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Review Article

Coronavirus Epidemic: An Opportunity to Protect Patients and Healthcare Workers from Respiratory Infections Acquired in Healthcare Settings

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Abstract

During the 1980s AIDS epidemic, U.S. healthcare providers introduced HIV prevention measures into facilities with the welcome but unintended consequence of reducing transmission of general blood-borne infections to patients and healthcare workers. WHO lists TB, pneumonia and influenza in the top ten causes of death worldwide. Yet as patients enter hospitals and clinics for these common conditions, care in facilities both treats as well as amplifies these respiratory infections. As measures are introduced to control SARS-CoV-2 infections, an opportunity exists to introduce infection prevention and control (IPC) measures that reduce healthcare-associated respiratory infections in general. As individuals change behaviors to prevent transmission, they will help change an industry where ingrained beliefs, habits and attitudes that allow respiratory disease to spread unchecked. This paper discusses key measures that facilities could enhance to decrease healthcare associated respiratory transmission. Tuberculosis control measures can be modified as the basis of an effective IPC model in public and private settings to reduce transmission of a variety of respiratory infections from COVID-19 to influenza to tuberculosis.

Keywords: *Coronavirus; Covid-19; SARS-nCoV-19; Occupational Health; Tuberculosis; Respiratory Infections; Healthcare settings; Infection Control; Latent TB*

Introduction

During the 1980s human immunodeficiency virus (HIV) epidemic, U.S. healthcare facilities introduced workplace protections to reduce the HIV transmission in healthcare facilities [1]. As an unintended but welcome consequence, the introduction of gloves, gowns, stricter sterilization of devices, cleaning and vaccines reduced the high rates of nosocomial blood-borne infections. Soon rates of infections in healthcare workers (HCW) [2] such as hepatitis that had been excessive fell below those of the general population [3]. These 'universal precautions' are now routinely applied worldwide as part of 'standard precautions [4,5]. The COVID-19 pandemic now presents an opportunity to introduce general respiratory protection measures to prevent SARS-nCoV transmission to HCW and patients and simultaneously reduce the underappreciated spread of other respiratory pathogens in healthcare facilities. While specific tests and eventually drugs and vaccine will be necessary to control COVID, application of general respiratory infection measures to prevent the transmission of tuberculosis, influenza, and Respiratory Syncticial Virus (RSV) will increase the benefits from the significant investments necessary to control this pandemic.

Before COVID-19, the transmission of respiratory pathogens in healthcare settings was common, serious and ignored.

Healthcare-associated respiratory infections (rHAI), including non-ventilator associated pneumonia, commonly affect patients but are not routinely monitored. WHO lists TB, pneumonia and influenza in the top ten causes of death worldwide (Figure 1) [6]. Yet as patients enter hospitals and clinics for these common conditions, care in facilities both treats and amplifies these respiratory infections. In 1997, CDC listed nosocomial pneumonia as the second most common nosocomial infection in the U.S., with a crude mortality of 20 - 50% and attributable mortality of 30 - 33% [7]. Unfortunately, rHAI are not part of routine surveillance systems, so it is invisible to most providers and health systems. The measurement of rHAI depends upon periodic research reports, often done during epidemic seasons that don't provide information if it is an ongoing problem. Using 2012 data from the U.S. National Inpatient dataset, Guiliano., *et al.* [8] found an incidence of non-ventilator associated hospital-acquired pneumonia (NV-HAP) in 1.6% of hospital inpatients (3.63 per 1,000 patient-days). Baker., *et al*. [9] reviewed data from 21 hospitals measuring pneumonia not present on admission and found a NV-HAP rate of 0.12-2.28 per 10,000 patient days. They found that "NV-HAP occurred on every hospital unit, including in younger, healthy patients. Although some patients are clearly at higher risk, all patients carry some NV-HAP risk". More than 70% of cases were in patients outside of intensive care units.

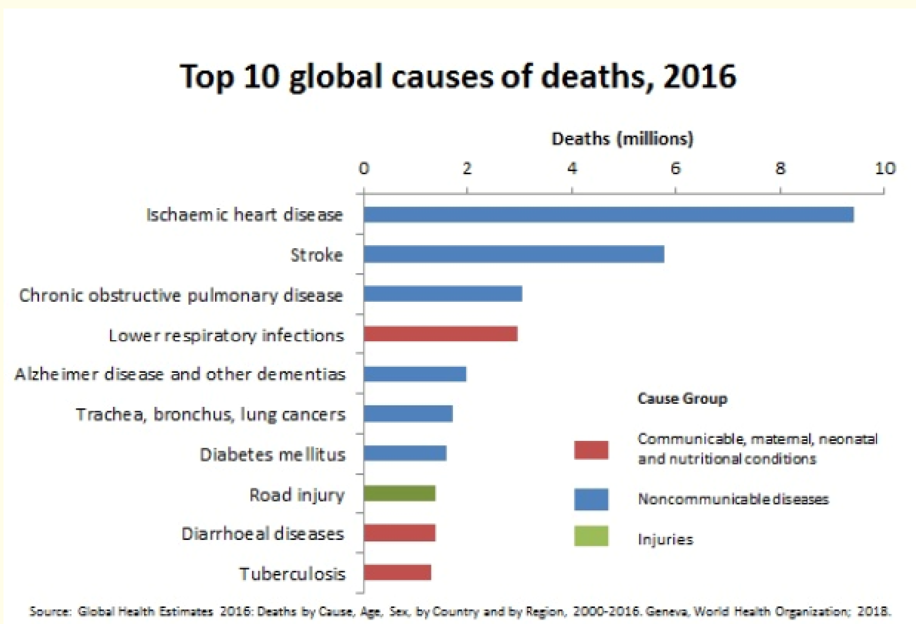

Figure 1: *Leading causes of death.*

The above studies reported healthcare-associated pneumonia killing patients at high rates regardless of viral and/or bacterial etiology or association with mechanical ventilation. Transmission of upper respiratory infections can also lead to severe disease. Chow and Mermi [10] reviewed 7 studies between 1973 - 2012 that measured nosocomial respiratory viral infections in patients. Attack rates varied from 4 and 55 cases per 10,000 admissions in adult and pediatric hospitals respectively; 11% of patients acquired routine coronavirus in neonatal and pediatric intensive care units; 17% percent of admissions in a pediatric facility developing RSV, parainfluenza, or influenza. Attack rates in pediatric facilities were often 10 times those of adult facilities. In their own two Rhode Island hospitals in 2016 [11], Chow and

Mermi, detected 17 nosocomial respiratory viral infections in adults and 23 possible cases in the pediatric hospital in one year (5/10,000 admissions and 44/10,000 respectively). In these cases, 5 (13%) patients died; 5 (13%) were transferred to the ICU; 6 (15% were intubated); and 17 (43%) started antibiotics despite having a viral etiology.

In France [11], Korea [12] and the U.S. [13] about a fifth of rHAI patients had viral etiologies. Bacterial or bacterial-viral results were most common nosocomial respiratory infection. Influenza A and rhinovirus were commonly identified. The variability in rates can be explained in part because some publications report during outbreaks while others report on national annual data. Routine surveillance is needed to establish baseline rates to be able to calculate the cost effectiveness of implementation of year round respiratory prevention measures.

Part of the reason that respiratory outbreaks are very common in health care settings is disease transmission by infectious health care workers [14]. The case study of the first U.S. death from SARS-nCoV-2 illustrates this in figure 2 below. While testing of those exposed still continues, as of March 18 the investigating team [15] found of the 167 confirmed cases in a nursing home, 50 were health care personnel and 16 were visitors. The ill healthcare staff also worked in other nursing homes which later developed COVID-19 outbreaks.

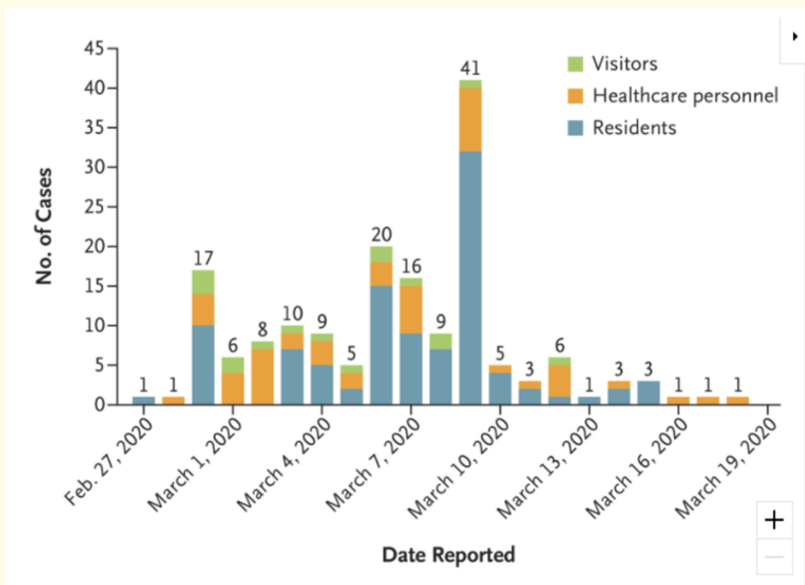

***Figure 2:** COVID-19 Cases in Seattle, Washington.*

Confirmed cases of COVID-19 linked to Facility A. Source: McMichael TM., *et al*. Epidemiology of Covid-19 in a Long-Term Care Facility in King County, Washington *N Engl J Med*. 2020;10.1056/NEJMoa2005412. doi:10.1056/NEJMoa200541.

CDC surveyed the 100 nursing home facilities in the area to ask about outbreaks. By week 12 of 2020, the number of facilities reporting outbreaks of 'influenza like illness' after the national attention grew from 19 to 71 [16]. Prior to the national attention surrounding COVID-19, there has been little public comment or concern about these epidemics, implying that respiratory epidemics are business as usual in understaffed nursing homes during flu season.

The rHAI outbreaks have been reported from adult [8] and pediatric hospitals [17], adult [18] and pediatric long-term care facilities. Where and when surveillance is conducted, rHAI are common although the bias is toward reporting patient impact in epidemic years. Despite this, the healthcare associated transmission of respiratory infections was not seen as a problem by the healthcare industry prior to COVID.

Because transmission in healthcare facilities is common, we must prioritize ongoing respiratory infection control measures to protect healthcare workers and patients from conditions ranging from COVID to TB.

The AIDS era also taught use that tuberculosis increased the death rates of HIV patients, and that active transmission of this respiratory infection was occurring in healthcare settings worldwide [19]. HCWs are at greater risk of TB infection, and consistently show greater rates of latent TB infection than the general population when effective IC measures are not used [20].

The global burden of TB disease is estimated to be 1.5 million deaths a year worldwide, with the costs rising from treatment of drug-resistant TB [21]. Worldwide, one in four persons is infected [22]. Figure 3 and table 1 shows the variation by region of the globe.

Figure 3: *Global prevalence of latent and active tuberculosis.*
Source: Cohen, A, VD Mathiasen, T Schone, C Wejse. The global prevalence of latent tuberculosis: a systematic review and meta-analysis. European Respiratory Journal 2019 54: 1900655; DOI: 10.1183/13993003.00655-2019.

Table 1: *Latent TB Infection prevalence by regions of the world, 2016.*

WHO region	All LTBI		Recent Infection prevalence (within 2 y)	
	Prevalence (%)	Proportion of Infections In children <15 y (%)	(%)	Proportion with INH-R Infection (%)
AFR	22.4 [20.6 - 24.6]	13.3 [11.8 - 14.6]	1.5 [1.3 - 1.7]	7.4 [6.4 - 8.7]
AMR	11.0 [7.0 - 20.0]	2.3 [1.3 - 3.7]	0.2 [0.1 - 0.2]	7.0 [6.0 - 8.8]
SEA	30.8 [28.3 - 34.8]	7.4 [6.3 - 8.2]	1.2 [0.9 - 1.6]	9.5 [8.8 - 10.3]
EMR	16.3 [13.4 - 20.5]	7.9[6.0 - 9.4]	0.7 [0.5 - 1.0]	13.1[10.0 - 15.5]
WPR	27.9 [19.3 - 40.1]	2.4 [1.7 - 3.5]	0.5 [0.4-0.7]	14.7 [13.9 - 15.6]
EUR	13.7[9.8 - 19.8]	2.0[1.3 - 2.7]	0.3 [0.2 - 0.3]	29.5 [23.8 - 45.1]
GLOBAL	23.0 [20.4 - 26.4]	5.9 [5.1 - 6.7]	0.8 [0.7 - 0.9]	10.9 [10.2 - 11.8]

Proportion of population by WHO region infected with Mycobacterium tuberculosis, 2014 (including proportion of LTBI burden that is in children, proportion recently infected, and proportion of recent infections with isoniazid-resistant (INH-R) Mycobacterium tuberculosis). Brackets indicate 95% uncertainty interval. AFR: African Region; AMR: Region of the Americas; EMR: Eastern Mediterranean Region; EUR: European Region; SEA: Southeast Asia Region; WPR: Western Pacific Region.
Source: Houben RMGJ, Dodd PJ (2016). The Global Burden of Latent Tuberculosis Infection: A Re-estimation Using Mathematical Modeling. PLoS Med 13(10): e1002152. Published Oct. 25, 2016. https://doi.org/10.1371/journal.pmed.1002152

While it is desirable that a large number of TB patients seek care in healthcare facilities, it is unacceptable that the majority of cases of TB in HCWs are acquired in their workplace, where transmission is preventable. As an egregious example, Baussano (Table 2) found 81% of the TB disease in health care workers in high burden settings was acquired at work.

Table 2: *Percent of TB cases in HCWs that are occupationally acquired.*

	Low incidence settings	Medium incidence settings	High incidence settings
Percent of HCW cases occupationally acquired at work	49%	27%	81%

Source: Baussano I, Nunn P., et al. Tuberculosis among healthcare workers. Emerg Infect Dis. 2011;17(3):488–494. doi:10.3201/eid1703.100947.

In Pune, India, nursing students and medical residents acquired latent TB infection at a rate of 26.8% per year (95% CI 8.6 - 37.2) [23]. In 212 TB care facilities in 12 Chinese provinces, 71 of 9,663 HCW developed TB disease, for an incidence of 760/100,000, 1.6 times higher than the national rate. The primary risk factor for occupational TB was a failure to institute recommended ventilation measures aOR = 2.42 (95% CI 1.31 - 4.47) and failure to institute recommended administrative measures. aOR 2.57, 95% CI: 1.37 - 4.80) [24]. In many countries with prevalent TB, the occupational risk to HCW remains high (Table 3). In Cape Town South Africa, 23 medical students per 100 person/years (95% CI 12 - 43) had a Tuberculin Skin Test conversion, a rate three times greater than that in HCW in other high burden countries [25].

Table 3: *Excess occupational risk of TB among HCWs in low and middle-income settings.*

HCW location	TB incidence rate ratio (Relative to general population)
Outpatient facilities	4.2 - 11.6
General medical wards	3.9 - 36.6
Inpatient facilities	14.6 - 99.0
Emergency rooms	26.6 - 31.9
Laboratories	78.9

Source: Joshi R, Reingold AL, Menzies D, Pai M (2006). Tuberculosis among Health-Care Workers in Low- and Middle-Income Countries: A Systematic Review. PLoS Med 3: e494.

It is possible and important to prevent the acquisition rHAI, including TB disease in healthcare settings. In the U.S. in the 1950s, nurses and medical students acquired TB infection at rates that were 10 to 100 times higher than the general population [26]. That rate is now below that of the general population [27]. It would be short sighted to implement prevention measures targeting only COVID when the need for broader protection for health care workers and patients is dire.

Why has the rHAI been ignored despite the frequency and severe impact on HCW and patients?

The authors posit the following:

1. Surveillance for specific viral respiratory healthcare-associated infections is not routine, easy or funded. Broad viral diagnostic testing beyond influenza or respiratory syncytial virus is rarely done unless treatments exist. Diagnosis of pneumonia may require X-rays, bronchoscopy and invasive measures. Surveillance of TB acquisition in healthcare has been neglected, even though both latent infection and disease can be treated and active case finding is strongly encouraged by WHO STOP TB. The F-A-S-T approach promotes use of rapid molecular sputum test including drug resistance and immediate initiation of treatment [28].

2. Viruses are often unidentified and their transmission in healthcare facilities is not well understood: at a Sloan Conference of Viruses in the Built Environment, it was noted only a few of the estimated 10^8 viruses in existence have been identified, and that scientists don't yet understood how viruses interact in the microbiomes of patients and built environments [29].

3. Local laboratories may lack resources to test for viral infections. Molecular methods for virus require laboratory equipment like thermocyclers for Polymerase Chain Reaction tests which may not exist in communities. However, the availability of test methods is improving, particularly since use of diagnostic tests is a key strategy to reducing inappropriate use of antibiotics. For example newer methods with small portable molecular devices used for MDR-TB (e.g. GeneXpert system), automate the specimen preparation and have cartridges that can also be used to detect SARS-NCoV-2 if public sector pricing is made affordable. The development of panels that test for viral respiratory pathogens is advancing.

4. Active case finding for respiratory infections in staff and patients is often voluntary, rarely done, and variable [30]. Some U.S. states mandate reporting of ventilator-associated pneumonia (VAP) to CDC's National Health Safety Network but the surveillance definition lacks sensitivity, specificity and simplicity, requiring significant staff resources [31]. Screening and treating TB disease and latent TB infections in healthcare staff has been effective both to prevent disease as well as to detect transmission occurring in facilities, but in the authors' experience ongoing active screening is not systematically implemented without leadership.

5. Facility administrators may not permit reporting of nosocomial respiratory outbreaks, fearing harm to an organization's revenue and reputation. Managers know if they furlough ill employees in already understaffed settings, they may need to close wards which may in turn cause patients to be boarded in crowded emergency room settings [32]. Sending ill staff home without replacement worsens understaffing and increases the risks of rHAI transmission and poor care [33]. Many HCW have no paid sick leave [34] and feel pressure not to abandon patients and staff. For example, nurses and allied staff in Seattle held a 3-day strike for understaffing which they felt was putting patients at risk. Their healthcare system had 900 unfilled positions out of their 7,800 nursing care staff [35]. Government regulatory authorities can require participation in surveillance systems and anonymize reports if appropriate.

Proposed strategy to reduce healthcare associated respiratory infections: reinforce infection control plans adapting principles of TB infection control measures as a base.

As a first step to prevent healthcare-associated respiratory infections, TB infection control programs should be strengthened with minor adaptations that broaden them to cover viral pathogens including COVID-19. In low prevalence, high- and middle-income countries, TB IC programs can be expanded at a low marginal cost to prevent a broad range of other respiratory infections. In high TB prevalence settings such reinforcement will address a leading cause of preventable death, already identified as an international priority. The key steps to strengthen in general infection control programs to decrease rHAI are summarized in figure 4.

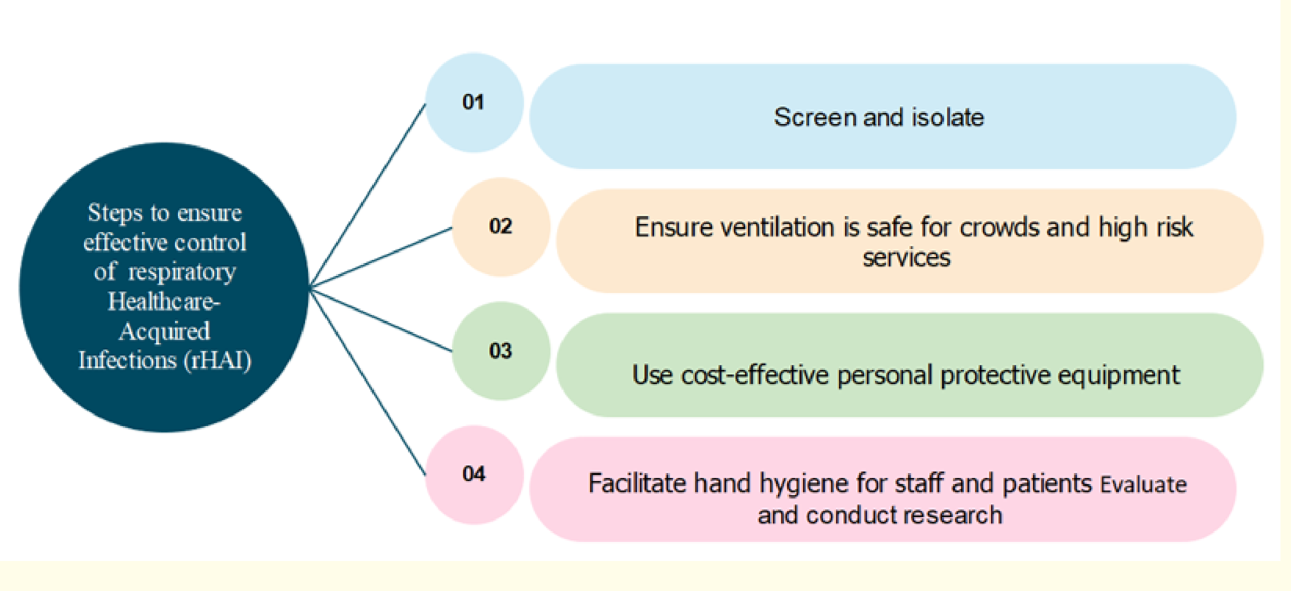

Figure 4: *Key IC measures to prevent respiratory transmission of healthcare associated infections.*
Source: H Almossawi, 2019.

1. Screen and isolate patients with respiratory symptoms

The goal of screening is to eliminate or reduce the number of infectious persons who can transmit disease to patients and staff. Programs should screen patients, family, visitors and staff with the objective of isolating patients, and sending sick staff, visitors and children home.

Greeters can welcome arriving patients and visitors before they enter the waiting area to screen for cough, body aches, sore throat, fever, rash. Staff can screen when making appointments or when persons enter a facility. Screening can be done by phone, on-line and then reinforced in person. Persons screened positive should be given a mask, offered hand gel if available, and taken directly to a private or isolation room. In countries with TB, clinicians should assess patients with a cough greater than 2 weeks and do rapid TB molecular testing if indicated and initiate treatment. To avoid infecting others, assessments can happen in a negative pressure isolation room with ACH > 12 or happen outside, or in a private room. Active case finding for TB patients is a high priority and both diagnostic testing and initiation of treatment should be fast tracked. The screening should include visitors and children. The presence of symptomatic visitors should be discouraged whenever possible. In outbreak settings all non-essential visitors can be excluded with exceptions for compassionate care approved on a case by case basis.

Outcome measures can include measures such as percent of persons screened, disease or syndrome rates in patients and in staff, the duration of time from facility entrance to isolation, and when treatment exists, from facility entrance to appropriate treatment initiation.

2. Ensure ventilation is safe for crowds and high-risk services

High risk areas include 1) where crowds gather and 2) where aerosol generating procedures (AGP) are done. These include sputum specimen collection, lab microscopy, intubation, nebulizer treatment, bronchoscopies, autopsies, use of uncovered flush toilets and medical waste disposal. Non-invasive positive air pressure ventilators, value masks, and ventilators all also can generate infectious aerosols if they do not have HEPA filters at the point of exhaust. Respiratory transmission is likely where crowds gather, which can include waiting areas, and staff break rooms.

The risk of such areas depends on the number of people present and the amount of virus in the air. The risk is decreased by decreasing the ratio of people to available air. Ventilation systems that do not recirculate air with infectious particles are safer, which is why air which flow from health care provider to the patient to the outside, or which flows through a HEPA filter, is safer. When assessing ventilation, healthcare workers will benefit from guidance from industrial hygienists, engineers with experience in heating and ventilation, or architects to assess their building ventilation and propose improvements. However, much can be done by nurses and physicians using the informative and detailed guidance and information [36-39].

Staff without expertise in ventilation systems should seek advice from experts. In addition, changes in patient flow in facility should be done for best usage of indoor and outdoor spaces and arrange indoor routes when patients move between services. While arranging for patient flow as well as creating spaces for specific procedures, attention should be paid to areas where aerosol generating procedures are done by staff or where patients with respiratory infections or conditions are waiting for services. Staff should mark current official and unofficial waiting areas and pay attention to patient waiting areas in hallways.

Even without external expertise, health care workers can often make some immediate improvements at low cost. At the simplest level, look for crowds, detectable movement of air, persistent of odors, direction of airflow. Adequate ventilation in waiting rooms will have detectable movement of air, directed flow to the outside and will remove odors rapidly. Crack open a door and place a tissue at the opening of isolation rooms to see if air is drawn into the room or being pushed out or neither. The facilities should document:

- Ventilation air changes per hour (see guides above and note on-line calculators exist)
- Locations where windows and doors can be opened for cross ventilation
- Use and availability of fans

- Areas where air is vented outside and not recirculated (for infectious patients)
- If any areas are using upper airway germicidal Ultraviolet lights, and if they are being maintained
- Location of the lab, if bio-safety cabinets function and are routinely maintained, specimen donation areas
- Presence of filters in the mechanical ventilation system and if they are routinely changed
- Where medical waste is burned or buried and if the fumes re-enter care faculties.

Priorities, after screening for infectious patients and staff include the 1) elimination crowded waiting rooms, like those outside of X-ray machines and 2) verification that ventilation is appropriate. Locate high risk services in settings where ventilation has the highest air exchanges per hour, and whether air is vented outside or filtered by high efficiency filters.

3. Use cost-effective personal protective equipment

Unfortunately, there is no good data on which combinations of PPE (e.g. mask, eye protection, respirator, gown, apron and gloves) are protective around symptomatic patients. As of 30 March 2020, both CDC and WHO [40] recommend use of surgical masks around patients when staff suspect them of respiratory illness, and use of N-95 when doing aerosol-generating procedures, and with known COVID-19 and TB patients.

There is good agreement on the use of N-95, eye protection, gloves and gown when doing aerosolizing procedures. Appendix A of the CDC Guidelines for Isolation Precautions, offers an example of PPE recommended by disease. https://www.cdc.gov/infectioncontrol/pdf/guidelines/isolation-guidelines-H.pdf [41].

The availability of PPE may vary during an epidemic, and HCW transmission may occur despite its use. Thus, it is important to follow your national program for PPE for general or specific respiratory conditions, and communicate issues detected. Singapore is one of the few countries which reports no cases of transmission to COVID-19 to healthcare workers and reportedly uses a strategy universal masks and gloves for all patient encounters, strict screening and isolation, and use of N-95, eye protection, gloves and gowns for care of patients with COVID during aerosolize generating procedures [42]. This suggests that universal masks and gloves may protect staff from the asymptomatic transmission in areas outside of the COVID isolation rooms. This is a core lesson from TB control programs as well: Disease transmission typically happens with patients not suspected to have TB, exposures happen in locations out side of isolation rooms [43] where staff feel the need to use no PPE.

Shortages of PPE make it difficult to know if transmission is happening because staff cannot use the PPE recommended, or if the recommendations fall short of protecting staff? During a shortage is it more important than ever to arrange high risk procedures and crowds in well-ventilated areas, screen and isolate infectious patients and staff, and exclude sick visitors. Screening and good ventilation can prevent transmission. When PPE shortages require adaption, establish a new standard and document PPE usage. Track symptoms in staff to evaluate if the adaption is safe.

4. Facilitate hand hygiene for staff and patients

WHO provides guidance on implementing hand hygiene in programs that monitor compliance [44]. Meta-analysis has shown that hand hygiene reduces transmission of respiratory infections in community settings [45] and hand hygiene is presumed to be important in hospital settings as well.

5. Evaluate and conduct research

The evaluation of Infection Control programs shows if IC measures are being implemented and if they are effective. Both process and outcome measures will provide information to show how to adjust course, with process measures being simpler to implement.

5. a. Evaluate programs by process measures: Examples include measures showing if patients are being screened for respiratory infections and the delays between admission and isolation. For TB important measures include the portion of person screened, those positive who were started on appropriate therapy and the delays between each step.

Simple checks on ventilation measures include doing rounds to note if crowds have moved to areas of appropriate ventilation, if filters in mechanical ventilation systems have been changed, if doors and windows are open, and maintenance done on lab hoods, UVGI lights are functioning.

5. b. Evaluate programs by outcome measures: The gold standard for evaluation of rHAI infection control is measurement of respiratory infections developing in patients and staff: HCW with COVID-19 or TB acquired at work should prompt investigation. The COVID-19 investigation is easier since symptoms show within days of exposure, when memories and records are available. Programs that test for latent TB infection annually can use this measure as a surrogate for disease transmission; rates of latent TB infection in HCW attributed to their workplace is an important clue about adequate respiratory protection. Where TB is transmitted, many other respiratory infections are also likely to be undetected. Infection Prevention staff should consult with units experiencing occupational LTBI conversion to identify issues and solutions. Similarly, acquisition of influenza, RSV, or even higher rates of influenza like illness in a unit should prompt investigation to see if the infection control strategy or PPE need to be revised.

Facilities with laboratory testing abilities may use either diseases specific outcomes, such as two or more cases of influenza developing in patients or staff. When lab testing is not, supervisors can use symptom surveys to detect patients with influenza-like illness not present on admission, and do staff surveys for symptoms. Programs can track measures like ventilator dependent pneumonia and post-operative pneumonias, although the patients' own organisms largely influence these conditions.

5. c. Measure of all-cause mortality as well as epidemic pathogens

During pandemics, public health programs track the specific disease death rates, for example those dying with a positive lab test for SARS-nCoV-19, but should keep an eye on all-cause, age-specific, mortality as well. Epidemic responses can divert funding from one health program to another, so measures that prevent deaths from one cause, can inadvertently contribute to deaths from other causes. Disease with worldwide economic collapse such as COVID can have many other impacts on human lives not captured if the only condition reported is COVID-19 infection.

Being sensitive to all cause mortality can maintain community cooperation. During the 2019-2020 Ebola outbreak in DRC, villagers were angry about Ebola prevention measures by outsiders. They perceived the 3,000 deaths from Ebola to be minor compared to their daily toil from malaria and war. They felt their decades of suffering had been ignored [46]. Some estimate between one to five million deaths from war, along with millions of malaria cases and rising maternal mortality. Communities and militia attacked HCWs who were addressing Ebola or polio over 600 times in 2019 - 2020 [47]. While an extreme example, it illustrates that other illness and death matters to those suffering and underserved people have valid needs for care. They should not be neglected or made to feel less important than those afflicted by a targeted disease.

5.d. and flush left is needed to identify which respiratory IC measures or bundles are effective and which prevent the most disease. While we know programs that institute multiple measures can reduce their targeted disease, we do not know which specific IC measures are most important. Different groups are different measures during the COVID-19 epidemic which is an opportunity to learn if recommended measures are derived from folklore or fact. We applaud the groups around the world that sharing their experiences of testing measures in trials controlling for different environmental conditions and including controls.

Below are key questions that need answering with data specific to COVID and as the basis for general respiratory precautions:

- What is the minimum bundle of infection control measures (screening, ventilation, PPE, testing etc.) that results in the lowest rates of respiratory disease transmitted to health care workers and staff?
- Do use of surgical masks use only when an infectious patient is suspected prevent HCW infection in settings with common viral respiratory infections? Does it vary by pathogen?
- Do higher nursing home ventilation standards that don't recirculate air decrease respiratory outbreaks safe in congregate care settings or seniors at risk for respiratory infections?
- What are the lessons from countries who rapidly developed high volume screening laboratory for COVID-19?
- When can employees with respiratory illnesses return to work when no etiology has been diagnosed (no lab testing done)?
- Are employees who have recovered from COVID-19 immune?
- Does surface disinfection decrease transmission? How important is this? We know viruses land on surfaces. OSHA notes that "It's currently unknown if a person can get COVID-19 by touching a surface or object that has the virus on it and then touching their own mouth, nose, or possibly their eyes [48].
- Is the current 5000 ppm of sodium hypochlorite recommended by WHO for disinfection necessary for SARS-nCOV-2? Or is the usual 100-500 ppm adequate?
- Do reprocessed masks or N-95 (FFP-2) masks prevent disease in healthcare workers? What is the maximum number of times they can be reprocessed? (By UV, Hydrogen vapor gas, dry and steam sterilization, or other).
- Has any transmission of respiratory viruses between susceptible people been prevented by wards with beds 1 or 2 meters apart? Are all respiratory infections a mixture of droplet and aerosolized particles? Is it time to move away from 'droplet' and 'airborne' as either/or categories?
- Which patients can safely go home during periods of understaffing when facilities have to furlough ill employees?
- When focusing on pandemic infections, what other category of mortality increases?
- How can facilities decrease unnecessary utilization of emergency departments and have patients go to outpatient clinics?
- Do mobile UV disinfection of rooms decrease transmission of respiratory infections?
- What are the HCW attack rates of COVID in a randomized controlled trial comparing surgical masks to N95 use for respiratory viruses in an airborne isolation room?
- How can facilities cost-effectively utilize molecular tests for respiratory disease surveillance?

- In the real world, do persons with goggles have lower rates of respiratory diseases? Are goggles and face shields comparable?
- Unless performing exposure prone procedures, are disposable gowns necessary if other measures are strictly adhered to?

These 5 measures summarize key points of infection control for respiratory infections in health care settings. A more comprehensive measures including existing screening and surveillance systems, are summarized in a related document [49].

Conclusion

Transmission of respiratory infections in healthcare settings represent a common, severe problem for which effective measures exist. The COVID pandemic is motivating the healthcare industry to implement and evaluate patient and staff protection. Such measures should be broadened to include other respiratory infections using TB measures as the basis. Given the burden of disease, these measures should remain in place. Application of current recommendations for TB control measures with expansion to include common rHAI can have a lasting benefit for viral infection control, as well as addressing the increasing and costly burden of TB disease acquired in healthcare settings.

Ethics Approval and Consent to Participate

Not applicable.

Consent for Publication

Not applicable.

Availability of Data and Materials

Not applicable.

Competing Interests

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Disclaimer

The views expressed herein are those of the authors and do not necessarily reflect the views of their affiliated organizations.

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