

# Epidemiology and Impact of Occupational Exposure to Bloodborne Pathogens in Healthcare Workers: A Literature Review

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## Abstract

Occupational exposure to bloodborne pathogens (BBPs) represents a critical health risk for healthcare workers (HCWs). Pathogens such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV) constitute major occupational hazards. This review examines the epidemiology, contributing factors, and consequences of BBP exposure among HCWs. A systematic review of peer-reviewed literature using PubMed, Scopus, Web of Science, and Google Scholar databases. We screened articles addressing BBP exposure among HCWs and analyzed relevant studies. The prevalence of BBP exposure varies significantly across regions, with higher rates observed in resource-limited settings. Contributing factors include insufficient training and limited access to safety-engineered devices and personal protective equipment (PPE) in low- and middle-income countries. BBP exposure results in significant psychological, physical, and economic burdens, contributing to stress and occupational burnout among HCWs. Ensuring stringent occupational safety standards, improving access to protective measures, and fostering safer healthcare environments are essential for mitigating BBP exposure risks. Strengthening global efforts to enhance safety practices can improve the resilience and quality of healthcare systems while protecting HCWs from these occupational hazards.

**Keywords:** Epidemiology, Occupational exposure impacts, bloodborne pathogens, healthcare workers

## 1. Introduction

Health workers are employees whose main goal is to enhance health. This encompasses health service providers, including physicians, nurses, midwives, and other public health professionals; laboratory technicians; health technicians; both medical and non-medical technicians; personal care workers; community health workers; as well as healers and practitioners of traditional medicine. The term encompasses health management and support personnel, including cleaners, drivers, hospital administrators, district health managers, social workers, and other occupational categories engaged in health-related activities as outlined by the International Standard Classification of Occupations (ISCO-08) (World Health Organization [WHO] & International Labour Organization [ILO], 2020).

Healthcare workers (HCWs) confront severe occupational hazards as a result of contact with bloodborne pathogens (BBPs) that include hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus. Needlestick injuries, contact with contaminated fluids, and other exposure incidents frequently transmit these pathogens, posing both acute and long-term health risks to healthcare personnel and increasing psychological and economic burdens on healthcare systems (Lee & Choi, 2023; Al Beshr et al., 2022). According to the World Health Organization (WHO), needlestick injuries, which account for over 80% of reported cases and are the leading cause of BBP exposures, expose millions of HCWs worldwide to BBPs each year (Stroffolini & Stroffolini, 2024; WHO, 2021).

The epidemiology of BBP exposures varies by area, reflecting variations in healthcare infrastructure, availability of safety-engineered equipment, and adherence to safety standards (Yilma et al., 2024). Occupational exposure has decreased over time in high-income nations such as Europe and North America due to regulatory frameworks and

enhanced safety training (Wolski et al., 2023; Deva et al., 2020). Low- and middle-income countries, including areas of Africa and Asia, have higher rates of BBP exposure because of limited resources, large patient numbers, and insufficient access to protective equipment and training (Takou Gang et al., 2024).

Based on research, some healthcare jobs, such as nursing, phlebotomy, and surgical personnel, are more vulnerable to exposure due to frequent patient contact and engagement in invasive procedures (Aliyo & Gemechu, 2024; Bun et al., 2024). Factors leading to exposure hazards include a failure to follow safety measures in high-pressure settings, poor infection control training, and insufficient use of personal protective equipment (PPE) (Van Huizen et al., 2024). Furthermore, the psychological repercussions of exposure episodes, such as anxiety, fear of infection, and stress associated with waiting for test results, might have long-term consequences for HCWs, leading to lower work satisfaction and burnout (Ballouz et al., 2024; Saberi et al., 2023).

In response to these issues, several health organizations, including the World Health Organization and the Occupational Safety and Health Administration (OSHA), have developed guidelines to increase HCW safety and limit BBP exposure. These guidelines encourage the use of personal protective equipment (PPE), frequent training, and the use of safety-engineered technologies to reduce the danger of exposure. However, adherence to these principles is variable, particularly in places with low resources and high patient demand (Yilma et al., 2024; Agarwala et al., 2019). This study investigates the worldwide and regional epidemiology of BBP exposure among healthcare workers, the variables that contribute to occupational risk, and the physical, psychological, and economic consequences of exposure. By synthesizing available evidence.

**2. Methodology**

This study relied on secondary data, primarily gathered from published articles, to derive its findings. The data collection process for this literature review involved systematically identifying, recording, analyzing, and synthesizing information from relevant sources. We conducted the literature review with a structured approach to ensure comprehensive data collection, thereby providing a solid basis for understanding the topic.

Table 1. The Search Terms in the PICO Framework

PICO Element	Search Terms
<b>Population (P)</b>	“Healthcare workers”, HCWs
<b>Intervention (I)</b>	“Bloodborne pathogens,” “BBP exposure,” “occupational hazards,” Health Consequences of BBP, Economic Burden of Occupational
<b>Comparison (C)</b>	“No intervention,” “low-resource settings,” “lack of PPE,” “absence of training programs” epidemiology of BBP exposures varies by area
<b>Outcome (O)</b>	“Reduced BBP exposure,” “improved occupational safety,” “increased PPE adherence,” “lower injury rates”

Table 2. The Obtained Articles from Different Databases

Database	Search Terms	Number of Articles Retrieved	Number of Relevant Articles After Screening
<b>PubMed</b>	Global epidemiology of BBP exposures in healthcare facilities	201	25
<b>Scopus</b>	“Needlestick injuries,” “PPE compliance,” “BBP exposure”	156	18
<b>Web of Science</b>	“Occupational exposure,” “safety interventions,” “healthcare systems”	103	11
<b>Cochrane Library</b>	Impact of occupational exposure to BBPs	46	9
<b>Google Scholar</b>	“Occupational health risks,” “HCW bloodborne pathogen exposure”	67	6
<b>Agreed titled</b>			13

Table 3. Summary of the included studies

Author(s)	Study	Country	Participants	Method	Conclusion
<b>Stroffolini &amp; Stroffolini (2024)</b>	Global Review of Needlestick Injuries and BBP Exposure	worldwide	Healthcare workers	Literature review	Needlestick injuries are the primary cause of BBP exposure, with significant data reporting variability worldwide.
<b>Takougang et al. (2024)</b>	Accidental Exposure to Body Fluids in Low-Resource Settings	Cameroon	Healthcare workers (Southwest)	Survey-based study	High exposure rates due to limited PPE, high workload, and infection control challenges in low-resource settings.
<b>Lee &amp; Choi (2023)</b>	Historical Analysis of BBP Exposure and Stigma	Multiple countries	Global healthcare workers	Analysis of historical data	The stigma around BBP exposure contributes to underreporting, affecting the accuracy of incidence data.
<b>Deva et al. (2020)</b>	Occupational Exposure to Bloodborne Pathogens	US	EMTs, nurses	Observations and injury reports	There are 1 million needlestick injuries annually, with the highest risks among nurses and phlebotomists in high-volume areas.
<b>Sharma et al. (2024)</b>	Bloodborne Infections and Safety Device Usage	India	Healthcare workers	Survey of various facilities	High rates of needlestick injuries are attributed to a lack of safety devices and inadequate infection control training.
<b>Alameer et al. (2023)</b>	Prevalence of Needlestick Injuries in Saudi Arabia	KSA	Healthcare workers	Survey-based analysis	32% of HCWs report needlestick injuries, with a high risk of bloodborne transmission from blood-stained needles.
<b>Yilma et al. (2024)</b>	Meta-analysis on Safety Practices in LMICs	Low- and middle-income countries	HCWs in LMICs	Review and synthesis of studies	Inconsistent safety practices due to resource constraints result in high BBP exposure rates.
<b>Hewitt &amp; Southard (2023)</b>	Health and Economic Impact of BBP Exposure	United States	Primary care workers	Quality improvement project	BBP exposure has severe health effects, including chronic infections and psychological distress; significant economic costs for healthcare facilities.
<b>Liu &amp; Kao (2023)</b>	Chronic Health Consequences of BBP Exposure	worldwide	Exposed healthcare workers	Literature review	Chronic infections like HBV and HCV can lead to liver disease and cancer; and increased risk of autoimmune disorders among affected HCWs.
<b>Ballouz et al. (2024)</b>	Psychological Impact of BBP Exposure in the OR	worldwide	Surgical healthcare workers	Longitudinal study	Exposure incidents lead to anxiety, PTSD, and burnout; operating room staff are at higher risk due to high-stress conditions.
<b>Saberi et al. (2023)</b>	Stigma and Mental Health Consequences of HIV Exposure	United States	Healthcare providers	Qualitative interviews	Significant fear of testing positive for HIV; concerns about stigma, discrimination, and job security contribute to long-term mental health issues.
<b>Rashidov et al. (2024)</b>	Needlestick and Sharp Injuries in Saudi Arabia	Saudi Arabia	Healthcare workers	Retrospective study	High incidence of needlestick injuries; emphasis on improved safety training and reporting mechanisms for HCWs.

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<b>Ryan et al. (2023)</b>	Economic Burden of Occupational BBP Exposure	United States	HCWs in long-term care settings	Cost analysis and staff survey	Occupational exposure increases compensation claims, absenteeism, and turnover, raising operational costs in healthcare facilities.
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### 3. Epidemiology

#### 3.1 An Overview of the Global Epidemiology of BBP Exposures in Healthcare Facilities

Globally, occupational exposures to blood-borne pathogens pose a significant risk to HCWs (Yilma et al., 2024). According to the World Health Organization (WHO), millions of healthcare workers worldwide are at risk of exposure to BBPs annually (Stroffolini and Stroffolini, 2024). The World Health Organization (WHO, 2018) estimates that needlestick injuries, which expose HCWs to BBPs, particularly HIV, HBV, and HCV, affect approximately 3 million HCWs annually. Studies show that needlestick injuries are the most common cause of occupational exposure to BBPs, accounting for about 80% of all reported incidents (Yilma et al., 2024; Stroffolini and Stroffolini, 2024; Al Beshr et al., 2022), compared to others (Khatrawi et al., 2023).

#### 3.2 Regional Epidemiology of BBP Exposures in the Healthcare Sector

The regional epidemiology of BBP exposures reflects the unique healthcare challenges and risks faced by HCWs in different geographical areas (Bun et al., 2024; Wolski et al., 2023). Highlights include:

##### 3.2.1 Europe

some studies report rates as high as 30% among surgical teams (Bun et al., 2024; Wolski et al., 2023; Schmid et al., 2016). Enhanced regulatory frameworks and training initiatives in countries such as the UK have resulted in a decrease in reported exposures in recent years.

##### 3.2.2 North America

The Centers for Disease Control and Prevention (CDC) estimates that approximately 1 million needlestick injuries occur annually in the United States. Despite rigorous training and protocols, HCWs continue to be at risk due to procedural complexity and high patient volumes (CDC, 2021). Reports indicate that nurses, phlebotomists, and surgical staff experience the highest rates of needlestick injuries (Bun et al., 2024; Sakr et al., 2021).

##### 3.2.3 Africa

African healthcare workers face significant risks due to limited resources and high rates of infectious diseases such as HIV (Takougang et al., 2024). A study in South Africa reported that approximately 20% of healthcare workers experienced needlestick injuries within a year (Takougang et al., 2024). The prevalence of untreated HIV and HBV in the population compounds the risk of exposure, further necessitating stringent infection control measures (Takougang et al., 2024).

### 3.2.4 Asia

In countries like India and Pakistan, the prevalence of needlestick injuries is alarmingly high, with studies indicating rates ranging from 12% to 40% among healthcare workers (Sharma et al., 2024). The lack of access to safety-engineered devices and inadequate training contribute to the region's high incidence of BBP exposures (Wolski et al., 2023). Various hospitals in Saudi Arabia conducted a study that revealed that eye/mouth splash injuries and needlestick injuries, the most common types of occupational injuries, frequently constitute nearly all work-related injuries (WRIs) at healthcare facilities (Alameer et al., 2023). Nearly one-third (32%) of healthcare workers have experienced needlestick injuries on the job, and over half (52.9%) of these needles were blood-stained (Albeladi et al., 2021). The prevalence of HBV and HCV infections among healthcare workers remains a concern, highlighting the importance of effective prevention measures (Rashidov et al., 2024). Factors contributing to occupational exposures in Saudi Arabia include high patient turnover, inadequate training programs, and limited access to safety-engineered devices (Almuzaini., 2023). Cultural factors, such as the stigma associated with infectious diseases, may also hinder reporting and management of exposure incidents.

## 4. Factors Contributing to Occupational Exposure

Several factors influence the risk of occupational exposure to BBPs among healthcare workers. Invasive procedures, particularly in emergency settings, often involve rushed actions that can increase exposure risk (Takougang et al., 2024). A lack of thorough adherence to safety protocols during high-pressure situations contributes to this issue (Takougang et al., 2024). Insufficient training regarding infection control practices can result in improper handling of sharps and failure to use PPE (Van Huizen et al., 2024). Regular training sessions can significantly improve awareness and compliance with safety measures. Also, long hours, high patient volumes, and burnout can lead to decreased vigilance in following safety protocols, increasing the risk of exposure (Aliyo & Gemechu, 2024). Stress management strategies and adequate staffing can help mitigate this risk (van Huizen et al., 2024). In addition, inadequate access to disposal containers for sharps, a lack of safety-engineered devices, and poor workplace organization can increase the likelihood of exposure incidents (Aliyo & Gemechu, 2024). Adherence to established safety protocols, such as the use of PPE and safe handling practices, is crucial in preventing occupational exposure. Non-compliance can arise from a lack of resources or inadequate enforcement of safety measures (Takougang et al., 2024). Healthcare workers face increased risk when working with patients known to have BBP or those whose status is unknown. The unpredictability of patient infections necessitates heightened precautions (van Huizen et al., 2024).

The impact of occupational exposure to BBPs is significant. Occupational exposure to BBPs presents significant health, psychological, and economic challenges for healthcare workers and the broader healthcare system (Lee and Choi, 2023).

### 4.1 Health Consequences for Workers

The health consequences of occupational exposure to BBPs can be severe and multifaceted (Hewitt & Southard, 2023). Exposure to pathogens such as HBV, HCV, and HIV can result in various acute and chronic health outcomes (Ratshisusu et al., 2024). Exposure to HBV can lead to acute hepatitis, which may progress to chronic liver disease in a significant number of cases (Hewitt & Southard, 2023). Unvaccinated individuals have an estimated 30% risk of developing chronic HBV infection after exposure (Ratshisusu et al., 2024). HCV exposure can lead to acute infection, and a substantial proportion of those infected may develop chronic liver disease, cirrhosis, or liver cancer (Liu & Kao, 2023). The risk of transmission from a needlestick injury is approximately 1.8% to 3% (Ratshisusu et al., 2024). Comparatively, the risk of HIV transmission from occupational exposure is lower than that of HBV or HCV; it can lead to a life-threatening condition if not promptly managed (Liu & Kao, 2023). The estimated transmission risk from a needlestick injury is about 0.3% (Stroffolini & Stroffolini, 2024).

HCWs who contract chronic infections like HBV and HCV may experience long-term health complications, including liver cirrhosis, liver failure, or hepatocellular carcinoma (Liu & Kao, 2023). On the other hand, some studies have suggested a link between occupational exposure and an increased risk of autoimmune disorders, potentially exacerbated by chronic infections (Stroffolini & Stroffolini, 2024; Liu & Kao, 2023). Healthcare workers may require postexposure prophylaxis (PEP) after potential HIV exposure, which involves taking antiretroviral medication for 28 days to reduce the risk of infection. The use of PEP can have side effects, including nausea, fatigue, and other adverse effects (Stroffolini & Stroffolini, 2024; Liu & Kao, 2023).

### 4.2 Psychological and Emotional Effects

The psychological and emotional consequences of occupational exposure to BBPs can be profound and lasting (Ballouz et al., 2024). Healthcare workers often experience significant fear and anxiety following potential

exposure incidents (Ballouz et al., 2024). The uncertainty of whether they have contracted a pathogen can lead to heightened stress and concern for their health and that of their families (Shaban et al., 2023). Many workers report a fear of testing positive for BBPs, particularly HIV, leading to anxiety about stigma, discrimination, and potential job loss (Saber et al., 2023). Exposure to traumatic events, such as needlestick injuries or witnessing severe infections, can lead to PTSD symptoms, including intrusive thoughts, hyperarousal, and emotional numbing (Saber et al., 2023). Studies indicate that healthcare workers involved in emergency and trauma care are particularly vulnerable to developing PTSD following exposure incidents (Saber et al., 2023).

The stress associated with occupational exposure can contribute to burnout, characterized by emotional exhaustion, depersonalization, and a reduced sense of personal accomplishment (Saber et al., 2023). High levels of burnout can lead to decreased job satisfaction, increased turnover rates, and a negative impact on patient care quality. Healthcare workers may feel isolated after exposure incidents due to stigma or fear of judgment from colleagues or patients, leading to decreased social support and increased emotional distress (Ballouz et al., 2024; Shaban et al., 2023).

#### *4.3 Economic Impact on the Healthcare System*

Occupational exposure to BBPs has substantial economic implications for healthcare systems, affecting both direct and indirect costs (Hewitt and Southard, 2023).

The direct costs, including treatment for infections resulting from exposure, can lead to significant healthcare costs, including hospitalization, long-term treatment, and management of chronic conditions. The cost of PEP for HIV exposure is also substantial, considering medication and follow-up testing. Increased incidence of occupational exposures can lead to higher workers' compensation claims, raising insurance premiums for healthcare facilities (Hewitt & Southard, 2023).

On the other hand, the indirect costs include HCWs, who experience occupational exposure and may require time off for treatment, recovery, or counseling, resulting in lost productivity and increased workload for other staff members. Healthcare facilities may incur costs related to retraining staff on safety protocols or hiring temporary replacements during workers' absences (Ryan et al., 2023).

The psychological and emotional effects of occupational exposure can contribute to decreased morale and productivity among healthcare workers, ultimately impacting the quality of patient care (Ryan et al., 2023). Lower staff morale and higher turnover rates can lead to staffing shortages, negatively affecting patient outcomes and satisfaction. To mitigate risks associated with occupational exposure, healthcare facilities must invest in compliance with safety regulations and guidelines, including staff training, PPE procurement, and implementing safer medical devices (Hewitt & Southard, 2023). These investments can be significant but are necessary for ensuring a safer workplace (Hewitt & Southard, 2023; Ryan et al., 2023).

## **5. Conclusion**

Occupational exposure to bloodborne infections is a critical concern in global healthcare, offering significant dangers to healthcare workers' health, safety, and well-being. This analysis emphasizes the high prevalence of needlestick injuries and other types of exposure, particularly in areas with limited access to safety-engineered equipment, poor training, and different levels of adherence to safety measures. The implications of BBP exposure go beyond the acute physical effects, including long-term psychological suffering and financial strain on healthcare systems.

BBP prevention demands a thorough and coordinated strategy. To limit the danger of occupational exposure, healthcare systems throughout the world must prioritize investment in safety-engineered technologies, ongoing training, and the implementation of standardized safety standards. Creating a strong culture of safety inside healthcare institutions is critical, allowing healthcare professionals to feel supported in prioritizing both their own safety and patient care. International health organizations, national governments, and healthcare institutions should work together to close gaps in resources and procedures, especially in low-resource settings where HCWs are most susceptible. Finally, by adopting and maintaining high standards for occupational safety, healthcare systems may limit the hazards associated with BBP exposures, therefore protecting healthcare workers and improving the overall quality and resilience of healthcare services globally.

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The authors declare that there are no competing or potential conflicts of interest.

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Ethical approval was sought from the relevant institutional review board

### Provenance and Peer Review

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### Data Availability Statement

The data that support the findings of this study are available.

### Competing Interests Statement

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