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Original Article

# Identifying and Evaluating Occupational Hazards of Infectious Waste Landfill Workers by the JHA Method

**Fariba Jalali[1*], Babak Pahlavan[2], Mohammad Mosayyebi[3], Ensieh Salehi Salut[4]**

[1]Department of HSE Management, School of Environment and Energy, Islamic Azad University, Science and Research Branch, Tehran, Iran
[2]Department of Civil Engineering, Technical and Engineering Faculty, Islamic Azad University, Shall Branch, Qazvin, Iran
[3]Department of Environmental Management and planning, Faculty of Natural Resources, Islamic Azad University of Bandar Abbas, Iran
[4]Department of Environmental Health Engineering, Faculty of Health, Tehran Medical Sciences, Islamic Azad University, Tehran, Iran

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***Corresponding author:**
Fariba Jalali,
Email: fariba.jalali74@gmail.com

**Abstract**

**Background:** In waste management, neglecting and mismanaging harmful biological factors can result in adverse consequences for both organizations and employees.

**Methods:** This study aimed to identify and assess the health and safety risks faced by workers at an infectious waste site using the job hazard analysis (JHA) method. This cross-sectional descriptive study was conducted in 1401 at the waste disposal center "Halgheh Dareh" in Karaj. The JHA method involved dividing the job into tasks, identifying safety and health risks associated with each task, determining the probability and severity of the risks, and finally classifying them using a matrix based on the MIL-STD-882B standard. Control measures were also presented. All calculations were performed using Excel 2010.

**Results:** The results revealed that out of the 20 risks analyzed, 40% were classified as unacceptable risks, 25% as undesirable risks, 30% as acceptable risks but in need of revision, and 5% as minor risks.

**Conclusion:** Through the application of the JHA method, we were able to evaluate and classify health and safety risks according to their level of severity. By implementing control measures such as the use of personal protective equipment, periodic medical examinations, administration of the Hepatitis vaccine, and adherence to safety protocols, it is possible to reduce the risks and prevent the occurrence of occupational diseases and accidents that can lead to harm.

**Keywords:** Infectious wastes, Job hazard analysis, Landfill workers, Waste burial center

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## Introduction

Sanitary waste encompasses waste generated from healthcare facilities, including hospitals, medical research centers, pharmaceutical factories, pharmacies, blood banks, and home healthcare activities. This waste is broadly categorized into general waste and hazardous waste. Terms such as health waste, medical waste, biomedical waste, and hospital waste are often used interchangeably. Health care waste (HCW) represents a distinctive waste category due to its potential inclusion of harmful substances, posing risks to the health of individuals exposed to it.[1] Sharp wastes present significant health risks as they can transmit infectious diseases such as human immunodeficiency virus (HIV), hepatitis B, and hepatitis C. These risks are particularly pronounced in areas where proper waste separation is not implemented.[2] Infectious wastes contain substantial amounts of agents that can cause infectious diseases if susceptible individuals come into contact with them. Each year, 5.2 million people die from diseases transmitted through hospital waste. Therefore, implementing control and preventive measures to reduce waste production and minimize hazardous waste in various health centers is one of the fundamental strategies advocated by the World Health Organization (WHO).[3] Hospital waste management encompasses a comprehensive set of regulations governing the production, maintenance, collection, transportation, recycling, and disposal of solid waste materials. These regulations adhere to the highest standards of public health, economic efficiency, resource conservation, aesthetics, and other environmental considerations, ensuring the well-being of the general public.[4] The

inadequate disposal of medical waste poses significant risks to public health and the environment as it serves as a breeding ground for various pathogenic microorganisms. If not properly managed, pathogens present in healthcare waste can enter the human body through skin abrasions or cuts, mucous membranes, inhalation, and ingestion. Exposure to healthcare waste may result in various health issues, including respiratory infections, gastrointestinal infections, skin infections, fever, viral hepatitis, and influenza.[5] In a general classification, occupational harmful factors can be divided into chemical, physical, biological, ergonomic, and psychological factors.[6] Today, various methods are known for identifying risks in the workplace, with the occupational safety analysis method being utilized as an efficient approach to identify risks proactively. Managers are particularly concerned with identifying health risks and implementing effective management strategies.[7] The most crucial component of any safety and health program, or in other words, a safety and health system, is hazard identification. Identifying risks is the initial step to propose strategies for managing and eliminating them. It also allows for the adjustment of health and safety goals and plans. The accuracy of risk identification directly influences the performance of the system.[8] The American Research Council NRC, specifically the United States National Research Council, defines risk assessment as the process of determining the potential adverse health effects resulting from exposure to environmental hazards.[9] Contact with hospital waste can lead to various diseases in humans, including bacterial diseases (tetanus, anthrax, tuberculosis, cholera, typhoid, skin infections, gastroenteritis, respiratory infections), viral diseases (hepatitis), parasitic diseases (giardiasis, ascariasis, anquilostomiasis, echinococcosis, malaria), and fungal diseases (candidiasis, cryptococcosis, coccidioidomycosis).[10] Job hazard analysis (JHA) is a detailed and systematic study method used to identify and evaluate existing or potential risks in any process or job. In this approach, the job is broken down into successive stages. In the next step, the risks associated with each stage are identified, assigned a risk number, and finally, control solutions are proposed.[11] The advantage of JHA lies in its role as a guide for audits. Auditors can utilize the form to comprehend the control measures implemented to mitigate risks in the workplace.[12] Wastes typically occur in nature in two forms: dry wastes and wet wastes. Dry wastes are further categorized into five groups, including normal wastes, medical wastes, special wastes, agricultural wastes, and industrial wastes. Some of these wastes are disposed of through burial or cremation.[13] Given that the implementation of this method is straightforward and requires minimal facilities, everyone in the workplace, including managers and personnel, can benefit from its positive results.[14] It enhances awareness of risk levels and occupational hazards.[15] In the health waste risk assessment conducted at Batna City Hospital, Algeria, using preliminary risk analysis and a risk assessment matrix, it was identified that infectious waste and anatomical waste pose significant risks to humans.[16] In a study investigating the environmental health effects of urban solid waste disposal, the results revealed various environmental impacts. These included chemical pollutants such as carbon monoxide (CO), hydrogen sulfide ($H_2S$), methane gas, microorganisms like coliform, shigella dysentery, clostridia perfringens, and heavy metals including magnesium, zinc, lead, nickel, iron, chromium, and cadmium. The health effects reported encompassed symptoms such as skin irritation, eye irritation, digestive system disorders, allergies, nasal irritation, and other related symptoms.[17] The challenges faced by the hospital waste management system in the country include the absence of suitable technology and advanced devices in hospitals, insufficient and efficient human resources, inadequate monitoring of device health and functionality, lack of regular monitoring of infectious waste producers, and a failure to establish a proper mechanism for waste collection from these centers. Additionally, the high volume of waste production exceeds the standards set by the WHO.[18,19] Every research endeavor represents a logical, organized, and scientific challenge aimed at answering a question or providing a solution to a problem. Each research method employed carries its own set of achievements. The primary findings of a research project essentially constitute hypotheses, the outcomes of which have been determined. As a researcher concludes their activity, they are obligated to present the results obtained after testing these hypotheses. These results form the basis upon which recommendations are developed. Therefore, the conclusions drawn from correct analysis represent a crucial aspect of the research, serving as a means to translate theories into practical solutions for future success. In our country, much like numerous developing nations, challenges such as a lack of forward-looking policies, insufficient allocation of funds for waste management, absence of adequate laws and regulations, and insufficient equipment in hospitals contribute to the main problem of hospital waste disposal in Iran.[10] Medical waste management poses a significant challenge to waste management systems and those involved in the process, given its association with the population requiring medical care. Despite constituting a relatively small portion of total waste, medical waste management is deemed a critical issue globally. Due to its hazardous nature, healthcare waste takes precedence and holds a high priority in waste management. The management of healthcare waste is deemed essential due to factors such as infection and toxicity.[20]

The research was conducted in the burial center of Halgheh Darreh in Karaj city. Given the hazardous nature of health and medical waste, health and safety assessments play a crucial role in controlling the hazards associated with an infectious landfill environment and mitigating adverse health effects on workers.

## Materials and Methods

The current study, conducted in a burial center in 1401, is a descriptive and cross-sectional investigation. It focuses on occupational safety analysis, also known by various synonymous names such as occupational activity analysis, occupational hazard breakdown, occupational hazard analysis, and determination of safe activities. This method plays a crucial role in preventing accidents and analyzing risks. Its implementation in industrialized countries dates back to the years before 1334. A key aspect of job safety analysis is the involvement of workers, who can contribute their job knowledge and help identify errors in the production process, thereby enhancing productivity. It is common to hear workers express the sentiment that their opinion on such matters is not sought. However, by involving workers in safety issues and decisions, their commitment to implementing safety measures can be significantly increased. Presently, this approach stands as one of the vital components and provisions within health and safety management standards.[21] The objective of this study was to examine occupations, employing the JHA risk assessment method. The research was conducted in a systematic process, involving five distinct steps, which are as follows:

### *First Step: Formation of the Risk Assessment Group*

During this stage, after establishing the scope and objectives of the risk assessment, a dedicated group was assembled to identify and assess health risks, along with their potential consequences. This risk assessment group comprised of experts in environmental health and HSE (health, safety, and environment), who possessed relevant experience in the field of waste management.

### *Second Step: Breaking Down the Job and Identifying Risks*

During this stage, the focus was on breaking down the job into its sequential stages and examining the associated risks of each task. Specifically, the job of an infectious waste landfill worker was investigated due to the potential for causing illness and severe injuries. Typically, a job consists of multiple tasks, and each task may carry its own set of risks. In order to effectively analyze the risks, it is essential to possess a thorough and comprehensive understanding of the job in question. In this step, the objective was to identify all potential risks associated with each step involved in performing a task.

### *Third Step: Determining the Risk Assessment Parameters*

The probability (P) of occurrence was determined using Table 1, which presents the sequence of events' probability related to the identified risks. By referring to Table 1, it was possible to assign a specific numerical value corresponding to the probability of occurrence. Table 1 provides the levels of probability associated with health hazards in the JHA method.

The severity (S) of the adverse human consequences resulting from events can be determined by referring to Table 2. This table provides a classification of the severity and extent of the consequences caused by health risks in the JHA method.

### *Criteria and Classification of Risks*

Next, the classification of risks and decision criteria were determined based on the risk assessment matrix, which follows the MIL-STD-882B standard. This classification can be found in Tables 3 and 4.

## Results and Discussion

Table 5 outlines the definition of eight tasks for workers employed in an infectious waste landfill. During the study, a total of 20 risks were identified and evaluated in terms of health and safety. Among these risks, eight were categorized as having an unacceptable level, accounting for 40% of the total. Additionally, there were five risks classified as undesirable, representing 25% of the total. Six risks were deemed acceptable but requiring revision, with a relative frequency of 30%. Finally, there was one minor case, making up 5% of the total risks (Figure 1). The objective of this study was to identify and assess health and safety risks.

The results obtained from the study revealed that the highest level of risks identified were associated with dust generated by soil and liming, as well as gases such as methane and $CO_2$. These risks were deemed unacceptable and had the potential to cause accidents. Additionally, risks related to animal bites and the presence of sharp objects were categorized as being at an unfavorable level.

A study was carried out to identify and assess the environmental resources of Tehran. The findings revealed that 52.94% of the identified environmental risks fell into the category of medium importance, whereas 35.29% were classified as high importance risks, and 11.76% were categorized as low importance risks.

The most significant risks encompassed occupational, HSE risks, along with those associated with the

**Table 1.** The Possibility of Danger

| Probability | Probability Level | Probability Description |
|---|---|---|
| X > 10-1 Frequent | A | It happens frequently. |
| 10-3 < X < 10–1 Probable | B | It occurs several times during the lifetime of the system. |
| 10-3 < X < 10–2 Occasionally | C | They occur occasionally during the lifetime of the system. |
| 10-4 < X < 10–3 Very little | D | The probability of its occurrence during the lifetime of the system is very low. |
| X < 10–4 Improbable | E | The probability of its occurrence during the lifetime of the system is so low that it can be considered as zero. |

**Table2.** Severity of Danger

| Type of Risk | Class | Definition |
|---|---|---|
| Catastrophic | 1 | Death or system failure |
| Critical | 2 | Injuries, occupational diseases or damage to the system are severe. |
| Border | 3 | Injuries, occupational diseases or damage to the small system. |
| Minor | 4 | Injuries, occupational disease or damage to the system are too small. |

**Table 3.** Risk Assessment Matrix Based on the MIL-STD-882B Standard

| Probability | | | | | | |
|---|---|---|---|---|---|---|
| | | A | B | C | D | E |
| Severity | 1 | 1A | 1B | 1C | 1D | 1E |
| | 2 | 2A | 2B | 2C | 2D | 2E |
| | 3 | 3A | 3B | 3C | 3D | 3E |
| | 4 | 4A | 4B | 4C | 4D | 4E |

**Table 4.** Decision Criteria Based on the Risk Index

| Risk Classification | Risk Measure |
|---|---|
| 1A-1B-1C-2A-2B-3A | Unacceptable |
| 1D-2C-2D-3B-3C | Undesirable |
| 1E-2E-3D-3E-4A-4B | Acceptable but needs revision |
| 4C-4D-4E | Minor |

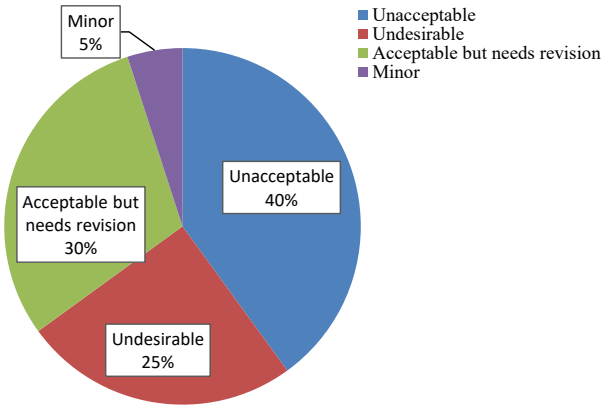


**Figure 1.** Occupational Hazards of Infectious Waste Landfill Worker

deterioration of environmental parameters such as air, water, and soil quality.[22]

A study was undertaken to prioritize health and environmental risks in the South Pars complex. The study identified 17 environmental risks, 4 health risks, and 6 safety risks. Notably, the high-priority risks were found within the health risk categories.[23]

In a study on environmental management of forest fire risk using the SWOT analysis model for the forest parks of the southern Alborz slopes, the results indicated that the most crucial factors in fire risk management, ranked by the highest relative weight, are "easy access to the forest park" (0.77), "lack of budget" (0.459), and "existence of road network" (0.76).

Additionally, factors such as "decreasing the motivation and interest of volunteers and the public" (0.417) were identified in the groups of strength, weakness, opportunity, and threat. The most important fire risk management strategies, determined through the SWOT matrix, PAH method, and Likert scoring, include "planning according to the degree of fire risk for each part of the forest park" (0.715), "establishment of a rapid response force and fire extinguishing equipment at the appropriate points of the forest park" (0.685), and "updating knowledge in the field of fire risk management" (0.635). The A'SWOT technique proves to be suitable for identifying factors and devising operational fire strategies for prevention and control in forest areas.[24]

## Conclusion

The evaluation results can serve as a basis for implementing adjustments and solutions to reduce the risks to an acceptable level. Managers can enhance the knowledge and awareness of employees regarding the hazards present in their work environment and the associated illnesses. Special attention should be given to periodic and pre-employment examinations of employees, focusing on job suitability and individual physical condition. Effective control measures to mitigate the identified risks include the utilization of personal protective equipment (PPE) such as safety shoes, high-visibility work clothing, and respiratory masks with appropriate filters. Regular replacement of cartridges is crucial to minimize respiratory system damage in workers. Additional measures include periodic health check-ups and annual monitoring of employees' health status, administration of hepatitis vaccines, complete enclosure of the infectious waste landfill area, avoiding blind spots for machines, and installing safety and warning signs. Certain hazards, such as shift work, prolonged exposure to traffic, job-related stress, and noise, were evaluated at an acceptable level. However, they can still be reviewed and addressed through control measures such as implementing rotating shift schedules, providing adequate employee benefits, assigning sufficient rest periods, ensuring fair distribution of work duties, and providing relevant training.

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## Authors' Contribution

**Conceptualization:** Fariba Jalali.
**Data curation:** Ensieh Salehi Salut.
**Formal analysis:** Mohammad Mosayyebi.
**Funding acquisition:** Babak Pahlavan.
**Investigation:** Babak Pahlavan.
**Methodology:** Mohammad Mosayyebi.
**Project administration:** Babak Pahlavan.
**Resources:** Fariba Jalali.

**Table 5.** Evaluation of Occupational Hazards of Infectious Waste Landfill Workers

| Row | Task | Hazard | Consequences | Possibility | Severity | Risk Level | Risk Measure | Control Action |
|---|---|---|---|---|---|---|---|---|
| 1 | Cooperating with the drivers carrying infectious waste in the matter of emptying the waste and guiding them | Voice | Hearing loss | A | 4 | 4A | Acceptable but needs revision | Using ear plugs or Using ear muffs |
| 2 | | Dust | Shortness of breath - pulmonary sensitivity | A | 2 | 2A | Unacceptable | Conduct annual occupational medicine examinations and use respiratory masks with cartridge |
| 3 | | Accident with a transporter | Death-disability-fracture-crushing-dislocation | C | 2 | 2C | Undesirable | Use of bright work clothes - not to be placed in the blind spots of cars |
| 4 | Instructions for the driver of other construction machinery | Voice | Hearing loss | A | 4 | 4A | Acceptable but needs revision | Using ear plugs or Using ear muffs |
| 5 | | Dust | Shortness of breath - pulmonary sensitivity - occupational asthma | A | 2 | 2A | Unacceptable | Conduct annual occupational medicine examinations and use respiratory masks with cartridge |
| 6 | | Accident | Death-disability-fracture-crushing-dislocation | C | 2 | 2C | Undesirable | Use of bright work clothes - not to be placed in the blind spots of cars |
| 7 | Preventing animals from entering the site | Animal bites | Injury-bleeding-swelling | C | 2 | 2C | Undesirable | Completely enclosing the infected landfill area and ensuring that the entrance door is closed |
| 8 | Preventing the entry of different people | Job stress | Increased heart rate and blood pressure-anxiety-fear-panic | B | 4 | 4B | Acceptable but needs revision | Completely enclosing the infected landfill area and ensuring that the entrance door is closed |
| 9 | Submit work report to superiors | Job stress | Increased heart rate and blood pressure-anxiety-fear-panic | A | 4 | 4A | Acceptable but needs revision | Equitable division of duties-conducting stress control training course |
| 10 | Supervision of trench digging | Uneven surfaces (earth erosion) | Superficial wounds-scratches-crushes or bruises and broken hands and feet | A | 2 | 2A | Unacceptable | Keeping a safe distance and not standing at dangerous points on the edge of the trench |
| 11 | | Falling from a height | Fracture - in dislocation and bruising of body parts - bleeding | A | 2 | 2A | Unacceptable | Drawing the danger tape and using warning signs |
| 12 | | Inhalation of dust particles | Shortness of breath - pulmonary sensitivity - occupational asthma | A | 1 | 1A | Unacceptable | Conduct annual occupational medicine examinations and use respiratory masks with cartridge |
| 13 | Monitoring the correct covering of waste by means of a layer of soil and lime | Sharp objects | Skin cuts on the fingers or toes, superficial or deep bleeding | C | 2 | 2C | Undesirable | Use resistant work gloves and safety shoes |
| 14 | | Inhalation of lime particles | Shortness of breath - pulmonary sensitivity - occupational asthma | B | 2 | 2B | Unacceptable | Use respiratory masks with cartridge |
| 15 | | Exposure to gas methane and $CO_2$ | weakness - dizziness - headache - nausea - Vomiting - cardiovascular, respiratory and nervous problems | A | 2 | 2B | Unacceptable | Use respiratory masks with cartridge |
| 16 | Patrolling | Prolonged walking | Knee pain-back pain-muscle fatigue | D | 3 | 3D | Acceptable but needs revision | Break time allocation |
| 17 | | Shift work | Job burnout-depression-reduction of job motivation | A | 4 | 4A | Acceptable but needs revision | Job rotation - allocation of special benefits |
| 18 | | Insufficient lighting at night | Falling down - Injury | D | 4 | 4D | Minor | No traffic on non-level roads |
| 19 | | Sharp objects | Skin cuts on the fingers or toes, superficial or deep bleeding | C | 2 | 2C | Undesirable | Use resistant work gloves and safety shoes |
| 20 | | Exposure to gas methane and co2 | Weakness - Dizziness - Headache - Nausea Vomiting - Cardiovascular - Respiratory and nervous problems | A | 3 | 3A | Unacceptable | Use respiratory masks with cartridge |

**Software:** Ensieh Salehi Salut.
**Supervision:** Fariba Jalali.
**Validation:** Mohammad Mosayyebi.
**Visualization:** Ensieh Salehi Salut.
**Writing–original draft:** Fariba Jalali.
**Writing–review editing:** Fariba Jalali.

## Competing Interests
There is no conflict of interest between the authors and others.

## Ethical Approval
In this research, ethical considerations have fully been observed.

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