Review Article

Infectious Respiratory Illnesses and their Impact on Healthcare Workers: A Review

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Abstract

Respiratory illnesses are increasingly recognised as a growing concern for healthcare workers (HCWs) and patients. The recent hospital-based outbreak of Severe Acute Respiratory Syndrome (SARS) has once again highlighted the vulnerability of HCWs. The new epidemic of the 21st century resulted in tremendous economic and psychological impact with its high rates of mortality and nosocomial transmission. Even as the epidemic was brought under control within months, many details about the SARS coronavirus remained a mystery. The threat of another potential global outbreak continues to lurk in the background. Many valuable lessons have been learned through the SARS epidemic. It is, therefore, timely for us to review some of the respiratory pathogens that are well-known to cause nosocomial outbreaks. We need to be better armed to deal with future potential outbreaks and biohazardous situations. The importance of safeguarding the health of our medical staff and the community cannot be over-emphasised. In this paper, we review the incidence, transmission and various preventive strategies of respiratory illnesses in HCWs, in particular, new diagnostic tools, infection control management strategies, personal protective equipments, vaccination programmes and post-exposure prophylaxis.

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Introduction

With the recent outbreak of severe acute respiratory syndrome (SARS) and its exceptionally high transmission rate in healthcare settings, healthcare workers (HCWs) and administrators have expressed heightened concern about respiratory illnesses and their impact on health services. Some infectious diseases have long been known to pose hazards in acute-care facilities. In this review article, we address the current problems encountered in the prevention, management and control of infectious respiratory illnesses in HCWs. We will focus on the most pertinent problems: influenza, pertussis, tuberculosis (TB) and SARS.

Influenza

Influenza outbreaks in hospital settings are well-described,[1,2] and usually follow community outbreaks. The virus has a short incubation period and is readily transmitted via droplet nuclei (airborne) or person-to-person contact. The disease may not present with full clinical syndromes, but the person remains infectious and capable of spreading the illness. It tends to be more serious in the very young or elderly.[3,4] The severity of each outbreak depends on the circulating strain, the pre-existing immunity in the community and the pattern of disease. An antigenic shift can result in epidemic or pandemic infection. The pandemic of 1918 to 1919, responsible for 40 million deaths and >500 million infections worldwide, resulted in the devastating disruption of healthcare delivery in many communities. In Asia, in 1957 and 1968, the pandemics resulted in approximately 6 million deaths worldwide. It was during 1957's pandemic that the epidemiology and clinical course of nosocomial influenza were first described and documented.[5] Thus, each outbreak always results in the disruption of healthcare and community services, sometimes with overwhelming effects.

Reviews of nosocomial outbreaks estimate the HCW attack rate to be as high as 60%.[6] Moreover, HCWs are often implicated in the nosocomial spread of influenza.

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Many affected HCWs with subclinical or even full clinical syndromes continue to report to work while unwell and become a source of influenza transmission for their patients.[7,8] One outbreak involving 4 infants in a neonatal unit was traced to 4 nurses who took medical leave just before the onset of the cases.[9] Transmission via HCWs was implicated in 1 outbreak involving a nursing home.[10] Mortality rates during nosocomial outbreaks varied according to the patient population and circulating strains. The highest mortality was seen in transplant or intensive care unit (ICU) settings, with mortality rates as high as 60%.[11-13] The socio-economic impact of nosocomial influenza is also tremendous because of prolonged hospitalisation, cost of diagnostic and therapeutic interventions and HCW absenteeism.[14]

Studies have shown that hospitals where 1) there are good vaccination programmes, 2) HCWs are encouraged to report respiratory symptoms, 3) HCWs are screened for influenza, 4) and sent home if unwell, have attack rates <2%. Increased vaccination among the elderly in the community, coupled with an increase in HCW vaccination compliance rate, seem to have a positive effect on the nosocomial transmission rate of influenza.[15,16]

Large-scale vaccination of HCWs can lower the total mortality rates from 17% to 10% among nursing home patients.[13,17] Influenza vaccination has also been shown to be effective in preventing influenza in healthcare professionals and to reduce work absence and febrile respiratory illnesses.[18]

Annual influenza vaccination has been recommended by the Advisory Committee on Immunization Practices in the United States for high-risk persons and their contacts, including HCWs, since 1981. However, its use has not been universally accepted. Among HCWs, the immunisation rates range from 2% to 60%.[19-21] Some of the most commonly cited reasons for non-acceptance of the vaccine among HCWs were fear of side effects, avoidance of medications, previous reactions to vaccines, an impression of being at low risk of acquiring influenza and dislike of injections.[22] More efforts are needed to educate HCWs about the importance of influenza vaccination as vaccination is the most important first step in the prevention and control of influenza outbreaks in hospital settings and in the community. Antiviral medication and secondary control with isolation, though effective, can only serve as adjuncts in the overall management of an influenza outbreak.

Influenza vaccination has gained huge publicity in recent times because of the outbreak of SARS and new threats of avian influenza infection in humans across Southeast Asia since 2003. Even though there is no evidence of sustained human-to-human transmission of avian influenza to date, influenza viruses have the capacity to change quickly and re-assort, thereby acquiring the ability for person-to-person transmission. Thus, many governing bodies, including the World Health Organization (WHO), are advocating widespread influenza vaccination in the hope of reducing the likelihood of co-infection with humans. The emergence of a novel subtype avian influenza virus could arise with sufficient human genes, and would be easily transmitted from person to person.

Still, future research needs to focus on improving the efficacy of influenza vaccines as current vaccines have an efficacy of only 70% to 80% in young healthy adults and 30% to 40% in the elderly.[23,24] It also does not offer protection against the highly pathogenic avian influenza H5N1 subtype, which is currently responsible for large outbreaks across Asia. Influenza in Southeast Asia is not associated with seasonal peaks as in the Northern Hemisphere; hence, there is an urgent need for well-controlled prospective studies to further determine the impact of influenza vaccination in this region.[25]

Pertussis

Pertussis, caused by the gram-negative bacillus, *Bordetella pertussis*, is a highly contagious but vaccine-preventable respiratory illness. Pertussis used to be a primarily childhood disease. With the implementation of good childhood vaccination programmes, the number of severe cases, complications and deaths among young children due to pertussis has dramatically decreased over the years. However, an increased incidence of pertussis among adolescents, young adults and the elderly has been reported, and this is because vaccination does not confer lifelong immunity.[26-28] Studies suggest that approximately 12% to 26% of adults with prolonged cough have pertussis.[29-31] Infections in adults, however, often remain undiagnosed due to a low index of suspicion and its atypical presentation. Infections in adults pose a significant health hazard as they are the main source of infection for pre-vaccinated infants. Three hundred thousand children worldwide died as a result of pertussis in 2000.[32]

There are many well-described reports of pertussis outbreaks in healthcare facilities which are caused by the infection of HCWs by patients, who subsequently infect other patients. Most of these outbreaks occur in paediatric settings and long-term care facilities for the elderly or developmentally disabled.[33-35] The incidence is higher if unrecognised cases are included, as highlighted by Deville et al, who found the overall annual incidence of infection to be 33%.[36] Wright et al[37] reported the annual incidence rates of symptomatic and asymptomatic pertussis among residents and Emergency Department (ED) staff to be 1.3% and 3.6%, respectively, which is higher than that of any other vaccine-preventable disease in HCWs except for influenza.

Previously, vaccinations against pertussis were not advised for adults because of the side effects associated with whole-cell vaccines. However, since the advent of acellular pertussis (aP) vaccines, vaccine-related complications have been much reduced. There were several studies which showed that adult formulation of the aP vaccine was well-tolerated in the adolescents and young adults, whether administered alone or in combination with diphtheria and tetanus vaccines.[38,39]

To date, there is no universal routine vaccination programme implemented for all age groups. However, the European Union carries a health directive stating that all HCWs who are exposed to micro-organisms for which a vaccine is available should be vaccinated.[40] Germany recommends that HCWs working in paediatric settings and in child-care facilities be vaccinated; thus far, it is the only country to do so.[41] France has recommended that adolescents be vaccinated.[42] Recently, the Center for Disease Control and Prevention (CDC) in the United States also suggested possible vaccination of exposed HCWs, but this has yet to be finalised.

Targeted vaccination of populations at the highest risk of transmission of disease (such as childcare personnel and family) might reduce the number of pertussis cases among newborns, even if it is unlikely to have a significant impact on the overall population. HCWs would be a good target group for potential vaccination.

Secondary chemoprophylaxis with erythromycin or another macrolide has been shown to be effective in the prevention of disease in the exposed.[35] Nonetheless, it would be more cost-effective and beneficial to direct efforts towards better surveillance and preventive programmes. However, it will be desirable for us to obtain local data on the incidence and natural history of pertussis in local HCWs first before such a vaccination programme can be implemented in Singapore.

Tuberculosis

Pulmonary TB caused by *Mycobacterium tuberculosis* is an airborne infection.[43] It has been recognised as an occupational hazard for HCWs since the 1920s.[44,45] The United States saw a fierce resurgence of TB in the mid- to late 1980s with several reports of nosocomial TB outbreaks, and this resurgence was associated with the advent of the human immunodeficiency virus (HIV) epidemic.[46,47] Several studies clearly documented high tuberculin conversion among exposed HCWs. At the Jackson Memorial Hospital, Miami (with a high admission rate of TB patients), 35% of 60 employees had documented tuberculin conversion after working on a ward where a patient with an index case had been present for 57 hours.[48] The outbreak was eventually attributed to a malfunctioning air-conditioning system, which allowed re-circulation of contaminated air. In the San Diego outbreak, 14 out of 45 exposed staff showed tuberculin conversion, with the highest rate among those who were present at bronchoscopy.[49] Bronchoscopy carries increased risk: the tuberculin conversion rate was significantly higher among pulmonary fellows in training compared to infectious diseases fellows in training.[50] Another outbreak in an ED in 1983 resulted in 11 tuberculin conversions out of 112 exposed ED staff, with 5 developing active disease.[51] From 1988 to 1990, there was an outbreak of multidrug-resistant TB among patients and an increased number of tuberculin conversions among HCWs, occurring in an HIV ward at the Jackson Memorial Hospital. Several other hospitals reported similar outbreaks. The outbreaks resulted in the deaths of several HCWs and patients, with many more infected.[52-55]

At the height of the resurgence in the United States, the tuberculin conversion rate in HCWs was 3% to 5%.[56] The estimated average lifetime risk of TB infection for hospital workers occupationally exposed to TB ranges from 30 to 386 infections per 1000 workers.[57]

By 1994, the CDC had established guidelines to try to reduce the risk of nosocomial TB in acute-care facilities.[58] The control measures include 1) placing any suspected TB patient in an isolation room with negative pressure with a "respiratory precaution" sign placed on the outside of the door, 2) using respiratory protection with a particulate filter rating of N95 when entering the room and 3) reducing the concentration of *M. tuberculosis* aerosol inside the isolation room by using dilution ventilation. With the implementation of these guidelines, there has been a dramatic reduction in the number of nosocomial transmissions among patients and HCWs.[59]

Nonetheless, there remain many pitfalls in the efforts to prevent nosocomial transmission. A study comparing written procedures and actual practices in 3 Californian hospitals found large variations in day-to-day work practices.[60] Several shortcomings were identified: imperfect containment of *M. tuberculosis* aerosol in isolation rooms due to lack of negative pressure, failure to ensure performance of engineering controls, failure to verify the underlying assumptions of the TB control plan and improper use of respirators.[60] Another study found a median delay of 3 to 5 days in the isolation of culture-proven TB cases, with the majority of patients having smear positivity. The delay was a result of insufficient isolation facilities and a failure to suspect TB.[61]

It is, therefore, important to maintain frequent surveillance of HCWs, especially in high-risk wards, and have up-to-date education in TB control policies and practices. Effective prevention will also require HCWs to be vigilant in identifying, isolating and treating patients with active TB.

Hospitals should enforce strict isolation of all suspected persons with pulmonary TB until smear negativity is confirmed to minimise HCWs' exposure to active pulmonary TB patients.

The prolonged duration of therapy necessary to achieve cure highlights the urgent need for more research work in this area. Cost-effective management of TB control in the future clearly requires much improvement in our understanding of TB transmission, treatment and mechanism of drug resistance.

Severe Acute Respiratory Syndrome

SARS has emerged as a new respiratory illness. It is caused by a novel corona virus[62,63] and is associated with substantial morbidity and mortality. The epidemiology and clinical spectrum of SARS have been described extensively in recent literature.[64,65] With respiratory droplets and bodily excretions being the main mode of transmission, there is a high risk of SARS transmission in the hospital setting, as HCWs are in close contact with patients and deal with body fluids constantly. In Hanoi, where the epidemic was first reported, the disease was noted to have an alarmingly high rate of transmission among HCWs at 63% of cases and in Hong Kong, at 46% of cases. In Singapore, surveillance indicated that 76% of infections were acquired in a healthcare facility and a similarly high rate of transmission was observed in Toronto.[66,67] In Taiwan, there was an accelerated SARS transmission and outbreak within the healthcare facilities as a result of 1 infected hospital employee. This resulted in a total of 137 probable cases associated with exposure at hospital A and secondary clusters at another 8 hospitals.[68]

The disease was eventually contained by strict adherence to infection control practices. Infection control practices include pre-exposure infection control training, droplet and contact precautions (masks, gowns, gloves and eye protection); these were shown to effectively reduce transmission in hospitals and in the community.[69-71]

In Singapore, we adopted a strategy involving: the active fever surveillance of all HCWs (and immediate isolation of febrile HCWs); the designation of a SARS hospital and SARS ambulances; Ministry of Health-endorsed home quarantine orders for exposed asymptomatic individuals; the active surveillance of patients discharged from a SARS hospital for 14 days; and proactive media broadcasting to increase public awareness of the disease and its preventive measures.[72,73]

Currently, we still have no reliable early diagnostic tool for SARS. HCWs have to continue to be aware − and suspicious – of all patients with signs and symptoms of respiratory tract illnesses, especially if there is a cluster of 2 or more HCWs in the same healthcare unit with symptoms of fever and lower respiratory tract infections.

Outbreak of SARS can still re-emerge from unidentified animal reservoirs or from persistently infected humans or laboratory lapses.[74,75] We have to rely on the vigilant application of clinical and epidemiologic criteria to evaluate clusters of febrile illnesses amongst HCWs and within the community, and swift public health response to this disease must be applied if and when the need arises.[76]

Conclusion

Valuable lessons can be learned from the SARS experience and these should be applied not only to the management of SARS, but also to other hospital-acquired respiratory illnesses. The spread of the respiratory illnesses described above can be prevented by simple barrier nursing methods. Active surveillance needs to be in place to identify clusters of febrile illnesses. The emphasis is on early identification of contagious respiratory illnesses in order to control their spread and, therefore, aggressive diagnostic measures should be in place. Although expensive, nasopharyngeal aspirates/throat swabs for respiratory viral immunofluorescence, baseline serologies for atypical bacterial infections and rapid molecular testings should be considered for all patients admitted with influenza-like illnesses (ILI) or atypical pneumonia.

For influenza, diagnosis relies on culturing the virus from respiratory secretions or by more rapid diagnostic tests using antigen detection, neuraminidase enzymatic activity or viral ribo nucleic acid (RNA) by reverse transcription-polymerase chain reaction (RT-PCR).[77-79] For pertussis, diagnosis is known to be difficult, but serology should be done if diagnosis is suspected.[80] Early diagnostic tools remain elusive for SARS and, therefore, isolation remains paramount until the diagnosis (or an alternative diagnosis) can be established.

All patients with ILI should be placed on droplet precautions and visitors with ILI symptoms discouraged from visiting patients. Ill HCWs must be restricted from working when symptomatic and once a cluster of respiratory illness occurs, steps must be implemented to identify the cause and prevent transmission.

More education amongst HCWs is urgently needed to raise the awareness that many of these diseases are vaccine-preventable. Vaccines against influenza and pertussis have proven to be efficacious in reducing the incidence of disease outbreaks. Regular tuberculin skin testing is advisable among HCWs (particularly those working in "high-risk" work areas such as the mycobacteriology laboratory and bronchoscopy suites) to identify new tuberculin converters, and isoniazid prophylaxis instituted when appropriate.

Research should be targeted at identifying distinctive

clinical and laboratory features of other respiratory diseases, as well as improving current early diagnostic tools. Hospital surveillance should be extended to all respiratory diseases amongst HCWs. Training for all HCWs on infection control precautions should be revisited on a regular basis. Pre-employment health screenings should incorporate education on vaccine-preventable diseases amongst HCWs.

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