limiting the access of visitors (especially children) to infected patients are needed
- There should be stricter policies on the circulation of infected patients in the hospital
- Patients actively coughing should be masked even when in own room
- There should be a plastic barrier/seal around the bed of infected patients, especially if coughing
- Lab techs should have a small set of phlebotomy supplies they take to the bedside of infected patients and then discard (rather than carrying tray of supplies from room to room)
- Need for more education on hand-washing

9. INFECTION CONTROL PRACTITIONERS/ OCCUPATION HEALTH AND SAFETY PROFESSIONALS - OTTAWA - November 23, 2003

6 participants

Key Points:

- **Perception of strong safety climate:** There is not a strong safety climate in healthcare in general, both from workers who are expected to apply infection control guidelines and management, who must provide adequate leadership and funding of occupational health and safety programs.
- **Safety-related attitudes and actions of management:** A key measure of the importance of safety in their place of work was whether management take actions and direct resources to occupational health programs and infection control. While this was not seen to be a priority before SARS, at the time of the SARS outbreaks in Ontario, resources were mobilized quickly to assist with the new Ontario Ministry of Labour directives on fit-testing and hire more safety officers, for example.
- **Purchasing policies with respect to safety:** Related to the above factor. Another way in which hospitals displayed their concern over safety in the workplace was how rapidly and willing they were to purchase a variety of personal protective equipment for healthcare workers during the time of the SARS outbreaks in Ontario.
- **Lack of consistency with safety instructions and recommendations from outside agencies:** Related to the individual factor discussed below about the lack of confidence in infection control guidelines, participants felt that the rapidly changing guidelines and directives which they received from authorities hindered their efforts to protect workers in that this undermined their credibility.
- **Individual beliefs that guidelines are not relevant:** Guidelines may not be relevant to HCWs in their place of work, predominantly because no cases of SARS presented to their institutions, but also because of the rapidly changing guidelines and directives which they were given.

Suggestions:

- Current infection control measures rely too heavily on the use of personal protective equipment and did not make enough use of other means of protecting workers and patients, such as source controls, engineering controls, and the design of physical space in hospitals.
- Many organizational structures in hospitals are important determinants of workplace health and safety with respect to infectious diseases such as where OH&S professionals fit in the administrative structure of the institution.

10. INFECTION CONTROL PRACTITIONERS - VANCOUVER - December 9, 2003

3 participants

Key Points:

- **Safety training:** Training in this context relates to training healthcare workers in infection control practices. Participants spoke at length about training activities in their facilities both for new staff and in-service training for currently employed staff, and how important they felt this was to protecting workers and patients. Training also included instruction on fit-checking of masks and follow-up to training with healthcare workers in their place of work.
- **Communication about safety from the organization to employees:** Part of the follow-up to safety training included ways of communicating with hospital staff. The primary means identified was by the use of posters and signs to remind staff about the need for PPE use. As well, participants felt that the use of email contributed to the dissemination of infection control information, especially when combined with printing out hard copies and posting for those without email access.
- **Availability of infection control practitioners:** This was seen in terms of needing more staff to follow-up with healthcare workers on the wards, to conduct in-service trainings and to review patients placed on specified precautions (air-borne, droplet, contact etc) in a timely fashion. Being infection control practitioners, they were aware of current recommendations regarding the number of ICPs based on the number of acute care beds and recognized that they were understaffed.
- **Policies and protocols for infection control:** Clear infection control policies and guidelines greatly facilitated the practice of good infection control and helped to protect healthcare workers. This included not only when to place patients under specific infection control precautions, but also when to follow-up on patients to ensure that precautions are not applied for an unnecessarily long time.
- **Lack of consistency with safety instructions:** Changing information contained in repeatedly updated infection control guidelines undermined the confidence that healthcare workers had in their effectiveness.
- **Availability of negative pressure rooms:** Participants mentioned the use of negative pressure rooms as a part of controlling respiratory infections, while recognizing that there is great variation in their availability.

Suggestions:

- Participants from one hospital noted that the creation of a separate cost-centre for SARS greatly facilitated internal dissemination of PPE to protect healthcare workers and allowed them to more directly measure the cost of the outbreak to their institution.

11. OCCUPATIONAL HEALTH AND SAFETY PROFESSIONALS - TORONTO– Group 1 – November 26, 2003

11 participants

Key Points:

- **Importance of OH&S:** The general opinion is that OH&S is undervalued compared to infection control, and that there generally is a lack of integration between OH&S and IC (where integrated, it works well). Also, it is difficult to find personnel with experience in both infection control and occupational health and safety.
- **Safety-related actions and attitudes of leaders:** Having a CEO who is involved in safety issues proves that the organization is committed to safety, and fosters trust among employees for management. When the CEO is not supportive, managers felt resentful and unsupported.
- **Merit of keeping non-essential staff out of the workplace during outbreaks:** This was done in different institutions with differing results. Pros: reduces possible exposures, eliminates personnel who may get in the way when there are increased demands on patient care because of PPE and ICP (eg: researchers). Cons: creates a double standard, staff shortages result in change in duties.
- **Adequacy of PPE Supplies:** The importance of having a centralized distribution system for supplies was recognized, with lack of a good supply system leading to stockpiling and lack of supplies for high-risk institutions. The importance of having at least a 2-week supply on site was recognized, with some discussion as to the benefit of having storage of supplies on every patient-care unit.
- **Methodology and resources used for fit-testing:** Discussed in detail.
- **Masks:** The discomfort associated with masks was seen as the greatest individual factor influencing compliance with PPE.

Suggestions:

- each hospital should have a manager of OH&S services in order to advocate for OH&S and give it the importance it deserves in the workplace
- have all non-essential personnel (to clinical care) work off-site and discharge patients from hospital whenever possible
- need to have policies regarding personnel who fail fit-testing: duties to accommodate, find alternate work, compensation if cannot work
- need for adequate room for storage of PPE supplies on-site both within institution and on each clinical care unit
- to study the question of whether successful fit-testing on one occasion persists (ie: is the success of the fit maintained with prolonged use?)

12. OCCUPATIONAL HEALTH AND SAFETY PROFESSIONALS - TORONTO - Group 2 – November 26, 2003

Key Points:

- **Composition of decision making team:** A key theme with this group was the lack of Occupational Health and Safety professional involvement in decision making at top levels in the province. Directives came down from decision makers who were not conversant with the issues of front line staff, including OHS and Infection Control professionals who were responsible for implementing the directives.
- **Directives must come with resources:** The directives did not come with the resources necessary to carry them out. There was a huge shortage of trained and experienced OHS and IC practitioners. There was a huge shortage of PPE, especially masks.
- **Good infection programs and protocols must be in place to ensure adequate level of readiness for next crisis:** The weaknesses in the system and the shortages that the crisis identified can be linked to a lack of attention to good infection control and health and safety programs and practices for the past decade at least. Though there are references to infection control in regulation in Ontario, there is no attention paid to health care by the regulator and practices have been very lax. When the crisis came, the system had to move too far too fast and couldn't cope.
- **Infection control practices already going back to pre-SARS levels:** The above observation is linked with a concern expressed that the state of infection control and occupational health is already going back to pre-SARS practices. For example, during the crisis, facilities were looking for professional staff to assist them through it. Now that it is over, these staff are being let go without consideration of what is necessary to maintain an effective prevention program in order to ensure an effective program and to be ready for the next crisis.
- **Ministry of Health needs to resource their standards whether they are called directives or guidelines:** There is a fear that the Ministry of Health has downgraded "directives" to "guidelines". This was interpreted to be the Ministry's attempt to get it off the hook for providing resources that should come with directives.
- **Protocols must be standardized and resourced:** The group emphasized the need for standard protocols and for support for organizations trying to implement these protocols in a crisis situation. The stress on OHS and IC was enormous and little support was provided to them. One issue that caused considerable stress was the fact that IC personnel were asked to educate and train staff when they were unsure of themselves of the directives or of proper techniques such as fit testing.

Suggestions:

- Occupational Health and Safety professionals must be part of the team making decisions and setting policy related to infectious diseases.
- Capital projects such as building new facilities or redeveloping old ones must be reviewed taking into consideration infection control requirements. The funding must be in place to incorporate needs identified by this assessment.
- All negative pressure and isolation rooms should have glass in them so patients can be observed without have to go into the room
- Ventilation must be monitored to ensure that it is functioning properly.
- Respiratory technologists have to be part of the decision making team in facilities.
- Clear roles and responsibilities have to be assigned to individuals within an organization so there is no confusion. Special consideration has to be given to how compliance is enforced; is enforcement strictly a management issue or not.
- In the era of nursing shortages, are nurses more likely to prefer a facility with tough standards and enforcement protocols or one that is lax? There is a balance between allowing nursing to make judgment calls and requiring them to follow appropriate infection control protocols.

13. PHYSICIANS - TORONTO – November 25, 2003

2 participants

Points of Interest:

- **Commitment to early training:** Training in the use of PPE and IC protocols needs to start in medical school, accompanied by a system for fit-testing for such “transient” HCW
- **Environmental factors:** This group discussed many environmental factors in detail, such as negative pressure rooms, sink/rinse availability, and availability of masks (particularly correct masks based on fit-testing). More emphasis was placed on environmental compared to individual or organizational factors.
- **Fear of transmitting infection:** Described as a factor affecting willingness to work and possibly compliance.

Suggestions:

- IC & OHS should be unified or same division
- Equip entire wards such that they can be rapidly converted to negative pressure when needed
- Reinforce the importance of doffing equipment when leaving patients’ rooms (because of concern regarding contamination of common surfaces and equipment)
- Monitoring of compliance / auditing of HCW with infection control is important
- Fit-testing should be more systematic, and should also be done for “transient” HCW such as medical students and residents
- Staff should be advised not to wash hands in the patients’ bathrooms/washrooms (often this is the only sink available)
- Need to start infection control training in medical school
- Should approach all respiratory secretions as being potentially infectious (analogous to experience with blood and body fluids)
- Rewarding HCW for “100% attendance” is a bad idea as it encourages HCW to come to work when sick
- Quality control for negative pressure rooms needs to be improved

14. MIXED GROUP 1 – TORONTO – November 26, 2003

9 participants

Key Points:

- **Organizational decision-making:** Having a centralized decision-making process for infection control issues allowed for rapid consensus and facilitated communication of directives to employees.
- **Education:** Education and training of employees was seen as key to ensuring compliance and appropriate use of infection control procedures.
- **Cohorting of infected patients:** During the SARS outbreaks, patients with SARS were placed in negative pressure rooms located all over the hospital. The disadvantages of this meant that there wasn't a team of employees looking after SARS patients, and that employees could be looking after both SARS patients and non-SARS patients with the possibility of nosocomial spread.
- **Compliance with IC procedures in medical and nursing leaders:** Physicians in particular were seen as idiosyncratic in their use of PPE and were not consistent in following guidelines, with a negative impact on other employees who were expected to behave differently.

Suggestions:

- **Education:** New approaches to education and training of HCW in infection control should be adopted, that are collaborative, interactive, and based on high quality material – that can be used across the province.

15. MIXED GROUP 2 - TORONTO – December 10, 2003

10 participants

Key Points:

- **Supervision and screening of non-HCW:** There was a lot of concern regarding the lack of screening of visitors to the hospital during the SARS outbreaks, and also the lack of enforcement of IC precautions among visitors. This was felt to pose a danger to HCW. There seemed agreement among members of the group that visiting hours, and numbers of visitors be restricted as they have been in the past.
- **Contamination of surfaces in the hospital:** In conjunction with the above point, there was a fear that common areas were contaminated (for example, common bathrooms without automatic taps and with a lack of paper towels for turning off taps).
- **Differential treatment from other HCW:** The make-up of this focus group appeared to be largely support staff, or non-patient-care staff. The group felt that they were treated differently from patient-care staff in terms of communication of information regarding infection control procedures. They also seemed to feel that their concerns were not listened to – that procedures and policies that would protect them from infection were not in place (ie: transporting soiled laundry). This led to a lack of trust in the management of the organization.
- **Communication:** the participants in this group felt that communication of infection control policies and procedures needed to be improved.

Suggestions:

- Temperature logs for inpatients should be scrutinized by HCW for the previous 24 hours (concern that elevated temperatures on other shifts were being missed)
- Have standardized screening tools for infection in the hospital (during outbreaks)
- There should be screening at all entrances (not just the emergency room) for all persons entering the hospital
- There should be tighter restrictions on visitors' access to hospital, perhaps even banning all visitors altogether (no children < 13, 2 visitors at a time, set hours)
- Need to publish an analysis of the SARS outbreaks and circulate to staff, create up-to-date policies and procedures for IC
- In-services should be short, pertinent, in unit of work, and with sufficient notice
- An annual course in IC is needed with requirements for certification
- Fit-testing should be done at the start of employment for all new employees, and orientation for new employees should include a section on IC
- Need for re-education of PSA's in IC procedures

- Pedestal sinks are preferred, or sinks with automatic sensors (where do not need to touch handles)
- Build a new hospital only for infectious diseases, that is well-equipped, and designated as a “respiratory hospital” or an “infectious diseases” hospital
- “somebody unplug the public purse”: health care is expensive and needs to be funded appropriately in order to prevent future outbreaks
- measures for danger pay/compensation should be consistent across all hospitals
- danger pay should not be “blanket” but tailored to risk and exposure (should be similar to overtime instead of double or triple-time; or use other options such as days off with pay)
- need for ongoing education for the community, and orientation for patients admitted to the hospital regarding IC

OHSAH Archive

Protecting the Faces of Health Care Workers

APPENDIX 3: PARTICIPATING INSTITUTIONS

Ontario:

Children's Hospital of Eastern Ontario
Credit Valley Hospital
Lakeridge Health Corporation
MDS Laboratory Services
Markham-Stouffville Hospital
Ministry of Labour
Mount Sinai Hospital
North York General Hospital
Ontario Nurses Association
Orthopaedic and Arthritic Institute
Scarborough General Hospital
Scarborough Grace Hospital
St. John's Rehabilitation Hospital
St. Joseph's Health Centre
St. Michael's Hospital
Sunnybrook and Women's College Health
Science Center
The Ottawa Hospital
Trillium Health Centre
University Health Network
West Park Healthcare Centre
William Osler Health Centre

British Columbia

Providence Health Care
St. Paul's Hospital
Surrey Memorial Hospital
Vancouver General Hospital
UBC Hospital

ABOUT THIS DOCUMENT

The Occupational Health and Safety Agency for Healthcare (OHSAH), which operated from 1998-2010, was a precursor to SWITCH BC. Conceived through the Public Sector Accord on Occupational Health and Safety as a response to high rates of workplace injury, illness, and time loss in the health sector, OHSAH was built on the values of bipartite collaboration, evidence-based decision making, and integrated approaches.

This archival research material was created by OHSAH, shared here as archival reference materials, to support ongoing research and development of best practices, and as a thanks to the organization's members who completed the work.

If you have any questions about the materials, please email hello@switchbc.ca or visit www.switchbc.ca