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# The Impact of Occupational Environmental Conditions on Tuberculosis Incidence Among Healthcare Workers

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## *ABSTRACT*

***Background**: Although environmental conditions in healthcare settings are recognized as causative factors of occupational diseases among healthcare workers, the specific relationship remains poorly understood. This systematic review synthesized evidence from the past five years on the influence of workplace environmental factors on the incidence of tuberculosis (TB) among healthcare workers (HCWs). **Methods**: A systematic literature search was conducted in PubMed, ProQuest, Google Scholar, and Springer for articles published between 2018 and 2023. The search used English keywords including "Environment," "Hygiene," "Occupational Health," "Health Workers," and "TB." The included articles were fully accessible, published in English, and were primary research or reviews whose main findings were related to hospital environmental conditions (e.g., ventilation, air quality, room temperature) and occupational health of HCWs. Study selection followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, and the included studies underwent a quality assessment process. **Results**: From the initial results of 58,023 articles, 11 met the inclusion criteria for analysis. Key findings identified inadequate ventilation, poor air circulation, and suboptimal room temperature control as critical environmental risk factors. These conditions are consistently associated with increased transmission and incidence of TB among healthcare workers, underlining the importance of engineering controls in the work environment. **Conclusions**: The evidence confirms that the working environment in the health sector is an important determinant in TB transmission at work. These findings highlight the urgent need to strengthen environmental controls, such as ventilation systems, combined with strong organizational policies, to protect healthcare workers and promote safer healthcare systems.*

**Keywords:**
*Environmental Hygiene And Occupational Health Workers And TB*

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## Introduction

The ILO estimates that there are 160 million cases of non-fatal work-related illnesses each year. This means that daily, about 6,400 people die from work-related accidents or illnesses, while 860,000 sustain injuries at work. These figures reveal that occupational diseases cause nearly six times more deaths than workplace accidents, emphasizing the need to shift prevention efforts to include occupational illnesses alongside injuries. Similarly, data from the Health and Safety Executive (HSE) indicate that 1.6 million workers suffer from work-

related diseases, with 30% of them experiencing significant impacts. Work-related musculoskeletal disorders (WRMSDs) have led to as many as 8.9 million work absences (Health and Safety Executive, 2019; Tutu, 2022). Another significant risk is tuberculosis (TB) among healthcare workers, who face a risk of contracting TB that is three times higher than the general population, increasing up to six times in areas with greater access to healthcare services, higher HIV/AIDS cases, and multidrug-resistant TB (MDR-TB) (Angelia et al., 2020). The current safety culture in healthcare facilities and the attitudes of healthcare workers towards TB have contributed to delays in diagnosis and treatment. Despite a 22% reduction in TB mortality between 2000 and 2015, TB remains the 10th leading cause of death worldwide (Angelia et al., 2020). The lack of clear data on active and latent TB cases among healthcare workers suggests underreporting and a potential concealment of TB incidence in this group. Without adequate government protection to prevent TB transmission, the healthcare workforce may decline, worsening TB rates in Indonesia (Anggraini et al., 2022).

Research at H. Adam Malik General Hospital in Medan found that 53% of 100 healthcare workers tested positive for latent TB via tuberculin tests, with risk factors including being over 35 years old, long working hours, and exposure to TB patients (Anggraini et al., 2018). The high prevalence of latent TB among healthcare workers is linked to widespread community and healthcare facility TB infections, as many patients seek treatment there. Risk increases vary by work location—such as laboratories, TB wards, emergency rooms, and specialty clinics—and by job role, including radiographers, nurses, doctors, cleaning staff, and lab analysts. A systematic review by Rajnish Joshi et al. reported an average latent TB prevalence of 54% among health workers, ranging from 33% to 79%. The estimated annual TB incidence in healthcare workers ranges from 69 to 5,780 cases per 100,000, significantly higher than the general population's 25 to 5,361 per 100,000. In 2021, it was estimated that 1.6 million people died from TB globally. According to WHO and ILO data, tuberculosis is consistently among the top 10 causes of death worldwide.

Tuberculosis (TB) represents a significant occupational hazard for healthcare workers (HCWs), who face a risk of infection up to three times higher than the general population—a figure that can increase sixfold in regions with high burdens of HIV/AIDS and multidrug-resistant TB (MDR-TB). Despite a global decline in TB mortality, it remains a leading cause of death worldwide, and its incidence among HCWs is likely underreported. This elevated risk is critically influenced by workplace environmental factors, such as inadequate ventilation and air circulation, compounded by systemic issues including delays in diagnosis and a lack of robust safety protocols. Without improved governmental and institutional protections focused on these

environmental and organizational controls, the healthcare workforce is vulnerable, potentially exacerbating national TB rates. This study therefore focuses on examining the specific environmental conditions within healthcare settings that contribute to occupational TB transmission. The percentage of TB in Southeast Asia (45%), Africa (23%), and the Western Pacific (18%), with the proportion Which more small in Mediterranean East (8.1%), American (2.9%) And Europe (2.2%). Health care workers, especially those who are exposed to tuberculosis (TB) patients daily, are at high risk of contracting the disease. Health care workers who become infected with TB can then become carriers of the disease, thus infecting those around them, including coworkers, patients, patients' families, and the workers' families. disease TB This. Still A little study in Indonesia about TB on health workers, therefore it is very important to conduct TB research in the health worker population. (Doda & Pangaribuan, 2022).

An imbalance between the disease components (agent), the human component (host), and the environment causes the infectious disease tuberculosis. Unsupportive environmental factors, such as unhealthy behavior, poverty, poor sanitation, and even the negative stigma that still exists in society, cause an imbalance in abiotic elements such as the Mycobacterium tuberculosis bacteria and air as a medium for the bacteria to enter the body. body man (biotic) Which released through droplets. (Satria et al., 2024) . In addition to the health conditions of the work environment, nurses as service providers have the highest interaction with TB patients and their families and have an important role in determining the health of their environment and conversely, low immune systems of nurses can cause infection. disease TB from patient/patient's family who are being cared for. (Martin & Hasibuan, 2010).

While the increased risk of tuberculosis (TB) among healthcare workers (HCWs) is well documented, significant gaps remain in our understanding of the specific and measurable causal relationships between factors in the hospital work environment and TB incidence. Existing data are often based on general job classifications or administrative reports, which lack the detail needed to isolate the impact of physical environmental variables. These research gaps are threefold: Methodological limitations: Many studies confirm that HCWs constitute a high-risk group, but they do not go beyond correlation to analyze which specific environmental determinants, such as hourly air exchange rates in different wards, room layout, or temperature and humidity control, are most predictive of transmission. **Contextual deficiencies**: There is a significant lack of studies at the local healthcare facility level, especially in countries with a high TB burden, such as Indonesia. The interactions between national TB prevalence, local hospital infrastructure, resource constraints, and resulting environmental conditions are

poorly understood, limiting the development of context-specific interventions. **Contextual gaps**: There is a significant lack of studies at the local facility level, especially in countries with a high TB burden, such as Indonesia. The interactions between national TB prevalence, local hospital infrastructure, resource constraints, and resulting environmental conditions are poorly understood, limiting the development of context-appropriate interventions. **Metrics-practice gap**: There is a lack of synthesis between quantitative environmental data and qualitative operational realities (e.g., staffing density, workflow patterns, and protocol adherence). This gap hinders a holistic understanding of how engineering controls and organizational practices combine to influence occupational risk.

**Therefore,** this study seeks to address this gap by systematically investigating the association between defined and measurable hospital environmental factors and the incidence of tuberculosis among healthcare personnel, in order to generate evidence for specific and effective prevention strategies.

## Materials and Methods

This literature review is based on established guidelines or protocols. These protocols include the rationale and objectives of the evaluation, study eligibility criteria, information sources, search strategies to be used, study selection, data collection process, expected results, and data synthesis.

### SEARCH STRATEGY

This research search uses databases from Pubmed, Springer, Google Scholar, and Science which are limited to publications from the last five years, namely from 2020 to 2025. The keywords in the article search use English, complete with the text, namely " *Environmental Hygiene And Occupational Health Workers And TB* " . After the researcher finds these articles, an analysis of each article will be carried out.

### INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria for articles (1) articles published in English (2) population is health workers related to the work environment that causes TB (3) articles published in 2020 – 2025 (4) articles that are fully accessible with a copy of the full article. This study includes health workers in hospitals, but there are several articles that describe health workers outside hospitals, but the researchers did not discuss incidents outside hospitals. Articles are excluded if the results do not match the main objective of this study.

### STUDY SELECTION

Study selection was conducted based on the PRISMA guidelines. All articles found were screened based on predetermined inclusion and exclusion criteria. All articles were reviewed based on their abstracts and then detailed full-text review for a more in-depth look at the article's methodology, results, and conclusions. Publications were obtained from searches in three databases: PubMed, Springer, and Google Scholar. Researchers screened articles based on

the title, " The Effect of Work Environment Conditions on the Incidence of TB in Healthcare Workers."

**DATA EXTRACTION**

For appropriate data, it will be extracted based on the form of writing, author's name, title, year of publication, measuring instrument, variables, interventions, results and theoretical framework.

## Results

### Study Selection

A total of 458 articles were identified. Several articles were then excluded because they did not meet the inclusion criteria, including publication more than five years ago, not being in English, incomplete text, and not using a randomized controlled trial method. Finally, 12 of the full-text articles were reviewed for completeness, leaving 12 to be reviewed for analysis.

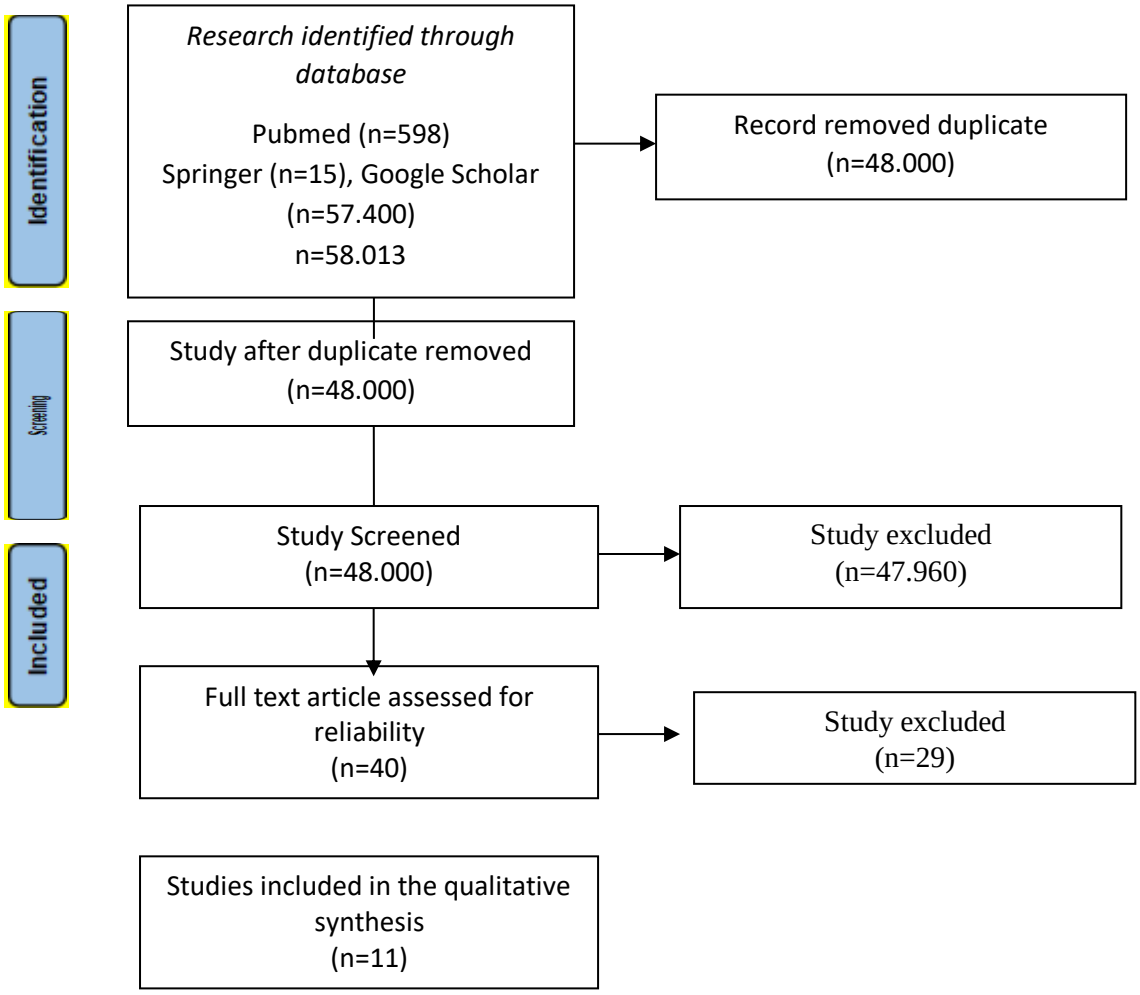


**Figure 1.** Prism Diagram

**CHARACTERISTICS STUDY**

The included articles were published between 2020 and 2025, drawn from selected databases originating from China, the United States, Hong Kong, and Iran. The total number of review respondents ranged from 50 to 200. Respondents included healthcare professionals, nurses, physiotherapists, and physicians, as well as stakeholders.

**INTERVENTION CHARACTERISTICS**

The intervention in this study is related to the relationship between work environment conditions and occupational diseases in health workers in hospitals, which causes TB incidents in workers.

## Discussion

TB HCWs experienced varying degrees of job burnout across CDC, designated hospitals, and PHC sectors in Chongqing, influenced by distinct hygiene and motivation factors. It is important for governments, organizations, and individuals to collaborate by enhancing communication and other strategies to address job burnout among TB HCWs. (Wang et al., 2024) . The Quantiferon TB Gold interferon-gamma release assay was used to assess TB infection. Findings from our study reveal that the prevalence of latent tuberculosis infection (LTBI) among healthcare workers in Italy is low. In conclusion, while LTBI itself is not contagious, its diagnosis and the implementation of safety measures demand particular clinical and preventive attention. (Tawiah et al., 2022) . To assess tuberculosis infection, we employed the Quantiferon TB Gold interferon-gamma release assay. Results:Our research emphasizes the low rate of latent tuberculosis infection (LTBI) among healthcare professionals in Italy. Conclusion:Even though LTBI is not infectious, its detection and the formulation of safety protocols necessitate targeted clinical and preventive measures. (Coppeta et al., 2021) . The key results indicate that Tuberculosis (TB) services remain a threat, especially for healthcare workers exposed to patients in hospitals. Those with latent TB face the danger of progressing to active disease. The research uncovered a lack of policies specifically aimed at safeguarding hospital staff from TB. There are also difficulties related to government funding. The study highlights the necessity of enhancing risk management and infection control measures to protect healthcare personnel, advocating for targeted hospital regulations aligned with national guidelines. Overall, it stresses the need for dedicated TB prevention policies, particularly from government authorities, to ensure worker protection is enforced in all hospitals. (Alfiyyah et al., 2024) . This research aimed to identify airborne Mycobacterium tuberculosis (MTB) in nine public health centers across three provinces in South Africa and to pinpoint possible risk factors for airborne spread. Personal samples (n = 264) and inpatient samples (n = 327) were collected from high-risk locations within districts, primary health clinics (PHCs), and TB treatment centers. Quantitative real-time

polymerase chain reaction (RT-PCR) was utilized for TB detection. Observations of movement and work practices were recorded via an infection prevention and control (IPC) questionnaire. Data analysis was conducted with Stata software version 15.2. Airborne MTB was found in 2.2% of the total samples (13 out of 572), while 97.8% tested negative. The highest number of TB-positive cases came from Western Cape district and provincial hospitals, specifically in medical, casualty, and TB wards. No MTB-positive samples were found in PHCs or during summer months. All facilities confirmed that healthcare workers received TB IPC training.

Identified risk factors for airborne TB included geographic location, type of facility, specific wards or areas, seasonality, absence of UVGI, and poor ventilation. Using environmental monitoring, PCR testing, IPC surveys, and mobile observations can help assess the risk of TB transmission across different settings. These insights can guide administrators and staff in enhancing TB infection prevention and control programs. (Matuka et al., 2021) . Healthcare workers (HCWs) are globally acknowledged as a group at high risk for tuberculosis (TB) infection, yet data on latent TB infection (LTBI) prevalence and related occupational risk factors in Mexico remain limited. Results:The LTBI prevalence was found to be 16.7%. After controlling for confounders, male HCWs showed significantly higher odds of LTBI compared to females (adjusted odds ratio [aOR] = 2.02; 95% confidence interval [CI]: 1.06–3.80). Although increased LTBI odds were also seen among physicians, stretcher bearers, and those directly contacting TB patients, these associations did not reach statistical significance. Conclusions:LTBI represents an important occupational health issue among HCWs, affecting nearly one in six. Early identification and prevention of TB in healthcare environments is essential to safeguard both staff and public health. The results underscore the importance of enhancing TB monitoring and preventive measures in comparable healthcare settings. (Hernández-Mariano et al., 2025).

Healthcare workers (HCWs) face at least double the risk of contracting tuberculosis (TB) compared to the general population. Attention on latent TB infection (LTBI) among high-risk groups is growing. Despite this, there is limited understanding of healthcare workers' views on LTBI testing and treatment, which is important for effective implementation in areas with high TB rates. To address this, a qualitative network method was created to explore healthcare workers' attitudes toward LTBI testing and treatment. (RRN Id et al., 2021) . Key findings outline that TB prevention and infection control (PPI) involves multiple complex factors. Healthcare workers' decisions to follow TB infection prevention and control (IPC) measures are shaped by their personal perceptions of occupational TB risk, often neglecting the role of TB IPC in protecting patient safety. Both healthcare workers and researchers revealed uncertainties remain—such as how long TB patients are infectious—

along with assumptions and misunderstandings about what effective TB IPC entails. For example, focusing TB IPC efforts mainly on patients already diagnosed and undergoing treatment, who have a low transmission risk, is misguided. Instead, TB IPC resources should prioritize high-risk transmission settings like crowded and poorly ventilated areas.

Additionally, TB IPC implementation strategies should assist healthcare workers in adapting guidelines to fit the local environment and practical application. (HVDW Id et al., 2022) . LTBI testing and treatment are well accepted by healthcare workers and can help challenge the belief that occupational TB infection is unavoidable, which often hinders efforts to reduce risk. However, these approaches need to be supported by strong administrative leadership and adequate infrastructure. The CARD analytical framework serves as a valuable tool for implementation scientists to analyze existing practices within complex healthcare systems. Using CARD can aid in designing interventions that are tailored to the specific context, effectively addressing key public health challenges such as occupational TB. (RRN Id et al., 2021) .

Healthcare workers encounter numerous occupational hazards that can greatly affect their health and well-being. While biological risks such as infection exposure are the most prevalent, physical and psychological hazards also play a significant role in the high rates of health issues. In countries such as Pakistan and China, where healthcare systems are already under strain, these risks are often worsened by insufficient protective measures and limited resources. To reduce these dangers, it is essential to implement comprehensive health and safety protocols, including appropriate use of personal protective equipment (PPE), ergonomic improvements, mental health support, and regular health monitoring.

Additionally, creating policies that prioritize the well-being of healthcare workers is vital to maintaining a sustainable workforce capable of providing quality care. (Aktas et al., 2022) . New and recurring occupational infectious diseases remain a significant threat to workers' health. Physicians need to be aware that respiratory infections may originate from the workplace. Effective communication and cooperation between physicians and public health professionals are crucial for detecting outbreaks of work-related respiratory infections. Addressing occupational risk factors and applying exposure control measures based on the hierarchy of controls are key strategies for preventing disease spread in the work environment. (Moyo et al., 2024).

Table 1. Literatur review

| NO | Author | Year | Country | Type of study | Research subjects | Main findings |
|---|---|---|---|---|---|---|
| 1 | Wang, Geng et all | 2024 | China | This cross-sectional study used both survey questionnaires and semi-structured interviews | Totally 9 participants were included in qualitative study | **Key findings**: Burnout rates among healthcare professionals caring for patients with tuberculosis are not uniform across all settings; they vary significantly depending on the workplace. Burnout rates are highest in primary healthcare (PHC) settings, primarily due to poor working conditions, hygiene, and safety issues. Burnout rates in specialized tuberculosis hospitals are strongly associated with low motivation, lack of recognition, and insufficient support. Burnout rates are lowest in Centers for Disease Control and Prevention (CDC) facilities, which typically have better infrastructure and resources. **Conclusion:** To effectively reduce burnout, solutions must be tailored to the specific needs of each healthcare setting, rather than using a one-size-fits-all approach. |
| 2 | Coppeta, Luca et al. | 2021 | Australia | Retrospective study | 825 respondents with characteristics are health workers in hospitals | To evaluate TB infection, we used the Quantiferon TB Gold interferon-gamma release assay. Results: Our study highlights the low prevalence of LTBI among healthcare workers in Italy. **Key Finding:** A study using a blood test to detect TB infection found a **low rate of latent (dormant) TB infection** among healthcare workers in Italy. **Conclusion:** Even though this dormant form is not contagious, the findings emphasize that **systematic screening and workplace safety measures remain essential** to protect healthcare workers from developing active TB |

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| 3 | Alfiyyah, Arifah et all | 2021 | Indonesia | Qualitative research | 7 respondents who were interviewed in-depth were health workers and health worker managers. | **Key Findings**: A significant policy gap exists, as hospitals lack specific regulations to protect healthcare workers from tuberculosis. Government funding and enforcement of these protections remain inadequate. A specific and mandatory government safety policy is urgently needed to guide all hospitals**. Conclusion:** To protect healthcare workers, the national government must establish and fund clear and enforceable standards that all hospitals must follow to prevent tuberculosis. |
| 4 | Matuka, Dikeledi O et all | 2021 | Africa | cross-sectional study test design | 327 respondents in health care facilities/hospitals | **Key Finding:** This study **directly detected airborne TB bacteria in the air of South African hospitals**, confirming a clear environmental transmission risk. The risk was highest in hospital wards and linked to specific, fixable problems like **ineffective ventilation and the absence of air disinfection systems**. **Conclusion:** The research demonstrates that **air monitoring can pinpoint exactly where and why transmission happens**, providing evidence to strengthen infection control measures where they are needed most. |
| 5 | Hernández-Mariano, José Angel et all | 2025 | Mexico | cross-sectional analysis | The subjects were 300 health workers in hospitals who were interviewed using a questionnaire in 2025. | This study assessed the occupational risk of latent tuberculosis infection (LTBI) among healthcare workers in Mexico, where such data are limited. Testing revealed an LTBI prevalence of 16.7%. Statistical analysis identified male gender as a significant risk factor, with male workers having double the odds of infection compared to females. While higher infection rates were also noted among physicians, stretcher bearers, |

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| | | | | | | and workers in direct contact with TB patients, these associations were not statistically significant. The findings underscore LTBI as a substantial occupational hazard and emphasize the critical need for enhanced TB surveillance and prevention programs in healthcare settings to protect workers and public health. |
| 7 | Id, Ruvandhi R Nathavithara na et. al | Year 202 1 | Africa | Qualitativ e with in-depth interviews | 22 nurses and other health workers | Healthcare workers (HCWs) are at least twice as likely to contract tuberculosis (TB) as the general population. There is increasing emphasis on latent TB infection (LTBI) in high-risk populations. However, we know little about healthcare workers' perspectives on LTBI testing and treatment to inform implementation in high-incidence settings. We developed a qualitative network approach to analyze healthcare workers' perspectives on LTBI testing and treatment. |
| 8 | Id, Helene-mari Van Der Westhuizen et.all | 2022 | Colombia | Qualitativ e Evidence Synthesis (QES) methods for developin g implemen tation recommen dations | 37 studies | **Key Findings**: Current approaches to tuberculosis infection prevention are often flawed by health care workers' perceptions and misunderstandings.This study highlights three fundamental problems:The approach is flawed by personal fear. Health care workers often base safety measures on their own perceived risk, rather than on objective data about where patient transmission actually occurs.Resources are wasted on low-risk targets. There is a misconception that prevention measures should focus only on diagnosed and treated patients, who are less infectious, rather than on crowded, poorly ventilated areas where undiagnosed transmission is higher. |

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| | | | | | | Guidelines lack practical applicability. Health care workers need direct support to adapt general tuberculosis prevention guidelines into specific and feasible plans for their own local clinical or hospital settings. |
| 9 | Dr. Amina Iqbal | 2025 | Pakistan | review | Against nurses in Pakistan and China | **Key Findings**: Healthcare workers face serious and complex occupational risks, particularly in overloaded systems, requiring comprehensive, multi-layered protection solutions.<br><br>**Conclusion:** Healthcare workers are exposed to a combination of biological, physical, and psychological risks. In countries with overloaded healthcare systems, such as Pakistan and China, these risks are exacerbated by a lack of protective measures and resources. To protect workers and maintain a sustainable workforce, it is crucial to implement integrated safety protocols, including personal protective equipment (PPE), improved ergonomics, mental health support, and health surveillance, all supported by strong institutional policies. |
| 9 | Perio, Marie A De Kobayashi, Miwako | 2020 | China | Qualitative | Doctor at the hospital | Emerging and re-emerging occupational infectious diseases continue to threaten workers' health. It is important for physicians to recognize that respiratory infections can be work-related. Communication and collaboration between physicians and public health practitioners are essential to identify clusters of work-related respiratory infections. Considering occupational risk factors and controlling worker exposure according to the |

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| | | | | | | hierarchy of controls will help prevent disease transmission in the workplace. |
| 10 | Hernández-Mariano, José Angel et all | 2025 | Mexico | cross-sectional study | 300 participants (including physicians, nurses, and stretcher-bearers) | **Key Finding:** About **20% of healthcare workers (1 in 5)** carry a latent TB infection, with male workers facing a notably higher risk. **Implication:** This underscores a significant occupational health threat. **Preventing this latent infection from becoming active TB** through systematic screening and protection of healthcare workers is vital for their health and for maintaining a functioning healthcare system. More research is needed to identify all specific risk factors. |

## Conclusion

This revision establishes that the work environment is a determining factor in the incidence of tuberculosis (TB) in private sanatoriums. Extremely cold indoor conditions, particularly inadequate ventilation, and the operation and control of technologies such as ultraviolet germicidal radiation (UVGI), facilitate direct transmission within the area, creating a highly dangerous zone in hospitals and clinics. Continuous immune system deficiencies exacerbate these environmental problems. These include errors in policy implementation specific to the context, inadequate perceptions leading to inappropriate assignments, and inadequate administration of infection prevention protocols. Out of caution, private sanatoriums face a disproportionate burden of latent and active TB infections. Therefore, we reduce the need for TB workplace intervention strategies by twofold: Ingenuity and environmental control: Exhaust and recirculation of large amounts of air, optimal distribution of sales and a valid air disinfection system to all areas in need. Good Organization and Policies: Implementing policies integral to occupational safety, including regular environmental monitoring, mandatory assessments and capacity building for personal hygiene, and management responsibility for providing necessary resources and protective infrastructure. Of course, personal health protection against tuberculosis is not solely an individual health issue; it is a fundamental requirement for a resilient health system. Prioritizing and safeguarding the work environment is a crucial step in maintaining workplace stability and public safety.

**SUGGESTION**

To effectively reduce the incidence of TB among workers, several measures should be prioritized: Strengthen environmental controls by improving ventilation systems and implementing ultraviolet germicidal irradiation (UVGI) in high-risk areas to minimize airborne transmission. Enhance administrative support through clear policies and adequate resource allocation focused on TB prevention and healthcare worker safety. Provide comprehensive and ongoing training for healthcare workers on infection prevention and control (IPC) practices tailored to local workplace conditions. Promote regular LTBI screening and timely treatment among healthcare workers, supported by accessible diagnostic tools and medical follow-up. Foster collaboration between healthcare institutions, public health authorities, and policymakers to develop and enforce workplace health and safety regulations addressing occupational TB risks. Integrate mental health support and ergonomic improvements as part of broader occupational health programs to address the psychological and physical burden on healthcare workers.

**FUTURE RESEARCHERS**

should consider exploring the following areas to deepen understanding and improve TB prevention among healthcare workers: Investigate the effectiveness of different environmental control strategies, such as advanced ventilation and UVGI systems, in various healthcare settings and climates. Examine healthcare workers' perceptions and behaviors regarding TB infection risk and prevention to identify barriers and facilitators for better compliance with IPC measures. Conduct longitudinal studies to assess the long-term impact of LTBI screening and treatment programs on TB incidence in healthcare personnel. Evaluate the role of organizational culture and leadership in implementing and sustaining TB prevention policies within healthcare facilities. Explore the psychological and social effects of occupational TB risk on healthcare workers, including burnout and mental health challenges, to inform comprehensive support interventions. Develop and test context-specific interventions that integrate environmental, administrative, and personal protective measures to optimize TB control in healthcare environments.

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