Occupational Respiratory Infections

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Introduction

Occupational lung diseases caused by exposures to gases, chemicals, and dusts at work have been long recognized. However, recent experiences with occupationally acquired respiratory infections including Middle East respiratory syndrome coronavirus (MERS-CoV), influenza, measles, and coronavirus disease 2019 (COVID-19) have highlighted the importance of understanding transmission of respiratory infections in the workplace [1–3]. Workplace exposures have been demonstrated to contribute substantially to the burden of community-acquired pneumonia, with an occupational population attributable fraction as high as 10% in one recent review [4]. Any infectious agent that is transmitted by airborne particles or by droplets can be acquired in the workplace [5]. Occupational respiratory infections can be caused by bacterial, viral, and fungal pathogens. Transmission in occupational settings can occur from other humans (such as co-workers or patients), animals, or the environment and occur in various occupations and industries. Factors that can facilitate transmission of infectious pathogens in the workplace include disease factors (such as mode of transmission), workplace factors (such as workplace conditions or work practices), and worker factors (such as impaired immunity) [6].

Occupational health and safety specialists have long used the hierarchy of controls [Figure 1] as an approach to determine how to implement feasible and effective control solutions, and this can be applied to infectious agents [6,7]. Elimination (removing the hazard) and

substitution (replacing the hazard) are the most effective ways to reduce occupational hazards but can be difficult to implement for infectious agents. Engineering controls are physical changes to work processes to remove the hazard or place a barrier between workers and hazards. They can effectively protect workers without placing the primary responsibility of implementation on the worker. Ventilation is the most common engineering control, especially for airborne pathogens. Administrative controls are methods that change the way the work is performed such as triaging and isolating ill patients or influenza vaccination of workers. Their effectiveness depends on the availability of the control and worker acceptance and commitment. Finally, use of personal protective equipment (PPE) provides a physical barrier between the worker and the hazard. PPE is considered the least effective control measure because it requires a comprehensive program and a high level of worker involvement and commitment for proper use [7].

The National Institute for Occupational Safety and Health (NIOSH) Health Hazard Evaluation (HHE) program responds to requests from workers, employers, and public health agencies and conducts investigations of hazards, including infectious diseases, that occur in workplaces [8]. In this paper, we describe four occupationally acquired respiratory infections at the focus of NIOSH investigations over the last decade: tuberculosis (TB), influenza, coccidioidomycosis, and psittacosis [9–14]. We describe their epidemiology, clinical manifestations, occupational risk factors, and prevention measures according to the hierarchy of controls. These examples demonstrate the breadth of infectious pathogens (bacterial, viral, and fungal) and transmission (from human, animals, and the environment) in the workplace.

Tuberculosis

Tuberculosis (TB) is caused by *Mycobacterium tuberculosis*, an acid-fast bacillus that is most often transmitted from person to person through the air in contaminated respiratory droplets. These droplets can dry into tiny particles called droplet nuclei that remain suspended in air for long periods of time. Pulmonary TB often presents with a prolonged cough of 2 or more weeks' duration. While pulmonary TB is the most common form of disease, TB disease can affect other organs, such as the larynx, abdomen, meninges, and spine. Patients with TB disease involving any organ system often have non-specific symptoms such as fatigue, weight loss, loss of appetite, chills, and night sweats. While some people become ill with TB disease soon after inhaling droplets contaminated with *M. tuberculosis*, most do not. Approximately 20–30% of contacts develop latent TB infection (LTBI), infection with *M. tuberculosis* [15,16]. Persons with LTBI are not infectious, and most persons with LTBI will have positive tests for TB infection (i.e., the tuberculin skin test [TST] or an interferon-gamma release assay [IGRA]). Treating LTBI is an effective way of preventing symptomatic, potentially contagious TB disease [17,18]. Overall, among untreated persons with LTBI, approximately 5–10% will develop symptomatic TB disease during their lifetimes; approximately half of those who develop TB disease will do so within 2 years of initially becoming infected with *M. tuberculosis* [15,16]. The risk for progression from LTBI to TB disease is markedly higher among persons living with HIV, young children <5 years old, and persons with certain immune-suppressing medical conditions or those taking certain immune-suppressing medications [15].

TB is extremely common worldwide; approximately one-fourth of the world's population is thought to have LTBI and approximately 10 million became ill with TB disease during 2018 [19]. In the United States, TB incidence is very low; overall LTBI prevalence has been estimated at approximately 5%, and 9,025 TB cases were reported during 2018, a 73% decline compared with 1991 [16,17]. Just as is the case globally, TB is unevenly distributed in the United States; since 2001, most cases have occurred in persons born outside of the United States in countries with comparatively higher TB incidence [20]. Many cases among non-US-born persons likely represent infection acquired outside the United States in the remote past [16]. TB in the United States also disproportionately affects people experiencing homelessness, incarcerated persons, and persons with weakened immune systems [16,20].

To maximize the predictive value of tests for TB infection and focus resources on evaluating and treating persons at-risk for LTBI and TB disease given the relatively low LTBI prevalence and TB incidence in the United States, CDC recommends testing only for persons with TB symptoms, epidemiologic risk factors for LTBI (e.g., birth in a country with higher TB incidence), or medical risk factors for progression to TB disease [17,21]. To evaluate for TB disease, medical providers should perform a thorough diagnostic evaluation on all persons with positive tests for TB infection; this diagnostic evaluation should include a medical history and physical exam, chest radiography, and, in certain circumstances, acid-fast bacilli (AFB) smear microscopy, culture, and nucleic acid amplification tests [22].

M. tuberculosis transmission is possible in any workplace with contagious persons; workplace-associated transmission has been described in healthcare settings such as hospitals, long-term care facilities, and laboratories [8, 24, 24], correctional facilities [25], homeless shelters [26], and even a refuge and zoo that housed elephants [11, 27]. When pulmonologists or occupational medicine or practitioners or other healthcare providers identify workers with TB symptoms, they should collaborate with local and state public health programs to facilitate prompt TB diagnoses among workers. These collaborations should also facilitate worksite-based contact investigations, focused efforts to identify persons exposed to infectious TB, so that they can be tested and treated for LTBI and TB disease [15]. Public health programs can use clinical, epidemiologic, and molecular data to determine whether LTBI and TB diagnoses among workers represent a cadre of workers with a high prevalence of risk factors for LTBI and TB disease or a workplace with *M. tuberculosis* transmission.

M. tuberculosis transmission in healthcare settings deserves special attention. Healthcare-associated transmission used to be common, and LTBI prevalence among healthcare workers was higher than the overall population [28]. Recognizing the importance of preventing healthcare-associated transmission, CDC has published guidelines for preventing *M. tuberculosis* transmission in healthcare settings since the 1980s [23]. The most recent version of these guidelines, published in 2005, promotes three categories of infection control measures: administrative, engineering (or environmental), and respiratory protection. The occupational health and safety hierarchy of controls typically prioritizes engineering controls over administrative controls. However, for tuberculosis, administrative controls, which are designed to reduce the risk of exposures to infectious TB, are prioritized over engineering controls and are the foundation of TB infection control and prevention strategies

[23]. Examples of TB prevention measures according to the hierarchy of controls are shown in Table 1.

In the context of declining overall TB incidence in the United States, limited specificity of TSTs and IGRAs, and no TB cases identified in large cohorts of healthcare workers despite widespread routine testing, the Centers for Disease Control and Prevention (CDC) amended guidance for TB screening, testing, and treatment of healthcare personnel in 2019 [29]. Table 2 depicts the amended guidance for testing of healthcare workers alongside the 2005 guidance. In the absence of ongoing transmission or exposure to infectious TB, CDC no longer recommends serial testing of healthcare personnel for LTBI or TB disease [29]. Current guidance recommends baseline screening for all healthcare personnel; screening includes assessing for TB symptoms, assessing for LTBI and TB risk factors, and performing a test for TB infection [29]. Those with positive tests should have a thorough diagnostic evaluation for TB disease; healthcare personnel with LTBI should be encouraged to take LTBI treatment to prevent TB disease unless medically contraindicated. Using the same test for TB infection (i.e., a TST or IGRA) helps facilitate results interpretation for individuals and making inferences about whether transmission is occurring among cohorts of workers [29]. Recommendations regarding other aspects of infection control and prevention in healthcare settings remain unchanged from the 2005 guidelines [23].

Influenza

Influenza infections are thought to spread mainly through droplet transmission though evidence for airborne transmission and transmission via direct contact also exists. Seasonal and pandemic influenza are important causes of morbidity and mortality in humans. Transmission occurs mostly from human to human. However, swine and poultry are two key reservoirs of influenza viruses and cause zoonotic infection. Influenza A viruses cause the most morbidity in both humans and animals among influenza viruses [30]. CDC has estimated that the number influenza-related illnesses that have occurred during influenza season in the United States has ranged from 9.2 million to 35.6 million, including 140 000 to 710 000 influenza-related hospitalizations [31]. The seasonal incidence of symptomatic influenza has been estimated at 8.9% for adults aged 18–64 years [32].

Symptoms of influenza infection include fever, cough, sore throat, runny or stuffy nose, body aches, headache, chills, and fatigue. Some patients have vomiting and diarrhea, while others have respiratory symptoms without a fever. Influenza illness can range from mild to severe. Health conditions known to increase the risk of serious complications from influenza include pregnancy, asthma and other chronic lung disease; diabetes mellitus; heart, neurologic, and kidney disease; and immunocompromising conditions [33].

Healthcare personnel are considered to be at risk for influenza infections from both seasonal and pandemic influenza through exposure to patients with influenza and may also transmit influenza to patients and other healthcare personnel [33]. A meta-analysis of 15 studies demonstrated a significantly increased odds for influenza A (H1N1) for healthcare personnel (odds ratio: 2.08, 95% confidence interval: 1.73, 2.51) during the 2009 H1N1 influenza epidemic [34]. Influenza has caused outbreaks of severe respiratory illness in

hospitals and long-term care facilities [35]. For pandemic influenza, the Occupational Safety and Health Administration (OSHA) considers healthcare personnel performing aerosol-generating procedures on known or suspected influenza patients and laboratory personnel handling specimens from these patients to be at very high exposure risk. Other healthcare personnel involved in healthcare delivery and support or transport are considered at high exposure risk. Workers with high-frequency contact with the general population such as those in schools, high population density work environments, and some high volume retail settings are considered at medium exposure risk [36].

Studies have shown that occupational risk factors have been associated with infection among healthcare personnel including job type (i.e., physicians and nurses), number of patient contacts, vaccination history, inadequate hand hygiene, and inadequate PPE use [34]. These occupational risk factors highlight the need for comprehensive infection prevention strategies in healthcare settings. Institutional strategies, primarily engineering and administrative controls, to prevent transmission of influenza among healthcare personnel and patients are shown in Table 1 [37,38].

Employer influenza vaccination requirements are associated with higher coverage rates, and, though controversial, mandatory influenza vaccination is supported by many healthcare personnel and multiple healthcare professional societies [39–41]. Mandatory influenza vaccination is increasingly common in healthcare settings, and multiple states have established influenza vaccination requirements for hospital healthcare personnel [42]. However, concerns have been raised related to the variable effectiveness of the vaccine and the ethical and legal impact of these policies [42–44]. The duty of healthcare personnel to protect the health of individual patients and the public competes with their right to personal autonomy. Mandates also invoke legal issues, including the applicability of state and federal constitutional laws and statutes [42–44].

Provision of appropriate PPE with adequate training and an expectation of consistent use may also prevent transmission of influenza to healthcare personnel (Table 1) [38]. N95 filtering facepiece respirators have been demonstrated to have a protective advantage over surgical masks in laboratory settings [45]. However, two meta-analyses and multiple newer studies have concluded mixed results about the difference between surgical masks and N95 respirators in the incidence of laboratory-confirmed influenza, influenza-like illness, and acute respiratory infection [45–48].

Animal workers have also been shown to be at higher risk for zoonotic transmission of influenza viruses. Influenza transmission from pigs was first recognized during the Spanish influenza pandemic of 1918–1919 [49]. Swine farmers, swine production workers, veterinarians, and meat processing workers have been shown to have higher risk of infection from swine influenza virus [50,51]. In addition, there is significant evidence of zoonotic transmission of avian influenza viruses from birds to humans with the 1997 outbreak of human H5N1 infections in Hong Kong and the 2013 outbreak of human H7N9 infections primarily in China [2]. H7 and H5 strains are the avian influenza viruses that have most commonly infected humans and often cause severe disease after exposures to infected or dead birds [30]. Poultry farmers and cullers, veterinarians, commercial poultry workers,

and poultry vendors at live animal markets are considered at higher risk of infection with avian influenza viruses [3,28,30]. Poultry contact involving mass culling during outbreaks, slaughtering and preparing of ill or deceased birds, and burial of carcasses have been implicated as modes of transmission [3]. More recently, transmission of influenza A (H7N2) infection has been documented from felines to humans in a city animal shelter [52,53].

Measures to prevent animal-to-human transmission of influenza involves a OneHealth approach that includes comprehensive biosecurity and biosafety measures and training at the farms, processing plants, and live markets, surveillance for influenza viruses, culling infected animals, and vaccination of poultry and swine [29,31]. Strategies to minimize risk among individual workers include training on their risk and preventive measures, annual influenza vaccination, and appropriate hand hygiene (Table 1) [2,51].

Coccidioidomycosis

Coccidioidomycosis, also known as Valley fever, is caused by inhalation of spores of the fungus *Coccidioides* spp., which grows in soil in semiarid areas. The infection is an example of transmission from the environment, and it is not generally spread from to person to person, or from animals to people. Coccidioidomycosis is endemic in the southwestern United States, particularly parts of Arizona and California, Mexico, and parts of Central and South America [54]. During 2011–2017, a total of 95,371 cases of coccidioidomycosis were reported to CDC from 26 states and the District of Columbia, with >95% of cases reported from Arizona and California [55]. An estimated 150,000 new infections occur annually in the United States [56] though only approximately 10,000 cases are reported annually, suggesting that the disease is greatly underdetected and underreported [57].

About 60% of coccidioidomycosis infections are asymptomatic [54]. People who develop symptoms, typically after a 1–3 week incubation period, may experience a flu-like illness. The infection can be clinically indistinguishable from community-acquired pneumonia caused by other pathogens, which can lead to inappropriate treatment [55]. A small percentage of infected persons (< 1%) may develop widespread disseminated infection [54]. People at greater risk for developing disseminated infection include people of African American and Asian (particularly Filipino) descent, pregnant women during their third trimester, and immunocompromised persons [54]. Coccidioidomycosis has been shown to be costly and debilitating, with nearly 75% of patients in whom the disease has been recognized missing work or school because of their illness and more than 40% requiring hospitalization [58].

This disease has important occupational risk factors. First, laboratory-acquired coccidioidomycosis has been documented, mostly arising from accidental laboratory exposure to *Coccidioides spp.* [59,60]. Second, environmental exposures exist through disruption of soil or strong dust-raising winds, which can aerosolize spores. Therefore, in *Coccidioides*-endemic areas, persons who work outdoors are at particular risk for coccidioidomycosis when their duties include soil-disruptive work or when working in dusty or windy conditions. Workers in endemic areas involved in soil disturbance, including but not limited to agricultural, construction, and archeological workers, military personnel,

and workers in mining, quarrying, and oil and gas extraction industries have been shown to be at higher risk for coccidioidomycosis [6,62]. A review of 47 coccidioidomycosis outbreaks during 1940–2015 revealed that 25 (53%) were associated with occupational exposures, including the military, construction, archaeology or other field studies, and laboratory activities [63]. Clusters of infections have also been found among employees and inmates at state prisons located in endemic areas [11,64]. Another paper reviewed four occupational coccidioidomycosis outbreaks from 2007–2014 in California, involving construction workers in a number of excavation projects and an outdoor filming event involving cast and crew [65]. It is important that healthcare providers consider a diagnosis of coccidioidomycosis in patients who live or work in or have traveled to areas with known geographic risk for *Coccidioides*.

The four occupational outbreaks in California illustrated multiple factors that facilitated transmission including operating heavy equipment without enclosed cabs or closed windows, inconsistent soil-wetting practices, little or no risk communication to workers, and infrequent use of respiratory protection [65]. Reducing the risk of coccidioidomycosis among workers in endemic areas can be accomplished through the hierarchy of controls approach (Table 1) [65]. However, the efficacy of engineering and administrative methods in preventing infection can be difficult to measure [63]. In addition, prevention can be challenging because of the limited understanding of the distribution of *Coccidioides* spp. in the environment, the effect of weather patterns, and the effectiveness of environmental mitigation efforts and respiratory protection [55,63]. In 2019, the state of California recently passed a bill requiring construction employers in highly endemic areas to provide awareness training on coccidioidomycosis for employees [66].

Psittacosis

Psittacosis refers to human infection by the bacteria *Chlamydia psittaci*. Psittacosis is most commonly associated with atypical pneumonia but can cause manifestations in multiple organ systems, including hepatic, central nervous system, cardiac, renal, and rheumatic disease [67]. Patients may develop mild illness with abrupt onset of fever, chills, headache, malaise, and myalgia after an incubation period of 5–14 days [68]. Dry cough is often present. Although rare, severe illness can occur [69]. *C. psittaci* can infect birds, humans, and other mammals; most human infections occur from exposure to infected birds, such as psittacines, pigeons, or poultry [70]. Eighteen psittacosis outbreaks were investigated by the Centers for Disease Control and Prevention's (CDC's) Epidemic Intelligence Service officers during 1946–2005. Of those, pet psittacine birds and turkeys were identified as frequent causes of outbreaks, affecting psittacine bird handlers and workers in turkey processing plants [71].

C. psittaci is transmitted to humans through inhalation of aerosolized dried droppings or secretions of infected birds [68]. Transmission can also occur through direct contact with feathers, tissues, secretions of infected birds, or by mouth-to-beak contact [68, 70]. Human-to-human transmission has been reported but is thought to be rare [69]. Workers in occupations that involve contact with live birds or bird carcasses, such as veterinarians [72], bird breeders [73], poultry handlers [14,74,75] and pet shop workers [76], are at increased

risk of infection. Prevention can be challenging, as infected birds may be asymptomatic or have few signs of illness [70]. Stress factors, such as transportation, relocation, crowding, injury, and illness may exacerbate shedding from infected birds [68,77]. Additionally, workers who develop psittacosis may remain undiagnosed because symptoms are often mild and non-specific and patients may not seek medical care. Moreover, the widely-available serologic test for psittacosis diagnosis requires acute and convalescent serum samples collected a few weeks apart, and can cross-react with other *Chlamydia* species [68]. Currently in the United States, a real-time polymerase chain reaction assay for human specimens (more sensitive and specific than serology) is only available at CDC [68]. Psittacosis is a reportable condition in most jurisdictions in the United States, and cases are voluntarily reported to CDC. However, during 2008–2017, only 60 cases (6 cases per year on average) were reported [78], which likely represents under detection.

Exposure to *C. psittaci* in the workplace varies by occupation. The Occupational Safety and Health Administration does not have a workplace standard for *C. psittaci* exposure [79]; however, professional organizations provide recommendations to prevent transmission to humans [68]. Basic principles can be categorized following a hierarchy of controls to prevent occupational exposures to *C. psittaci* (Table 1). These include quarantine procedures of newly acquired birds or birds exposed to ill birds and other animal husbandry practices.

A Re-emerging Occupational Respiratory Infection

Several studies have shown increased risk of pneumonia (defined as bacterial, lobar, and pneumococcal) and mortality among welders and other workers exposed to metal fumes and mineral dusts [80–86]. A recent review demonstrated that the median population attributable fraction was 10% for the occupational burden of pneumonia. The review also demonstrated that metal fumes/welding exposures had a median occupational attributable fraction of community-acquired pneumonia of 52% in cohort studies [4]. Several hypotheses have been posed that might explain this increased occupational risk. Theories have included that metal fumes (or iron) act as a growth nutrient for bacteria, enhance the binding of bacteria to lung tissues, or impair immune responses in the lung through oxidative stress [84–87]. Therefore, it is hypothesized that the occupational risk of this infection is not primarily from exposures to the pathogen at work but rather that the occupational exposure (metal fumes) is a risk factor for infection and subsequent disease. While further research is needed to establish this association and quantify the dose response relationship, a preventive approach using the hierarchy of controls has already been implemented at workplaces and corporations in some countries, including the United Kingdom. Engineering controls have consisted of methods to minimize fume inhalation through local exhaust ventilation. Administrative measures have included offering welders the 23-valent pneumococcal polysaccharide vaccination and cleaning workpieces to remove contaminants prior to welding [88,89].

An Emerging Occupational Respiratory Infection

In the United States, SARS-CoV-2, the novel coronavirus that causes coronavirus disease 2019 (COVID-19), was first detected during January 2020 [90]. Since then, >2.1 million cases have been reported in the United States, including >116,000 associated deaths as

of June 17, 2020 [91]. Data suggest that close-range aerosol transmission by droplet and inhalation, and contact followed by self-delivery to the eyes, nose, or mouth are likely routes of transmission [92]. Transmission by asymptomatic and presymptomatic individuals has been described [93–95].

In their occupational risk pyramid similar to the one for influenza, OSHA has divided jobs into four risk exposure levels for COVID-19: very high, high, medium, and lower risk. These categories are based on the industry type and the need for contact within 6 feet of people with suspected or confirmed COVID-19 [96] and form the basis of recommendations for preventing transmission in the workplace. Healthcare personnel are considered to be at very high or high risk of exposure [96]. Characteristics of healthcare personnel with COVID-19 reported to CDC from February 12–April 9 have been summarized [97]. As of June 17, more than 78,000 COVID-19 cases and 422 deaths have been reported among healthcare personnel [91]. In first several months of the COVID-19 pandemic, COVID-19 outbreaks have occurred in several types of medium risk and high risk workplaces, including long-term care facilities, meatpacking plants, correctional facilities, and homeless shelters [95, 98–101]. Efforts to characterize the occupational burden of COVID-19 are ongoing, and prevention measures in workplaces have emphasized the use of engineering and administrative controls and personal protective equipment.

Conclusions

Emerging and re-emerging work-related infectious diseases will continue to threaten workers' health. It is important for clinicians to recognize that respiratory infections can be occupationally related. Communication and cooperation between clinicians and public health practitioners is important to identify work-related clusters of respiratory infections. Considering occupational risk factors and controlling exposures among workers according to the hierarchy of controls will help prevent disease transmission in the workplace.

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Key Points

- Workers in specific settings are at increased risk for occupational respiratory infections, including tuberculosis, influenza, coccidioidomycosis, psittacosis, and other bacterial pneumonia

- Clinicians should recognize that respiratory infections can be occupationally acquired.

- Considering occupational risk factors for infection such as workplace factors and worker factors can help in implementing prevention and control strategies.

- Controlling exposures among workers according to the hierarchy of controls will help prevent disease transmission in the workplace.

Synopsis

Occupational respiratory infections can be caused by bacterial, viral, and fungal pathogens. Transmission in occupational settings can occur from other humans, animals, or the environment and occur in various occupations and industries. In this paper, we describe four occupationally-acquired respiratory infections at the focus of NIOSH investigations over the last decade: tuberculosis (TB), influenza, psittacosis, and coccidioidomycosis. We highlight the epidemiology, clinical manifestations, occupational risk factors, and prevention measures.
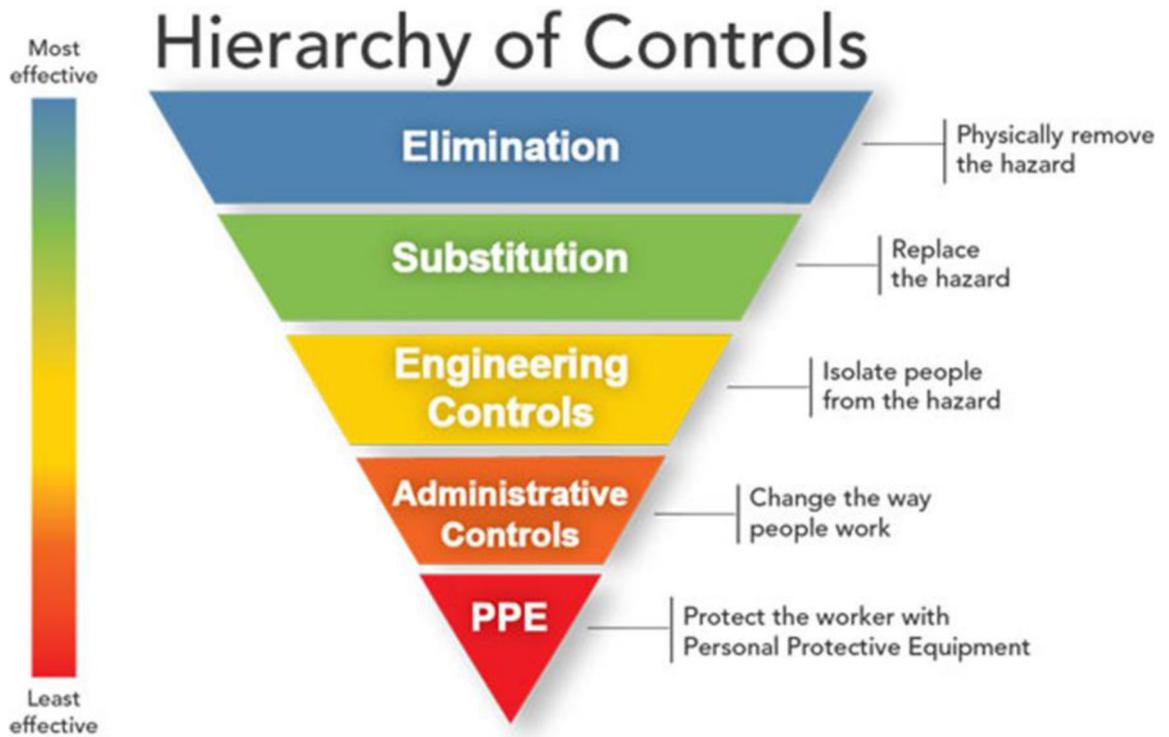
Figure 1.
Hierarchy of Controls

Table 1.

Occupations at risk and examples of prevention measures according to the hierarchy of controls

	Tuberculosis[a]	Influenza	Coccidioidomycosis	Psittacosis
Example Occupations at Risk	Healthcare personnel Laboratory workers Correctional workers Homeless shelter workers	Healthcare personnel Swine and poultry farmers Veterinary personnel Meat processing workers	Agricultural workers Construction workers Archeological workers Military personnel Laboratory workers	Veterinary personnel Bird breeders Poultry processing workers Pet shop workers
Control Type				
Elimination/ Substitution	Exclusion of infectious workers	Exclusion of ill workers from work Biosecurity/biosafety measures at farms, plants, live markets	Reduction in grading or need for trenching of land	Quarantine of newly acquired birds or birds exposed to ill birds Isolation of ill birds
Engineering Controls	General ventilation to reduce concentrations in air Airborne infection isolation rooms (AIIRs) High efficiency particulate air (HEPA) filtration Ultraviolet germicidal irradiation (UVGI)	Partitions in triage areas Maintenance of air-handling systems Closed suctioning systems for airway suction Use of AIIRs for aerosol generating procedures	Frequent, effective soil wetting Use of enclosed cabs Planting of vegetation, ground cover	Exhaust ventilation Cleaning/disinfection of cages Repair of malfunctioning tools
Administrative Controls	Written TB control plan Prompt identification, isolation of persons with TB disease Treatment of TB disease and latent TB infection TB screening of exposed or at-risk workers Thorough and efficient contact investigations	Influenza vaccination Non-punitive sick leave policies Infection prevention training Triage, isolation of infectious patients Hand hygiene Cull infected animals	Suspension of work during excessive dust/wind Training workers about risks, symptoms Have onsite monitoring personnel to implement additional control measures	Maintain accurate records of bird-related transactions Good animal husbandry practices Educating workers about risks Hand hygiene Appropriate cleaning, disinfection protocols for cages
Personal protective equipment	Airborne precautions Use of NIOSH-approved filtering facepiece respirators[b]	Droplet precautions: surgical masks Standard precautions: gowns, gloves as needed Use of NIOSH-approved filtering facepiece respirators[b] for aerosol generating procedures and for novel strains	Use of NIOSH-approved filtering facepiece respirators[b] for workers at high risk of exposure	Use of NIOSH-approved filtering facepiece respirators[b] for workers at high risk of exposure (ie. handling ill birds or cleaning cages) Gloves, eye protection as needed based on job duties

[a] For the hierarchy of controls for tuberculosis, administrative controls take priority over engineering controls.

[b] Respirators for employees must be used within an Occupational Safety and Health Administration (OSHA) compliant respiratory protection program that includes medical clearance, fit testing, training, and procedures for disposing, cleaning, and maintaining respirators

Table 2.

CDC recommendations for tuberculosis screening, testing, and treatment of U.S. healthcare personnel[a]

Category	2005 Recommendations[23]	2019 Recommendations[29a]

Baseline (preplacement) screening and testing	• Symptom evaluation
	• Test for TB infection (e.g., TST or IGRA) for those without documented history of TB disease or LTBI[b]
		• Symptom evaluation
		• Test for TB infection (e.g., TST or IGRA) for those without documented history of TB disease or LTBI[b]
		• Individual risk assessment[c]
		  ○ Previous residency ≥1 month in country with high TB rates[d]
		  ○ Current or planned immune suppression[e]
		  ○ Close contact with someone with infectious TB

Serial screening and testing for healthcare personnel without LTBI	Varies according to facility and setting risk assessment
	• Potential for ongoing transmission:
	  ○ Test for TB infection every 8–10 weeks until effective infection controls implemented and no additional evidence for ongoing transmission
	• Medium risk:
	  ○ Annual symptom evaluation
	  ○ Annual test for TB infection
	• Low risk:
	  ○ None in the absence of exposure to *M. tuberculosis*
		Not routinely recommended except for:
		• Selected groups who might be at increased occupational risk of exposure (e.g., pulmonologist or respiratory therapists)
		• Certain settings if transmission has occurred in the past (e.g., selected emergency departments)
		• Contact investigations[f]
		• Exposure to infectious TB outside of workplace
		• Evidence for ongoing TB transmission[f]

Annual TB education for healthcare personnel	Recommended	Recommended, with emphasis on: • Risk factors • Signs and symptoms of TB • Discussing occupational and nonoccupational TB exposures with primary care and occupational health providers as soon as practical after exposure
Evaluation and treatment of positive test results	Referral to determine whether LTBI treatment is indicated	Encouraged for all with untreated LTBI unless medically contraindicated

Abbreviations: TST, tuberculin skin test; IGRA, interferon-gamma release assay; TB, tuberculosis; LTBI, latent tuberculosis infection

[a] Recommendations outside of the scope of healthcare personnel screening, testing, treatment, and education, including facility risk assessments for guiding infection control policies and procedures, remain unchanged from the 2005 guidelines.[23,29]

[b] Asymptomatic healthcare personnel who have positive tests, are unlikely to be infected with M. tuberculosis, and are at low risk for progression on the basis of their risk assessment should have a second test (either an IGRA or a TST) as recommended in the TB diagnostic guidelines of the American Thoracic Society, Infectious Diseases Society of America, and CDC.[22] These healthcare personnel should be considered infected with *M. tuberculosis* only if both the first and second tests are positive.

[c] CDC's Health care personnel baseline individual TB risk assessment found at: https://www.cdc.gov/tb/topic/infectioncontrol/pdf/healthCareSettings-assessment.pdf

[d] This includes any country other than Australia, Canada, New Zealand, the United States, and those in western or northern Europe.

[e] Includes human immunodeficiency virus (HIV) infection, receipt of an organ transplant, treatment with a TNF-alpha antagonist, chronic steroids (equivalent of prednisone ≥15 mg/day for ≥1 month), or other immunosuppressive medication.

[f]Consultation with the local or state health department is encouraged in making these determinations.