# BEHIND THE WASTE: A SYSTEMATIC REVIEW OF LEADING CAUSES CONTRIBUTING TO OCCUPATIONAL HEALTH AND SAFETY ISSUES AMONG MUNICIPAL SOLID WASTE HANDLERS

THISAKYA, P.G.[1*] AND DISSANAYAKE, P.[2]
[1]University of Adelaide, Australia
[2]University of Moratuwa, Sri Lanka
[*]Correspondence E-mail: geethmithisakya.pattividanalage@adelaide.edu.au

**Abstract.** Municipal solid waste (MSW) handlers are among the most vulnerable occupational groups, frequently operating in hazardous environments with limited protective measures. Despite increasing awareness of these risks, scientific studies investigating the root causes of occupational health and safety (OHS) issues among MSW handlers remain limited and, in many cases, outdated. A comprehensive synthesis is therefore essential to deepen our understanding of the multifaceted causes contributing to unsafe working conditions in this sector. This study aims to address this gap by systematically synthesising the existing literature on the causes of OHS issues faced by MSW handlers. To achieve this aim, the study is guided by the three objectives: 1) review the overview of the OHS of MSW handlers, 2) review the rea-sons behind the OHS issues of MSW handlers and 3) explore the next line of research in OHS of MSW handlers. A total of 117 peer-reviewed articles published between 1995 and March 2025 were selected from the Web of Science (WoS) database and analysed using a combination of descriptive and content analysis. The descriptive findings indicate a predominant publication contribution on developing and emerging economies, where OHS issues among waste handlers are particularly acute. The content analysis revealed that the causes of OHS risks can be broadly grouped into three thematic categories: organisational factors (e.g., lack of training, absence of safety protocols, and inadequate provision of personal protective equipment), individual factors (e.g., low awareness of occupational hazards, informal employment, and limited education), and physical factors (e.g., exposure to hazardous waste, extreme weather, and unsanitary work environments).This study makes a significant contribution by not only identifying these core causes but also proposing a structured set of strategies to mitigate OHS risks. It further identifies emerging trends and gaps in the literature, suggesting that future research should focus on context-rich, empirical case studies to evaluate the practical effectiveness of existing and proposed OHS interventions. Key directions for future research include the development of integrated approaches to OHS risk assessment in MSW handling, the enhancement of OHS standards in informal waste sectors, and policy evaluation and implementation studies to assess the impact of regulatory measures. Through this comprehensive synthesis, the study contributes meaningfully to the literature and provides a foundation for policymaking, practice, and academic inquiry aimed at safeguarding the health and dignity of MSW handlers.

**Keywords.** Occupational Health and Safety (Ohs), Municipal Solid Waste (MSW) Handlers, Municipal Waste, Leading Causes, Occupational Issues, Waste Workers, Systematic Review

## 1. Introduction

Occupational Health and Safety (OHS) is a multidisciplinary concept aimed at enhancing the safety, health, and well-being of individuals in the workplace (Amponsah-Tawiah & Mensah, 2016). It involves creating safe and healthy working environments by addressing physical, emotional, and mental well-being, preventing work-related accidents and illnesses, and ensuring overall welfare. While there is no universal classification system to define OHS issues, the American Bureau of Labor Statistics (2012), and the Occupational Injury and Illness Classification System (OIICS) are used for effective data collection and analysis, primarily focusing on occupational injuries and illnesses.

Over the past decades, significant global efforts have been made to promote workplace health and safety (International Labour Organisation (ILO), 2020). However, enhancing OHS remains a debated and unresolved issue (Arastoo et al., 2015). Work-related injuries and illnesses continue to pose serious problems worldwide, varying across occupations and sectors (Gizaw et al., 2014; McDonald et al., 2000; Parejo-Moscoso et al., 2013). For instance, solid waste management is ranked as the sixth most hazardous occupation, with an incident rate of 35.5 per 100,000, following fisheries, logging, aviation, iron and steel work, and farming (Gizaw et al., 2014). Given this context, this study focuses on OHS issues in the Municipal Solid Waste (MSW) sector.

https://doi.org/10.31705/ICFMF2025.25

MSW refers to solid waste generated from households, commercial, industrial, institutional (including hospitals), market, and public areas(Sarkar, 2003; Turan et al., 2016), which is typically collected and treated by municipalities (Ertz et al., 2016). It comprises diverse materials such as plastics, metals, food waste, wood, and paper (Farmanbordar et al., 2018). Globally, MSW generation is increasing (Dharmasiri, 2019), leading to challenges such as weakened public health, ecological degradation, and reduced quality of life (Karak et al., 2012).

Improper MSW management contributes to economic losses and poses significant risks to public health and the environment (Abduli et al., 2013). According to Alam & Ahmade, (2013), various groups are adversely affected by poor waste management, including residents without access to treatment facilities, children, waste handlers, and communities near waste dumps. Among these, waste handlers are especially vulnerable due to their consistent exposure to hazardous waste (Shazwin & Nakagoshi, 2010).

These waste handlers commonly suffer from a range of health issues, including respiratory and gastrointestinal disorders, musculoskeletal problems, skin diseases, eye infections, headaches, and mental health challenges such as stress and depression (Cointreau, 2006; Englehardt et al., 2003; Gutberlet et al., 2013; Krajewski et al., 2002; Kuijer et al., 2010; Poulsen et al., 1995; Rachiotis et al., 2016; Salve et al., 2017; Schibye et al., 2001). OHS issues are more prevalent in developing countries, where waste handlers are at greater risk due to limited protection and support systems (Athanasiou et al., 2010; Gizaw et al., 2014; Passetti et al., 2014). For example, in Sri Lanka specifically, MSW handlers are often afflicted by back pain, slips and falls, knee pain, and migraines due to the demanding nature of their work (Thisakya & Dissanayake, 2022).

Nearly 4,000 occupational accidents are reported annually in Sri Lanka, resulting in an estimated 600,000 lost working days (ILO, 2013). In Sri Lankan Minstry of Healt, (2011) noted that approximately 15% of all admissions to the Colombo National Hospital were due to occupational injuries. Although specific data for MSW handlers is limited, it is well acknowledged that this group faces significant OHS challenges (Mudalige & Dharmathilake, 2000). Despite the recognition of these issues, scientific studies on the causes behind OHS problems among MSW handlers in Sri Lanka are scarce and outdated. Therefore, a comprehensive synthesis is necessary to better understand the underlying causes of these occupational issues. This study aims to synthesise the existing literature on exploring the causes behind the OHS issues in MSW handlers. Therefore, the current study intends to fulfil three objectives.

1. Review the overview of the OHS of MSW handlers.
2. Review the reasons behind the OHS issues of MSW handlers.
3. Explore the next line of research in OHS of MSW handlers.

The next section discusses the research methodology used to meet the aforementioned research objectives.

## 2. Research Methodology

This study employed a systematic literature review (SLR) as its methodological approach to identify, analyse, and synthesise existing evidence on the causes of OHS issues among MSW handlers. The decision to use an SLR is grounded in the objective of this study: 1) Review the overview of the OHS of MSW handlers, 2) Review the reasons behind the OHS issues of MSW handlers and 3) Explore the next line of research in OHS of MSW handlers. Unlike narrative reviews, the systematic approach ensures transparency, replicability, and methodological rigour by following a predefined protocol for identifying, selecting, and analysing relevant studies (Azarian et al., 2023).

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used as the guideline for the study, which is widely accepted as a standard procedure for doing SLRs. PRISMA assists in planning the study in a way to improve the transparency, accuracy, quality and completeness of the review (Moher et al., 2009). The current study follows the process model adopted by Mayring & Fenzl, (2019) and the following sections explain each phase more comprehensively.

## 2.1. MATERIAL COLLECTION

The systematic search starts with selecting search engines and keywords to find articles. After considering several research databases (Emerald Insight, Web of Science (WoS), Scopus, Science Direct and Taylor & Francis), it was found that Scopus and WoS had the highest number of relevant results. This is because they include a wide range of social science-based articles. The relevant literature was identified for review using the Scopus database. The rationale behind this decision was that Scopus contains a significantly greater volume of published papers compared to other databases (Aghimien et al., 2020). One search string with several keywords was used to search for articles. A search string was developed by combining the keywords using the Boolean operators, "AND" and "OR" as follows: *("Municipal solid waste" OR "MSW" OR "solid waste" OR "municipal waste" AND "Occupational health and safety" OR "OHS" OR "occupational issue" OR "occupational injury*" OR "occupational illness*" OR "occupational accident*" OR "occupational hazard*" AND "Waste worker" OR "waste handler" OR "waste picker*").*

The asterisk (*) symbol was used as a wildcard character to broaden the scope of the search by capturing alternative endings for the keywords. This search string enabled capturing studies that focused on OHS associated with MSW handlers, as evidenced through the primary database search. The timeline for the search was set from 1995 to March 2025, at which point the search was carried out. According to the qualitative meta-analysis done by Ncube et al., (2017) the publications related to OHS in MSW handlers appeared around the year 1995. Thus, the time horizon for the search for articles was set from 1995 to 2025. Accordingly, the initial search resulted in 455 articles. Figure 1 illustrates the methodological process followed in the study.

To further limit the sample size, the introduction and conclusion sections of each article were examined. Herein, 93 articles were excluded from the review since they were duplicates and not related to the topic under study. It includes 18 inaccessible articles. Consequently, 139 articles were included for the subsequent exhaustive examination. Next, a comprehensive examination of the 97 articles was carried out. After the full document review, 22 articles were excluded as a result of final quality screening. Under this final quality screening, the articles were checked to assess their association regarding the topic, methods, findings and contribution to the knowledge (Schwandt, 1996). Consequently, a total of 117 articles were subjected to the final full document review.

## 2.2. ANALYSIS OF LITERATURE

Informed by Grant and Booth, (2009) the results of this SLR are reported under two categories: a descriptive analysis and a content analysis. The descriptive analysis of the articles provides a robust basis for subsequent content analysis (Vaismoradi et al., 2013). In this step, the bibliographic details of the articles were presented. Herein, the articles were tabulated based on their year of publication, location of data collection and occurrences of keywords. Alternatively, content analysis reveals key themes in existing literature and associations among them (Fereday & Muir-Cochrane, 2006) which in this case are leading causes behind the OHS issues of MSW handlers and precautionary practices. In this step, the authors organised the selected articles into categories that were already established in previous research. Specifically, a similar categorisation of causes was done in a recent study by Ziae, Choobineth, Abdoli-Eramaki and

Ghaem (2018), where they used proper naming of these categories, namely organisational, individual and physical.

## 2.3. MATERIAL EVALUATION

In content analysis, researchers could be able to be biased and make various decisions about the content of the paper (Bailis, 1996). Such a risk can be lessened by incorporating two or more researchers to search and analyse literature findings. Thus, two researchers were included to reduce the potential of developing prejudice. Herein, the first researcher evaluated and analysed the findings of the review. Subsequently, any ambiguities that arose were resolved by involving the other researcher. A similar procedure was adopted by Prajapati et al., (2019) to improve the reliability and quality of the content analysis.

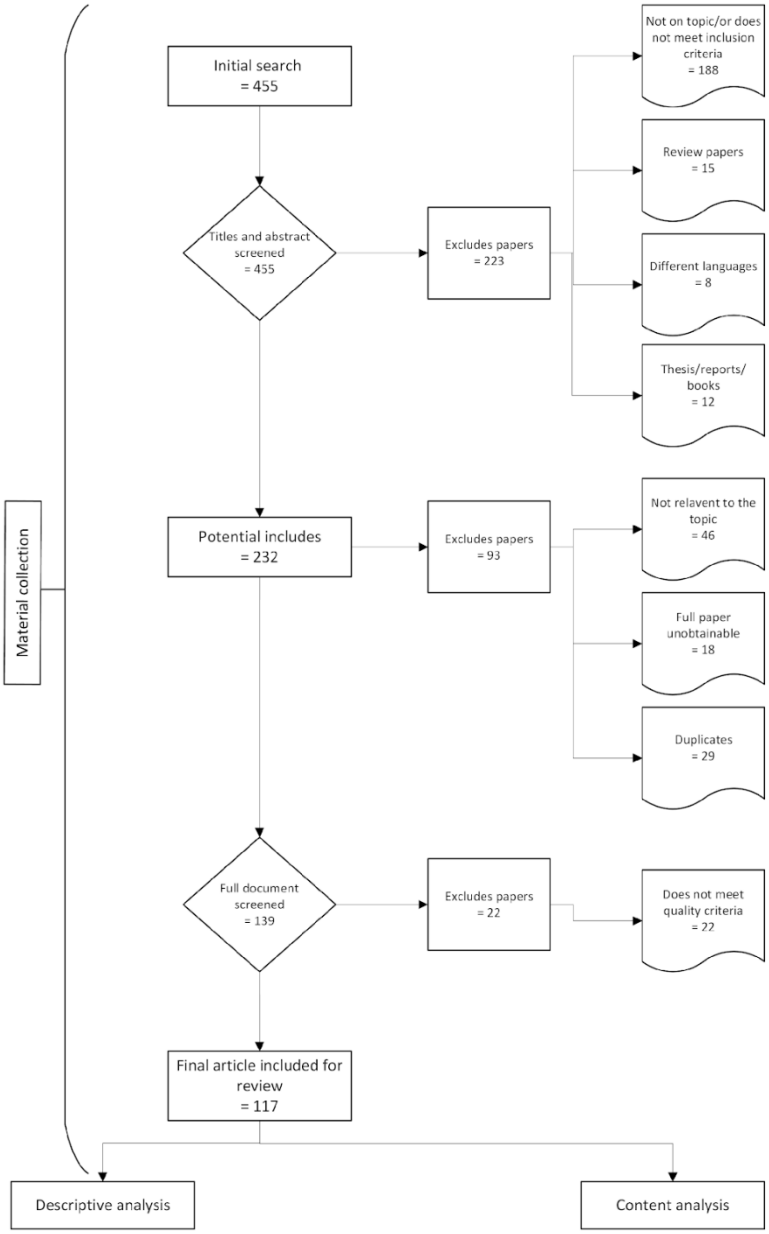


*Figure 1: The methodological process followed in the study*

*Adopted from (Ali et al., 2017)*

## 3. Results of the Descriptive Analysis

This section provides an overview of the aspects and findings of the descriptive analysis conducted for this study. The following sections entail publication per year, publication per country, and keyword analysis.

### 3.1. PUBLICATION PER YEAR

Among the 117 extracted articles, Figure 2 represents the distribution of articles based on their publication year. Even though the studies on OHS in MSW handlers started to emerge around 1995 (Ncube et al., 2017)Notably, none of the articles published in that year related to the domain of the current study. Interestingly, there is a dip in publications between 2004 and 2011. However, a surge in publications is evident after 2021, with the highest number of publications per year at 22 being recorded in 2023 and 2024. While 2025 has seen eight publications so far, the number of articles for the year 2025 can be higher since the search was limited to articles published till the end of March 2025, at which point the literature search was carried out.

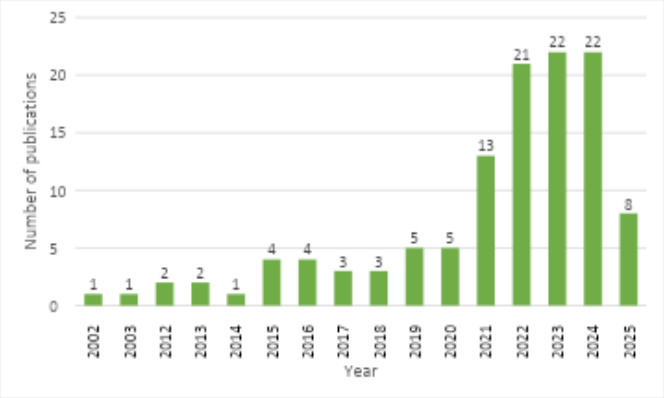


*Figure 2: Distribution of articles based on the year of publication*

### 3.2. PUBLICATION PER COUNTRY

Twenty-one countries contributed a total of 117 documents to this field of research. Figure. Figure 3 displays the countries that have a minimum of two articles and three citations.

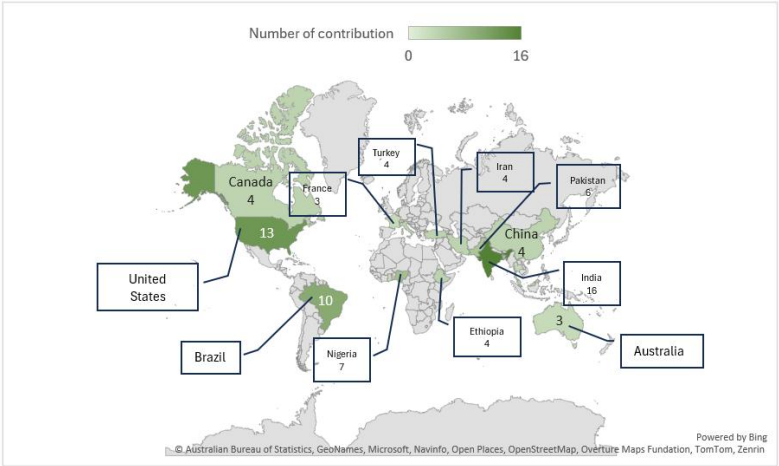


*Figure 3: Distribution of articles based on geographic locations*

According to Figure 3, the map uses varying shades of green to represent the number of contributions from each country, with darker shades indicating a higher number of articles. India stands out as the leading contributor with 16 articles, reflecting a significant body of research

on the topic, possibly due to the country's growing urban population, waste generation challenges, and associated health concerns (Srivastava et al., 2015). The United States follows with 13 articles, suggesting a strong research presence from a developed country perspective. Brazil also demonstrates considerable involvement, contributing 10 articles, likely due to its well-documented informal waste sector and evolving waste management strategies.

Other notable contributors include Nigeria with 7 articles and Pakistan and China with 6 and 5 articles, respectively, highlighting a growing interest in these regions, which face similar environmental and occupational health challenges in the context of solid waste management. Moderate contributions are also observed from countries such as Canada, Iran, Turkey, and Ethiopia, each contributing 4 articles, as well as France and Australia with 3 articles each. Overall, the map reflects a broad global interest in the topic, with contributions spanning Asia, Africa, the Americas, Europe, and Oceania. However, there appears to be a particularly strong focus on developing and emerging economies.

### 3.3. KEY-WORD ANALYSIS

A total of 68 keywords were retrieved from the 117 articles using VOSviewer software. The selection of these keywords was based on their occurrence in a minimum of three publications. The frequency of a keyword in a document reflects its overall scope, while co-occurrence highlights how often two keywords appear together in a title, abstract, or keyword list. The findings of this study are depicted in Figure 4 using a minimum requirement of four keywords. The illustration shows the frequency of co-occurring terms in the publications through the size of the nodes. The thickness of the linking lines represents the strength of relationships. The proximity of nodes in the figure shows a strong linkage between them. According to the visual network map, these keywords may be categorised into four clusters.

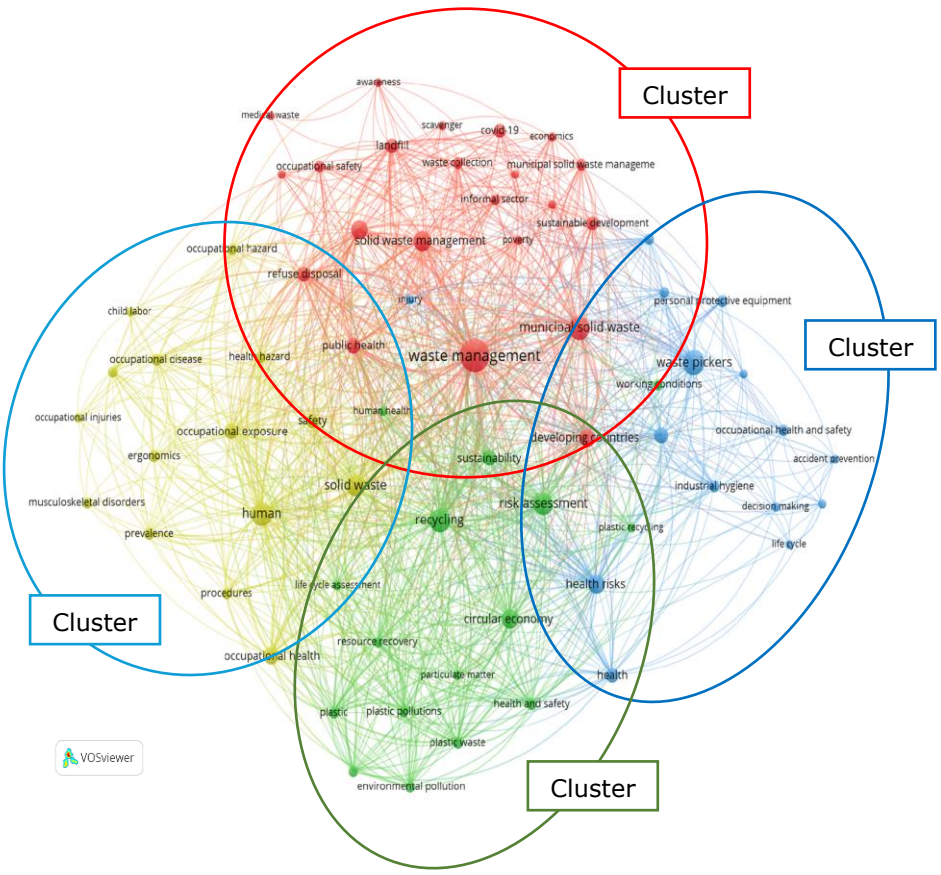


*Figure 4: Co-occurrence of keywords in the literature*

According to Figure 4, there are terms associated with the solid waste management and governance issues, which are indicated in cluster 1 (red). This cluster is focused on waste governance, urban infrastructure, and policy-level issues related to managing MSW. It includes both formal systems (e.g., landfills, municipal services) and informal actors (e.g., scavengers, informal sector). It often overlaps with socio-economic and institutional concerns. Cluster 2 (blue) highlighted the keywords related to OHS of waste handlers since this cluster is centred on worker-level safety and health protection. It deals with challenges faced by waste handlers, especially in developing countries, touching on OHS frameworks, safety gear, and working conditions. Cluster 3 (green) focuses on environmental sustainability, waste valorisation, and the circular economy model. It includes themes like pollution control, material recovery, and lifecycle assessments, emphasising ecological impacts and economic reuse of waste materials. The final cluster (yellow) relates to health consequences of waste handling — especially physical and biological risks faced by waste handlers. It overlaps with medical and ergonomic concerns and tends to align with epidemiological studies or occupational medicine research. Accordingly, Table 1 tabulates the cluster naming summary, most representative keywords and focus area.

*Table 1: Cluster naming summary, representative keywords and focus area*

| Cluster | Cluster name | Representative keywords | Focus area |
|---|---|---|---|
| ***Clust 1*** | Waste Governance & Management Systems | waste management, municipal solid waste, solid waste management, landfill, refuse disposal, scavenger, informal sector, sustainable development, poverty, awareness | Municipal waste systems, landfill, informal sector |
| ***Clust 2*** | Occupational Health & Safety of Waste handlers | waste handlers, occupational health and safety, personal protective equipment, accident prevention, working conditions, industrial hygiene, decision making | Waste handlers, safety equipment, work conditions |
| ***Clust 3*** | Environmental Impact & Circular Economy | recycling, circular economy, plastic, pollution, environmental pollution, plastic waste, plastic recycling, resource recovery, life cycle assessment | Recycling, pollution, circular economy, LCA |
| ***Clust 4*** | Human Health Risks & Occupational Exposure | human, health hazard, occupational exposure, ergonomics, musculoskeletal disorders, prevalence, occupational injuries, occupational disease | Health issues, ergonomics, occupational diseases |

## 4. Results of the Content Analysis

In the subsequent step, the selected articles were examined, synthesised, and organised into predefined categories, including the underlying causes of OHS issues among MSW handlers, as well as the practices implemented to address these challenges. The following sections provide an in-depth discussion of each category.

### 4.1. REASONS BEHIND THE OCCUPATIONAL HEALTH AND SAFETY (OHS) ISSUES OF MUNICIPAL SOLID WASTE (MSW) HANDLERS

OHS issues of MSW handlers can happen due to several reasons. According to Robson et al. (2012), causes for OHS issues of the MSW handlers can be classified into three categories as unsafe employee behaviour, the working environment, and management practices. Further, a similar categorisation of causes was done in a recent study by Ziaei et al. (2018), where they

used proper naming of these categories, namely organisational, individual and physical. The authors have derived these categories through researching and expounding on the risk factors for musculoskeletal disorders among municipal solid waste collectors in Shiraz, Iran.

Thus, the following sub-sections are descriptively reviewed aforementioned three categories by exploring the different causes under each category.

*4.1.1. Organisational category*

The organisational category can be identified as the characteristics of the organisation that influence handlers' behaviour, such as training, top management support, etc.(Ling et al., 2013). The organisational category greatly affects the OHS issues of MSW handlers (Thormar et al., 2013). Hence, Table 2 summarises the literature findings on causes under the organisational category that influence OHS issues of MSW handlers.

*Table 2: Causes under the organisational category which influence OHS issues of MSW handlers*

| **Cause** | **References** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** |
| • Poor working environment | x | | | | | x | | | | | |
| • Poor quality of Personal Protective Equipment (PPE) | x | | x | | x | | x | x | x | | x |
| • Lack of training and instruction | | x | x | x | x | x | x | | | x | |
| • Lack of supervision | | | | | | | | | x | x | |
| • Lack of routine medical checkup programs | | | | x | | | | | x | x | |
| A:(Bleck & Wettberg, 2012), B:(Bogale et al., 2014), C:(Diniz et al., 2019), D:(Ewis et al., 2013), E:(Gebremedhin, 2016), F:(Gizaw et al., 2014), G:(Jerie, 2016), H:(Kandasamy et al., 2013), I:(Thakur et al., 2018), J:(Salazar et al., 2001), K:(Wilson et al., 2006) | | | | | | | | | | | |

As shown in Table 2, most previous studies argue that poor quality has highly impacted adverse health. A study based in Nigeria disclosed that about 73.6% of MSW handlers were disappointed about the quality of the PPE. This implied that their protective equipment was not to the right quality and not suitable for the tasks (Inyang, 2007). As a result, a lack of safety intervention with the provision of PPE may increase the number of occupational hazards associated with the collection and disposal of solid waste (Jerie, 2016).

Other than the PPE, many preceding research pieces have emphasised that a lack of training and instruction from the organisation could also be another vital reason that causes adverse health effects. The training of waste handlers on OHS issues has also been an important part of improving working conditions (Bogale et al., 2014). The research was done by Ewis et al. (2013), revealed, among the 138 respondents from Egypt, none of them reported training before employment. However, in the end, lack of training, practice, instruction, and supervision will have a positive relationship with adverse OHS problems since waste handlers may not have been given proper guidance (Diniz et al., 2019).

Despite a lack of more discussion, it appears that the working environment influences all hazards, and Bleck & Wettberg, (2012) provide the examples of restricted workspace, slippery surface, and dim lighting enhance mechanical risks such as slipping, falling, cutting, and insufficient hygienic behaviour, often due to a lack of facilities, which increases exposure to biological agents. Additionally, it seems that the provision to provide routing medical checkup

programs was also discussed by a few authors. Accordingly, most MSW handlers were never medically examined in Egypt (Ewis et al., 2013). When it comes to a developing country like India, there is no difference in the situation. Most MSW handlers are deprived of medical facilities and, therefore, are unsatisfied with their job (Thakur et al., 2018).

Most importantly, it could be argued that some of the causes revealed even in the first half of this century are still unresolved.

*4.1.2. Individual category*

The individual category focuses on the handler's mix of skills, knowledge, experience, attitudes, motivations, habits, and personality, as well as their demographic characteristics (Athanasiou et al., 2010) such as sex and age of handlers, and the level of education (Gizaw et al., 2014). Salminen, Simo ; Gyekye, Seth Ayim ; Ojajärvi (2013), discovered that the individual category has more impact than the organisational category. Literature findings on the causes under individual categories that influence OHS issues of MSW handlers are listed in Table 3.

*Table 3: Causes under the individual category which influence OHS issues of MSW handlers*

| Cause | References | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
| Inadequate skills and knowledge of the MSW handler | | | | | x | x | x | x | x | x | x | | | | x |
| Gender of the MSW handler | x | | | | | x | x | x | x | x | | x | x | x | |
| Age level of the MSW handler | x | | | | | x | x | x | x | x | | x | x | x | |
| Poor educational level | x | | x | | | x | x | x | x | x | | x | x | x | |
| Insufficient income | | | | x | | | x | | | | | | | | |
| Negligence in the use of PPE | x | | | | x | | x | x | | | x | | | | |
| Lack of sleep | | x | | x | x | | x | | | | | | | | |
| Work experiences | | | | x | x | | | | x | x | | | | | |
| A:(Bogale et al., 2014), B:(Bulduk, 2019), C:(Bunn et al., 2011), D:(Eskezia et al., 2016), E:(Ewis et al., 2013), F:(Gebremedhin, 2016), G:(Gizaw et al., 2014), H:(Hoefel et al., 2013), I:(Inyang, 2007), J:(Jeong et al., 2016), K:(Kandasamy et al., 2013), L:(Mehrdad et al., 2008), M:(Salve et al., 2017), N:(Thakur et al., 2018), O:(Wilson et al., 2006) | | | | | | | | | | | | | | | |

As shown in Table 3, the years of education, age, the overall level of knowledge and duration of work experience were the most important variables impacting the overall OHS of MSW handlers (Gebremedhin, 2016). Jeong et al. (2016) proved that a total of 41.7% of the illnesses occurred in handlers with 5-10 years of experience in Korea. Nevertheless, a different study conducted in Ethiopia argued that the likelihood of occupational injury was significantly higher among handlers with three or fewer service years (Eskezia et al., 2016). However, there is minimal variance in the accident rate based on work experience because this job may not involve specialised procedures or techniques (Jeong et al., 2016). More precisely, Gizaw et al. (2014) revealed that handlers aged >=30 years were 1.834 times more likely to be injured than handlers aged < 30 years. However, it implies that elderly handlers are more vulnerable to accidents since they must constantly move around, work on their feet all day, and carry heavy plastic waste bags. These result in frustration and a loss of concentration (Jeong et al., 2016). Moreover, Hoefel et al. (2013), highlighted that those accidents are more severe among women in Brazil. Hence, it seems gender is also a significant variable to the degree of the impact. The impact of the low educational level of MSW handlers towards the adverse OHS problems is also disclosed in

previous research. As an example, it was proved that 60.3% of handlers do not have any formal education in Nigeria (Gebremedhin, 2016).

Despite the criticality of OHS issues that MSW handlers are experienced with, their usage of PPE is low (Gebremedhin, 2016) . According to a study conducted in Addis Ababa, 43.6% of solid waste collectors used PPE at all times while on duty, which might result in the possibility of occupational health concerns (Bogale et al., 2014). Thakur et al. (2018), convinced by their study, also that 6.67% of MSW handlers denied getting any type of protective gear. The argument was similar to the result of an Egyptian survey done by Ewis et al. (2013), who also statistically proved that MSW handlers are not using protective devices such as face masks, goggles, gumboots or gloves while working. By reasoning, Gebremedhin (2016), showed that 21.5% and 8.3% of handlers did not wear PPE because of discomfort and to save their time, respectively. Similarly, Bogale et al. (2014) also emphasised that the main reasons for not wearing PPE are discomfort (25.6%), saving time (12.8%), and not having access (83.7%). Other than that, Jerie (2017) disclosed, lack of awareness and their low social status are also caused by not using PPE even when MSW handlers are supplied. Consequently, MSW handlers who were not using protective devices were 2.6 times more likely to get injured (Bogale et al., 2014). However, since they do not use safety precautions, they may contact with pathogens/allergens through skin and inhalation (Kandasamy et al., 2013). For example, approximately 13.8% of street sweepers reported skin irritations, which could be explained by direct contact with waste while wearing no protective equipment (Ewis et al., 2013). Moreover, among the MSW handlers, the likelihood of occupational injury was 2.57 times higher among those who reported sleeping disturbance as compared to their counterparts (Eskezia et al., 2016).

*4.1.3. Physical category*

The physical category focuses on the different variables of the handler's specific job or task that influence their safety-related behaviour, including the nature of the work, duration of exposure, workload, etc. (Mélan & Cascino, 2014). Matching the job to the person will ensure that they are not overloaded and that the most effective contribution to the organisation results (Ziaei et al., 2019). Accordingly, Table 4 discloses the literature findings on causes under the physical category which influence OHS issues of MSW handlers.

*Table 4: Causes under the physical category which influence OHS issues of MSW handlers*

| Causes | References | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | A | B | C | D | E | F | G | H | I | J |
| Highly intensive physical activities | x | | x | | x | x | | x | | x |
| Excessive workload | x | | | | x | | | | | x |
| Weather conditions | | | | | x | | | | | |
| Long duration of work exposure | | x | x | x | x | | | x | x | x |
| Manual handling of solid waste | | | | | x | | x | | | |
| A:(Abou-ElWafa et al., 2012), B: (Bleck & Wettberg, 2012), C: (Bogale et al., 2014), D: (Bulduk, 2019), E: (Gizaw et al., 2014), F: (Jerie, 2017), G: (Kandasamy et al., 2013), H: (Mehrdad et al., 2008), I: (Salazar et al., 2001), J: (Salve et al., 2017) | | | | | | | | | | |

As shown in Table 4, it could be argued that many studies conducted with waste collectors revealed that the nature of the work is highly subject to OHS risks. Moreover, they have a higher probability of developing musculoskeletal disorders as compared to the general population due to the nature of their work (Abou-ElWafa et al., 2012; Mehrdad et al., 2008). Similarly, handlers who are repeatedly exposed to lifting, bending, pushing, and pulling for more prolonged periods have also been recognised as having a higher risk of developing musculoskeletal problems

(Schibye et al., 2001). The situation is significantly worse in developing countries, where waste management is mainly done manually (Marimuthu et al., 2021).

Considering the above-identified causes, it is evident that OHS problems can occur with MSW handlers under any circumstances. Hence, those causes can be eliminated by espousing precautionary methods. Therefore, the next section of the chapter discusses the literature findings of precautionary practices.

## 4.2. PRECAUTIONARY PRACTICES TO MITIGATE THE OCCUPATIONAL HEALTH AND SAFETY ISSUES OF MUNICIPAL SOLID WASTE HANDLERS

Having strong precautionary measures created a thriving safety culture for MSW handlers. Accordingly, many studies discovered a series of precautionary practices in order to minimise the causes discussed in this section. Basically, handlers need to have adequate training and information before starting their job in order to be able to understand the severity of the job and protect their health (Gebremedhin, 2016). The training should deal with the knowledge of the subjective area, equipment, and tools; recognised hazards in the operations and how to control these hazards; potential health concerns; hygiene requirements; background of incidents and accidents, and wearing and use of PPE (Bogale et al., 2014). PPE should also be provided and managed by the responsible authorities (Ewis et al., 2013). Job rotation among work components, improvement of employees' income, job-specific guidelines for maximum production limitations, and replacement of bags and bins with wheeled containers are also expected to make the situation better (Eskezia et al., 2016). Further, the government should make provisions for regular medical checkups and a separate medical allowance to detect early signs of work-related complaints and monitor workability (Eskezia et al., 2016; Thakur et al., 2018).

Moreover, improving the working conditions helps reduce the times the waste handlers come into direct contact with the waste (Diniz et al., 2019). For example, after the age of 40, senior handlers' eyesight begins to deteriorate, with their field of vision narrowing and contracting, unable to transmit as much light as previously (Jeong et al., 2016). Therefore, the previous study further elaborated that MSW handlers should be provided with lighting equipment, and waste-collecting vehicles should be outfitted with lighting capabilities to ensure enough visibility to prevent injuries. On the other hand, since musculoskeletal disorders are common, awkward postures can be reduced by improving appropriate work methods or ergonomically designed work tools (Fewster et al., 2020; Gallagher, 2005).

Thakur et al. (2018), pointed out that the appointment of safety managers is vital to make all altogether practices above. It was further revealed that to improve the work culture of MSW handlers, safety managers ensure that handlers are safe, including providing protective equipment to all types of MSW handlers to avoid exposure to occupational health hazards initially. Moreover, the development and establishment of documentation systems of occupational injuries and illnesses will inminimising future occurrences (Gizaw et al., 2014).

Figure 5 illustrates a summary of precautionary measures extracted from the reviewed literature within this study.

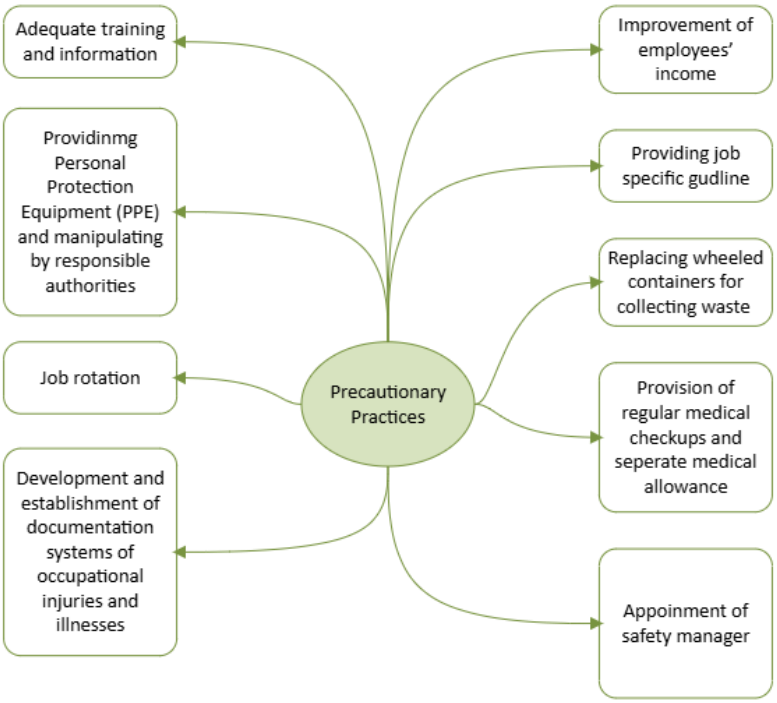


*Figure 5: Precautionary practices to mitigate the occupational health and safety issues of the municipal solid waste handlers*

## 5. Future Research Directions

Sections 4.1 and 4.2 outline both the primary factors contributing to OHS issues among MSW handlers and the existing measures implemented to mitigate these issues. The review underscores the critical role of identifying these underlying causes in fostering a safer working environment for MSW handlers, while also highlighting the necessity of linking this understanding to the development and implementation of effective preventive practices. Based on these insights, the following pragmatic future research directions are proposed to further advance our knowledge of OHS within this sector.

### 5.1 INTEGRATED APPROACHES TO UNDERSTANDING OHS RISKS IN MSW HANDLING

The existing body of research largely isolates occupational health risks from broader systemic issues such as socio-economic status, informal employment, or governance structures. Although many studies have identified individual risks such as musculoskeletal disorders, exposure to toxic substances, or lack of protective equipment (Diniz et al., 2019; Kandasamy et al., 2013), few have taken an integrative approach that considers how these factors intersect (Gizaw et al., 2014; Hoefel et al., 2013). Future research could adopt systems thinking or socio-ecological frameworks to explore how environmental, organisational, and individual factors interact to shape OHS outcomes. Such an approach would help design more holistic interventions tailored to complex real-world contexts.

### *5.2 ENHANCING OHS IN INFORMAL WASTE SECTORS*

Most existing research disproportionately focuses on formal waste management systems, overlooking the large proportion of waste handlers in informal sectors (outside of government-regulated or formally organised waste management systems)—particularly in low- and middle-income countries—who face heightened OHS vulnerabilities due to lack of regulation, job security, and access to healthcare. Future research should prioritise the informal sector, including

ethnographic studies, community-based participatory research, and policy analyses to develop inclusive and context-sensitive strategies that do not inadvertently marginalise these handlers.

### 5.3 POLICY EVALUATION AND IMPLEMENTATION RESEARCH

Although numerous guidelines and frameworks for improving OHS in waste handling exist, there is limited evidence on their implementation effectiveness or policy uptake (Kandasamy et al., 2013; Thakur et al., 2018). Future work should focus on evaluative research to determine which interventions are working, under what conditions, and for whom. Comparative studies between countries with differing regulatory environments may help identify best practices that can be adapted and scaled. Furthermore, research should explore the role of institutional capacity, governance quality, and multi-stakeholder collaboration in shaping policy outcomes.

## 6. Discussion

The findings of this study reveal that the causes behind OHS issues among MSW handlers can be grouped into three broad categories: organisational, individual, and environmental/physical factors. These findings align with and expand upon prior studies in the field. Poor provision of PPE, lack of regular training, and weak enforcement of OHS policies were recurring themes in the reviewed literature. These organisational shortcomings mirror the findings of Tshivhase et al. (2022), who reported inadequate PPE and poor adherence to safety guidelines as primary hazards facing MSW handlers in a South African municipality. The current study reinforces the systemic nature of these issues, suggesting they are not isolated but widespread across similar low- and middle-income country (LMIC) contexts.

Similarly, Tolera et al. (2023) in their global systematic review emphasise that institutional deficiencies—such as limited OHS monitoring mechanisms and fragmented policy implementation—are key contributors to adverse safety outcomes among sanitation and hygiene workers. Findings of current study further illustrate how these institutional weaknesses manifest at the ground level, resulting in both acute injuries and long-term health risks among MSW handlers. The study identified several individual-level determinants, including lack of awareness, risk-taking behaviour, and low levels of education or training. These personal factors were found to compound organisational failings, especially when waste handlers are unaware of the health implications of unsafe practices or are compelled to take shortcuts due to productivity demands. Tolera et al. (2023), in their review of cross-sectional studies, also highlight behavioural and cognitive dimensions—such as safety attitudes and risk perceptions—as significant predictors of health outcomes among sanitation workers. This convergence underscores the need for behaviourally informed interventions, including targeted safety education and behavioural nudges, to reinforce safety compliance. Unhygienic working environments, extreme weather exposure, and handling of hazardous waste without segregation were common environmental hazards identified in this review. These findings echo those of Tshivhase et al. (2022), who noted that workers were often exposed to dangerous waste types, including sharps and biomedical waste, due to the absence of pre-collection segregation. Moreover, the findings point to widespread environmental risks exacerbated by poor urban infrastructure and informal work arrangements.

Taken together, this study confirms that OHS outcomes among MSW handlers result from an interplay of systemic, behavioural, and contextual factors. The thematic categories identified here correspond closely with the risk domains emphasised in the global literature. However, the current review contributes a more granular understanding of how these categories intersect in LMIC contexts, especially where informal employment and under-resourced municipal systems prevail.

## 7. Conclusion and recommendations

This study provides a comprehensive thematic synthesis of the reasons underlying OHS issues faced by MSW handlers. The analysis, which spans literature published from 1995 to 2025 March, identifies a complex interplay of organisational, individual, and physical factors that contribute to unsafe working conditions for MSW handlers. Organisational factors such as the lack of OHS training, inadequate provision of PPE, absence of clear safety policies, and inefficient waste management practices significantly compromise worker safety. Individual-level factors, including low educational backgrounds, poor awareness of occupational risks, and negligence in using PPE, further exacerbate vulnerability to injury and illness. In parallel, physical factors — ranging from exposure to hazardous waste, heat, and dust to poor sanitation and unsanitary work environments — directly threaten the health of waste handlers.

The review also uncovers a general trend of systemic neglect regarding OHS in the waste management sector. Institutional accountability appears minimal, with weak enforcement of existing safety regulations and limited inclusion of MSW handlers, especially those in informal sectors, in OHS planning. Overcoming these challenges requires a multidimensional approach that extends beyond technical interventions. It demands a stakeholder-inclusive framework that acknowledges and responds to the broader socio-political and institutional contexts shaping the everyday realities of MSW handlers. The recurrence of similar OHS issues over nearly three decades of literature underscores the urgency for integrated, context-sensitive policy responses and sustained action from municipal authorities, public health institutions, and civil society organisations.

While this review has discussed the causes of OHS issues and precautionary practices to mitigate them, it also highlights a critical gap in the literature: the lack of focus on the interrelationship between specific causes and targeted mitigation strategies. Most studies tend to address these dimensions in isolation, rather than examining how particular causes can be directly matched with context-appropriate precautionary measures. Future research should thus explore integrated approaches to understanding OHS risks in MSW handling, enhance knowledge and protections within informal waste sectors, and undertake policy evaluation and implementation research to assess the effectiveness of existing interventions and frameworks.

However, this review is not without limitations. It is restricted to English-language publications, which may exclude relevant research conducted and published in other languages, particularly from regions with significant informal waste management activities. Additionally, the analysis is primarily based on secondary data and therefore lacks direct empirical validation through real-world case studies. As such, future research should aim to bridge this gap by conducting in-depth, context-rich case studies that can offer practical insights into the application and effectiveness of OHS interventions in diverse municipal settings.

Despite these limitations, the findings offer a robust foundation for informing research, practice, and policy. The study allows policymakers to strengthen national and municipal OHS regulations with clear standards tailored to the waste sector. Formalise informal waste workforces through legal inclusion and social protection. Allocate targeted investments in infrastructure, training, and waste segregation systems. Industry practitioners, including municipal authorities and private waste management companies, must ensure the consistent provision and monitoring of PPE, implement regular training programs, and foster a culture of safety through participatory planning and transparent reporting mechanisms. Academic researchers have a crucial role to play in addressing the identified knowledge gaps by undertaking longitudinal and mixed-methods research that explores the causal linkages between specific hazards and mitigation strategies.

Therefore, ensuring the health and safety of MSW handlers is a shared responsibility that requires integrated action. Collaborative efforts among governments, industry stakeholders, and

researchers are vital to crafting inclusive, evidence-based, and sustainable solutions. The knowledge synthesised through this review offers valuable direction for advancing OHS in waste management systems and upholding the dignity of those who sustain them.

## 8. References


Abduli, M. A., Tavakolli, H., & Azari, A. (2013). Alternatives for solid waste management in Isfahan, Iran: A case study. *Waste Management and Research*, *31*(5), 532–537. https://doi.org/10.1177/0734242X13477718

Abou-ElWafa, H. S., El-Bestar, S. F., El-Gilany, A. H., & Awad, E. E. S. (2012). Musculoskeletal disorders among municipal solid waste collectors in Mansoura, Egypt: A cross-sectional study. *BMJ Open*, *2*(5), e001338. https://doi.org/10.1136/bmjopen-2012-001338

Aghimien, D. O., Aigbavboa, C. O., Oke, A. E., & Thwala, W. D. (2020). Mapping out research focus for robotics and automation research in construction-related studies: A bibliometric approach. *Journal of Engineering, Design and Technology*, *18*(5), 1063–1079. https://doi.org/10.1108/JEDT-09-2019-0237

Alam, P., & Ahmade, K. (2013). Impact of Solid Waste on Health and the Environment. *International Journal of Sustainable Development and …*, *2*(1), 165–168. http://irnet.sg/irnet_journal/IJSDGE/IJSDGE_doc/IJSDGE_V2I1,2_papers/31.pdf

Ali, A., Mahfouz, A., & Arisha, A. (2017). Analysing supply chain resilience: integrating the constructs in a concept mapping framework via a systematic literature review. *Supply Chain Management*, *22*(1), 16–39. https://doi.org/10.1108/SCM-06-2016-0197

American Bureau of Labor Statistics. (2012). *Occupational Injury and Illness Classification Manual Version 2.01*.

Amponsah-Tawiah, K., & Mensah, J. (2016). Occupational Health and Safety and Organizational Commitment: Evidence from the Ghanaian Mining Industry. *Safety and Health at Work*, *7*(3), 225–230. https://doi.org/10.1016/j.shaw.2016.01.002

Arastoo, H., Azimov, P. H., & Esfandiarpour, S. (2015). Assessment of barriers to establish OSH: A country report. *Industrial Health*, *53*(4), 378–384. https://doi.org/10.2486/indhealth.2013-0234

Athanasiou, M., Makrynos, G., & Dounias, G. (2010). Respiratory health of municipal solid waste workers. *Occupational Medicine*, *60*(8), 618–623. https://doi.org/10.1093/occmed/kqq127

Azarian, M., Yu, H., Shiferaw, A. T., & Stevik, T. K. (2023). Do We Perform Systematic Literature Review Right? A Scientific Mapping and Methodological Assessment. *Logistics*, *7*(4), 89. https://doi.org/10.3390/logistics7040089

Bailis, D. S. (1996). Estimating liability risks with the media as your guide: A content analysis of media coverage of tort litigation. *Law and Human Behavior*, *20*(4), 419–429. https://doi.org/10.1007/BF01498978

Bleck, D., & Wettberg, W. (2012). Waste collection in developing countries - Tackling occupational safety and health hazards at their source. *Waste Management*, *32*(11), 2009–2017. https://doi.org/10.1016/j.wasman.2012.03.025

Bogale, D., Kumie, A., & Tefera, W. (2014). Assessment of occupational injuries among Addis Ababa city municipal solid waste collectors: A cross-sectional study. *BMC Public Health*, *14*(1), 169. https://doi.org/10.1186/1471-2458-14-169

Bulduk, E. Ö. (2019). Work-related stress levels and musculoskeletal disorders among municipal solid waste collectors in Ankara. *Work*, *63*(3), 427–433. https://doi.org/10.3233/WOR-192949

Bunn, T. L., Slavova, S., & Tang, M. (2011). Injuries among solid waste collectors in the private versus public sectors. *Waste Management and Research*, *29*(10), 1043–1052. https://doi.org/10.1177/0734242X11410115

Cointreau, S. (2006). Occupational and environmental health issues of solid waste management. *Urban Papers*, *2*, 57.

Dharmasiri, L. M. (2019). Waste Management in Sri Lanka: Challenges and Opportunities. *Sri Lanka Journal of Advanced Social Studies*, *9*(1), 72. https://doi.org/10.4038/sljass.v9i1.7149

Diniz, N., Castro, P., Lago, E., da Cruz, F., Zlatar, T., Wasnievski, D., Pereira, A., & Junior, B. B. (2019). Work-related accidents in urban solid waste collection. In *Studies in Systems, Decision and Control* (Vol. 202, pp. 43–51). https://doi.org/10.1007/978-3-030-14730-3_5

Englehardt, J. D., An, H., Fleming, L. E., & Bean, J. A. (2003). Analytical predictive bayesian assessment of occupational injury risk: Municipal solid waste collectors. *Risk Analysis*, *23*(5), 917–927. https://doi.org/10.1111/1539-6924.00369

Ertz, M., Karakas, F., & Sarigöllü, E. (2016). Exploring pro-environmental behaviors of consumers: An analysis of contextual factors, attitude, and behaviors. *Journal of Business Research*, *69*(10), 3971–3980. https://doi.org/10.1016/j.jbusres.2016.06.010

Eskezia, D., Aderaw, Z., Ahmed, K. Y., & Tadese, F. (2016). Prevalence and associated factors of occupational injuries among municipal solid waste collectors in four zones of Amhara region, Northwest Ethiopia. *BMC Public Health*, *16*(1), 862. https://doi.org/10.1186/s12889-016-3483-1

Ewis, A., Mohamad, E. ., Rahma, M. ., Hifnawy, T. ., & Arafa, A. . (2013). Occupational Health-Related Morbidities Among Street Sweepers and Waste Collectors At Beni-Suef, Egypt. *Egyptian Journal of Occupational Medicine*, *37*(1), 79–94. https://doi.org/10.21608/ejom.2013.773

Farmanbordar, S., Karimi, K., & Amiri, H. (2018). Municipal solid waste as a suitable substrate for butanol production as an advanced biofuel. *Energy Conversion and Management*, *157*, 396–408. https://doi.org/10.1016/j.enconman.2017.12.020

Fereday, J., & Muir-Cochrane, E. (2006). Demonstrating Rigor Using Thematic Analysis: A Hybrid Approach of Inductive and Deductive Coding and Theme Development. *International Journal of Qualitative Methods*, *5*(1), 80–92. https://doi.org/10.1177/160940690600500107

Fewster, K. M., Gallagher, K. M., Howarth, S. H., & Callaghan, J. P. (2020). Low back pain development differentially influences centre of pressure regularity following prolonged standing. *Gait and Posture*, *78*, e1–e6. https://doi.org/10.1016/j.gaitpost.2017.06.005

Gallagher, S. (2005). Physical limitations and musculoskeletal complaints associated with work in unusual or restricted postures: A literature review. *Journal of Safety Research*, *36*(1), 51–61. https://doi.org/10.1016/j.jsr.2004.12.001

Gebremedhin, F. (2016). Assessment of Knowledge, Attitude and Practices Among Solid Waste Collectors in Lideta Sub-city on Prevention of Occupational Health Hazards, Addis Ababa, Ethiopia. *Science Journal of Public Health*, *4*(1), 49. https://doi.org/10.11648/j.sjph.20160401.17

Gizaw, Z., Gebrehiwot, M., Teka, Z., & Molla, M. (2014). Assessment of occupational injury and associated factors among municipal solid waste management workers in Gondar town and Bahir Dar City, northwest Ethiopia, 2012. *International Research Journal of Medicine and Medical Sciences*, *05*(09), 181–192. https://doi.org/10.14303/jmms.2014.103

Grant, M. J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. *Health Information and Libraries Journal*, *26*(2), 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

Gutberlet, J., Baeder, A. M., Pontuschka, N. N., Felipone, S. M. N., & dos Santos, T. L. F. (2013). Participatory research revealing the work and occupational health hazards of cooperative recyclers in Brazil. *International Journal of Environmental Research and Public Health*, *10*(10), 4607–4627. https://doi.org/10.3390/ijerph10104607

Hoefel, M. da G., Carneiro, F. F., Santos, L. M. P., Gubert, M. B., Amate, E. M., & Santos, W. dos. (2013). Accidents at work and living conditions among solid waste segregators in the open dump of Distrito Federal. *Revista Brasileira de Epidemiologia*, *16*(3), 774–785. https://doi.org/10.1590/S1415-790X2013000300020

ILO. (2013). *Safety and health at work in Sri Lanka and the Maldives (ILO in Sri Lanka)*. Decent Work Country Programme for Sri Lanka. https://www.ilo.org/colombo/areasofwork/safety-and-health-at-work/lang--en/index.htm

International Labour Organisation (ILO). (2020). *Safety and health at work*.

Inyang, M. P. (2007). Health and Safety Risks Amongst the Municipal Solid Waste Collectors in Port Harcourt Metropolis Of the Niger Delta Region Of Nigeria. *International Conference "Waste Management, Environmental Geotechnology and Global Sustainable Development"*, *57*, 58.

Jeong, B. Y., Lee, S., & Lee, J. D. (2016). Workplace Accidents and Work-related Illnesses of Household Waste Collectors. *Safety and Health at Work*, *7*(2), 138–142. https://doi.org/10.1016/j.shaw.2015.11.008

Jerie, S. (2016). Occupational risks associated with solid waste management in the informal sector of Gweru, Zimbabwe. *Journal of Environmental and Public Health*, *2016*, 1–14. https://doi.org/10.1155/2016/9024160

Jerie, S. (2017). Prevalence of Adverse Health Effects among Municipal Solid Waste Workers, Southern Thailand. *International Journal of Occupational Hygiene*, *9*(4), 186–191. https://doi.org/10.1155/2016/9024160

Kandasamy, S. P., Akolkar, A. B., Manoharan, A., & Paranji, S. (2013). Municipal solid waste management at Chennai in southern India - An occupational health perspective. *International Journal of Health Promotion and Education*, *51*(1), 50–61. https://doi.org/10.1080/14635240.2012.750068

Karak, T., Bhagat, R. M., & Bhattacharyya, P. (2012). Municipal solid waste generation, composition, and management: The world scenario. *Critical Reviews in Environmental Science and Technology*, *42*(15), 1509–1630. https://doi.org/10.1080/10643389.2011.569871

Krajewski, J. A., Tarkowski, S., Cyprowski, M., Szarapińska-Kwaszewska, J., & Dudkiewicz, B. (2002). Occupational exposure to organic dust associated with municipal waste collection and management. *International Journal of Occupational Medicine and Environmental Health*, *15*(3), 289–301.

Kuijer, P. P. F. M., Sluiter, J. K., & Frings-Dresen, M. H. W. (2010). Health and safety in waste collection: Towards evidence-based worker health surveillance. *American Journal of Industrial Medicine*, *53*(10), 1040–1064. https://doi.org/10.1002/ajim.20870

Ling, T. C., Poon, C. S., & Wong, H. W. (2013). Management and recycling of waste glass in concrete products: Current situations in Hong Kong. *Resources, Conservation and Recycling*, *70*, 25–31. https://doi.org/10.1016/j.resconrec.2012.10.006

Marimuthu, R., Shanthi, M., Aramvith, S., & Sivaranjani, S. (2021). Smart Waste Management Model for Effective Disposal of Waste Management Through Technology. In *EAI/Springer Innovations in Communication and Computing* (pp. 213–229). https://doi.org/10.1007/978-3-030-70183-3_9

Mayring, P., & Fenzl, T. (2019). Qualitative Inhaltsanalyse. In *Handbuch Methoden der empirischen Sozialforschung* (pp. 633–648). Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-21308-4_42

McDonald, N., Corrigan, S., Daly, C., & Cromie, S. (2000). Safety management systems and safety culture in aircraft maintenance organisations. *Safety Science*, *34*(1–3), 151–176. https://doi.org/10.1016/S0925-7535(00)00011-4

Mehrdad, R., Majlessi-Nasr, M., Aminian, O., Sharifian, S. A., & Malekahmadi, F. (2008). Musculoskeletal disorders among municipal solid waste workers. *Acta Medica Iranica*, *46*(3), 233–238.

Mélan, C., & Cascino, N. (2014). A multidisciplinary approach of workload assessment in real-job situations: Investigation in the field of aerospace activities. *Frontiers in Psychology*, *5*(AUG). https://doi.org/10.3389/fpsyg.2014.00964

Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., Altman, D., Antes, G., Atkins, D., Barbour, V., Barrowman, N., Berlin, J. A., Clark, J., Clarke, M., Cook, D., D'Amico, R., Deeks, J. J., Devereaux, P. J., Dickersin, K., Egger, M., Ernst, E., … Tugwell, P. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement (Chinese edition). *Journal of Chinese Integrative Medicine*, *7*(9), 889–896. https://doi.org/10.3736/jcim20090918

Mudalige, O. M. D. C. ., & Dharmathilake, A. . (2000). Health problems among Colombo Municipal Council workers. *IneFaculty of Medic,* 15–20.

Ncube, F., Ncube, E. J., & Voyi, K. (2017). A systematic critical review of epidemiological studies on public health concerns of municipal solid waste handling. *Perspectives in Public Health*, *137*(2), 102–108. https://doi.org/10.1177/1757913916639077

Parejo-Moscoso, J. M., Rubio-Romero, J. C., Pérez-Canto, S., & Soriano-Serrano, M. (2013). Health and safety management in olive oil mills in Spain. *Safety Science*, *51*(1), 101–108. https://doi.org/10.1016/j.ssci.2012.06.015

Passetti, E., Battaglia, M., & Frey, M. (2014). *Investing in safety in the environmental hygiene sector*. https://books.google.com.br/books?hl=pt-BR&lr=&id=THL-

CQAAQBAJ&oi=fnd&pg=PA5&dq=investing+in+safety+in+the+environmental+hygiene+sector&ots=rh4jBj6OJ2&sig=mdfmatQKMaf9qeywc6DJh1rhISI#v=onepage&q=investing in safety in the environmental hygiene sector&f=fa

Poulsen, O. M., Breum, N. O., Ebbehøj, N., Hansen, Å. M., Ivens, U. I., van Lelieveld, D., Malmros, P., Matthiasen, L., Nielsen, B. H., Nielsen, E. M., Schibye, B., Skov, T., Stenbaek, E. I., & Wilkins, C. K. (1995). Collection of domestic waste. Review of occupational health problems and their possible causes. *Science of the Total Environment*, *170*(1–2), 1–19. https://doi.org/10.1016/0048-9697(95)04524-5

Prajapati, H., Kant, R., & Shankar, R. (2019). Bequeath life to death: State-of-art review on reverse logistics. *Journal of Cleaner Production*, *211*, 503–520. https://doi.org/10.1016/j.jclepro.2018.11.187

Rachiotis, G., Tsovili, E., Papagiannis, D., Markaki, A., & Hadjichristodoulou, C. (2016). Are municipal solid waste collectors at increased risk of Hepatitis A Virus infection? A Greek cross-sectional study. *Infezioni in Medicina*, *24*(4), 299–303.

Robson, L. S., Stephenson, C. M., Schulte, P. A., Amick, B. C., Irvin, E. L., Eggerth, D. E., Chan, S., Bielecky, A. R., Wang, A. M., Heidotting, T. L., Peters, R. H., Clarke, J. A., Cullen, K., Rotunda, C. J., & Grubb, P. L. (2012). A systematic review of the effectiveness of occupational health and safety training. *Scandinavian Journal of Work, Environment and Health*, *38*(3), 193–208. https://doi.org/10.5271/sjweh.3259

Salazar, M. K., Connon, C., Takaro, T. K., Beaudet, N., & Barnhart, S. (2001). An evaluation of factors affecting hazardous waste workers' use of respiratory protective equipment. *American Industrial Hygiene Association Journal*, *62*(2), 236–245. https://doi.org/10.1080/15298660108984627

Salminen, Simo ; Gyekye, Seth Ayim ; Ojajärvi, A. (2013). Individual and organizational factors of safe behaviour among Ghanaian industrial workers. *Engineering Management Research*, 98–110.

Salve, P., Chokhandre, P., & Bansod, D. (2017). Assessing musculoskeletal disorders among municipal waste loaders of Mumbai, India. *International Journal of Occupational Medicine and Environmental Health*, *30*(6), 875–886. https://doi.org/10.13075/ijomeh.1896.01049

Sarkar, P. (2003). Solid Waste Management In Delhi-A Social Vulnerability Study. *International Conference on Environment and Health*, 451–464.

Schibye, B., Søgaard, K., Martinsen, D., & Klausen, K. (2001). Mechanical load on the low back and shoulders during pushing and pulling of two-wheeled waste containers compared with lifting and carrying of bags and bins. *Clinical Biomechanics*, *16*(7), 549–559. https://doi.org/10.1016/S0268-0033(01)00039-0

Schwandt, T. A. (1996). Qualitative data analysis: An expanded sourcebook. In *Evaluation and Program Planning* (Vol. 19, Issue 1). sage. https://doi.org/10.1016/0149-7189(96)88232-2

Shazwin, T., & Nakagoshi, N. (2010). Sustainable Waste Management through International Cooperation : Review of Comprehensive Waste Management Technique 2 Training Course. *Sustainable Waste Management through International Cooperation : Review of Comprehensive Waste Management Technique 2 Training Course*, *16*(1), 23–33.

Sri Lankan Minstry of Health. (2011). *Yearly report*.

Srivastava, V., Ismail, S. A., Singh, P., & Singh, R. P. (2015). Urban solid waste management in the developing world with emphasis on India: challenges and opportunities. *Reviews in Environmental Science and Biotechnology*, *14*(2), 317–337. https://doi.org/10.1007/s11157-014-9352-4

Thakur, P., Ganguly, R., & Dhulia, A. (2018). Occupational Health Hazard Exposure among municipal solid waste workers in Himachal Pradesh, India. *Waste Management*, *78*, 483–489. https://doi.org/10.1016/j.wasman.2018.06.020

Thisakya, P. G., & Dissanayake, D. M. P. P. (2022). Occupational health and safety of municipal solid waste handlers in Sri Lanka. *15th International Research Conference - FARU 2022*, 238–247. https://doi.org/10.31705/faru.2022.27

Thormar, S. B., Gersons, B. P. R., Juen, B., Djakababa, M. N., Karlsson, T., & Olff, M. (2013). Organizational factors and mental health in community volunteers. The role of exposure, preparation, training, tasks assigned, and support. *Anxiety, Stress and Coping*, *26*(6), 624–642. https://doi.org/10.1080/10615806.2012.743021

Tolera, S. T., Temesgen, S., Mulat Endalew, S., Alamirew, T. S., & Temesgen, L. M. (2023). Global systematic review of occupational health and safety outcomes among sanitation and hygiene workers. *Frontiers in Public Health*, *11*, 1304977. https://doi.org/10.3389/fpubh.2023.1304977

Tshivhase, S. E., Mashau, N. S., Ngobeni, T., & Ramathuba, D. U. (2022). Occupational health and safety hazards among solid waste handlers at a selected municipality South Africa. *Health SA Gesondheid*, *27*, 1978. https://doi.org/10.4102/hsag.v27i0.1978

Turan, N. G., Baki, O. G., & Ergun, O. N. (2016). Municipal solid waste characteristics and management in Sinop, Turkey. *Environmental Engineering and Management Journal*, *15*(1), 13–18. https://doi.org/10.30638/eemj.2016.002

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing and Health Sciences*, *15*(3), 398–405. https://doi.org/10.1111/nhs.12048

Wilson, D. C., Velis, C., & Cheeseman, C. (2006). Role of informal sector recycling in waste management in developing countries. *Habitat International*, *30*(4), 797–808. https://doi.org/10.1016/j.habitatint.2005.09.005

Ziaei, M., Choobineh, A., Abdoli-Eramaki, M., & Ghaem, H. (2018). Individual, physical, and organizational risk factors for musculoskeletal disorders among municipality solid waste collectors in Shiraz, Iran. *Industrial Health*, *56*(4), 308–319. https://doi.org/10.2486/indhealth.2018-0011

Ziaei, M., Choobineh, A., Abdoli-Eramaki, M., Ghaem, H., & Jaberi, O. (2019). Psychological and physical job demands, decision latitude, and work-related social support among Iranian waste collectors. *Waste Management*, *95*, 377–387. https://doi.org/10.1016/j.wasman.2019.06.031