Assessment of Personal Protective Equipment Utilisation Among Solid Waste Workers in Osogbo, Nigeria

Bosede Oyindamola Adeleke
Department of Urban and Regional, Obafemi Awolowo University, Ile-Ife
apanisilebose@gmail.com

Abstract

The use of personal protective equipment (PPE) is critical for safeguarding solid waste management workers against occupational hazards, particularly in tropical environments where heat and humidity may limit compliance. This study assesses the availability, utilisation, and challenges associated with PPE use among solid waste management workers in Osogbo, Osun State, Nigeria. A cross-sectional descriptive research design was adopted, and data were collected from 111 respondents using structured questionnaires and field observations. Descriptive statistics and Pearson correlation analysis were employed to analyse the data. The findings revealed that although 79.3% of respondents reported being provided with PPE, utilisation was generally low: only 35.0% reported consistent use, 54.2% reported infrequent use, and 10.8% never used PPE. Basic items such as gloves and face masks were readily available, whereas critical PPE, including protective clothing, safety boots, goggles, and earmuffs, was largely unavailable. Behavioural factors such as discomfort, lack of awareness of the importance of PPE, and low risk perception were the major reasons for non-utilisation. A significant positive relationship was found between tropical climate conditions and PPE usage ($r = 0.67$, $p = 0.032$), while years of work experience showed no significant relationship with PPE use ($p = 0.488$). Heat and discomfort from PPE usage and unavailability emerged as the most significant challenges. The study concludes that climatic conditions, inadequate provision, and usability challenges constrain PPE utilisation among solid waste management workers in Osogbo. It recommends adopting climate-adapted PPE, ensuring a regular and comprehensive supply of PPE, providing targeted safety training, and designing PPE in a gender-sensitive way to improve compliance and reduce occupational health risks in tropical urban settings.

Keywords: *Occupational health and safety; personal protective equipment; solid waste management; Nigeria; tropical climate.*

Introduction

Solid waste management is a high priority for society (Adebola et al., 2019; Adeleke et al., 2025; Thakur et al., 2018). It has a direct impact on environmental quality, public health, and urban aesthetics (Mazhindu et al., 2012; Nwosu & Chukwueloka, 2020). However, it is among the most dangerous occupations, as it exposes workers to significant hazards (Sapkota et al., 2020). It has been estimated by the International Labour Organization (ILO) that 2.78 million workers die each year because of occupational illness and accidents. Solid waste workers are not exempt from these risks (Hasanah et al., 2023). They face occupational hazards, including lifting-related strains, injuries from sharp objects, and exposure to pathogens when manually handling waste (Patil & Kamble, 2017; Tiwari et al., 2020). To mitigate these risks, the use of Personal Protective Equipment (PPE) is essential (Melaku & Tiruneh, 2020; Ramitha & Koneti, 2023).

The use of PPE by waste management workers is essential for safeguarding them from workplace hazards, including accidents, illnesses, and environmental exposures. (Singh etal. 2020). The Occupational Safety and Health Administration (OSHA, 2005) defines PPE as gear used to reduce workers' exposure to various risks. It encompasses ocular and facial protection (safety glasses, goggles, or face shields), pedal protection (safety shoes), manual protection (gloves), cranial protection (hard hats/helmets), and auditory protection (earplugs/earmuffs). Hasanah et al. (2023) described PPE as important items, such as face masks, gloves, goggles, protective clothing, and boots, that workers use to protect themselves from exposure to pathogens, contaminants, and sharp objects.

However, previous studies have revealed that workers do not effectively use PPE due to factors ranging from the unavailability of PPE to a lack of workers' knowledge of self-safety and health. Wu et al. (2020) found that workers may refrain from using personal protective equipment when it is unpleasant or hinders their productivity. Ahmed et al. (2015) highlighted many factors contributing to this predicament, including PPE-related pain, claims of reduced productivity, poor PPE availability, infrequent employer enforcement of PPE use, and inadequate training on PPE use. Lawrence Green, as

cited in Notoatmodjo (2012), stated that behaviour is influenced by three factors: predisposing factors, such as knowledge, attitudes, beliefs, and values; reinforcing factors, such as the attitudes and behaviours of workers or other officers; and enabling factors, such as the physical environment and the availability of health facilities. Therefore, the physical environment is an important factor that can greatly influence PPE utilisation. According to Jiang et al. (2023), high temperatures reduce the environmental tolerance of PPE wearers.

Osogbo is the capital city of Osun State, located in southwestern Nigeria. The city lies within the tropical climatic zone, with an average annual temperature of about 30°C. Under such conditions, heat stress and thermal discomfort can significantly limit the consistent use of personal protective equipment (PPE) by solid waste management workers.

Given these workers' daily direct contact with municipal waste, exposure to occupational hazards remains high. To reduce the incidence of work-related diseases and accidents, it is necessary to assess the availability and utilisation of PPE, as well as the challenges associated with its use, among solid waste management workers. Such an assessment will provide an empirical basis for proposing appropriate intervention strategies and guidelines to improve PPE provision, compliance, and ergonomic suitability for solid waste management workers in Osogbo, the capital of Osun State, southwestern Nigeria.

Study Area

Osogbo is the capital city of Osun State. The city hosts the headquarters of two local government areas: Osogbo Local Government Area, located in Oke Baale, and Olorunda Local Government Area, situated in Igbona. Osogbo is located in southwestern Nigeria within the South-West geopolitical zone and lies approximately 250 kilometres northeast of Lagos, Nigeria's commercial capital. Geographically, Osogbo is located at about latitude 7°46′15.74″ N and longitude 4°33′25.13″ E of the Greenwich Meridian (Figure 1). The city is strategically positioned along the Osun River, which holds significant historical and cultural importance for the indigenous population. Osogbo is part of the Yoruba-speaking region and is situated in a landscape characterised by a blend of savannah and forest vegetation. This ecological setting contributes to the city's natural resource availability and supports agricultural activities. Osogbo has a tropical climate with an average annual temperature of 26.1°C and average rainfall of 1150mm, which starts from April to late October or early November. The dry season lasts from December to March, a period of intense heat. The mean land surface temperature increased from 26.2°C in 1984 to 30.5°C in 2015, indicating progressive warming in the region (Eresanya et al., 2019). In response to the laxity of the local government in effectively carrying out its statutory role in solid waste management, the Osun State Government established an agency in 2010 charged with the responsibility of coordinating the various services of solid waste management. Through the Osun Waste Management Agency (OWMA), the government provides solid waste storage, collection, transportation, and disposal services (Adeleke et al., 2025).

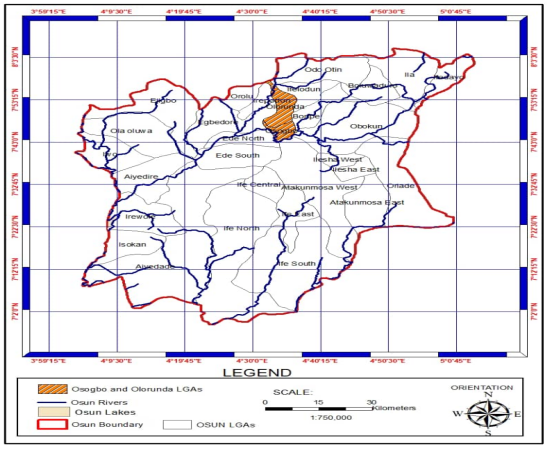


Figure 1: Osogbo and Olorunda Local Government Areas in the Context of Osun State
Source: National Space Research and Development Agency (NARSDA, 2025).

Methodology

This study employed a cross-sectional descriptive research design to assess the availability, utilisation, and challenges associated with the use of personal protective equipment (PPE) among solid waste management workers. The design was considered appropriate because it allows data to be collected from respondents at a single point in time and enables the examination of prevailing conditions and practices related to PPE utilisation. The study population comprised all solid waste management workers engaged in waste collection, transportation, and disposal activities under the Osun State solid waste management system in Osogbo. These workers are routinely exposed to occupational hazards due to direct contact with municipal solid waste and therefore constitute a relevant population for this assessment. The sample size was calculated using a simplified proportion formula, as described by Glenn (2013).

Where;
n = Sample size
N = Population size in the sample unit
e = Level of precision, which is ±5% (0.05)

The calculated sample size was approximately 133 respondents. For practical purposes, the sample size was taken as 133 solid waste management workers. This formula was adopted because it is suitable for finite populations and provides a reliable sample size that ensures representativeness while minimising sampling error. A simple random sampling technique was employed to select respondents from the study population. This method ensured that all eligible solid waste management workers had an equal chance of being selected, thereby reducing selection bias and enhancing the generalisability of the findings. Primary data were collected using a structured questionnaire designed to capture information on socio-demographic characteristics, availability of PPE, frequency and consistency of PPE use, and challenges associated with PPE utilisation. The total number of questionnaires administered was 133, but 111 were retrieved. In addition, direct field observation was conducted to validate self-reported responses and assess the actual use of PPE during waste handling operations. Ethical considerations were observed, including informed consent, respondent anonymity, and voluntary participation.

Collected data were coded and analysed using descriptive statistical techniques, including frequencies, percentages, and mean scores. These methods were used to summarise PPE availability, utilisation patterns, and perceived challenges among the respondents. Results were presented using tables to enhance clarity and interpretation.

Findings

Table 1: Socioeconomic Characteristics

Characteristics		Frequency	Percentage (%)
Age	18-25	16	14.4
	26-45	80	72.1
	46 and above	15	13.5
	Total	111	100
Gender	Male	42	37.8
	Female	69	62.2
	Total	111	100
Marital status	Single	27	24.3
	Married	39	35.1
	Widowed	18	16.2
	Divorced	27	24.3
	Total	111	100
Level of education	No formal education	15	13.5
	Primary	55	49.5
	Secondary	40	36.0
	Tertiary	1	0.9
	Total	111	100
Year of experience	less than 1 year	26	23.4
	1-3 years	55	49.5
	4-6 years	18	16.2
	more than 6 years	12	10.8
	Total	111	100

Table 1 shows the socio-economic characteristics of the respondents. Of the 111 solid waste management workers surveyed, 16 respondents (14.4%) were aged 18-25 years, 80 (72.1%) were aged 26–45 years, and 15 (13.5%) were aged 46 years and above. This indicates that most of the workers were within the active working-age population. In terms of gender distribution, 42 respondents (37.8%) were male and 69 (62.2%) were female. This shows that female workers constituted a larger proportion of the workforce in the study area.

With respect to marital status, 27 respondents (24.3%) were single, 39 respondents (35.1%) were married, 18 respondents (16.2%) were widowed, and 27 respondents (24.3%) were divorced. This reveals that married workers formed the largest group among the respondents. Regarding educational attainment, 15 respondents (13.5%) had no formal education, 55 (49.5%) had primary education, 40 (36.0%) had secondary education, and 1 (0.9%) had tertiary education. This indicates that most workers had low to moderate levels of formal education.

Concerning years of work experience, 26 respondents (23.4%) had less than one year of experience, 55 respondents (49.5%) had between one and three years of experience, 18 respondents (16.2%) had four to six years of experience, while 12 respondents (10.8%) had more than six years of experience. This suggests that nearly half of the workers had relatively short work experience, ranging from one to three years.

Table 2: PPE Provision

Provided?	Frequency	Percentage (%)
Yes	88	79.3
No	23	20.7
Total	111	100

Table 2 presents information on the provision of personal protective equipment (PPE) to solid waste management workers. Of the 111 respondents surveyed, 88 workers (79.3%) reported receiving PPE, while 23 (20.7%) reported not receiving any. This indicates that although a majority of workers had access to PPE, a substantial proportion were not provided with protective equipment, thereby exposing them to occupational health and safety risks during waste management activities.

Table 3: Availability of Personal Protective Equipment

PPE		Frequency	Percentage (%)
Gloves	Yes	88	79.3
	No	23	20.7
	Total	111	100
Mask	Yes	88	79.3
	No	23	20.7
	Total	111	100
Protective clothing	Yes	32	28.8
	No	79	71.2
	Total	111	100
Safety boots	Yes	5	4.2
	No	106	95.8
	Total	111	100
Goggle	Yes	0	0.0
	No	111	100
	Total	111	100
Ear muff	Yes	0	0
	No	111	100
	Total	111	100

Table 3 presents the availability of different types of personal protective equipment (PPE) among solid waste management workers. Of the 111 respondents, gloves were available to 88 workers (79.3%), while 23 (20.7%) reported they were not available. Similarly, face masks were available to 88 respondents (79.3%), whereas 23 respondents (20.7%) indicated non-availability. Protective clothing was available to only 32 respondents (28.8%), while a large majority of 79 respondents (71.2%) reported that such clothing was not available. Safety boots were very scarce, with only five respondents (4.2%) reporting access, compared with 106 (95.8%) reporting non-availability. Furthermore, none of the respondents reported having goggles, as all 111 respondents (100%) indicated that they were not provided. Similarly, earmuffs were completely unavailable, with all respondents (100%) reporting they were unavailable. The findings indicate that while basic PPE items such as gloves and masks were relatively available, critical protective equipment, including protective clothing, safety boots, goggles, and earmuffs, was largely unavailable to most solid waste management workers, thereby increasing their vulnerability to occupational hazards.

Table 4: Frequency of Use of the PPE

Use	Frequency	Percentage (%)
Always	39	35.0
Rarely	60	54.2
Never	12	10.8

Table 4 shows the frequency of use of the personal protective equipment (PPE) provided to the respondents. Of the 111 solid waste management workers surveyed, 39 (35.0%) reported always using the PPE provided to them. In contrast, 60 respondents (54.2%) reported rarely using the PPE, while 12 (10.8%) reported never using it. These findings indicate low compliance with PPE use, despite the provision of PPE to a large proportion of respondents. The high percentage of respondents who rarely or never used PPE suggests barriers such as discomfort, inadequate supervision, or lack of enforcement, which may increase workers' exposure to occupational health and safety risks.

Table 5: Reasons for non-utilisation of PPE

Reason	Mean	Std. Deviation
Peer influence	1.12	0.33
Inappropriacy of available PPE	1.26	0.44
Lack of proper training on PPE usage	1.38	0.48
Considered not necessary	1.63	0.48
Inadequate supply of PPE	1.75	0.43
Not aware of the importance of PPE	1.83	0.37
Uncomfortable to wear in hot weather	1.95	0.20
Uneasy to wear	1.96	1.96

Table 5 presents the reasons for non-utilisation of personal protective equipment (PPE) among the respondents using a 2-point scale. On this scale, higher mean values indicate stronger agreement with the stated reason for non-utilisation. The results show that "Uncomfortable to wear PPE" recorded the

highest mean score (Mean = 1.96, SD = 0.20), indicating that discomfort associated with wearing PPE is the most influential factor discouraging its use among workers. This was closely followed by "Uncomfortable to wear in hot weather" (Mean = 1.95, SD = 0.20), suggesting that climatic conditions influence PPE usage decisions. Other important reasons identified include being unaware of the importance of PPE (Mean = 1.83, SD = 0.37) and an inadequate supply of PPE (Mean = 1.75, SD = 0.43), highlighting deficiencies in occupational safety education and PPE provision. The perception that PPE is not necessary also contributed to non-utilisation (Mean = 1.63, SD = 0.48). Factors related to inadequate sensitisation and PPE suitability recorded comparatively lower mean values. These include a lack of proper training on PPE use (Mean = 1.38, SD = 0.48), inappropriateness of available PPE (Mean = 1.26, SD = 0.44), and peer influence (Mean = 1.12, SD = 0.33). Although these factors were less dominant than behavioural factors, they still contributed to PPE non-utilisation.

Table 6: Relationship between Years of Experience and PPE Usage

		Years of experience in SWM	How often do you use the provided PPE?
Years of experience in SWM	Pearson Correlation	1	.067
	Sig. (2-tailed)		.488
	N	111	111
How often do you use the provided PPE	Pearson Correlation	.067	1
	Sig. (2-tailed)	.488	
	N	111	111

Table 6 presents the relationship between years of experience in solid waste management and the frequency of PPE usage among respondents. The Pearson correlation coefficient between years of experience and PPE usage was r = 0.067, indicating a very weak positive relationship between the two variables. This suggests that increases in years of experience are associated with only a minimal increase in PPE use frequency. The relationship was not statistically significant at the 0.05 level (p = 0.488). This implies that years of experience do not significantly influence how often solid waste management workers use the provided PPE. The result indicates that PPE usage among the workers is not dependent on length of work experience, suggesting that both experienced and less experienced workers exhibit similar PPE usage behaviours.

Table 7: Relationship Between Tropical Climate and PPE Usage

		How often do you use the provided PPE	How does the tropical climate affect your use of PPE
How often do you use the provided PPE	Pearson Correlation	1	0.67
	Sig. (2-tailed)		.032
	N	111	111
How does the tropical climate affect your use of PPE	Pearson Correlation	0.67	1
	Sig. (2-tailed)	.032	
	N	111	111

Table 7 shows the relationship between tropical climatic conditions and the frequency of PPE usage among solid waste management workers. The Pearson correlation coefficient between PPE usage and the effect of the tropical climate was r = 0.67, indicating a moderately strong positive relationship between the two variables. The relationship was statistically significant at the 0.05 level (p = 0.032). This suggests that the tropical climate may influence PPE utilisation, although causality cannot be established. As the perceived negative effects of the tropical climate increase, PPE usage patterns are noticeably affected. This result suggests that heat, humidity, and thermal discomfort associated with the tropical climate play a major role in shaping PPE utilisation behaviour among solid waste management workers. Unlike years of experience, which showed no significant relationship with PPE use, climatic conditions appear to be a critical determinant of PPE compliance in the study area.

Table 8: Challenges Affecting PPE Utilisation

Challenge	Mean	Std. Deviation
Poor quality of PPE	1.02	.16290
Lack of fitting sizes	1.25	.43627

Inappropriacy	1.39	.49137
Restriction of movement	1.60	.49137
Unavailability	1.67	.47024
Maintenance and cleaning of PPE	1.80	.40045
Heat and discomfort	1.81	.39344

Table 8 presents the challenges facing the utilisation of PPE among solid waste management workers. Using a 2-point scale, higher mean values indicate stronger agreement that a factor constitutes a challenge to PPE utilisation. The results show that heat and discomfort recorded the highest mean score (Mean = 1.8108, SD = 0.39344), indicating that the workers strongly acknowledged heat stress as a major challenge. This was closely followed by maintenance and cleaning of PPE (Mean = 1.8018, SD = 0.40045), suggesting that the hygienic upkeep of the PPE after usage significantly discourages effective use. Other notable challenges include the unavailability of PPE (Mean = 1.6757, SD = 0.47024) and restrictions on movement due to PPE (Mean = 1.6036, SD = 0.49137), reflecting concerns about limited supply, comfort, convenience, and usability. Inappropriateness of PPE also posed a challenge, with a mean score of 1.3964 (SD = 0.49137). Challenges related to the lack of fitting sizes recorded a relatively lower mean value (Mean = 1.2523, SD = 0.43627), while poor quality of PPE had the lowest mean score (Mean = 1.0270, SD = 0.16290), indicating weaker agreement compared to other factors.

Discussion

Socio-economic characteristics

The majority of workers being female aligns with the fact that women constitute a larger share of informal waste workers in developing countries. A larger percentage of them are in their productive age (26-45) and are responsible for their families, whether married, widowed, or separated. This indicates that children may also be indirectly exposed to the health-related vulnerabilities associated with waste work. Mothers are the primary carers for their wards in African societies (Oguntoyinbo, 2018); this exposes the younger ones, who are the future generations, to the health hazards associated with waste, which may have long-term health implications or leave them with major health challenges that can mar their future. Hence, there is a need for targeted intervention.

The educational profile, with the majority having primary education, suggests limited formal training, which may contribute to low awareness of the importance of PPE, as evidenced by the mean score of 1.8378 for lack of awareness as a reason for non-use. This finding corroborates previous studies indicating that low educational attainment among waste workers correlates with poor occupational safety practices (Suleman et al., 2015).

The workers' 1-3 years of experience suggest recent entry into the sector, coinciding with the new government's recruitment drive after it resumed office three years ago, which may limit their accumulation of safety knowledge. Interestingly, the Pearson correlation analysis ($p = 0.488$) showed no significant relationship between years of experience and PPE usage, suggesting that even experienced workers do not necessarily adopt better PPE practices. This could be attributed to systemic issues, such as inadequate training or inconsistent PPE supply, rather than individual factors alone.

PPE Provision and Availability

Many of the sampled workers reported receiving PPE from the government. However, critical PPE such as protective clothing, safety boots, goggles, and earmuffs was severely underprovided. This selective provision aligns with findings from other studies in Nigeria, where employers often fail to provide comprehensive PPE, leaving workers vulnerable to health risks such as cholera (Anaele et al., 2014). Gloves and masks were the major PPE claimed to be primarily supplied. Moreover, the oral interviews with supervisors indicated that the government's provision of PPE is inconsistent. It could be once every two years. This further exacerbates the issue, as infrequent supply cannot meet the daily demands of hazardous waste handling. This gap in provision directly contributes to the low utilisation rates, with 54% of workers rarely using PPE and 11% never using it. The inadequate supply (mean = 1.7513) was a significant barrier, echoing global studies in which the unavailability of PPE is a primary reason for non-compliance among waste workers (Alam et al., 2022).

Impact of Tropical Climate on PPE Utilisation

A key finding of this study is the significant relationship between tropical climate and PPE usage (Pearson correlation, $p = 0.032$). The main reason for non-use was discomfort in hot weather (mean = 1.9510). Heat and discomfort were identified as the most significant challenge (mean = 1.8170). Osogbo's tropical climate is characterised by high temperatures and humidity for most of the year, which exacerbate the discomfort associated with wearing PPE, particularly heavy or non-breathable items such as protective clothing and boots. This

finding is consistent with previous studies reporting discomfort, breathing difficulties, and overheating as barriers to PPE use among waste workers (Mahbub, 2018; Salmawati et al., 2018; Alam et al., 2022). The absence of climate-adapted PPE, such as lightweight, breathable materials, further discourages compliance. This highlights a critical oversight in PPE design and procurement, as most available equipment is not tailored to tropical environments, a factor often neglected in occupational health policies (Thakur et al., 2018).

Other Challenges to PPE Utilisation

Beyond climate, other challenges include the unavailability of PPE, maintenance difficulties, and the inappropriateness of the available PPE. The lack of fitting sizes and poor quality of PPE further compounds the issue, as ill-fitting or substandard equipment reduces both comfort and effectiveness. These findings align with the global literature, in which improper sizing and low-quality PPE are significant barriers to compliance (Salmawati et al., 2018). Additionally, the lack of proper training and awareness of the importance of PPE indicates a need for enhanced educational programs. The low influence of peer pressure suggests that individual and systemic factors, rather than social dynamics, are the primary drivers of non-compliance.

Policy and Practice Implications

The findings underscore the need for targeted interventions to improve PPE utilisation. First, policymakers should prioritise the procurement and distribution of climate-adapted PPE, such as breathable fabrics and lightweight boots, to mitigate heat-related discomfort. Second, regular and comprehensive provision of PPE, including goggles and earmuffs, is essential to address current gaps. Third, training programmes tailored to low-literacy workers can enhance awareness and proper usage techniques, as suggested by Patil and Kamble (2017). Finally, gender-sensitive approaches, such as providing PPE designed for women, could address the specific needs of the predominantly female workforce.

Conclusion

This study provides a comprehensive assessment of PPE utilisation among solid waste management workers in Osogbo, Nigeria, highlighting the critical interplay between tropical climate, socioeconomic factors, and logistical challenges. The significant correlation between hot weather and low PPE use underscores the urgent need for climate-adapted protective equipment to improve compliance in tropical regions. While the government provides some PPE, its inconsistent and selective supply, coupled with inadequate training and low awareness, limits effective utilisation. These findings have broader implications for occupational health policies in similar settings, emphasising the need for tailored PPE designs, regular provisions, and targeted education programs. Future research should examine the design and evaluation of climate-appropriate PPE and assess the influence of training interventions on compliance rates. By addressing these gaps, policymakers and employers can significantly reduce occupational hazards for solid waste workers, thereby improving public health and workplace safety.

References

Adeleke, B. O., Afon, A. O., & Ojo, D. B. (2025). Awareness of government-provided solid waste management services in Osun State. *Ibadan Planning Journal, 11*(1), 22–29.

Adebola, A. A., & Adewale, M. A. (2019). Potential occupational health effects of municipal solid waste management in Nigeria, the case of Lagos and Ibadan. *Ife Journal of Science, 21(2). https://dx.doi.org/10.4314/ijs.v21i2.15*

Ahmed, S. M., Azhar, S., Farooqui, R. U., & Panthi, K. (2015). Addressing the issue of compliance with personal protective equipment on construction worksites: A workers' perspective. In *ASC 45th (2009) Conference. Florida International University, Miami, Florida, United States*.

Anaele, E. O., Adelakun, O. A., & Olumoko, B. O. (2014). Re-engineering technical vocational education and training (TVET) towards safety practice skill needs of sawmill workers against workplace hazards in Nigeria. *Journal of Education and Practice, 5*(7), 150–157.

Alam, M. U., Sharior, F., Shoaib, D. M., Hasan, M., Tabassum, K. F., Ferdous, S., & Ahmed, T. (2022). Hygiene knowledge and practices and determinants of occupational safety among waste and sanitation workers in Bangladesh during the COVID-19 pandemic. *Hygiene and Environmental Health Advances*, *4*, 100022.

Awwad, R., El Souki, O., & Jabbour, M. (2016). Construction safety practices and challenges in a Middle Eastern developing country. *Safety Science*, *83*, 1–11.

Babalola, F. D., & Oladipupo, A. D. (2018). Use of personal protective equipment by sawmill workers in Nigeria. *J Multidiscip Stud*, *7*, 190–208.

Eresanya, E. O., Daramola, M. T., Durowoju, O. S., & Awoyele, P. (2019). Investigation of the changing patterns of land use and land cover over Osogbo and its environs. *Royal Society*

Open Science, 6(12), 191021. Royalsocietypublishing.org

Glenn, H. P. (2013).*The cosmopolitan state*. OUP Oxford.

Hasanah, N., Ambarwati, R., & Indriatie. (2023). Knowledge and behavior of using personal protective equipment among garbage collectors. *6th International Conference of Health Polytechnic Surabaya (ICoHPS, 2023), 252-262.atlantis-pree.com*

Izudi, J., Ninsiima, V., & Alege, J. B. (2017). Use of personal protective equipment among building construction workers in Kampala, Uganda. Journal of Environ Public Health. 2017; 2017:1–5. doi: 10.1155/2017/7930589. doi: 10.1155/2017/7930589. Retrieved on 27th October, 2025 from https://pmc.ncbi.nlm.nih.gov/articles/pmc5672632/

Lai, D. N. C., Liu, M., & Ling, F. Y. Y. (2011). A comparative study on adopting human resource practices for safety management on construction projects in the United States and Singapore. *International Journal of Project Management, 29*(8), 1018–1032.

Lette, A., Ambelu, A., Getahun, T., & Mekonen, S. (2018). A survey of work-related injuries among building construction workers in southwestern Ethiopia. *International Journal of Industrial Ergonomics, 68, 57- 64*.

Man, S. S., Chan, A. H., & Wong, H. M. (2017). Risk-taking behaviors of Hong Kong construction workers–A thematic study. *Safety Science*,*98*, 25-36.

Mahbub, R. (2018). Occupational health risks of waste workers in developing countries. *Saf. Sci.67, 12–25*

Mazhindu, E., Gumbo, T., & Gondo, T. (2012). Waste management threats to human health and urban aquatic habitats: A case study of Addis Ababa, Ethiopia. In *Waste management – An integrated vision*. IntechOpen. https://doi.org/10.5772/48077

Melaku, H. S., & Tiruneh, M. A. (2020). Occupational health conditions and associated factors among municipal solid waste collectors in Addis Ababa, Ethiopia. *Risk Management and Healthcare Policy, 13*, 2415–2423. https://doi.org/10.2147/RMHP.S276790

Narendra Singh. (2020). Environmentally sustainable management of used personal protective equipment. *Environmental Science & Technology, 54*(14), 8500–8502. https://doi.org/10.1021/acs.est.0c03022

Notoatmodjo, S.: Promosi Kesehatan dan Perilaku Kesehatan (edisi revisi). Jakarta: Rineka Cipta. (2012).

Nwosu, A. O., & Chukwueloka, H. E. (2020). A review of solid waste management strategies in Nigeria. *Journal of Environment and Earth Science, 10*(6), 1–10.

Occupational Safety and Health Administration (OSHA) (2005). OSHA Quick Card. Protect yourself, construction personal protective equipment (PPE). OSHA 3289; 2005. Available online at https://www.osha.gov/Publications/construction_ppe.html

Oguntoyinbo, S. I. (2018).Kafirin viscoelastic masses: Factors influencing their formation and rheological behaviour. University of Pretoria (South Africa).

Patil, P. V., & Kamble, R. K. (2017). Occupational health hazards in municipal solid waste collecting workers of Chandrapur city, Central India. International Journal of Environment, 6(1), 46–57.

Ramitha, K. L., & Koneti, L. R. (2023). Solid waste workers in India and the COVID-19 pandemic: A review of intersecting challenges. *International Journal of Occupational Safety and Health, 13*(1), 126–139. https://doi.org/10.3126/ijosh.v13i1.43113

Salmawati, L., Hermiyanti, D., Hamid, A., Nur, R., & Faradiba, D. (2018). Garbage collector behavior towards the use of personal protective equipment at Inpres Market, Manonda, Palu City. *Asian Journal of Environment, History and Heritage, 2*, 67–72.

Sapkota, S., Lee, A., Karki, J., Makai, P., Adhikari, S., Chaudhuri, N., & Heckmann, A. F. (2020). Risks and risk mitigation in waste-work: A qualitative study of informal waste workers in Nepal. *Public Health in Practice, 1*, 100028. https://doi.org/10.1016/j.puhip.2020.100028

Singh, N., Tang, Y., Zhang, Z., & Zheng, C. (2020). COVID-19 waste management: Effective and successful measures in Wuhan, China. Resour. Conserv. Recycl. 163, 10–11. https://doi.org/10.1016/j.resconrec.2020.105071.

Suleman, F., Dincer, I., & Agelin-Chaab, M. (2015). Environmental impact assessment and comparison of some hydrogen production options.*International journal of hydrogen energy*, *40*(21), 6976–6987.

Thakur, V., Mangla, S. K., & Kumar, P. (2018). A systematic review of sustainable waste management. *Journal of Cleaner Production, 198*, 142–160.

Wu, X., Luo, X., Wang, H., Wang, Q., & Sapkota, S. (2020). Safety compliance behavior of workers: The role of safety supervision and regulation enforcement. *Safety Science, 128*, 104764