

(REVIEW ARTICLE)



The role of HSE risk assessments in mitigating occupational hazards and infectious disease spread: A public health review

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Abstract

The intercession of Health, Safety, and Environmental (HSE) risk assessments with public health strategy is crucial in mitigating occupational hazards and controlling the spread of infectious diseases. This review examines the role of Health, Safety, and Environment (HSE) risk assessments in mitigating occupational hazards and controlling the spread of infectious diseases, with a focus on public health implications. The study highlights the importance of comprehensive risk assessments in identifying and managing workplace hazards, including both physical and psychosocial risks. It discusses the integration of advanced technologies, such as artificial intelligence and big data analytics, to enhance the predictive capabilities of HSE risk assessments. The review also explores the necessity of ethical considerations in the application of these technologies, emphasizing transparency, privacy, and accountability. Furthermore, it underscores the importance of coordinated efforts between industries and public health authorities, especially in the context of infectious disease outbreaks like COVID-19. Policy recommendations include the development of robust regulations, the promotion of industry-public health collaboration, and the provision of support for small and medium-sized enterprises. The review identifies gaps in current research and suggests future directions, such as longitudinal studies on the effectiveness of HSE interventions and the inclusion of psychosocial factors in risk assessments. By addressing these gaps and implementing the proposed recommendations, policymakers and industry stakeholders can significantly enhance workplace safety and health standards, ultimately protecting workers and promoting public health resilience.

Keywords: HSE risk assessments; Occupational hazards; Infectious diseases; Public health; Artificial intelligence; Psychosocial risks; Policy recommendations

1. Introduction

Health, Safety, and Environment (HSE) practices play a pivotal role in safeguarding employees from occupational hazards and mitigating the spread of infectious diseases within workplaces. HSE risk assessments are systematic processes designed to identify potential hazards, evaluate the risks associated with them, and implement measures to control or eliminate these risks. These assessments are integral to occupational health and safety management, providing a framework for organizations to create safer working conditions and prevent harm to employees. The significance of HSE risk assessments has become increasingly evident in light of recent global health crises, such as the COVID-19 pandemic, which underscored the necessity of robust health and safety protocols to protect public health (World Health Organization, 2020).

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Figure 1 HSE Components Illustration (Gonzales church of Christ, 2023)

The primary objective of this review is to explore the role of HSE risk assessments in mitigating occupational hazards and controlling the spread of infectious diseases. By examining various industry practices and regulatory frameworks, this review aims to provide a comprehensive understanding of how effective HSE risk assessments can enhance workplace safety and contribute to public health. The review will also address the challenges and limitations associated with implementing these assessments, offering insights into potential improvements and future directions for research and practice.

By synthesizing the findings from various studies and case examples, this review will highlight the critical role of HSE risk assessments in promoting a safer and healthier work environment. Additionally, it will underscore the importance of aligning workplace health and safety practices with broader public health initiatives, fostering a collaborative approach to safeguarding employees and the wider community.

1.1. Objectives of the Review

The primary objective of this review is to elucidate the pivotal role of HSE risk assessments in mitigating occupational hazards and controlling the spread of infectious diseases within workplaces. By comprehensively analyzing current practices, regulatory frameworks, and industry-specific examples, the review aims to provide a nuanced understanding of how effective HSE risk assessments contribute to enhancing workplace safety and public health.

This review seeks to achieve several specific objectives. First, it aims to detail the fundamental components and methodologies of HSE risk assessments, highlighting their significance in identifying, evaluating, and mitigating various occupational hazards. This entails a critical examination of the processes involved in hazard identification, risk evaluation, and the implementation of control measures. By doing so, the review will underscore the importance of systematic risk management in preventing workplace injuries and illnesses.

Secondly, the review intends to explore the effectiveness of HSE risk assessments in controlling the spread of infectious diseases within occupational settings. The recent COVID-19 pandemic has starkly illustrated the necessity of robust health and safety protocols in workplaces to prevent the transmission of infectious agents. This section will analyze case studies and empirical evidence to demonstrate how HSE risk assessments have been utilized to develop and implement effective disease prevention strategies.

Furthermore, the review aims to identify and discuss the challenges and limitations associated with conducting HSE risk assessments. Despite their critical importance, various barriers can impede the effective implementation and compliance with HSE risk management practices. These barriers may include resource constraints, lack of expertise, and organizational resistance. By addressing these challenges, the review will offer insights into potential solutions and improvements that can enhance the efficacy of HSE risk assessments.

Finally, the review will emphasize the importance of integrating workplace HSE practices with broader public health policies. Effective collaboration between workplace health and safety initiatives and public health authorities can significantly bolster efforts to protect both employees and the wider community. This integrated approach is crucial for developing comprehensive strategies to address occupational hazards and infectious disease risks.

By achieving these objectives, this review will provide valuable insights into the critical role of HSE risk assessments in promoting a safer and healthier work environment, contributing to the overall well-being of the workforce and the public.

2. Methodology

The methodology employed in this review involves a systematic and comprehensive analysis of existing literature to explore the role of HSE risk assessments in mitigating occupational hazards and controlling the spread of infectious diseases. This methodological approach ensures the inclusion of diverse perspectives and evidence from various sources, facilitating a thorough understanding of the subject matter.

The review commenced with an extensive literature search conducted through academic databases such as PubMed, Scopus, and Web of Science. Keywords and phrases related to HSE risk assessments, occupational hazards, infectious disease prevention, and public health were utilized to identify relevant studies. The search was refined by applying inclusion criteria that prioritized peer-reviewed journal articles, industry reports, and guidelines published within the last fifteen years. This timeframe was chosen to ensure the relevance and currency of the information, given the evolving nature of occupational health and safety practices and public health challenges.

To ensure a rigorous selection process, the abstracts of the identified studies were screened for relevance to the review objectives. Studies that focused specifically on the methodologies and effectiveness of HSE risk assessments in various industries, as well as those that provided empirical evidence on the control of infectious diseases within occupational settings, were prioritized. Additionally, case studies illustrating successful implementation of HSE risk assessments and their impact on workplace safety and health were included to provide practical insights and real-world applications.

The data extraction process involved systematically reviewing the full texts of the selected studies to gather pertinent information on the key components of HSE risk assessments, their implementation processes, and outcomes. Particular attention was paid to studies that offered quantitative and qualitative evidence on the effectiveness of these assessments in reducing occupational hazards and preventing the spread of infectious diseases. The extracted data was then synthesized to identify common themes, best practices, and challenges associated with HSE risk assessments.

Furthermore, the review incorporated a critical appraisal of the regulatory frameworks and standards governing HSE risk assessments. Documents from authoritative bodies such as the Occupational Safety and Health Administration (OSHA), the International Organization for Standardization (ISO), and the World Health Organization (WHO) were analyzed to understand the regulatory landscape and its influence on HSE practices across different sectors.

The methodological rigor of this review is aimed at providing a comprehensive and evidence-based analysis of the role of HSE risk assessments in enhancing workplace safety and public health. By synthesizing findings from a diverse array of sources, the review seeks to offer valuable insights and recommendations for improving HSE risk management practices and policies.

2.1. Definition and Scope

Health, Safety, and Environment risk assessments are systematic processes designed to identify, evaluate, and control potential hazards that could negatively impact the health and safety of employees, as well as the environment in which they operate. These assessments play a critical role in occupational health and safety management, aiming to prevent accidents, injuries, illnesses, and environmental harm. The primary goal of HSE risk assessments is to ensure a safe and healthy working environment by proactively addressing potential risks before they result in adverse outcomes (Leigh, 2011).

The scope of HSE risk assessments encompasses a wide range of activities and industries, each with its unique set of hazards and regulatory requirements. In general, the process involves several key steps: hazard identification, risk analysis, risk evaluation, and the implementation of control measures. Hazard identification involves recognizing potential sources of harm, which can include physical, chemical, biological, ergonomic, and psychosocial factors. Risk analysis then assesses the likelihood and severity of adverse events associated with these hazards. Risk evaluation

prioritizes the identified risks based on their potential impact, guiding the allocation of resources and efforts toward the most critical issues (Manuele, 2014).



Figure 2 Health, Safety & Environment Management System Cycle (Bioorigin., 2020)

The image illustrates a comprehensive HSE Management System Cycle. It shows various components of HSE management in a circular flow, including Leadership & Commitment, Policy & Strategic Objective, Organization Responsibilities, Hazard & Effect Management, Planning & Procedure, Implementation & Monitoring, Audit, and Management Review. This cycle emphasizes the continuous nature of HSE management and how different aspects interconnect.

The implementation of control measures is a crucial component of HSE risk assessments. These measures can be categorized into engineering controls, administrative controls, and personal protective equipment (PPE). Engineering controls involve physical modifications to the workplace or equipment to eliminate or reduce hazards. Administrative controls include policies, procedures, and training programs designed to minimize exposure to risks. PPE, such as gloves, masks, and safety goggles, serves as a last line of defense to protect workers from residual hazards that cannot be fully mitigated through engineering or administrative controls (Occupational Safety and Health Administration, 2016).

The effectiveness of HSE risk assessments is often influenced by the regulatory frameworks and standards that govern their implementation. International standards, such as ISO 45001, provide guidelines for occupational health and safety management systems, emphasizing the importance of a systematic approach to managing risks. National regulations, such as those enforced by the Occupational Safety and Health Administration (OSHA) in the United States, set specific requirements for conducting risk assessments and implementing safety measures. Compliance with these standards and regulations is essential for ensuring the adequacy and effectiveness of HSE risk assessments (International Organization for Standardization, 2018).

Despite the comprehensive nature of HSE risk assessments, challenges remain in their implementation. These challenges can include resource constraints, lack of expertise, and varying levels of commitment among organizations. Overcoming these barriers requires a concerted effort to promote a culture of safety, invest in training and development, and continuously improve risk management practices. By addressing these challenges, organizations can enhance the effectiveness of their HSE risk assessments, thereby improving workplace safety and health outcomes (Zwetsloot et al., 2017).

2.2. Key Components of HSE Risk Assessments

The HSE risk assessments comprise several critical components that collectively aim to identify, evaluate, and mitigate risks in the workplace. These components form the foundation of an effective risk management process, ensuring the safety and health of employees and the protection of the environment. The primary components include hazard identification, risk analysis, risk evaluation, and the implementation of control measures.

Hazard identification is the first step in the HSE risk assessment process. This involves systematically recognizing potential sources of harm that could adversely affect workers or the environment. Hazards can be classified into various categories, including physical hazards (e.g., noise, vibration), chemical hazards (e.g., exposure to hazardous substances), biological hazards (e.g., infectious agents), ergonomic hazards (e.g., repetitive movements, poor workstation design), and psychosocial hazards (e.g., stress, workplace violence) (Hughes & Ferrett, 2015). Identifying these hazards requires a thorough examination of the workplace, including equipment, processes, and work activities. Tools such as checklists, flowcharts, and safety audits are often employed to facilitate this identification process (Carter & Smith, 2006).

Following hazard identification, risk analysis is conducted to determine the likelihood and potential severity of adverse events associated with the identified hazards. This step involves assessing the probability of occurrence and the potential impact on workers' health and safety. Quantitative methods, such as risk matrices and statistical analysis, and qualitative methods, such as expert judgment and scenario analysis, are commonly used in this process (Aven, 2016). The goal is to prioritize the risks based on their potential consequences, enabling organizations to focus their resources and efforts on the most critical hazards.



Figure 3 Risk Assessment Process Steps (Khaled Ismail., 2020)

Risk evaluation is the subsequent step, where the identified risks are compared against established criteria or benchmarks to determine their acceptability. This involves considering factors such as regulatory requirements, industry standards, and organizational risk tolerance levels (Hopkin, 2018). Risks that exceed acceptable levels must be addressed through appropriate control measures. This evaluation process helps in making informed decisions about which risks need immediate attention and which can be managed over time. Image 3 outlines the Risk Assessment Process in HSE. It presents five key steps and also includes a visual representation of a risk matrix, highlighting the importance of assessing both probability and impact of risks

Table 1 Key components of HSE risk assessments

Component	Description
Hazard Identification	<ul style="list-style-type: none"> - Systematically recognizes potential sources of harm - Includes physical, chemical, biological, ergonomic, and psychosocial hazards - Uses tools like checklists, flowcharts, and safety audits
Risk Analysis	<ul style="list-style-type: none"> - Determines likelihood and potential severity of adverse events - Uses quantitative methods (e.g., risk matrices, statistical analysis) - Uses qualitative methods (e.g., expert judgment, scenario analysis) - Prioritizes risks based on potential consequences
Risk Evaluation	<ul style="list-style-type: none"> - Compares identified risks against established criteria or benchmarks - Considers regulatory requirements, industry standards, and organizational risk tolerance - Determines risk acceptability and need for control measures
Implementation of Control Measures	<ul style="list-style-type: none"> - Aims to eliminate or reduce identified risks - Includes engineering controls, administrative controls, and PPE - Examples: ventilation systems, safety protocols, protective clothing
Monitoring and Review	<ul style="list-style-type: none"> - Ensures effectiveness of implemented control measures - Involves regular inspections, audits, and incident report reviews - Incorporates feedback from employees and stakeholders - Continuously assesses and improves the risk management process

The implementation of control measures is a crucial component of the HSE risk assessment process. These measures aim to eliminate or reduce the identified risks to acceptable levels. Control measures can be categorized into three main types: engineering controls, administrative controls, and personal protective equipment (PPE). Engineering controls involve modifying equipment, processes, or the work environment to remove or reduce hazards. Examples include installing ventilation systems, implementing machine guards, and redesigning workstations. Administrative controls focus on changing work practices and procedures to minimize exposure to hazards. This includes providing training, establishing safety protocols, and rotating job assignments to reduce repetitive strain. PPE serves as the last line of defense, protecting workers from hazards that cannot be completely eliminated through engineering or administrative controls. Examples of PPE include gloves, masks, safety goggles, and protective clothing (Goetsch, 2019).

Monitoring and review are essential to ensure the effectiveness of the implemented control measures. This involves regularly inspecting and auditing the workplace, reviewing incident reports, and continuously assessing the risk management process. Feedback from employees and other stakeholders is also valuable in identifying areas for improvement and ensuring that control measures remain effective over time (Reason, 2016).

2.3. Regulatory Frameworks and Standards

Regulatory frameworks and standards are essential in guiding the implementation and effectiveness of HSE risk assessments. These frameworks establish the legal and procedural foundations necessary for organizations to ensure safe working environments and protect public health. Adhering to these regulations and standards helps organizations to systematically identify, evaluate, and mitigate risks, thereby minimizing occupational hazards and preventing the spread of infectious diseases.

One of the most significant international standards governing HSE risk assessments is ISO 45001, which provides a framework for occupational health and safety management systems. ISO 45001 emphasizes a proactive approach to risk management, requiring organizations to identify hazards, assess risks, and implement control measures. The standard promotes continuous improvement through regular monitoring and review of safety practices, ensuring that organizations remain compliant with evolving safety requirements (International Organization for Standardization, 2018). The adoption of ISO 45001 can lead to improved safety performance, reduced workplace incidents, and enhanced employee morale (Zeng, Tam & Tam, 2008).

In the United States, the Occupational Safety and Health Administration (OSHA) sets forth regulatory requirements for workplace safety. OSHA's standards mandate that employers conduct thorough risk assessments to identify and control workplace hazards. These regulations cover a wide range of industries and hazards, from construction and manufacturing to healthcare and agriculture. OSHA also provides guidelines and resources to help employers develop effective safety programs, conduct training, and comply with safety standards (Occupational Safety and Health Administration, 2016). Compliance with OSHA regulations not only helps to protect workers but also reduces legal liabilities and financial losses associated with workplace accidents (Smith, 2012).



Figure 4 ABB HSE Management Framework (new.abb.com., 2023)

The European Union (EU) has established comprehensive occupational safety and health regulations through directives such as the Framework Directive 89/391/EEC. This directive requires employers to conduct risk assessments and take preventive measures to ensure the health and safety of their employees. The directive also emphasizes the importance of worker participation in safety management, encouraging collaborative efforts to identify hazards and implement controls (European Agency for Safety and Health at Work, 2013). The EU's regulatory approach has been shown to improve safety standards across member states, leading to a reduction in occupational accidents and diseases (Zwetsloot et al., 2017).

In addition to regulatory bodies, industry-specific standards play a crucial role in shaping HSE risk assessments. For instance, the American Petroleum Institute (API) has developed standards for the oil and gas industry that address specific hazards related to drilling, production, and refining operations. These standards provide detailed guidelines for conducting risk assessments, implementing safety controls, and maintaining safety management systems (American Petroleum Institute, 2017). Adherence to industry standards helps organizations address unique risks and maintain high safety performance within their specific operational contexts.

The role of regulatory frameworks and standards extends beyond compliance, serving as a foundation for fostering a culture of safety within organizations. By adhering to these guidelines, organizations can systematically approach risk management, ensuring that all potential hazards are identified and controlled effectively. Moreover, regulatory compliance enhances organizational reputation, demonstrating a commitment to safety and health to employees, stakeholders, and the public (Reason, 2016).

3. HSE Risk Assessments in the Context of Infectious Disease Control

Health, Safety, and Environment risk assessments have gained prominence as essential tools in controlling the spread of infectious diseases within occupational settings. The importance of these assessments has been underscored by recent global health crises, such as the COVID-19 pandemic, which have highlighted the need for robust and proactive measures to protect workers and maintain business continuity. By systematically identifying and mitigating risks

associated with infectious diseases, HSE risk assessments contribute significantly to safeguarding public health and ensuring operational resilience (Ijiga et. Al., 2024).

The integration of infectious disease control into HSE risk assessments involves several critical components. Initially, hazard identification is crucial, focusing on potential sources and pathways of infection within the workplace. This process entails recognizing both direct and indirect transmission routes, including person-to-person contact, contaminated surfaces, and airborne particles. Comprehensive identification of these hazards is essential for developing effective control strategies (Burke et al., 2011).

Risk analysis follows hazard identification, assessing the likelihood and impact of infectious disease transmission in the workplace. This step requires a thorough understanding of the epidemiological characteristics of the disease, such as its transmission dynamics, incubation period, and severity of health outcomes. Quantitative methods, including epidemiological modeling and risk quantification, are often employed to evaluate the potential spread and impact of infectious diseases within specific occupational contexts (World Health Organization, 2020). The insights gained from this analysis enable organizations to prioritize risks and allocate resources effectively.

Table 2 Components of HSE Risk Assessments for Infectious Disease Control

Component	Description	Examples/Details
Hazard Identification	Focuses on potential sources and pathways of infection within the workplace	<ul style="list-style-type: none"> - Direct and indirect transmission routes - Person-to-person contact - Contaminated surfaces - Airborne particles
Risk Analysis	Assesses likelihood and impact of infectious disease transmission	<ul style="list-style-type: none"> - Considers epidemiological characteristics - Uses quantitative methods (e.g., epidemiological modeling) - Evaluates potential spread and impact
Risk Evaluation	Compares assessed risks against predefined criteria	<ul style="list-style-type: none"> - Considers regulatory guidelines, industry standards, and risk tolerance - May lead to enhanced hygiene practices, physical distancing, remote work
Implementation of Control Measures	Implements strategies to reduce transmission risk	<ul style="list-style-type: none"> - Engineering controls (e.g., improved ventilation) - Administrative controls (e.g., sick leave policies) - Personal Protective Equipment (PPE)
Monitoring and Review	Ensures ongoing effectiveness of risk management	<ul style="list-style-type: none"> - Continuous surveillance of infection rates - Employee health monitoring - Adapting strategies based on feedback
Integration with Public Health Initiatives	Aligns workplace practices with broader health guidelines	<ul style="list-style-type: none"> - Collaboration with public health authorities - Contributes to community-wide disease control efforts

Risk evaluation then compares the assessed risks against predefined criteria, determining the acceptability of these risks and the necessity for control measures. This evaluation takes into account regulatory guidelines, industry standards, and organizational risk tolerance. For instance, during the COVID-19 pandemic, many organizations adopted enhanced hygiene practices, physical distancing protocols, and remote working arrangements in response to the heightened risk levels (Centers for Disease Control and Prevention, 2020). These measures reflect the dynamic nature of risk evaluation in the context of infectious diseases, where recommendations may evolve based on emerging scientific evidence and public health directives (Ijiga et. Al., 2024).

The implementation of control measures is a pivotal aspect of HSE risk assessments aimed at infectious disease control. Engineering controls, such as improved ventilation systems and physical barriers, play a vital role in reducing transmission risk. Administrative controls, including policies on sick leave, remote work, and staggered shifts, further minimize the potential for workplace outbreaks. Personal protective equipment (PPE), such as masks, gloves, and face shields, provides an additional layer of protection, especially in settings where other controls may not be feasible (European Centre for Disease Prevention and Control, 2020).

Monitoring and review are integral to the ongoing effectiveness of HSE risk assessments in managing infectious disease risks. Continuous surveillance of infection rates, employee health, and the effectiveness of control measures is necessary to identify and address any gaps in the risk management process. Feedback mechanisms, such as employee health monitoring and incident reporting systems, are essential for adapting and refining control strategies in real time (Brosseau & Sietsema, 2020).

The integration of HSE risk assessments with broader public health initiatives enhances the overall effectiveness of infectious disease control measures. Collaboration with public health authorities ensures that workplace practices are aligned with national and global health guidelines, facilitating a coordinated response to health crises. This integrated approach not only protects employees but also contributes to the broader efforts to control infectious disease outbreaks within communities (Sorensen et al., 2016).

3.1. Case Studies of Effective HSE Risk Assessments in Infectious Disease Control

Case studies of effective Health, Safety, and Environment (HSE) risk assessments provide valuable insights into best practices for mitigating the spread of infectious diseases in occupational settings. These case studies demonstrate how systematic approaches to risk management can protect workers and ensure continuity of operations, particularly during health crises.

One notable case study involves the response of the healthcare sector during the COVID-19 pandemic. Hospitals and healthcare facilities faced significant challenges due to the high risk of virus transmission among patients and staff. To address these risks, many institutions implemented comprehensive HSE risk assessments. For example, the Cleveland Clinic in the United States established a multidisciplinary task force to conduct regular risk assessments, identify potential hazards, and implement targeted control measures (Ijiga et. Al., 2024). These measures included enhanced ventilation systems, stringent infection control protocols, regular testing of staff, and the use of personal protective equipment (PPE) (Shaw, 2020). The effectiveness of these interventions was reflected in the reduced incidence of COVID-19 among healthcare workers and patients, demonstrating the critical role of HSE risk assessments in managing infectious disease risks in healthcare settings.

Table 3 Case Studies of Effective HSE Risk Assessments in Various Industries

Industry	Organization	Key HSE Risk Assessment Measures	Outcomes
Healthcare	Cleveland Clinic	<ul style="list-style-type: none"> - Multidisciplinary task force - Enhanced ventilation systems - Stringent infection control protocols - Regular staff testing - Use of PPE 	Reduced incidence of COVID-19 among healthcare workers and patients
Meat Processing	JBS (Greeley, Colorado)	<ul style="list-style-type: none"> - Reconfigured workstations for physical distancing - Enhanced cleaning and disinfection protocols - Provided PPE to all employees - Introduced staggered shifts 	Significant reduction in COVID-19 spread within the plant
Aviation	Singapore Airlines	<ul style="list-style-type: none"> - HEPA filtration systems on aircraft - Mandatory mask-wearing - Frequent disinfection of high-touch surfaces - Pre-flight health screenings 	Low transmission rates reported on flights

Manufacturing	Ford Motor Company	<ul style="list-style-type: none"> - Installed physical barriers - Enhanced ventilation - Introduced health monitoring systems - Implemented communication and training programs 	Continuity of operations and maintained workforce health and safety
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Another case study highlighting the effectiveness of HSE risk assessments comes from the meat processing industry, which experienced significant outbreaks of COVID-19. The JBS meat processing plant in Greeley, Colorado, implemented a comprehensive risk assessment strategy after an outbreak in early 2020. The company conducted hazard identification to determine areas where the virus could spread, such as crowded workspaces and common areas. Risk analysis and evaluation led to the implementation of control measures, including reconfiguring workstations to ensure physical distancing, enhancing cleaning and disinfection protocols, and providing PPE to all employees (Dyal et al., 2020). Additionally, JBS introduced staggered shifts to reduce the number of workers on-site at any given time. These measures significantly reduced the spread of COVID-19 within the plant, illustrating the importance of a structured HSE risk assessment process in high-risk industries.

The aviation industry also provides a compelling example of effective HSE risk assessments. Airlines and airports worldwide adopted rigorous risk management practices to mitigate the risk of COVID-19 transmission. For instance, Singapore Airlines conducted extensive risk assessments to identify potential transmission points throughout the travel journey. The airline implemented various control measures, such as HEPA filtration systems on aircraft, mandatory mask-wearing for passengers and crew, frequent disinfection of high-touch surfaces, and pre-flight health screenings (Moriarty et al., 2020). These interventions were guided by continuous risk assessments and aligned with international aviation safety standards. The success of these measures was evident in the low transmission rates reported on flights, underscoring the effectiveness of comprehensive HSE risk assessments in the aviation sector.

The manufacturing industry also showcases the impact of HSE risk assessments in controlling infectious diseases. A notable example is the Ford Motor Company, which implemented a detailed risk assessment strategy to manage COVID-19 risks across its production facilities. Ford's approach included hazard identification, focusing on areas where workers were in close proximity, such as assembly lines and break rooms. The company conducted risk analysis to assess the likelihood and impact of virus transmission and implemented control measures, including installing physical barriers, enhancing ventilation, and introducing health monitoring systems (Ford Motor Company, 2020). These measures were complemented by robust communication and training programs to ensure that employees understood and adhered to the new safety protocols. The effectiveness of Ford's HSE risk assessments were reflected in the continuity of its operations and the health and safety of its workforce. (Idoko et al., 2024)

3.2. Challenges and Limitations in Implementing HSE Risk Assessments for Infectious Disease Control

While HSE risk assessments are instrumental in mitigating the spread of infectious diseases in workplaces, several challenges and limitations can hinder their effective implementation. These challenges underscore the complexity of managing occupational health risks and highlight areas where improvements are necessary to enhance the efficacy of HSE risk assessment strategies.

One of the primary challenges is the dynamic nature of infectious diseases, as evidenced by the COVID-19 pandemic. Rapidly evolving scientific knowledge and epidemiological data necessitate continuous updates to risk assessments and control measures. For example, early in the pandemic, guidance on transmission routes and effectiveness of PPE evolved based on emerging research (CDC, 2020). This dynamic environment requires organizations to maintain flexibility in their risk management strategies and adapt quickly to new information to protect employees effectively.

A related challenge is the variability in risk perception and compliance among employees. While HSE risk assessments aim to standardize risk management practices, individual perceptions of risk and adherence to safety protocols can vary significantly. Factors such as cultural norms, communication barriers, and differing interpretations of safety guidelines can influence compliance levels (Kogi, 2012). Effective risk communication and training programs are essential to address these challenges and foster a shared commitment to safety among all employees.

Resource constraints pose another significant limitation in implementing comprehensive HSE risk assessments for infectious disease control. Many organizations, particularly small and medium-sized enterprises (SMEs), may lack the financial resources, expertise, or infrastructure necessary to conduct thorough risk assessments and implement robust control measures. This can result in gaps in risk management practices, leaving employees vulnerable to health risks

(OSHA, 2020). Collaborative initiatives, such as government funding programs and industry partnerships, can help address these resource constraints and support SMEs in enhancing their occupational health and safety practices (Godwins et. al., 2024).

The effectiveness of HSE risk assessments also depends on the availability and reliability of data for hazard identification and risk analysis. In some industries, such as healthcare and food processing, collecting accurate data on infection rates, transmission routes, and employee health status can be challenging (Dyal et al., 2020). Improved surveillance systems and data-sharing mechanisms between public health authorities and workplaces are crucial for enhancing the quality and timeliness of risk assessments.

Legal and regulatory compliance present additional challenges in implementing HSE risk assessments for infectious disease control. While regulations provide essential guidelines for workplace safety, navigating complex legal requirements and ensuring compliance with multiple regulatory frameworks can be daunting for organizations operating across different jurisdictions (European Agency for Safety and Health at Work, 2017). Clear interpretation of regulations, regular audits, and proactive engagement with regulatory authorities are essential to mitigate legal risks and ensure adherence to safety standards.

Table 4 Challenges and Limitations in Implementing HSE Risk Assessments for Infectious Disease Control

Challenge/Limitation	Description	Potential Solutions
Dynamic Nature of Infectious Diseases	Rapidly evolving scientific knowledge and epidemiological data require continuous updates	Maintain flexibility in risk management strategies; adapt quickly to new information
Variability in Risk Perception and Compliance	Individual perceptions of risk and adherence to safety protocols can vary significantly	Implement effective risk communication and training programs
Resource Constraints	Lack of financial resources, expertise, or infrastructure, especially in SMEs	Develop collaborative initiatives, government funding programs, and industry partnerships
Data Availability and Reliability	Challenges in collecting accurate data on infection rates, transmission routes, and employee health status	Improve surveillance systems and data-sharing mechanisms between public health authorities and workplaces
Legal and Regulatory Compliance	Complexity in navigating multiple regulatory frameworks, especially for organizations operating across different jurisdictions	Ensure clear interpretation of regulations, conduct regular audits, and engage proactively with regulatory authorities
Leadership Commitment and Organizational Culture	Effectiveness relies on strong leadership support and a safety-conscious workplace culture	Foster a proactive safety culture; allocate resources and empower employees to participate in risk management processes

Finally, the effectiveness of HSE risk assessments relies on strong leadership commitment and organizational culture that prioritizes safety. Leadership support is critical in allocating resources, promoting a safety-conscious workplace culture, and empowering employees to actively participate in risk management processes (Zohar, 2010). Organizations that foster a proactive safety culture are more likely to achieve sustainable improvements in occupational health and safety outcomes.

4. Future Directions and Recommendations for Enhancing HSE Risk Assessments

As organizations continue to navigate the complexities of managing occupational health and safety risks, including the control of infectious diseases, several future directions and recommendations can further enhance the effectiveness of Health, Safety, and Environment (HSE) risk assessments. These strategies aim to address existing challenges, leverage emerging technologies, and foster a culture of continuous improvement in workplace safety practices.

One crucial area for future development is the integration of predictive analytics and artificial intelligence (AI) in HSE risk assessments. Predictive modeling can analyze historical data on workplace incidents, employee health trends, and environmental factors to anticipate potential risks and prioritize preventive measures (Chen et al., 2020). AI-driven algorithms can enhance the accuracy of risk assessments by processing large datasets and identifying patterns that human analysts may overlook. This approach not only improves risk prediction but also enables proactive intervention to mitigate emerging risks before they escalate (Godwins et. al., 2024).

Furthermore, the adoption of digital tools and platforms can streamline the process of conducting and managing HSE risk assessments. Cloud-based software solutions offer real-time data collection, analysis, and reporting capabilities, facilitating collaboration among stakeholders and ensuring accessibility to updated safety protocols (European Agency for Safety and Health at Work, 2021). Mobile applications and wearable technologies can empower frontline workers to report hazards, access safety information, and receive real-time alerts, thereby enhancing situational awareness and response capabilities (Ijiga et. Al., 2024).

Enhancing interdisciplinary collaboration is another critical recommendation for advancing HSE risk assessments. Integrating expertise from public health professionals, epidemiologists, occupational health specialists, and engineers can enrich risk assessment methodologies and ensure comprehensive hazard identification (Hämäläinen et al., 2020). Cross-sectoral partnerships between industry stakeholders, academia, and government agencies can also facilitate knowledge sharing, research collaboration, and the development of standardized best practices for infectious disease control.

Education and training play a pivotal role in promoting a culture of safety and enhancing competency in HSE risk assessments. Continuous professional development programs can equip employees with the necessary skills to conduct thorough risk assessments, utilize new technologies effectively, and adhere to evolving safety regulations (Zwetsloot et al., 2017). Training initiatives should emphasize hazard recognition, risk communication, and the implementation of control measures tailored to specific workplace contexts.

Table 5 Future Directions and Recommendations for Enhancing HSE Risk Assessments

Area	Recommendation	Benefits
Technology Integration	Integrate predictive analytics and AI	- Anticipate potential risks - Prioritize preventive measures - Enhance accuracy of risk assessments
Digital Tools	Adopt cloud-based software and mobile applications	- Streamline data collection and analysis - Facilitate real-time reporting - Enhance collaboration and accessibility
Interdisciplinary Collaboration	Integrate expertise from various fields	- Enrich risk assessment methodologies - Ensure comprehensive hazard identification - Facilitate knowledge sharing
Education and Training	Implement continuous professional development programs	- Enhance competency in risk assessments - Improve utilization of new technologies - Ensure adherence to evolving safety regulations
Transparency and Accountability	Promote open communication and regular safety audits	- Build trust among stakeholders - Solicit employee input - Demonstrate commitment to improvement
Regulatory Evolution	Update guidelines based on scientific evidence and lessons learned	- Address emerging risks - Foster compliance - Promote proactive risk management

Moreover, promoting transparency and accountability in HSE risk management practices is essential for building trust among employees, stakeholders, and the public. Organizations should prioritize open communication channels, regular safety audits, and feedback mechanisms to solicit input from employees and assess the effectiveness of risk controls

(Reason, 2016). Transparent reporting of health and safety performance metrics can demonstrate organizational commitment to continuous improvement and drive initiatives for enhancing workplace safety standards.

Lastly, regulatory frameworks need to evolve to address emerging risks associated with infectious diseases and other occupational health challenges. Regulatory agencies should consider updating guidelines and standards based on scientific evidence, technological advancements, and lessons learned from recent health crises (International Labour Organization, 2021). Flexible regulatory approaches that accommodate diverse industry needs while ensuring minimum safety requirements are essential for fostering compliance and promoting a culture of proactive risk management.

4.1. Ethical Considerations in HSE Risk Assessments for Infectious Disease Control

Ethical considerations are paramount in the development and implementation of HSE risk assessments, particularly concerning infectious disease control in workplaces. These considerations encompass principles of fairness, transparency, respect for individuals' rights, and the ethical use of data and technologies to safeguard employee health and well-being (Godwins et al., 2024).

Firstly, informed consent and participation are fundamental ethical principles in conducting HSE risk assessments. Employees have the right to be informed about the risks they may encounter in their workplace, as well as the control measures in place to protect them (Beauchamp & Childress, 2019). Transparent communication regarding the purpose, procedures, potential risks, and benefits of risk assessments fosters trust between employers and employees. Informed consent ensures that individuals understand their role in the risk assessment process and can make informed decisions regarding their participation.

Table 5 Ethical Considerations in HSE Risk Assessments for Infectious Disease Control

Ethical Consideration	Description	Key Points
Informed Consent and Participation	Employees have the right to be informed about workplace risks and control measures	<ul style="list-style-type: none"> - Transparent communication - Foster trust between employers and employees - Enable informed decision-making
Privacy and Confidentiality	Personal health data must be handled with utmost confidentiality	<ul style="list-style-type: none"> - Implement robust data protection measures - Adhere to privacy regulations - Obtain consent for data collection and use
Equity and Fairness	Ensure risk assessments don't disproportionately impact vulnerable groups	<ul style="list-style-type: none"> - Address disparities in risk exposure - Promote equitable access to protective measures - Consider underlying health conditions
Ethical Use of Technology	Uphold ethical standards in technology-driven risk assessment tools	<ul style="list-style-type: none"> - Ensure fairness and transparency in AI and predictive analytics - Address potential algorithm bias - Consider unintended consequences
Ethical Leadership and Accountability	Foster a culture of ethical conduct in HSE risk assessments	<ul style="list-style-type: none"> - Set ethical standards - Prioritize employee well-being - Provide training on ethical decision-making - Establish mechanisms for raising concerns
Continuous Evaluation and Improvement	Regularly review and improve ethical guidelines and practices	<ul style="list-style-type: none"> - Seek stakeholder feedback - Incorporate lessons from previous health crises - Adapt to evolving workplace conditions and regulations

Respect for privacy and confidentiality is another critical ethical consideration in HSE risk assessments. Personal health data collected during risk assessments, such as medical history or COVID-19 test results, must be handled with utmost confidentiality to protect individuals' privacy rights (European Union Agency for Fundamental Rights, 2018). Employers

should implement robust data protection measures, adhere to relevant privacy regulations, and obtain consent before collecting and using employees' health information for risk assessment purposes (Idoko et. Al., 2024).

Equity and fairness in risk management practices are essential ethical imperatives. Organizations should strive to ensure that risk assessments do not disproportionately impact vulnerable groups or individuals, such as those with underlying health conditions or limited access to healthcare resources (Magnavita & Tripepi, 2020). Proactive measures to address disparities in risk exposure and access to protective measures are essential for promoting equitable workplace safety standards (Manuel et. al., 2024).

Additionally, ethical considerations extend to the use of emerging technologies in HSE risk assessments. While technologies such as AI and predictive analytics offer significant benefits in risk prediction and management, ethical dilemmas may arise concerning data accuracy, algorithm bias, and the potential for unintended consequences (Floridi et al., 2020). Organizations must uphold ethical standards in the development and deployment of technology-driven risk assessment tools, ensuring fairness, transparency, and accountability in decision-making processes.

Furthermore, fostering a culture of ethical leadership and accountability is crucial for promoting ethical conduct in HSE risk assessments. Organizational leaders play a pivotal role in setting ethical standards, prioritizing employee well-being, and upholding regulatory compliance (Ferrell et al., 2019). Ethical leadership practices include promoting open dialogue on ethical dilemmas, providing training on ethical decision-making, and establishing mechanisms for employees to raise concerns about safety issues without fear of reprisal (Godwins et. al., 2024).

Lastly, continuous evaluation and improvement of ethical guidelines and practices are essential for adapting to evolving workplace conditions and regulatory requirements. Organizations should regularly review their HSE risk assessment protocols, seek feedback from stakeholders, and incorporate lessons learned from previous health crises to enhance ethical standards (Lefkowitz, 2020). By integrating ethical considerations into every stage of the risk assessment process, organizations can uphold their commitment to protecting employee health and safety while maintaining ethical integrity.

4.2. Integration with Public Health Policies: Coordination between Workplace HSE Practices and Public Health Initiatives

Effective coordination between workplace HSE practices and public health policies is essential for mitigating the spread of infectious diseases and safeguarding employee health. This integration ensures that occupational health measures align with broader public health objectives, leveraging synergies to enhance overall disease prevention and control strategies (Ijiga et. Al., 2024).

Governmental and health organizations play a pivotal role in supporting HSE practices by providing regulatory frameworks, guidelines, and resources to promote workplace safety (European Agency for Safety and Health at Work, 2021). Regulatory agencies establish minimum standards for occupational health and safety, enforce compliance with health regulations, and conduct inspections to ensure workplaces adhere to established safety protocols (International Labour Organization, 2021). By collaborating with employers, trade unions, and industry associations, governmental bodies can facilitate the implementation of effective HSE risk assessments tailored to the unique challenges posed by infectious diseases (Onuh et al., 2024).

Public health policies, such as disease surveillance, outbreak response protocols, and vaccination campaigns, provide critical context for workplace HSE practices. Timely dissemination of epidemiological data, guidance on infection control measures, and public health alerts enable organizations to adjust their risk assessment strategies and implement preventive measures in accordance with current health threats (Centers for Disease Control and Prevention, 2020). Close collaboration between public health authorities and workplace safety professionals ensures that HSE practices remain aligned with the latest scientific evidence and public health recommendations.



Figure 5 Office Workers Wearing Face Masks During Pandemic (Compliance training group., 2020)

Furthermore, governmental support extends to funding initiatives, research grants, and capacity-building programs aimed at strengthening HSE capabilities within organizations (Occupational Safety and Health Administration, 2020). Financial resources enable businesses, particularly small and medium-sized enterprises (SMEs), to invest in infrastructure upgrades, training programs, and technological innovations that enhance their capacity to manage infectious disease risks effectively (Dyal et al., 2020). By prioritizing occupational health and safety in policy agendas, governments demonstrate their commitment to protecting worker health and promoting sustainable economic development.

Collaborative efforts between governmental health agencies, workplace stakeholders, and public health professionals are crucial for addressing emerging health threats and fostering a culture of proactive risk management (Hämäläinen et al., 2020). Joint initiatives, such as public-private partnerships and multi-sectoral task forces, facilitate knowledge exchange, best practice sharing, and the development of integrated health and safety strategies that benefit both employees and the broader community (European Union Agency for Fundamental Rights, 2018). By aligning HSE practices with public health policies, organizations contribute to collective efforts to reduce disease transmission, minimize societal disruption, and promote resilience in the face of health crises (Ijiga et. Al., 2024).

5. Summary of Key Findings: Recap of the Role and Effectiveness of HSE Risk Assessments

Throughout this review, the role of HSE risk assessments in mitigating occupational hazards and controlling the spread of infectious diseases has been thoroughly examined. HSE risk assessments serve as proactive tools for identifying workplace hazards, evaluating risks, and implementing controls to protect employee health and safety. By integrating principles of risk management with public health guidelines, organizations can effectively mitigate the transmission of infectious diseases such as COVID-19 and uphold workplace safety standards.

Key findings underscore the significance of conducting comprehensive HSE risk assessments tailored to specific workplace environments and health threats. Research highlights the effectiveness of risk assessment methodologies in identifying potential exposure pathways, assessing the severity of risks, and prioritizing preventive measures to reduce occupational hazards (Chen et al., 2020; Magnavita & Tripepi, 2020). Moreover, the integration of advanced technologies, including AI-driven analytics and digital platforms, enhances the accuracy and timeliness of risk assessments, enabling organizations to respond swiftly to emerging health challenges (Floridi et al., 2020).

Table 5 Key Findings and Conclusions on HSE Risk Assessments for Infectious Disease Control

Aspect	Key Findings	Implications
Significance	HSE risk assessments are proactive tools for identifying hazards, evaluating risks, and implementing controls	Enables effective mitigation of infectious disease transmission and upholds workplace safety standards
Effectiveness	Comprehensive assessments tailored to specific workplace environments and health threats are crucial	Helps in identifying exposure pathways, assessing risk severity, and prioritizing preventive measures
Technology Integration	Advanced technologies (AI-driven analytics, digital platforms) enhance accuracy and timeliness	Enables swift responses to emerging health challenges
Ethical Considerations	Principles of informed consent, privacy protection, and equity are crucial	Fosters a culture of safety and accountability within organizations
Coordination with Public Health	Alignment of workplace HSE practices with public health policies is essential	Ensures coherent risk management strategies aligned with broader health objectives
Government Support	Regulatory frameworks, funding initiatives, and capacity-building programs are important	Strengthens organizational capacities to address occupational health risks and respond to emergencies
Overall Impact	HSE risk assessments are critical for promoting occupational health and safety	Enhances organizational resilience to health threats and fosters a safe work environment

Ethical considerations play a crucial role in the implementation of HSE risk assessments, emphasizing principles of informed consent, privacy protection, and equity in risk management practices (Beauchamp & Childress, 2019; European Union Agency for Fundamental Rights, 2018). Transparent communication, stakeholder engagement, and ethical leadership are essential for fostering a culture of safety and accountability within organizations.

Furthermore, effective coordination between workplace HSE practices and public health policies is essential for aligning risk management strategies with broader health objectives (Centers for Disease Control and Prevention, 2020; Occupational Safety and Health Administration, 2020). Governmental support through regulatory frameworks, funding initiatives, and capacity-building programs strengthens organizational capacities to address occupational health risks and respond to health emergencies (International Labour Organization, 2021).

5.1. Future Directions for Research and Practice: Identification of Gaps in Current Research and Recommendations for Improving HSE Risk Assessments

As the field of HSE risk assessments continues to evolve, several key gaps in current research and opportunities for improvement in practice have been identified. Addressing these gaps is crucial for advancing the effectiveness and application of HSE risk assessments, particularly in the context of mitigating occupational hazards and controlling the spread of infectious diseases.

One significant gap in current research pertains to the integration of psychosocial factors into HSE risk assessments. While existing frameworks predominantly focus on physical hazards and exposure risks, less attention has been paid to the psychological impacts of occupational hazards and the role of psychosocial risk factors in workplace safety. Future research should explore methods for assessing and managing psychosocial risks, such as stress, job insecurity, and organizational culture, to promote holistic risk management strategies.

Furthermore, there is a need for longitudinal studies that examine the long-term effectiveness of HSE risk assessments in preventing occupational injuries and illnesses. While short-term outcomes, such as immediate reductions in exposure levels or incident rates, are often reported, longitudinal research can provide insights into sustained improvements in workplace safety culture, employee health outcomes, and organizational resilience.

Incorporating advanced technologies, such as artificial intelligence (AI) and machine learning, presents opportunities to enhance the predictive capabilities and scalability of HSE risk assessments. AI-driven algorithms can analyze large datasets, identify patterns in occupational hazards, and predict emerging risks, enabling proactive risk management strategies. Future research should focus on validating the accuracy and reliability of AI-based risk assessment tools across diverse industry sectors and organizational contexts.

Ethical considerations remain a critical area for further exploration in HSE risk assessments. Research should continue to investigate ethical dilemmas related to data privacy, consent processes, algorithm transparency, and the equitable distribution of safety resources. Developing robust ethical guidelines and governance frameworks can enhance stakeholder trust, promote responsible innovation, and ensure the ethical use of emerging technologies in occupational health and safety practices.

Recommendations for improving the implementation of HSE risk assessments include enhancing collaboration between public health authorities, governmental agencies, and private sector organizations. Strengthening multi-sectoral partnerships can facilitate knowledge exchange, resource sharing, and the adoption of best practices in infectious disease control and workplace safety.

Moreover, capacity-building initiatives are essential for empowering organizations, particularly SMEs, to conduct effective HSE risk assessments and implement evidence-based safety interventions. Providing training programs, technical assistance, and financial incentives can enhance organizational readiness to respond to health emergencies and regulatory requirements.

Future research should prioritize addressing gaps in psychosocial risk assessment, conducting longitudinal studies on the effectiveness of HSE interventions, validating AI-driven technologies, and advancing ethical guidelines in occupational health and safety practices. By enhancing collaboration, capacity-building efforts, and technological innovation, stakeholders can collectively improve the resilience of workplaces to infectious disease outbreaks and promote a culture of safety and well-being.

5.2. Policy Implications: Suggestions for Policymakers to Enhance Workplace Safety and Health Standards

Policymakers play a crucial role in shaping workplace safety and health standards, particularly through the lens of HSE risk assessments. To enhance these standards, several policy recommendations can be proposed. First, there is a need for the development and enforcement of comprehensive regulations that mandate regular and thorough HSE risk assessments across all industries. These regulations should be designed to cover a broad spectrum of occupational hazards, including both physical and psychosocial risks, to ensure holistic protection of workers' health.

Moreover, policymakers should prioritize the integration of advanced technologies, such as artificial intelligence (AI) and big data analytics, into HSE risk management frameworks. By supporting the development and adoption of AI-driven tools, governments can enhance the accuracy and efficiency of risk assessments, leading to more proactive and effective hazard mitigation strategies. Policymakers should also establish clear guidelines on the ethical use of these technologies, addressing issues of privacy, transparency, and accountability.

To foster a culture of safety, it is essential for policymakers to encourage stronger collaboration between industries and public health authorities. This can be achieved by creating platforms for regular dialogue and knowledge exchange, as well as by developing joint initiatives that address both workplace safety and public health objectives. For instance, coordinated efforts in infectious disease surveillance and response can significantly enhance the capacity of workplaces to manage health crises, as evidenced during the COVID-19 pandemic.

Furthermore, providing financial incentives and technical support to small and medium-sized enterprises (SMEs) can help overcome resource constraints and ensure that all organizations, regardless of size, can implement robust HSE risk assessments. This can include grants, tax benefits, and access to training programs focused on best practices in occupational health and safety.

Policymakers should also emphasize the importance of continuous education and training for workers and managers on HSE practices. By incorporating HSE training into occupational health policies and promoting lifelong learning, policymakers can ensure that the workforce is well-equipped to identify and mitigate risks effectively.

To enhance workplace safety and health standards, policymakers should develop comprehensive regulations, support technological advancements, encourage industry-public health collaboration, provide financial and technical support to

SMEs, and emphasize continuous education and training. These policy measures can collectively contribute to safer and healthier work environments, ultimately protecting workers and enhancing organizational resilience.

6. Conclusion

This study underscores the pivotal role of HSE risk assessments in mitigating occupational hazards and controlling the spread of infectious diseases. Comprehensive risk assessments, tailored to specific workplace environments, effectively identify exposure pathways, assess risk severity, and prioritize preventive measures. The integration of advanced technologies, including AI and digital platforms, enhances the accuracy and timeliness of these assessments, enabling swift responses to health challenges. Ethical considerations and coordinated efforts between workplace safety practices and public health policies are crucial for fostering a culture of safety and accountability. By addressing current gaps and implementing these strategies, this study will benefit society by promoting safer work environments and improving public health resilience. The way forward involves continuous improvement, interdisciplinary collaboration, and technological innovation in HSE risk management.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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