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Health Burdens of Solid Waste Mismanagement at Thanjavur: Assessing Occupational, Psychological, and Community Risks

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Abstract

Solid waste mismanagement in Thanjavur poses substantial occupational, psychological, and community health risks, particularly affecting municipal sanitation workers and nearby residents. Waste workers experience high rates of musculoskeletal disorders (69.3%), respiratory illnesses (57.9%), and skin-related conditions (42.9%) due to continuous direct exposure to hazardous and mixed waste materials. Psychological stress, including anxiety, depression, and sleep disorders (37.4%), is also prevalent, largely driven by poor working conditions, inadequate access to personal protective equipment, job insecurity, and social stigma associated with sanitation work. Beyond occupational impacts, community health is significantly affected, as improper waste disposal contributes to air and water contamination, increased prevalence of vector-borne diseases (28.2%), and chronic fatigue (35.3%) among local residents. An assessment of workplace safety practices revealed low participation in training programs, with only 17.6% of workers receiving occupational safety training and 18.1% trained in waste handling, along with inconsistent use of protective gear, further exacerbating health risks. Based on field data collection, structured interviews, and environmental sampling, this study underscores the urgent need for location-specific waste management strategies, improved occupational health safeguards, and stronger policy interventions to protect public health and promote environmental sustainability in Thanjavur.

Keywords: Health Risks, Municipal Solid Waste Disposal, Occupational Hazards, Respiratory Morbidities, Waste Workers.

Introduction

Solid waste management (SWM) continues to be a major public health and environmental challenge in developing countries, where rapid urbanization and inadequate infrastructure contribute to improper waste disposal and environmental degradation (1, 2). Inefficient SWM systems result in soil, air, and water contamination, thereby increasing the risk of communicable and non-communicable diseases among both waste handlers and the general population. In India, the escalating volume of municipal solid waste has placed immense pressure on existing waste management systems, particularly in semi-urban and rural regions where institutional capacity, funding, and technical resources remain limited (3, 4). As a consequence, improper waste handling and open dumping are common, creating persistent public health concerns. Mismanagement of solid waste has been strongly linked to the spread of vector-borne diseases and respiratory illnesses, especially among sanitation workers who are directly exposed to mixed and hazardous waste streams (5, 6). Socio-demographic determinants such as low education levels, poverty, and informal employment further exacerbate occupational health risks, while inadequate public awareness regarding waste segregation and disposal amplifies environmental contamination (7–9). Poorly managed waste sites serve as breeding grounds for disease vectors, particularly mosquitoes, leading to increased transmission of dengue and chikungunya, with reported incidence rates rising by up to 40% in affected regions (10–14). Municipal waste workers in India experience disproportionately high occupational health burdens, including respiratory illnesses (42.8%) and obstructive lung function patterns (44%), often intensified by the absence of structured training programs and limited access to personal protective equipment (6, 15, 16). Continuous exposure to particulate matter, including PM2.5 and PM10, contributes to chronic

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respiratory conditions such as asthma and chronic obstructive pulmonary disease (17, 18). In regions such as Thanjavur, these risks are compounded by low literacy rates, poverty, and limited enforcement of occupational safety regulations, further undermining effective waste management practices (8, 19). In addition to respiratory outcomes, sanitation workers commonly experience dermatological conditions and musculoskeletal disorders, as documented in studies from Kerala and other regions, reflecting widespread occupational hazards associated with manual waste handling (20–22). Addressing these risks requires comprehensive interventions, including ergonomic training, regular health surveillance, and improved workplace safety protocols (23–25). The public health implications of poor SWM extend beyond workers to surrounding communities, as evidenced in rural areas such as Mappedu, where inadequate waste disposal practices have contributed to vector-borne disease outbreaks (26). Education, community participation, and public awareness campaigns are critical for mitigating these risks and promoting safer waste behaviors (13, 18, 19, 27). Collaborative efforts between government bodies and local communities can strengthen waste management infrastructure and foster sustainable practices (4, 8).

Beyond physical health outcomes, sanitation workers also experience considerable psychological and social stress associated with their occupation. Long working hours, job insecurity, inadequate wages, and limited social recognition contribute to elevated levels of anxiety, depression, and sleep disturbances among waste handlers (6, 24). These psychological burdens are often intensified for women and workers from socially marginalized groups, who face compounded discrimination and reduced access to healthcare and welfare benefits. The stigma attached to sanitation work further affects mental well-being and reduces job satisfaction, ultimately influencing work performance and safety compliance. Despite the growing evidence linking occupational stress to long-term health deterioration, mental health dimensions of solid waste management remain insufficiently addressed in policy frameworks, underscoring the need for integrated occupational health strategies that encompass both physical and psychological well-being (6, 24). Against this background, the present study investigates the health impacts of solid waste mismanagement in a socio-economically diverse region, with a specific focus on occupational health risks, psychological stress among sanitation workers, and community-level health challenges.

Methodology

Study Design

This study is a case study of Thanjavur, a region with a rich agricultural landscape, where solid waste management (SWM) remains a significant challenge due to improper disposal methods and inadequate sanitation infrastructure. Thanjavur was selected after a thorough assessment of multiple zones within the district, considering factors such as waste accumulation patterns, socio-economic conditions, and municipal interventions.

Data Collection

This study utilizes both primary and secondary data sources. A structured survey was developed to assess key socioeconomic factors, including gender, social classification, literacy levels, family size, family type, and access to household sanitation facilities (7). Additionally, the questionnaire gathered comprehensive data on health, hygiene, and sanitation practices, with a specific focus on occupational health risks among waste workers and community health concerns arising from improper waste disposal (6, 11). The Secondary data sources include government reports on health, hygiene, and sanitation, statistical abstracts from the Tamil Nadu state planning commission, district handbooks of statistics published by the chief planning office, Thanjavur and online databases relevant to SWM and public health.

Sampling Method

Based on population estimates and statistical recommendations, a sample size of 238 was selected from the estimated 2,500 municipal sanitation workers in Thanjavur's waste management sector. The sample was distributed across urban, semi-urban, and rural municipal zones to ensure comprehensive representation as shown in table 1. A simple random sampling technique was employed to eliminate bias and enhance representativeness. Among the 238 sampled workers, 176 were male and 62 were female, covering diverse job roles, including waste

collection, transportation, and landfill management. The final questionnaire was refined based on initial field visits and focus group discussions with sanitation workers and local community members to ensure relevance and accuracy.

Data Analysis

To achieve the study's objectives, descriptive statistical tools such as percentages, mean, and standard deviation were used to assess health risks and satisfaction levels with existing safety measures. The mean and standard deviation were specifically applied to classify health problems and satisfaction levels into high, medium, and low categories.

To examine associations between demographic factors and health risks, Chi-square tests for attribute independence were conducted, analyzing the relationship between age, gender, education, occupation, and social status with health issues and safety measures among sanitation workers.

The study utilized multiple complementary strategies to comprehensively assess occupational health risks among solid waste management workers. These included evaluating the use of personal protective equipment and behavioral safety practices, along with a zone-wise analysis of the distribution of male and female sanitation workers to highlight employment patterns across different municipal zones. The research further analyzed the prevalence of common health issues among waste handlers, such as musculoskeletal disorders, respiratory ailments, skin conditions, and infectious diseases. In addition, it documented health problems experienced by workers after job shifts, including allergic reactions, fatigue, and psychological stress. The impact of demographic factors such as gender, education, and social status on health risks was examined using Chi-square analysis to determine statistical significance. Finally, the study assessed levels of satisfaction with existing safety measures across different demographic groups, thereby identifying critical gaps in training, availability of protective equipment, and workplace safety protocols.

The combined statistical approach provides a comprehensive analysis of occupational health risks, community health concerns, and safety perceptions, offering data-driven insights for improving solid waste management practices in Thanjavur.

Results

Sociodemographic and Working Condition Characteristics

A total of 238 workers participated in this study. The mean age of the workers was 47.1 (±8.87) years. The majority were males (73.9%), illiterate (65.9%), and belonged to the lower middle class (45.8%) when classified according to the modified BG Prasad's classification. Most of them were street sweepers or waste collectors (86%), working in day shifts (73.5%), and had more than 5 years of work experience as shown in table 1.

Table 1: Sociodemographic and Working Condition Characteristics of Solid Waste Management Workers in Thanjavur (n=238)

Variables	Summary Statistics
Age of Respondents, mean (±SD)	47.1 (±8.87) years
Gender, n (%)	
Male	176 (73.9%)
Female	62 (26.1%)
Educational Qualification, n (%)	
Illiterate	157 (65.9%)
Primary School	50 (21.0%)
Secondary School	20 (8.4%)
High School and above	11 (4.7%)
Socioeconomic Status, n (%)	
Upper class	1 (0.4%)
Upper middle class	23 (9.7%)
Middle class	97 (40.8%)
Lower middle class	99 (41.6%)
Lower class	18 (7.6%)
Type of Work, n (%)	
Street Sweepers/Waste Collector	205 (86.1%)
Lorry Drivers/Office Staff	33 (13.9%)
Nature of Work Shift, n (%)	
Day	175 (73.5%)

Night	63 (26.5%)
Work Experience, n (%)	
≤5 years	153 (64.3%)
>5 years	85 (35.7%)

Utilization of Personal Protective Equipment and Behavioral Status

The analysis of PPE usage among sanitation workers reveals that protective measures are inconsistently followed. Only 54.6% of workers reported consistent use of face masks, while 22.3% never used them. Similarly, 58.4% wore gloves regularly, whereas 21.9% did not use them at all. These statistics highlight the urgent need for stricter enforcement of PPE usage to reduce occupational health hazards. Additionally, only 17.6% of workers received occupational safety training, and 18.1% were trained in waste handling practices, indicating a critical gap in workplace safety education as shown in table 2.

Table 2: Utilization of Personal Protective Equipment and Behavioral Status of Solid Waste Management Workers in Thanjavur (n=238)

Variables	Summary Statistics
Use of face mask on duty, n (%)	
All the time	130 (54.6%)
Some time	55 (23.1%)
No	53 (22.3%)
Use of hand gloves on duty, n (%)	
All the time	139 (58.4%)
Some time	47 (19.7%)
No	52 (21.9%)
Occupational safety training done, n (%)	
Yes	42 (17.6%)
No	196 (82.4%)
Waste handling training done, n (%)	
Yes	43 (18.1%)
No	195 (81.9%)
Alcohol consumption, n (%)	
Yes	25 (10.5%)
No	213 (89.5%)
Tobacco consumption, n (%)	
Smoke form	16 (6.7%)
Smokeless form	38 (16.0%)
No	184 (77.3%)

Zone-Wise Distribution of Male and Female Sanitation Workers

Table 3 shows the distribution of sanitation workers across Thanjavur's municipal zones highlights a significant gender disparity, with 176 male workers (73.9%) and 62 female workers (26.1%) engaged in waste management tasks. The highest number of workers is observed in Zones 1, 5, 8, 11, and 12, with each employing 20 staff members. In contrast, Zones 3, 7, and 10 report the lowest workforce at 16 workers per zone. These findings suggest that workforce allocation is relatively uniform across zones, yet variations in staffing levels may indicate differing waste management demands or resource availability.

Table 3: Zone-wise Distribution of Male and Female Sanitation Workers in Thanjavur

Zone	Wards Covered	Male	Female	Total Staff
Zone 1	Wards 1–4	14	6	20
Zone 2	Wards 5–8	13	5	18
Zone 3	Wards 9–12	12	4	16
Zone 4	Wards 13–16	15	5	20
Zone 5	Wards 17–20	14	6	20
Zone 6	Wards 21–24	13	5	18
Zone 7	Wards 25–28	12	4	16
Zone 8	Wards 29–32	14	6	20
Zone 9	Wards 33–36	13	5	18
Zone 10	Wards 37–40	12	4	16
Zone 11	Wards 41–44	15	5	20

Zone 12	Wards 45–47	14	6	20
Zone 13	Wards 48–49	13	5	18
Zone 14	Wards 50–51	12	6	18
Total	All Wards (51)	176	68	238

Prevalence of Health Problems among Waste Collection Workers

The study identifies musculoskeletal problems as the most prevalent health issue, affecting 69.3% of sanitation workers, particularly due to repetitive movements, heavy lifting, and prolonged standing. Respiratory conditions (57.9%), including cough, phlegm, and wheezing, were also widespread, likely linked to exposure to dust, smoke, and bioaerosols as shown in Table 4. Additionally, 63.9% of workers reported frequent headaches, while 42.9% suffered from skin-related ailments such as itching and dermatitis, attributed to direct contact with waste and poor hygiene conditions. These findings underscore the need for improved occupational health monitoring, regular medical check-ups, and protective measures.

Table 4: Health Problems in Solid Waste Collection Workers of Thanjavur during Job

Type of Health Problem	Number of Workers (238)	Percentage (%)
Musculoskeletal problems (Low back pain, Elbow pain, Wrist pain)	165	69.3
Respiratory problems (Cough, Phlegm, Asphyxiate, Wheezing)	138	57.9
Headache	152	63.9
Skin-related problems (Itching, Rashes, Dermatitis)	102	42.9
Gastrointestinal problems (Nausea, Diarrhea, Vomiting, Stomach Pain)	46	19.3
Eye Irritation and Vision Problems (Conjunctivitis, Blurred Vision)	74	31.1
Psychological stress (Anxiety, Depression, Sleep Disorders)	89	37.4
Infectious Diseases (Dengue, Typhoid, Hepatitis)	67	28.2
Hearing Issues (Noise-induced Hearing Loss, Ear Infections)	54	22.7
Allergic Reactions (Sneezing, Breathlessness, Skin Sensitivity)	77	32.4

Health Problems Experienced After Job Shifts

Beyond immediate occupational hazards, sanitation workers continued to experience health issues post-work, with allergic reactions (58.0%), chronic fatigue (35.3%), and stress-related conditions (32.4%) being major concerns. Furthermore, asthma and bronchitis (29.8%), cough and cold (41.2%), and eye infections (17.6%) were frequently reported as shown in table 5, suggesting long-term health deterioration due to persistent exposure to hazardous waste environments. Diseases such as typhoid (5.9%) and malaria (3.4%) indicate poor sanitation and hygiene conditions in workplaces, further emphasizing the need for improved waste handling protocols and healthcare access for workers.

Table 5: Type of Health Problems Experienced by Solid Waste Collection Workers of Thanjavur

Type of Health Problem	Number of Workers (238)	Percentage (%)
Allergy (Skin & Respiratory)	138	58.0
Stomach Pain	46	19.3
Asthma & Bronchitis	71	29.8
Cough and Cold	98	41.2
Vomiting	28	11.8
Hearing Disorder	16	6.7
Typhoid	14	5.9
Malaria	8	3.4
Tuberculosis (TB)	9	3.8
Eye Infections (Redness, Burning Sensation)	42	17.6
Chronic Fatigue	84	35.3
Stress & Depression	77	32.4

Health Risks across Demographic Groups

The Chi-square analysis of health risks by demographic groups reveals statistically significant associations between gender, education level, and social status with the severity of health conditions. Male workers (19.3%) were more likely to experience high-risk health conditions than female workers (9.7%), potentially due to greater involvement in physically demanding tasks. Similarly, illiterate workers (15.5%)

exhibited higher health risks compared to their educated counterparts, suggesting that lack of awareness and training contributes to greater occupational exposure. Socially disadvantaged groups, particularly Scheduled Caste workers (10.1%), also reported a higher burden of health issues, reinforcing the need for targeted interventions addressing socio-economic disparities in workplace safety as shown in Table 6.

Table 6: Level of Health Problems Experienced by Various Demographic Groups of Thanjavur Municipality Workers in Solid Waste Collection

Variables	Groups	High	Low	Medium	Total	Chi-Sq Value
Gender	Male	46 (19.3)	33 (13.9)	42 (17.6)	121 (50.8)	6.46*
	Female	23 (9.7)	16 (6.7)	15 (6.3)	54 (22.7)	
Education	Illiterate	37 (15.5)	18 (7.6)	30 (12.6)	85 (35.7)	14.04*
	Primary	23 (9.7)	10 (4.2)	12 (5.0)	45 (18.9)	
	Upper Primary	9 (3.8)	6 (2.5)	6 (2.5)	21 (8.8)	
	Secondary & above	4 (1.7)	7 (2.9)	8 (3.4)	19 (8.0)	
Social Status	Scheduled Caste	24 (10.1)	17 (7.1)	25 (10.5)	66 (27.7)	12.61*
	Scheduled Tribe	12 (5.0)	4 (1.7)	9 (3.8)	25 (10.5)	
	Backward Caste	22 (9.2)	14 (5.9)	11 (4.6)	47 (19.7)	
	Other Communities	11 (4.6)	7 (2.9)	6 (2.5)	24 (10.1)	
Total		92 (38.7)	61 (25.6)	72 (30.2)	238 (100.0)	

Satisfaction Levels with Safety Measures

Despite widespread health concerns, sanitation workers exhibited varying levels of satisfaction with workplace safety measures. Table 7 shows the Chi-square test identified significant differences in perceptions of safety across gender, education, and social categories. Male workers (16.4%) and illiterate workers (17.2%) reported higher satisfaction with existing safety measures, whereas female workers (8.8%) and more educated workers (2.9–3.8%) were less satisfied, possibly due to greater awareness of occupational risks. Socially disadvantaged groups, particularly Scheduled Caste workers (8.8%), also expressed lower satisfaction levels, suggesting unequal access to protective resources and training opportunities.

Table 7: Satisfaction Levels of Various Demographic Groups of Thanjavur Municipality Workers on Safety Measures Followed in Solid Waste Collection

Variables	Groups	High	Low	Medium	Total	Chi-Sq Value
Gender	Male	39 (16.4)	30 (12.6)	52 (21.8)	121 (50.8)	15.59*
	Female	21 (8.8)	29 (12.2)	18 (7.6)	68 (28.6)	
Education	Illiterate	41 (17.2)	33 (13.9)	26 (10.9)	100 (42.0)	6.90*
	Primary	17 (7.1)	16 (6.7)	18 (7.6)	51 (21.4)	
	Upper Primary	9 (3.8)	8 (3.4)	6 (2.5)	23 (9.7)	
	Secondary & above	7 (2.9)	6 (2.5)	10 (4.2)	23 (9.7)	
Social Status	Scheduled Caste	21 (8.8)	18 (7.6)	20 (8.4)	59 (24.8)	12.78*
	Scheduled Tribe	12 (5.0)	8 (3.4)	7 (2.9)	27 (11.3)	
	Backward Caste	17 (7.1)	14 (5.9)	12 (5.0)	43 (18.1)	
	Other Communities	10 (4.2)	9 (3.8)	6 (2.5)	25 (10.5)	
Total		88 (37.0)	81 (34.0)	79 (33.2)	238 (100.0)	

Discussion

The findings of this study reveal critical occupational and public health concerns associated with solid waste management (SWM) in Thanjavur. Sanitation workers experience multiple health risks, including musculoskeletal disorders, respiratory conditions, dermatological issues, and vector-borne diseases. Additionally, demographic factors such as gender, education level, and socio-economic status significantly influence both health outcomes and satisfaction with workplace safety measures. The discussion below contextualizes these findings within recent literature, highlighting key occupational risks, socio-demographic disparities, and areas for policy intervention.

Occupational Health Risks among Sanitation Workers

Sanitation workers in Thanjavur experience severe occupational health risks, with musculoskeletal disorders (69.3%), respiratory

illnesses (57.9%), and dermatological conditions (42.9%) being the most prevalent, as illustrated in Figure 1. These findings align with research indicating that waste collectors are frequently exposed to heavy lifting, toxic fumes, airborne pathogens, and sharp objects, leading to chronic joint pain, respiratory illnesses, and skin infections (6, 28).

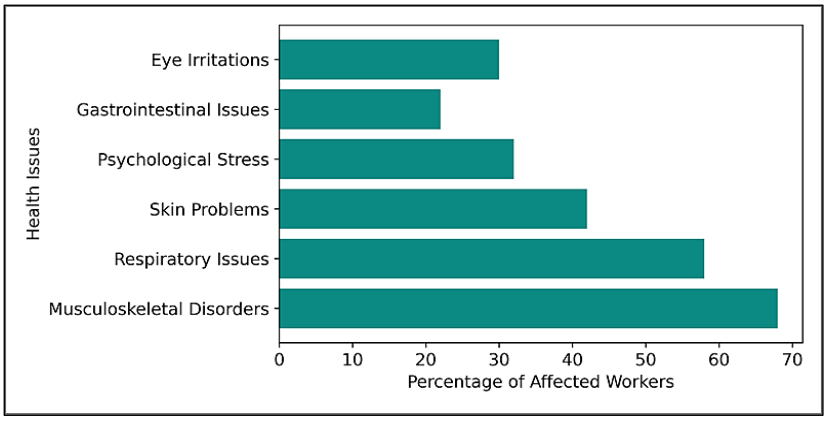

Figure 1: Common Health Issues Experienced by Sanitation Workers

Gender-Based Differences in Occupational Health Risks

Figure 2 reveals that female workers reported higher levels of severe health problems (22.0%) compared to males, who mostly experienced moderate health risks (24.3%) ($\chi^2 = 6.46$, $p < 0.05$). Female workers exhibited a higher prevalence of severe health problems compared to their male counterparts, while male workers predominantly reported moderate health risks. The chi-square analysis confirms that gender is significantly associated with the severity of health risks experienced ($p < 0.05$). The elevated health burden among female workers may be attributed to factors such as limited access to appropriate personal protective equipment, unequal participation in safety training programs, and the additional physical and psychological stress arising from dual work responsibilities at the workplace and home. These findings highlight the need for gender-sensitive occupational health policies, including equitable distribution of protective gear, targeted training interventions, and enhanced health monitoring for female sanitation workers. This suggests that women in waste collection roles are more vulnerable, possibly due to heavier workloads, lack of ergonomic support, and greater exposure to hazardous waste materials (29, 30).

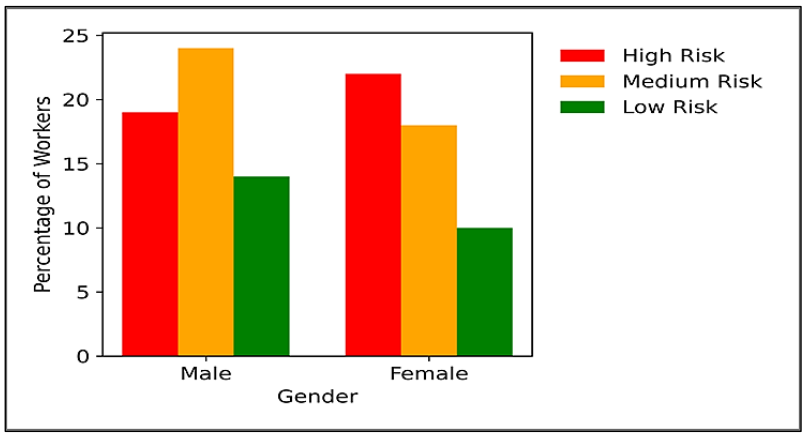

Figure 2: Distribution of Health Risks Based on Gender

Use of Personal Protective Equipment and Access to Safety Training

Usage of personal protective equipment (PPE) and participation in safety training highlights substantial gaps in occupational safety practices among solid waste management workers as illustrated in figure 3. The lack of safety training is a major contributing factor to health risks. Only 17.6% of workers received occupational safety

education, and 18.1% were trained in waste handling. A considerable proportion of workers reported inconsistent or inadequate use of PPE, including gloves, masks, and protective footwear, despite regular exposure to hazardous waste materials. Participation in formal safety training programs was notably low, indicating limited institutional emphasis on occupational health education (11, 12). The lack of training was closely associated with improper waste-handling practices and reduced awareness of health risks, thereby increasing vulnerability to injuries, infections, and long-term occupational illnesses.

Lower education levels are associated with reduced awareness of safety protocols and improper use of protective equipment, increasing exposure to occupational hazards (2,11). These findings emphasize the critical need for structured safety training programs and the consistent provision and enforcement of PPE usage to mitigate health risks among sanitation workers.

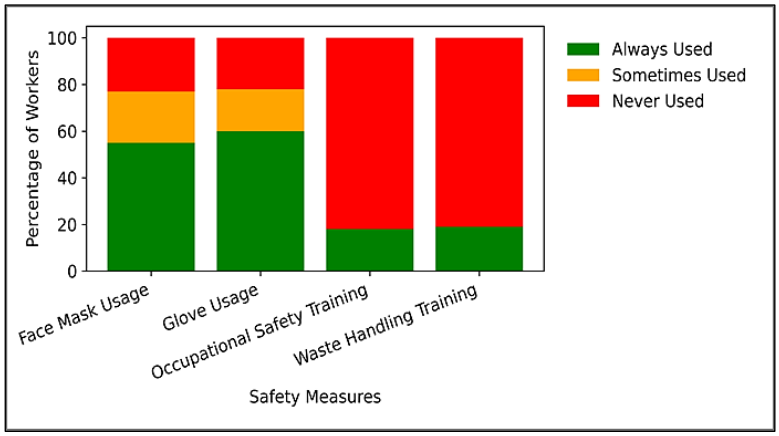

Figure 3: Usage of Personal Protective Equipment (PPE) and Participation in Safety Training

Long-Term Health Burdens and Psychological Stress

Beyond immediate occupational risks, sanitation workers continue to experience long-term health complications post-shift. Chronic fatigue (35.3%), allergic reactions (58.0%), and psychological stress (32.4%) were commonly reported, as shown in table 5. These results are consistent with studies showing that continuous exposure to hazardous waste materials can lead to chronic inflammatory responses, persistent fatigue, and respiratory deterioration (24, 31).

Psychological stress is another key concern, particularly among female and lower-educated workers, who often lack financial security and face social stigma. Studies indicate that sanitation work is associated with higher rates of anxiety, depression, and sleep disorders, necessitating integrated mental health support systems within occupational safety programs (30, 32, 33). Addressing these issues requires improving workplace conditions, ensuring fair wages, and integrating mental health support programs into occupational safety frameworks.

Demographic Variations in Satisfaction with Workplace Safety Measures

Workplace safety satisfaction across different demographic groups illustrates marked disparities in perceived safety conditions among solid waste management workers based on gender, education, and social status. Male workers predominantly reported moderate satisfaction with existing workplace safety measures, whereas a higher proportion of female workers expressed low satisfaction, indicating gender-based differences in access to protective equipment, training opportunities, and institutional support (27,28). Educational background also influenced safety perceptions, with workers possessing higher levels of education demonstrating lower satisfaction, likely reflecting greater awareness of deficiencies in safety protocols and occupational standards. In contrast, workers with little or no formal education tended to report higher satisfaction, possibly due to lower expectations regarding workplace safety norms. Social status further shaped satisfaction levels, revealing uneven distribution of safety provisions across different community groups (34-36). Overall, the figure underscores the need for inclusive, gender-

sensitive, and education-oriented safety interventions to address inequities in occupational safety and improve worker confidence in protective measures. This suggests that historically marginalized communities continue to face systemic health disparities, possibly due to limited healthcare access and poor working conditions (33, 34).

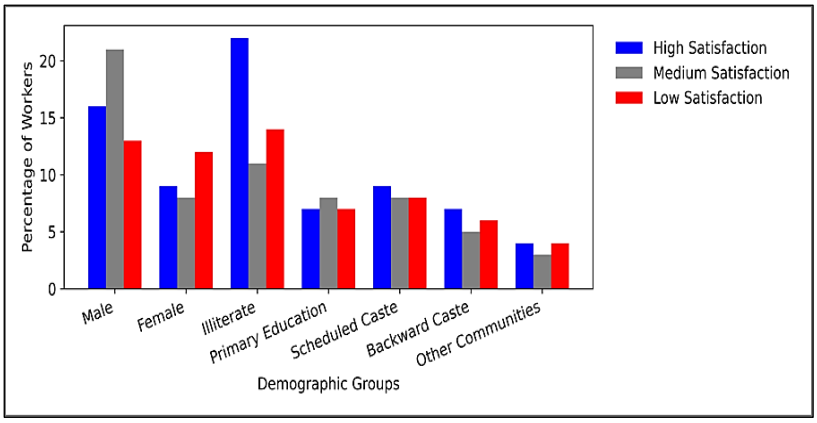

Figure 4: Workplace Safety Satisfaction across Different Demographic Groups

Figure 4 shows that the male workers predominantly reported medium satisfaction (25.7%), while female workers (26.5%) reported low satisfaction with existing safety protocols (χ^2 = 15.59, p < 0.01). The higher dissatisfaction among women suggests gender-based disparities in access to protective gear and training programs, reinforcing the need for gender-sensitive safety interventions. Education and Satisfaction: Illiterate workers (22.7%) reported higher satisfaction, while workers with primary and upper primary education expressed lower satisfaction (χ^2 = 6.90, p < 0.05). This paradox may indicate that less-educated workers have lower expectations regarding workplace safety standards, whereas those with formal education may be more aware of deficiencies in safety protocols (15, 28).

Influence of Social Status on Perceptions of Workplace Safety

Scheduled Caste workers mostly experienced medium satisfaction (15.4%), while Scheduled Tribe workers reported high satisfaction (8.8%). However, Backward Caste (13.2%) and Other Community (8.1%) workers faced higher health risks, leading to lower satisfaction levels (χ^2 = 12.61, p < 0.05). These findings highlight inequalities in workplace safety provisions across caste-based social hierarchies (33, 37).

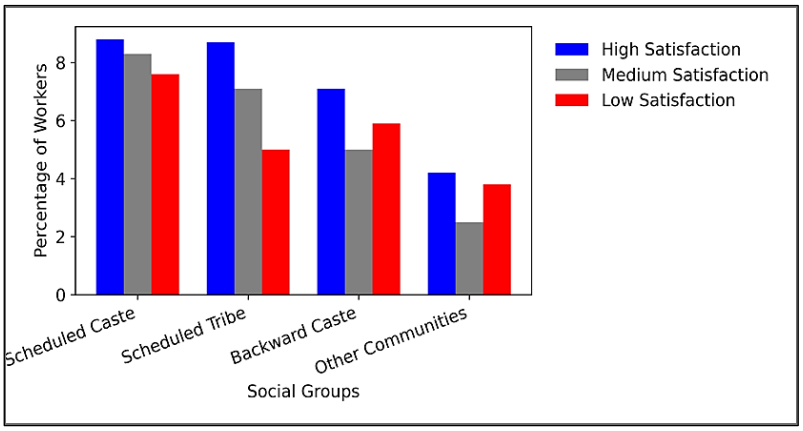

Figure 5: Workplace Safety Perceptions among Various Social Groups

Figure 5 demonstrates clear variations in perceived workplace safety among sanitation workers across different caste-based social categories. Workers from Scheduled Caste groups largely reported moderate levels of satisfaction with existing safety measures, while Scheduled Tribe workers more frequently indicated higher satisfaction levels. In contrast, workers belonging to Backward Caste and Other Community groups reported lower satisfaction, reflecting greater

exposure to health risks and perceived inadequacies in protective measures. These differences suggest that workplace safety provisions are not uniformly implemented and may be influenced by underlying social hierarchies. The findings highlight persistent social inequities in occupational safety, emphasizing the need for equitable distribution of protective resources, targeted training programs, and inclusive policy measures that address caste-based disparities within sanitation work environments.

Impact of Educational Attainment on Occupational Health Risks

Relationship between education level and health risks in sanitation workers illustrates a clear inverse association between educational attainment and the severity of occupational health problems. Illiterate workers experienced the highest proportion of severe health risks, indicating greater vulnerability to work-related hazards. In contrast, workers with secondary and higher education reported substantially lower levels of severe health problems (28-31). The chi-square analysis confirms that this association is statistically significant ($\chi^2 = 14.04$, $p < 0.05$). Lower education levels are likely linked to limited awareness of occupational safety guidelines, improper use of personal protective equipment, and reduced participation in safety training programs, all of which increase exposure to physical, chemical, and biological hazards. These findings underscore the critical role of education in risk perception and safe work practices, highlighting the need for targeted awareness and training interventions specifically designed for less-educated sanitation workers to reduce occupational health disparities (38).

Studies confirm that well-structured training programs significantly reduce workplace injuries and improve PPE compliance (39, 40). The absence of adequate training increases exposure to biological hazards, improper handling of waste and higher accident rates, underscoring the urgent need for structured educational interventions.

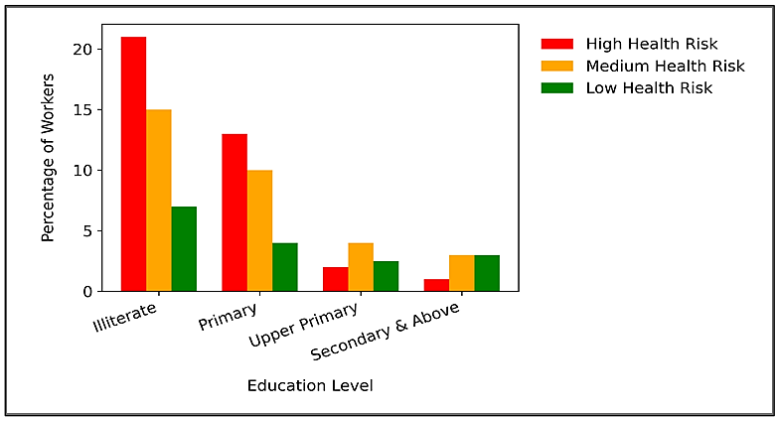

Figure 6: Relationship between Education Level and Health Risks in Sanitation Workers

Similarly, illiterate workers (20.5%) experienced higher levels of severe health problems, while those with secondary or higher education (1.5%) reported significantly fewer health risks ($\chi^2 = 14.04$, $p < 0.05$) as illustrated in figure 6. Lower education levels are associated with reduced awareness of safety protocols and improper use of protective equipment, increasing exposure to occupational hazards (2, 11).

Policy Recommendations for Improved Waste Management

To address the observed demographic disparities and occupational health risks among sanitation workers, several policy interventions are recommended. Mandatory compliance with personal protective equipment should be strictly enforced for all workers, with particular emphasis on women and socially marginalized groups who face higher vulnerability. Regular and targeted health screenings are essential to monitor respiratory, musculoskeletal, and dermatological conditions, especially among high-risk populations such as women, illiterate workers, and those from disadvantaged social backgrounds (25, 28). Gender-sensitive workplace policies should be introduced, including the provision of separate hygiene facilities, ergonomically designed tools, and flexible work schedules to accommodate the specific needs of female sanitation workers. In

addition, comprehensive occupational safety training programs must be expanded, particularly for workers with lower educational attainment, to enhance awareness of health risks and promote safe waste-handling practices (33, 41). Promoting social equity within waste management systems is equally important and requires ensuring equal access to healthcare services, fair wages, and workplace benefits for Scheduled Caste and Scheduled Tribe workers to reduce long-standing structural inequalities. Finally, community engagement programs should be strengthened to raise public awareness on proper waste disposal practices, thereby minimizing environmental contamination and reducing the risk of community-level disease transmission.

Conclusion

This study examines the occupational health risks faced by Thanjavur Municipality sanitation workers, emphasizing that while environmental concerns about solid waste management (SWM) are widely discussed, worker health and safety remain underexplored. By adopting a multi-method research design, combining quantitative surveys, qualitative interviews, and material separation analysis, the study provides a comprehensive assessment of health risks and worker satisfaction with safety measures. The findings show that manual waste collection significantly contributes to musculoskeletal disorders, particularly low back, elbow, and wrist pain. Respiratory symptoms such as cough, phlegm, wheezing, and asphyxiation were commonly reported due to prolonged exposure to airborne contaminants. Additional health issues, including headaches, skin conditions, and gastrointestinal problems, further illustrate the diverse occupational hazards faced by sanitation workers. Although many workers reported satisfaction with municipal safety measures, these perceptions were often unrelated to actual waste-related risks, indicating a gap between policy implementation and on-ground occupational realities. The study emphasizes the need for improved protective measures, consistent use of personal protective equipment, ergonomic training to reduce physical strain, and regular health monitoring to identify long-term effects of waste exposure. Developing region-specific waste management strategies that reflect local socio-economic and environmental conditions is also essential.

Limitations and Future Directions

This study is limited by its cross-sectional design, which restricts causal interpretation of the observed health outcomes. The reliance on self-reported health data may introduce recall bias, and the findings are specific to sanitation workers in Thanjavur Municipality, limiting broader generalization. Future studies should adopt longitudinal designs to assess long-term occupational health impacts and incorporate clinical assessments and environmental exposure measurements for greater accuracy. Expanding research across multiple municipalities and evaluating targeted intervention programs would further support the development of scalable, region-specific occupational health and waste management policies.

Abbreviations

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Author Contributions

Madhan Krishnamoorthy: conceptualization, article, methodology, research, data collection, data generation, interpretation, original document preparation, editing, Parthiban Pandian: methodology, research, data collection, data generation, interpretation, original document preparation, editing, Ravichandran Chandrahasan: methodology, research, data collection, data generation, interpretation, original document preparation, editing, revision, finalization of the manuscript, Ashutosh Das: conceptualization, methodology, research, data collection, data generation, interpretation, original document preparation, editing, revision, finalization of the manuscript.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

Declaration of Artificial Intelligence (AI) Assistance

The authors declare no use of artificial intelligence (AI) for the write-up of the manuscript.

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Not applicable.

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