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Understanding occupational health challenges in managing hospital solid waste in Zimbabwe: a critical review

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Abstract

Industrialisation and service provision expose involved people to occupational health risks, including solid waste workers. In Zimbabwe, many concerns focus on occupational health risks affecting workers in industries, giving little attention to those involved in hospital solid waste management. This review aims to understand occupational health risks arising from hospital solid waste management in Zimbabwe, using existing literature. With a population of about 15.1 million, Zimbabwe is located in Southern Africa and shares borders with Mozambique, Zambia, Botswana and South Africa. The study employed a systematic methodology following the PRISMA framework to analyze data obtained from PubMed, Scopus, Web of Science, Google Scholar, and various websites. Results from the study showed that hospital solid waste is increasing due to outbreak and spread of diseases, population increase, disposal of outdated materials and compulsory high utilisation of disposable items. Its management is difficult since its increase overwhelms capacity of responsible authorities and a hazardous proportion worsens the challenge. Hospitals are among sources of hazardous waste including cytotoxic, radioactive, infectious, pathological, pharmaceutical and sharp waste, however non-hazardous waste includes non-contaminated materials. Hospital solid waste management strategies involves handling, storage, collection, transportation, treatment and disposal. Occupational health risks related to the activity encompass biological, psychological, physical, chemical and ergonomic risks which expose workers to acute and chronic health problems. Occurrence of risks is ascribed to lack of resources, hazardous nature of the waste, inadequate knowledge, lack of effective legal framework and insufficient research. Curbing occupational health risks require training and use of proper personal protective equipment, clear legal framework and adoption of hospital solid waste minimization strategies.

Keywords Hospital solid waste, Management strategies, Biological risks, Physical risks, Chemical risks, Ergonomic risks, Psychological risks

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1 Introduction

1.1 Global context

In recent times, the rapid growth of industrialisation and service sectors has led to an acceleration in development [24], but they introduced new challenges and risks to workers' health. A staggering number of 6300 individuals lose their lives due to either occupational accidents or diseases per day, translating to a death toll of over 2.3 million people annually [34]. Occupational health risks emanate from various factors including working environment, equipment used, nature of the job, behavior of individuals and other workers within the workplace. Work related risks affecting employees vary and encompass physical, chemical, ergonomic, biological and psychological hazards [50]. Noise, vibration, radiation exposure, extreme temperatures, manual handling and risk of slips and falls are part of physical risks while musculoskeletal disorders are ergonomic risks [31, 70]. Workers in the manufacturing, transportation, farming and mining industry are vulnerable to chemicals such as solvents, detergents, pesticides, heavy metals and asbestos [66]. Similarly, workers involved in the health sector are also affected by ergonomic, chemical, physical, biological and psychological work related risks. This clearly signifies that individuals involved in management of hospital solid waste are vulnerable to work related injuries, diseases and death. Exposure to pathogens results in occurrence of infectious diseases among solid waste workers. In Sub-Saharan Africa, approximately 30% of new hepatitis B and C infections and 2.5% of new HIV infections are attributed to annual injuries caused by solid waste [5].

Addressing work related diseases and injuries is essential to ensure safety and wellbeing of employees in various sectors, not excluding the health sector [18, 41]. The World Health Organization and the International Labour Organization both actively support the safety of workers [47, 78]. Occupational health risks are getting attention across the globe since they devastate workers' health. In numerous countries, work related risks are managed through assessing the workplace for potential hazards and evaluating the level of risk associated with each hazard [17, 66]. Implementation of hierarchical control measures namely engineering, administrative, substitution and elimination control measures as well as use of personal protective equipment/clothing also support safety of workers [57–61]. The problem in developing countries like Zimbabwe is relying on strategies which occupy the base of the safety hierarchy of the control ladder, yet they are least prioritised.

1.2 Zimbabwean context

In Zimbabwe effectiveness of occupational accidents minimisation and prevention programs is lessened by lack of commitment, resources and lack of knowledge [42]. Among other challenges, more priority is given to safety of employees in manufacturing, construction and mining industries at the expense of workers involved in hospital solid waste management. A view upheld by Asibey et al. [9] and Shin et al. [65] that in most developing countries industrial workers are more protected than those involved in management of waste, a scenario noted in Zimbabwe by Jerie [31] and Chireshe et al. [19, 20]. Nevertheless, while solid waste management may not involve immediate harm to workers on the same scale as industries, it presents long-term health challenges. People involved in waste management face a high risk of both fatal and non-fatal occupational accidents due to factors such as heavy machinery operation, exposure to hazardous

materials, physical demands and outdoor working conditions [25, 26]. Nevertheless, research related to occupational health risks associated with hospital solid waste management is still at an embryonic stage in Zimbabwe [54, 55].

Management of hospital solid waste is crucial for maintaining a safe and healthy environment, but it also poses several work-related risks that need to be addressed [33, 62]. However, most of the occupational health risks in recent studies in Zimbabwe put much emphasis on industries, particularly the mining sector and impacts of hospital waste on the natural ecosystem. Hence, there is a substantial knowledge gap regarding the potential dangers and hazards faced by individuals involved in hospital solid waste management. Nevertheless, safety of workers is regarded as essential by Zimbabwe Vision 2030, National Social Security Authority of Zimbabwe, International Labour Organisation and Sustainable Development Goals. This paper aims to unearth occupational health risks associated with hospital solid waste management focusing on Zimbabwe. A comprehensive analysis of how effective solid waste management intersects with global and national goals aimed at improving health outcomes and ensuring decent work conditions within the healthcare sector. The study creates low hanging fruits to attain SDGs like 3 (good health and wellbeing), 3.9 (reducing the number of workplace deaths and illnesses), 8.8 (protecting labour rights and promoting safe and secure working environments by 2030) and achievement of Zimbabwe national targets like Vision 2030.

2 Methodology

The review paper was compiled using already published literature as well as grey literature. The methodology of the paper adopted a systematic approach which is summarised by PRISMA flowchart (Fig. 1). A comprehensive literature search was conducted to identify relevant articles, books, reports, papers and book chapters with information related to hospital solid waste management and work-related risks. Literature was retrieved from various databases namely PubMed, Scopus, Web of Science, Google Scholar and websites was utilised to ensure a wide coverage of available literature. A combination of Key words used during searching of secondary sources encompassing databases include hospital solid waste, management strategies, risks, injuries, Zimbabwe and management

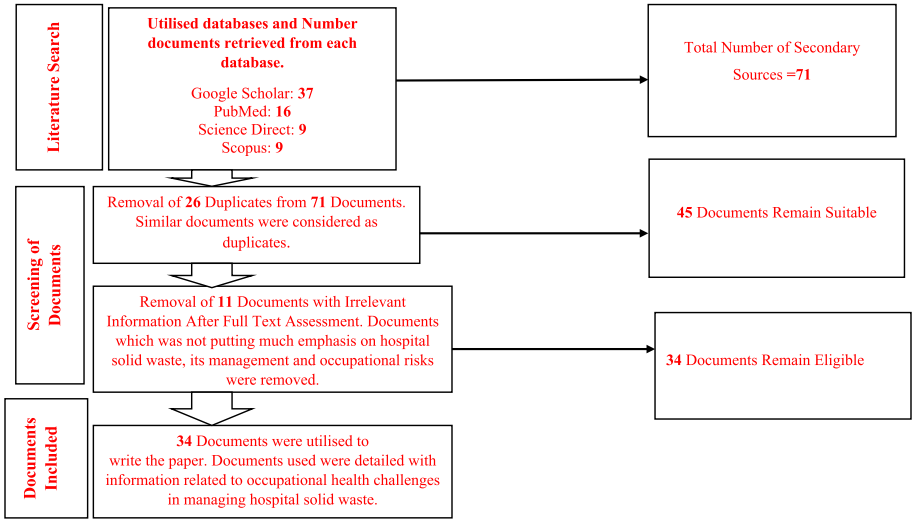

Fig. 1 Literature search and documents screening flowchart. Source: Authors

challenges among others. Boolean operators such as "and", "or", "quotation marks" and "parenthesis" were used to combine search terms, refine searches and narrow down the results. Documents written in English language with relevant abstract content and key words were regarded as suitable during compilation of appropriate documents. Databases utilised, documents inclusion and exclusion flowchart is summarised by Fig. 1. Figure 1 shows that 71 secondary data sources were retrieved from Google Scholar (37), PubMed (16), Science Direct (9) and Scopus (9). During the screening process 26 duplicates were subtracted from 71 and 45 documents remain suitable. However, after carrying out full text assessment only 34 documents became eligible since 11 secondary sources were removed. Literature was analysed quantitatively and qualitatively to increase validity and reliability of the paper as well as opportunity to derive appropriate conclusions. Thematic analysis approach was adopted to identify themes and interpreting patterns of the important aspects during the study. The findings of the review were presented in a clear and organised manner. This includes summarising the key findings, highlighting hospital solid waste management activities, main work-related risks associated with hospital solid waste management and intervention methods.

3 Hospital solid waste management activities in Zimbabwe

The management of hospital solid waste encompasses segregation, storage, collection, transportation, treatment and disposal activities [12, 69]. Segregation is a critical step in hospital solid waste management as it helps categorise different types of waste for appropriate handling, storage and disposal. Hospital solid waste should be segregated into different categories such as infectious waste, sharps, pharmaceutical waste, chemical waste, radioactive waste and general non-hazardous waste [14, 22]. Therefore, each category of hospital solid waste requires specific handling procedures to minimize risks associated with improper disposal or accidental exposure. However, in Zimbabwe, solid waste separation including hospital solid waste can be termed substandard [37, 79] translating to indiscriminate storage of hospital solid waste. This is supported by studies which was carried at Parirenyatwa hospital in Harare [71], hospitals in Kwekwe [38] and at rural hospitals in Zimbabwe including those in Chirumanzu rural district. Storage areas and containers should be proper to prevent access by unauthorised personnel and minimise the risk of contamination or spread of diseases [4, 46]. Infectious waste should be stored in leak-proof containers with secure lids to prevent spillage or leakage. Sharps should be placed in puncture-resistant containers specifically designed for their safe storage [14, 22]. This is rare in Zimbabwe due to inapt waste segregation and shortage of storage receptacles, triggered by shortage of resources particularly finance and the problem is acute at rural hospitals in Mashonaland, Midlands, Manicaland and Matebeleland provinces. Another stage in the management of hospital solid waste is the collection process [46]. It involves the systematic gathering of waste from various points within the healthcare facility and should be carried utilizing appropriate equipment. Although at most rural hospitals in Zimbabwe, multipurpose trolleys and wheelbarrows are used to collect hospital solid waste from generation points to storage sites. Additionally, waste collection should be performed regularly to prevent hospital solid waste accumulation in wards, rooms and offices as stipulated by World Health Organisation, Zimbabwe Ministry Health and Child Care. In urban areas, hospital solid waste is transported to disposal by municipal lorries which are manually loaded.

Transportation of hospital solid waste from healthcare facilities to treatment or disposal sites is another crucial stage in hospital solid waste management. In urban areas of Zimbabwe, such as Gweru, Harare, Mutare, Masvingo among others, hospitals are offered waste collection services as articulated by Urban Councils Act. However, inadequate resources experienced by these municipalities hinder their efficiency in servicing urban hospitals, therefore management of solid waste at these hospitals remains a challenge. In addition, solid waste management services and policies give much attention to urban areas at the expense of rural areas, therefore rural hospitals shoulder the burden of managing their waste. A situation attributed to the fact that the Rural District Council Act is less clear in terms of management of solid waste from rural institutions including hospitals. The World Health Organisation is clear that hospital solid waste should be transported in vehicles specifically designated for this purpose, ensuring that they are leak-proof and equipped with appropriate safety features [1, 14]. This scenario is rare in Zimbabwe since hospital solid waste from urban health institutions is transported together with general municipal solid waste, yet hospitals are among sources of hazardous waste which are toxic, reactive, corrosive and can easily ignite. Hospital solid treatment strategies used by urban and rural hospitals involve autoclaving, chemical disinfection as well as microwave treatment. Disposal of hospital solid waste is highly pinned on traditional methods namely landfilling, deed burial, open pits, incineration, open burning and open dumping [32]. Most of the disposal approaches utilised are least prioritised by the waste management hierarchy, hence have potential to cause environmental health risks. Proper management of hospital solid waste management is significant to safeguard the environment while ensuring safety of waste workers [31, 80]. In developing countries appropriate management of hospital solid waste is difficult to achieve due to socio-economic and political challenges. Sustainable hospital solid waste management strategies are lacking in Zimbabwe owing to limited resources, poor waste segregation strategies, limited public awareness and ineffective regulatory framework. At hospital level, lack of resources, including funding, storage containers, infrastructure and trained personnel, significantly hinders proper solid waste management, leading to increased occupational health risks and environmental pollution. Consequently, owing to the dwindling economy of the country, averting work related risks associated with hospital solid waste management remain difficult.

4 Occupational health risks affecting hospital solid waste handlers in Zimbabwe

4.1 Biological risks

Hospital solid waste management poses several biological risks that can have significant implications for public health and safety [2, 22]. Hospitals in Zimbabwe generate a significant amount of infectious waste, with potential to accommodate pathogens such as bacteria, viruses, parasites and fungi [33, 57–61]. Improper handling of infectious waste lead to the transmission of infectious ailments namely hepatitis, HIV and AIDS, tuberculosis, influenza and COVID-19 to waste handlers in Zimbabwe. Sharps injuries are common work related risks that affect works involved in management of hospital solid waste [2, 43]. Improper handling and transportation of sharps in non-recommended containers increases the risk of accidental injuries to waste handlers in Zimbabwe. These sharp injuries result in the transmission of blood borne pathogens with potential to

cause hepatitis B, hepatitis C, human immunodeficiency virus (HIV) and tetanus [63, 67]. Hospital solid waste may contain airborne pathogens that can be released into the environment during handling or transportation processes. This normally occurs when bags containing infectious waste are torn or punctured and aerosols containing microorganisms are released [6, 28]. These aerosols may contain bacteria like Staphylococcus aureus or fungi like Aspergillus spp., which can cause respiratory infections if inhaled by hospital waste handlers. Improper storage or disposal of hospital solid waste can attract vectors namely flies. These vectors can come into contact with infectious waste and subsequently spread pathogens when they come into contact with clothes of waste workers, increasing the risk of disease transmission. Flies from transported as well as disposed hospital solid waste can carry bacteria like Escherichia coli and Salmonella spp [3, 16]. Waste workers are susceptible to rodents which can transmit diseases such as leptospirosis and Hantavirus.

4.2 Chemical risks

In addition to biological risks, hospitals use a variety of chemical disinfectants and cleaning agents or detergents to maintain hygiene and suppress the spread of infections which raise concern of chemical risks [7, 49]. Zimbabwean hospitals such as Mpilo, Parirenyatwa, Chitungwiza, Ingutsheni, Gweru General, Masvingo General, ST Theresa Chirumanzu hospitals among others utilise chemicals including disinfectants like chlorines, hydrogen peroxide and quaternary ammonium compounds, as well as cleaning agents and sterilising agents. These products often contain hazardous substances including chlorine compounds, formaldehyde, phenols, ethylene oxide and heavy metals. Exposure to these chemicals can have adverse effects such as respiratory problems and skin irritation to human health. Flammable materials such as containers with remains of alcohol-based hand sanitizers, aerosol cans and chemical solvents are part of healthcare waste in Zimbabwe [40, 44]. Therefore, increase the risk of injuries and burns associated with erratic fire among hospital solid waste workers. To worsen the scenario some of the hospital chemicals like chemotherapy drugs and anesthetic gases are carcinogenic [39, 49] hence have potential to cause various types of cancer to waste workers. Continuous exposure to pollutants with heavy metals like lead and mercury during incineration and open burning of hospital solid waste cause neurological damage. Additionally, some medical devices or equipment containing batteries may explode if not disposed properly during solid waste management processes. However, batteries can release toxic chemicals namely, cobalt dioxide, lithium salts zinc and manganese dioxide with potential to cause nausea, nose and throat irritation among solid waste workers.

4.3 Ergonomic risks

One of the major ergonomic risks in solid waste management involving hospital solid waste management is related to manual handling and lifting of heavy or awkwardly shaped waste containers [76]. Hospital waste receptacles in Zimbabwe include containers full of sharps, soiled linens and bottles. Manual lifting of heavy containers Fig. 2 [31] and Fig. 3 [19, 20] leads to ergonomic risks, translating to musculoskeletal disorders such as strains, sprains and hand, neck, shoulder and back pain. Shabani et al. [57–60] indicated that effects of ergonomics risks reported at Muvonde hospital most (51.4%) specified back injuries, followed by neck pain (21.1%), shoulder discomfort (16.5%) and

Fig. 2 Manual lifting with potential to cause ergonomic risks. Source: Jerie [31]

Fig. 3 Manual loading with potential to cause ergonomic risks. Source: Chireshe et al. [19, 20]

Fig. 4 Workers lifting heavy solid waste receptacle without ergonomic aids. Source: Chireshe et al. [19, 20]

the least (11%) muscular strain. Another ergonomic risk in hospital solid waste management is associated with performing tasks in awkward postures Fig. 4 [19, 20] and repetitive motions during loading of solid waste trucks. Awkward posture positions such as bending, twisting, reaching or squatting result in low back pain, neck and shoulder pain, carpal tunnel syndrome, tendonitis and bursitis among hospital waste workers. Solid waste workers bend, twist and stretch muscles excessively during lifting of containers and loading of waste trucks [76]. This can put permanent or temporary strain on the muscles and joints of hospital waste workers leading to discomfort and injuries over time. Implementing ergonomic principles in hospital waste collection areas by ensuring proper workstation design, adjustable equipment and minimizing unnecessary movements reduce these risks. Repetitive motions such as opening and closing heavy lids on

waste containers also contribute to cumulative trauma disorders like tendonitis and carpal tunnel syndrome [36]. The constant exposure to distressing situations erode their mental well-being over time.

4.4 Physical risks

Moreover, in addition to ergonomic risks, physical risks associated with management of solid waste management from institutions is the potential of being affected by injuries [31, 54, 55]. This suggests that those involved in the management of hospital solid waste are susceptible to physical risks. Handling of hospital sharp waste during collection, transportation and loading of incinerators causes pricks, cuts, skin piercing and punctures among waste workers [8]. Burning and incineration of hospital solid waste expose waste workers to high radiation and heat [53, 77] resulting in skin burns, rash coupled by continuous headaches and high blood pressure. Excessive radiation from incinerators has the potential to cause genetic mutation and cancer among hospital waste workers. Hospitals in Zimbabwe are sources of compressed chemical containers, however these containers explode during combustion processes causing eye and face injuries among waste workers. Furthermore, solid waste workers encompassing those dealing with waste from the health sector are vulnerable to falls [31]. Falling of solid waste collectors result in head, knee, elbow injuries while joint permanent or temporary dislocation to hospital waste workers. Most of the time solid waste workers are susceptible to high or low day temperatures during collection and disposal processes [31, 48] and hospital solid waste workers are not spared. Exposure to cold temperatures among hospital solid waste collectors, is ascribed to carrying of duties during morning hours, even in winter. Therefore, hospital waste workers are affected by shallow breathing, persistent coughs, blood thickening, chest pain and pneumonia due to low temperatures. Solid waste collectors are affected by vibration due to pushing of wheelbarrows, trolleys and carts on rugged terrain or rough surfaces as well as by being in the trailer of waste collection trucks [31]. As a result of vibration, hospital waste workers are vulnerable to bone damage, motion sickness, hand and back pain.

4.5 Psychological risks

In addition to physical risks, psychological risks associated with solid waste management like hospital solid waste management is fear and anxiety [15, 75]. Hospital solid waste workers involved in waste management activities experience fear and anxiety due to concerns about exposure to hazardous materials or infectious waste. This fear is heightened during outbreaks of infectious diseases for instance COVID-19 or when dealing with patients with highly contagious diseases [27, 45]. The fear of contracting a disease or spreading it to others, particularly family members leads to increased stress levels and psychological distress. Waste management activities are often seen as dirty or unpleasant tasks [23, 52], leading to negative perceptions and attitudes towards those involved in hospital waste management activities. In Zimbabwe, solid waste management workers face stigmatisation from their colleagues or society at large [31, 68], causing detrimental impact on their self-esteem and overall well-being. Hospital solid waste management gives rise to moral distress among involved workers since they face stigma and social isolation. In the context of waste management, workers experience moral distress and stress if they perceive that waste is not being managed in an environmentally

acceptable manner [64]. Work related stress increased by working without adequate resources in managing hospital solid waste in Zimbabwe. This leads to feelings of guilt and frustration, which can have a significant impact on their psychological well-being.

5 Possible strategies to safeguard workers involved hospital solid waste management in Zimbabwe

One of the most crucial strategies for minimizing environmental health risks in solid waste management is providing comprehensive training, education to involved people and applying approaches which supports circular economy [11, 73, 74]. Training should cover various aspects, including waste segregation, handling techniques, personal protective equipment/clothing PPE/C usage, and infection control measures. Hospital waste workers must receive education regarding spill response procedures as well as proper disposal and treatment procedures. Jerie [31] and Shabani et al. [57–61] concur that by ensuring that all staff members are well-informed and trained on best practices, risks of accidents, injuries, and exposure to hazardous materials can be significantly reduced. Hospital solid waste workers should be trained on safe handling, lifting and transportation techniques and the use of mechanical aids to prevent musculoskeletal injuries. Workers involved in lifting of heavy waste receptacles must be equipped with enough knowledge to reduce cropping of ergonomic risks. Provision of personal protective equipment/clothing enhances safety of solid waste workers [31], (Shabani and Jerie 2022), including those involved in hospital solid waste management. Therefore, workers involved in hospital solid waste management should be provided with appropriate PPE/C such as hard gloves, masks, goggles, safety shoes and work suits to protect themselves from potential hazards. Appropriate containers with secure lids and puncture proof nature should be used to store hospital sharp waste in order to minimise risk of sharp injuries during collection of sharp waste containers [22, 38]. This reduces infectious diseases associated with hospital sharp waste injuries and infectious solid waste.

Hospital solid waste contains infectious materials, including blood and body fluids contaminated items like linen [8, 22]. Implementing robust infection control measures is crucial to minimize health risks associated with infections among workers involved in hospital solid waste management. This includes regular hand hygiene practices, proper use of PPE/C, routine cleaning and disinfection of waste storage areas and equipment and adherence to Zimbabwe Ministry of Health and Child Care and World Health Organisation standards. Regular monitoring and auditing of hospital solid waste management practices are essential to identify any gaps or deficiencies in the system [10, 72]. This should be conducted by the Environmental Management Agency supported by Environmental Health Departments at hospitals in the Zimbabwean context. This is achieved through periodic inspections, waste stream analysis and performance evaluations. Solid waste management audits assist to comply with waste management regulations, identify areas for improvement and implement corrective actions to mitigate work related risks effectively [21, 29]. This signifies that by conducting these audits, hospitals assess their current solid waste management practices, identify gaps, and enhance their waste management performance while minimizing work related risks.

Collaborating of all stakeholders such as waste management experts or engaging professional waste management services provides valuable expertise and support through sharing of ideas [73]. Collaboration of various stakeholders translates to an integrated

approach resulting in minimisation of occupational health risks associated with hospital solid waste management [31]. In the Zimbabwean context, there should be collaboration of hospital solid waste workers, hospital Environmental Health Department, Environmental Management Agency, National Social Security Authority, Zimbabwe Ministry of Health and Child Care and researchers. Integration of these organisations, departments and research experts assist in developing customised waste management plans, conducting risk assessments, providing training programs and ensuring compliance with local regulations and best practices. Through inclusion of researchers, innovative strategies to improve hospital solid waste management strategies are developed [13], causing reduction of hospital solid waste work related risks. Hospital solid waste management practices should be subject to continuous improvement and innovation to enhance safety of workers and sustainable management [30, 35]. Healthcare facilities should stay updated with the latest advancements in waste management technologies, such as automated waste segregation systems, on-site treatment options like autoclaving or shredding, and alternative disposal methods like recycling or energy recovery [10, 46]. Innovative solutions enable hospitals to reduce the volume of waste generated, hence minimising ergonomic, psychological, chemical, physical risks and biological risks associated with managing hospital solid waste. Additionally, sufficient legislation or policies and adequate financing are essential in managing solid waste effectively and reducing vulnerability of involved people to work related risks [51]. This implies that the Zimbabwean government must develop a legal framework directed to occupational health risks emanating from hospital solid waste management while channeling enough finance to management of hospital solid waste.

6 Specific categories of potential strategies to safeguard workers involved in hospital solid waste management in Zimbabwe

6.1 Role of policies and legislation in safeguarding workers involved hospital solid waste management

The role of policies and legislation in safeguarding workers involved in hospital solid waste management is crucial for ensuring their health and safety. Regulations provide a framework for managing hazardous and non-hazardous waste, mandating safe handling, treatment, and disposal practices. Policies and legislation sets standards that protect workers from exposure to hazardous materials, including blood borne pathogens found in medical waste. Policies require healthcare facilities to implement training programs for staff on proper waste segregation and disposal techniques, thereby minimizing risks associated with sharp injuries and infections. Furthermore, state-specific regulations often enhance federal guidelines by addressing local environmental concerns, ensuring comprehensive protection for workers engaged in hospital solid waste management. Effective legislation fosters a safer work environment by promoting compliance with best practices in waste handling.

7 Training and personal protective equipment role in safeguarding workers involved in hospital solid waste management

Training and personal protective equipment (PPE) are crucial in safeguarding workers involved in hospital solid waste management. Workers must receive comprehensive training on the types of waste they will handle, including infectious and hazardous

materials, to understand the risks associated with improper handling. This training typically covers safe disposal methods, emergency procedures, and the importance of hygiene practices to prevent contamination. PPE plays a vital role by providing physical barriers against exposure to harmful substances. Essential PPE includes gloves, masks, gowns, and eye protection, which help minimize direct contact with potentially infectious waste. Proper use of PPE is reinforced through training sessions that emphasize correct donning and doffing techniques to avoid cross-contamination. Together, effective training programs and appropriate PPE significantly reduce the risk of injury or infection among workers, ensuring a safer working environment in hospital solid waste management.

8 How technology can be used to safeguard workers involved in hospital solid waste management

Technology can significantly enhance the safety of workers involved in hospital solid waste management through various innovative solutions. Smart waste segregation systems utilize sensors and artificial intelligence to accurately classify waste at the point of generation, minimizing human error and reducing contamination risks. Automated handling systems such as hands-free disposal units, limit direct contact with hazardous materials, thereby decreasing exposure to biohazardous waste. Real-time tracking technologies enable facilities to monitor waste levels and optimize collection schedules, preventing overflow and potential accidents. Training programs delivered via digital platforms ensure that staff are well-informed about best practices in waste management, further enhancing safety protocols. Moreover, by integrating these technologies into hospital operations, healthcare facilities can create a safer working environment for their employees while ensuring compliance with regulatory standards.

9 How collaboration of Zimbabwe Environmental Management Agency, hospitals, non-governmental organisations safeguard those involved in hospital solid waste management

Stakeholder collaboration among the Zimbabwe Environmental Management Agency, hospitals, and Non-Governmental Organizations (NGOs) is crucial for addressing environmental health issues. EMA plays a pivotal role in regulating environmental practices and ensuring compliance with environmental laws. Hospitals contribute by providing data on health impacts related to environmental degradation, such as air and water pollution. NGOs often act as intermediaries, facilitating communication between communities, EMA and healthcare providers. This collaboration enables the development of comprehensive strategies to mitigate health risks associated with environmental factors. For instance, joint initiatives can focus on public awareness campaigns about pollution's effects on health or programs aimed at improving waste management practices. Furthermore, leveraging each stakeholder's strengths regulatory from EMA, medical insights from hospitals and community engagement from NGOs, the effectiveness of interventions aimed at promoting public health and protecting the environment in Zimbabwe is improved.

10 Conclusion and recommendations

This paper puts much emphasis on understanding occupational health risks associated with the management of hospital solid waste. Hospital solid waste generated in Zimbabwe encompasses hazardous waste namely infectious, pathological, pharmaceutical, radioactive, cytotoxic, sharps and chemical waste, a situation also highlighted by studies in Namibia, Mozambique and Malawi. Non-hazardous waste for instance food waste and non-contaminated plastics, bottles, boxes and papers that are considered as general waste, however due to indiscriminate storage, the waste stream became wholly hazardous. Management of hospital solid waste includes segregation, storage, collection, transportation, treatment and disposal. All these stages have potential to expose hospital solid waste workers to significant work related risks. Major risks affecting hospital solid waste workers are biological, ergonomic, physical, psychological and chemical risks. Owing to dealing with solid waste with bacteria, viruses, parasites and fungi hospital waste workers are exposed to biological risks translating to occurrence of hepatitis B virus (HBV), hepatitis C virus (HCV), tuberculosis, COVID-19 and human immunodeficiency virus (HIV). One of the main ergonomic risks associated with handling hospital waste is the manual lifting and carrying of heavy containers or bags. Hospital waste workers need to lift and carry these containers for disposal or transportation purposes, which put strain on their muscles and joints, particularly in the back, shoulders and arms. Chemical risks arise from various sources, including pharmaceuticals, disinfectants, laboratory chemicals and other potentially harmful materials. These chemicals result in respiratory problems, eye and nasal irritation, skin burns, headaches among waste workers. Physical risks affecting hospital solid waste workers involve sharp injuries, causing occurrence of infectious diseases among waste handlers in Zimbabwe, a similar situation in neighboring countries like South Africa and Botswana.

Hospital solid waste workers are vulnerable to injuries, chronic and acute illnesses as well as death under extreme conditions like falling from a moving garbage truck. Nevertheless, there is scanty literature related to work related risks emanating from hospital solid waste management in Zimbabwe, pointing to the need for continuous research in this domain. Recommendations suggested involve adopting the safety hierarchy of controls' most prioritised risk control elements to safeguard hospital waste workers. The Zimbabwe Ministry of Health and Child Care should channel enough finance for management of solid waste generated from rural and urban hospitals in Zimbabwe. Moreover, there is a need to implement training and awareness programs as well as safety legislation and policies which support safety of industrial and waste workers equally as compared to existing approaches which give more attention to industrial workers. Provision of enough and appropriate Personal Protection Equipment/Clothing to people involved in hospital waste management should be mandatory and must be clearly stated in Zimbabwe's Public Health Act. Intervention strategies to reduce work-related risks associated with hospital solid waste management are far from satisfactory in developing countries, a scenario worsened by lack of co-operation among accountable stakeholders, hence an integrated approach is essential. Despite rampant innovations towards upholding safety of hospital solid waste workers in developed countries, there is still a notable gap in Zimbabwe. This study highlights critical issues related to waste management that directly impact occupational health and safety. Through identification of these challenges, the research provides insights into improving waste management practices,

which is essential for achieving Sustainable Development Goal 8 (Decent Work and Economic Growth). Effective waste management contributes to a healthier workforce, thereby enhancing productivity and economic stability. Furthermore, aligning with Zimbabwe's National Development Strategy 1 and Vision 2030, the study advocates for sustainable practices that promote public health and environmental sustainability, ultimately fostering national development. This facilitates attainment of SDG 8.8 which aims to protect labour rights and promote safe and secure working environments for all workers in Zimbabwe.

11 Implications of the research in relation to Zimbabwe's National Development Strategy 1 and Vision 2030

The research titled understanding occupational health challenges in managing hospital solid waste in Zimbabwe: a critical review highlights significant implications for Zimbabwe's National Development Strategy 1 (NDS1) and Vision 2030. The findings underscore the urgent need for improved waste management practices within healthcare facilities, which directly aligns with NDS1's goals of enhancing public health and environmental sustainability. Effective management of hospital solid waste is crucial to mitigate health risks for healthcare workers and the surrounding communities, thereby supporting the strategy's emphasis on health sector reform. Addressing these occupational health challenges contributes to Vision 2030's objective of achieving a prosperous and empowered upper-middle-income economy. Furthermore, by prioritizing safe waste disposal methods and training for healthcare personnel, Zimbabwe can enhance its healthcare system's resilience, ultimately fostering economic growth through a healthier workforce. This alignment between research findings and national strategies underscores the importance of integrating occupational health considerations into broader developmental frameworks.

12 Limitations of the study

In terms of limitations, the study's reliance on secondary data limits insights into workers' current experiences because it often lacks contextual depth, fails to capture current realities, limits participant voice, risks oversimplification, depends on personal interpretations while raising ethical concerns and ultimately affects policy implications adversely.

13 Future research

In terms of future studies, it is recommended that development of occupational health and safety frameworks, supported by current technology tailored to protect people involved in management of hospital solid waste in Zimbabwe is essential. Additionally, primary studies which put much emphasis on work-related problems experienced by people involved in hospital solid waste management are significant, to deal with current and future challenges faced by the people.

Author contributions

The first draft of the manuscript was written by Takunda Shabani (T.S) and Tapiwa Shabani (T.S). Reviewing and editing of the paper was done by Steven Jerie (S.J), Timothy Vurayayi Mutekwa (T.V.M) and Amato Chireshe (A.C).

Funding

No funding was received to assist with the preparation of this manuscript.

Availability of data and materials

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
All authors agreed to publish the review.

Competing interests
The authors declare no competing interests.

Received: 28 February 2025 / Accepted: 3 June 2025
Published online: 20 June 2025

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