

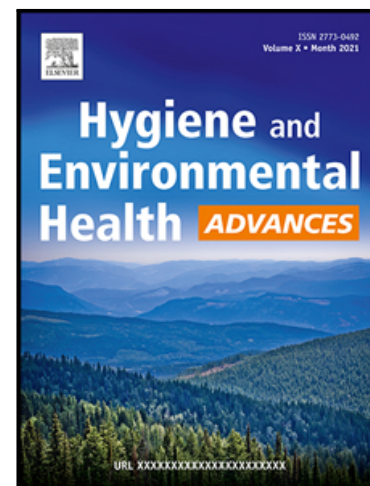


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Hygiene knowledge and practices and determinants of occupational safety among waste and sanitation workers in Bangladesh during the COVID-19 pandemic



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## Title

**Hygiene knowledge and practices and determinants of occupational safety among waste and sanitation workers in Bangladesh during the COVID-19 pandemic**

## Authors

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## Highlights

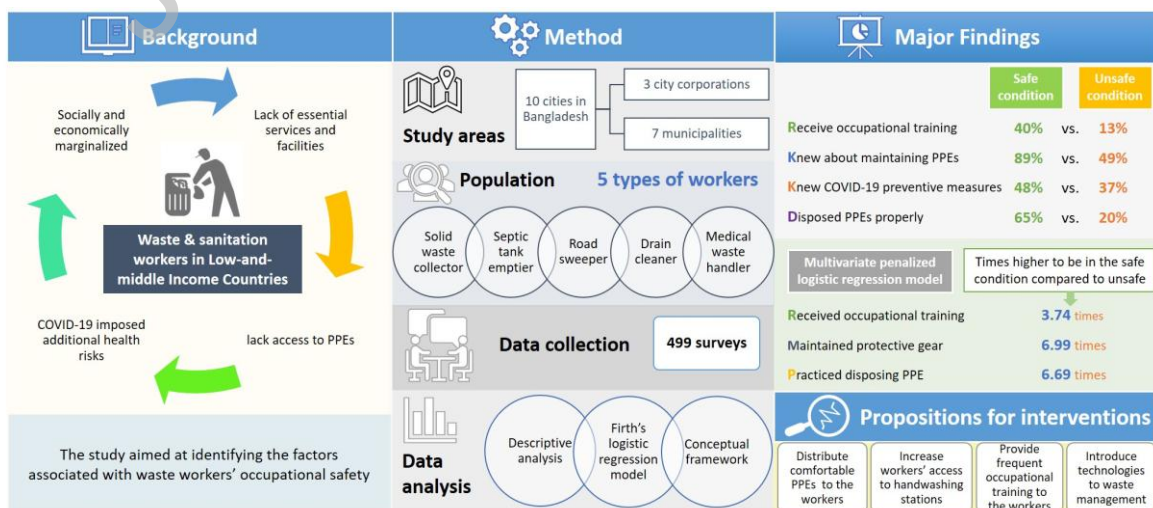
- Most waste and sanitation workers do not have a clear understanding of proper preventive measures, and necessary protective equipment is not adequately provided to them.
- Waste and sanitation workers who received occupational training, maintained wearing protective gear, and practiced disposing of PPE were more occupationally safe
- Ethnicity and accommodation facilities have a significant impact on the workers' health-safety conditions.
- To improve condition, provide functional facilities necessary to practice personal hygiene and occupational safety such as handwashing stations, changing rooms, and disposal facilities of used PPEs at the workplace
- Introduce national institutional programs to increase awareness, training on proper use and disposal procedures for PPE, health and safety monitoring committees, committees to oversee PPE supply, quality, and disposal to ensure the sustainability of the initiatives required

## **Abstract**

Waste and sanitation workers provide essential services to society. In most low-and middle-income countries, they are often mistreated and lack access to necessary personal protective equipment (PPE) and hygiene facilities that ensure occupational safety in workplaces. COVID-19 has also imposed serious health risks upon these worker groups. This study explores factors associated with poor occupational health and safety based on a conceptual framework. We conducted 499 surveys with five categories of waste and sanitation workers across ten cities in Bangladesh. We performed descriptive analysis and used Firth's logistic regression model following the conceptual framework. The analysis revealed consistent distinctions between workers considered to be in "safe" versus "unsafe" working conditions. The result showed that workers had not been adequately trained, not provided with proper equipment, and many had an informal status that prevented access to hygiene facilities. The workers who received occupational training, knew

how to prevent COVID-19 by wearing a face mask, hand washing, and maintaining social distance, maintained protective measures, and practiced proper disposing of PPEs were more likely to be in safe condition. Initiatives to improve the situation of the waste workers who work in unsafe work conditions are still inadequate. Therefore, we recommend supplying proper protective equipment, ensuring a regular supply of gender-specific PPEs, and providing functional facilities necessary to practice personal hygiene and occupational safety, such as handwashing stations, changing rooms, and disposal facilities of used PPEs at the workplace. We also urge increased institutional management procedures, infrastructure that facilitates hygiene practices, and social policies to reduce occupational hazards for the waste workers in Bangladesh during and beyond the COVID-19 pandemic.

## Graphical abstract



**Keywords**

Waste and sanitation workers; health risks; occupational safety; protective measures; hygiene practice; COVID-19

Journal Pre-proof

**1. Introduction**

Waste and sanitation workers – those involved in cleaning and managing human and solid waste – are some of the most vulnerable workers in low and middle-income countries like Bangladesh. They are often ignored, ostracised and their work undervalued [1]. These worker groups are likely to be extremely poor and marginalised members of society who take on risky work. In some high-income countries, waste and sanitation workers receive health benefits, pensions, and explicit

legal protections [2, 3]. Similar to most South-Asian countries, waste and sanitation workers in Bangladesh face severe inequalities and distressing experience and various socio-cultural barriers, often due to caste stigma and discrimination [1, 4] as most of them are from *Harijan* or *Dalit* castes of the Hindu religious group. There are few examples of good practices in this sector, but a growing number of actors are working to improve the work conditions and rights of waste and sanitation workers. However, efforts are fragmented, and the underlying factors responsible for weak occupational safety need to be identified and addressed more systematically to mitigate the existing hazards.

Sanitation workers mainly engage in cleaning latrines and emptying septic tanks or may take on multiple similar jobs [4]. In Bangladesh, waste and sanitation workers commonly have limited access to various essential services, and the evidence of social and economic marginalisation is perceptible in their living and working conditions [4, 5]. They are also exposed to various occupational hazards [6]. A study in Khulna, Kushtia, and Jhenaidah cities in Bangladesh showed that over 90% of septic tanks and pits were being emptied manually without any protective measures taken [7, 8] which is also prevalent among street or drain-cleaners [9]. They are often exposed to various risks such as exhaust gases, extreme noise, poisonous/toxic substances, sharp objects and dust particles, increasing the risk of infections and injuries [9, 10]. Waste and sanitation workers are also more prone to chronic hypertension, heart disease, respiratory disorders, kidney disease, and liver issues [11]. Moreover, pit-emptiers and other waste workers have neither health insurance nor compensation for the days lost due to illness or any occupational accidents [1].

During the COVID-19 pandemic in Bangladesh, most waste workers and their families experienced COVID-19-related symptoms [12]. The outbreak has imposed serious health risks upon the waste workers and increased the risk of losing alternate income opportunities due to movement restrictions [11, 13]. Since waste workers collect solid waste from residential areas, roads, hospitals, and other institutions, they are highly vulnerable to economic shocks from COVID-19 infection

and spread [5]. Most waste and sanitation workers are deprived of any handwashing facilities or soaps and sanitisers at their workplace, essential for COVID-19 prevention [11, 14]. Spending money on handwashing agents is considered a luxury since the workers earn a low salary [5]. If they get infected with COVID-19, they usually seek treatment from nearby drug stores or administer self-treatment [15].

In Bangladesh, medical waste handlers are currently the most vulnerable [16, 17] since they are highly exposed to the increased infectious wastes generated in healthcare facilities during the pandemic [18]. Approximately 23% of medical waste cleaners in Bangladesh do not wash their hands after collecting medical waste, which is often dumped openly, directly exposing the workers [19]. Most waste workers lack sufficient knowledge of maintaining personal hygiene [20] and opportunities to practice hygiene at their workplace. Most waste workers in Bangladesh appointed for sweeping the streets are female and often do not have enough facilities to maintain personal hygiene at their workplace [5], including menstrual hygiene. On the other hand, personal protective equipment (PPE) is inadequate [21, 22], and ill-fitted for several body types [23]. Furthermore, most workers have never received any training on occupational health and safety issues [5, 20] or how to wear and dispose of PPE, which is essential for controlling the re-emergence of viral infection [24].

Currently, more research is being conducted towards understanding the challenges of these waste-related jobs [25]. However, little work has focused on the relationship between training and access to PPE materials, and occupational safety. Understanding infectious disease exposure, work-related injuries, and the vulnerability of waste workers is critical, especially in light of the pandemic. Underlying factors that contribute to poor occupational safety for the waste workers in Bangladesh must be explored. A well-developed conceptual framework can assist our understanding of the pattern of interconnections across knowledge and experiences. However, we found only a few conceptual frameworks available to understand occupational safety at the workplace [26, 27], and none were applicable to the present context of Bangladeshi waste and sanitation workers. Limited



knowledge exists about waste and sanitation work, especially in the context of COVID-19, and there are few studies that quantify the factors associated with occupational safety practices.

### *1.4 Study Objectives*

The objectives of the study were to: a) assess the working conditions of different waste worker groups in ten cities of Bangladesh during COVID-19; b) explore the level of waste worker's knowledge and practice for occupational safety, infectious disease prevention, and hygiene practice during work; and c) identify the factors associated with waste and sanitation workers' occupational safety.

## **2. Methodology**

### *2.1 Study Sites*

We conducted this study in ten cities of Bangladesh with two different local government structures: City Corporations and Municipalities. While both Municipalities and City Corporations are self-governing bodies, their autonomy is bounded by the fact that the government serves as the Municipality's prescribed authority and holds the authority to intervene in the activities of the City Corporations. Both governing bodies were included to capture the different socio-demographic backgrounds of the waste and sanitation workers. We included three City Corporations (Mymensingh City Corporation, Cumilla City Corporation, Rangpur City Corporation) and seven Municipalities (Satkhira Municipality, Sirajganj Municipality, Cox's Bazar Municipality, Moulvibazar Municipality, Bhola Municipality, Manikgonj Municipality, Laksam Municipality). Municipalities (locally known as "*Paurashava*") are the local governing bodies that deal with the state government directly, while the City Corporations deal with the state government through the district administration and often work with the national ministry.

### *2.2 Study Design, Sampling and Respondent Selection*

This cross-sectional study includes five categories of waste and sanitation workers: septic tank/pit-emptiers, solid waste collectors, drain cleaners, road sweepers, and medical waste handlers.

We estimated sample size by assuming 50% prevalence of the outcome of interest among the waste and sanitation workers, a 95% confidence level, and a 5% margin of error. After adjusting by 20% non-response rate, the estimated total sample size was 480. For the equal allocation of the workers among these ten selected cities, we conducted 499 surveys, with 50 from each city targeted. Participants were selected randomly from the list of workers available in the City Corporations and Municipalities offices. We used a snowball sampling procedure to select unlisted (some waste and sanitation workers were not on the list as the list was incomplete) workers of the City Corporations and Municipalities.

### *2.3 Data Collection*

Before the field-level data collection, we informed each Mayor about the study via official letters and sought permission for data collection in their administrative areas. After obtaining permission from each Mayor, we collected a list of the waste workers from each City Corporation/Municipality office. Afterwards, we communicated with those workers and chose study participants among them to collect primary data. Participation was completely voluntary, and participants had the right to refuse participation at any stage. Our field staff maintained social distancing and took mandatory protective measures during the data collection period, such as maintaining safety protocols, carrying handwashing agents, wearing face masks and gloves, and cleaning devices periodically.

We developed the questionnaire through an iterative process so that questions were culturally sensitive, context-oriented, and easy to understand. The research team was experienced in this research topic and we adopted a few questions from the team's previous studies. We went through an intensive literature review to determine the appropriate variables needed to examine and arranged several brainstorming

sessions to finalise the questions. We made multiple modifications to the questionnaire after pilot testing, and during enumerator training sessions. To ensure that the data collectors understood the questionnaire, we arranged an intensive 5-days long training session for the enumerators before primary data collection. We recruited data collectors from the respective study locations so that they could communicate in the local language, accent, and culturally approved gestures.

The duration of this study was three months, from September to November 2020. Throughout this assessment, we conducted face-to-face surveys with the waste workers to explore their present conditions, knowledge, practices, and attitude towards occupational safety and infectious diseases. Face-to-face interviews were preferred to help assess the emotions, behaviour, and non-verbal cues of the respondents [28]. We designed a close-ended questionnaire that was easy to respond to, code, and analyse [29].

#### *2.4 Conceptual Framework*

We generated a conceptual framework to identify the factors associated with the occupational safety of waste and sanitation workers at their workplace considering our study objectives, current evidence and literature [4, 6, 10, 18, 23, 24, 33, [30]. The framework was used to specify *a priori* potential relationships between variables of interest to inform our analytical approach. The framework was beneficial to understand and explore the gaps in occupational health and safety of waste and sanitation workers.

#### *2.5 Measures*

##### *Outcome variables*

We constructed the outcome 'occupational safety' considering five indicators: have necessary safety equipment according to job type<sup>1</sup> (i. e for septic tank/pit emptier, required safety equipment is a face mask, apron, gloves, gumboot), received occupational safety guidelines from recruiters, received training on PPE use, cleaned working equipment with cleaning products, and have any form of PPE. Workers who responded positively to all of the above indicators were categorised as "safe," and others were "unsafe" as negative responses to any of the indicators represent a risk.

### *Independent variables*

We explored the socio-demographic characteristics of the waste and sanitation workers to assess the relationship with their occupational safety at the workplace. We assessed waste and sanitation workers' 'knowledge' by six binary variables and 'practices' by six variables. The items under each of these variables were merged together to create two new binary variables by considering only items with higher frequencies. We considered waste and sanitation workers' 'attitudes' towards the use of safety equipment by a binary variable – 'feeling problem with PPE', and a Likert scale variable - 'the level of satisfaction with the quality of PPE'.

International Labour Organizations (ILO) defines "decent work involves opportunities for work that are productive and deliver a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organise and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men" [31]. As such, we considered 'job facilities' here by three binary variables (i.e having incentives, receiving payment regularly, and having treatment facilities from the recruitment agencies) and one categorical variable (i.e type of accommodation facilities).

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<sup>1</sup> <https://itn.buet.ac.bd/web/resources/training-manual-on-sanitation-and-waste-workers-occupational-health-and-safety-ohs-and-infection-prevention-and-control-ipc/>

We considered the socio-economic conditions of sanitation and waste workers as a factor in the conceptual framework. This dimension focuses on the social and economic status depending on their caste, ethnicity, accommodation types, and individual income as exposure to their occupational safety measures.

## *2.6 Statistical Analysis*

We collected our quantitative data by tablets using the KoBoCollect App. We conducted an exploratory analysis to present the frequency distribution of the socio-demographic variables of the waste and sanitation workers by their working station. Afterwards, we performed bivariate analysis to measure the association between workers' different socio-demographic factors, and each of the variables within the knowledge, practice, attitudes, and job facilities with their occupational safety. We conducted a Chi-square test to estimate the prevalence difference for workers' occupational safety for the interested independent variables considered in our conceptual model. We used this association to identify the relevant variables with a  $p < 0.25$  in our final model. We then fitted a binary logistic regression model separately among the variables within each block 'knowledge', 'practice,' 'attitude' and 'socio-economic condition' considering all the significant variables retained from the bivariate analysis and considering other essential variables in our conceptual model to estimate the crude odds ratio (OR) and 95% confidence interval. Then we built an adjusted multivariate logistic regression model for each of the blocks separately considering those variables from the unadjusted model which were significant at the  $p < 0.5$  level. Further, we adjusted the internal causal relationship captured among the knowledge, practice, attitude and socio-economic condition factors in our conceptual framework. We considered socio-demographic characteristics as confounders in our final adjusted model. Finally, we only considered those variables which have a statistically significant association with the outcome of interest at a  $p$ -value of  $< 0.05$  threshold. We performed all analyses using the statistical software Stata version 14.

## *2.7 Ethical Approval*

The Ethics Review Panel of the International Training Network Centre (ITN-BUET) approved this study. Enumerators read out an information sheet to the respondents in the local language and answered any questions/confusions if raised, and obtained written informed consent from the respondents for participation in the study. Respondents were given a copy of the information sheet with the contact numbers of the study lead. We also took consent from the respondents before capturing any field photos with them.

## **3. Results**

### *3.1 Respondents and the demographics*

We found that more than half of the waste workers were appointed as "Muster Roll" employees, whereas 31% were listed as "Non-Muster Roll." The Muster roll engagement is a semi-formal contractual service where the workers are hired for temporary services usually under a project for a certain period. Locally it is also known as 'no work no pay' job type. Though these employees often have a chance of being hired as permanent staff or extension of their present contract; except for overtime, they usually do not get any other regular job facilities (e.g., medical, insurance, accommodation, provident fund) that the permanent ("Non-Muster Roll") employees can. We also found that 16% of workers were unlisted (informal daily laborers). The waste workers usually received salaries based on the total number of days they worked in a month. Only the septic tank cleaners reported receiving assignments via direct calls from city authorities and individual citizens.

Around 81% of the respondents were male, and waste workers were split equally between Muslims and Hindus. Females were most likely to be road sweepers, comprising about half of the total, followed by approximately 17% being medical waste handlers. On the other hand, septic tank/pit emptiers were over 98% male, followed by drain

cleaners (97%) and solid waste collectors (92%). In Mymensingh and Rangpur City Corporation and Laksham Municipality, more than 70% of the waste workers belonged to the Hindu religion, most of whom were from *Harijan (low-caste Hindu)* caste. Most respondents were *Bengali* (60%) and aged between 25-40 years. Around 45% of the workers had attained education levels within grades 1-8, whereas 48% had received no institutional education or could only sign their names.

More than half of the workers lived in either their own homes or rented accommodations. Waste workers working in City Corporations received more government-provided accommodation facilities (60%) than those of municipalities (34%). Salaries of these different types of waste workers vary with their work type and working hours. Nearly half of the total waste workers earned a salary within the range of 5000-10,000 BDT (US\$ 59 – 118). However, NGO-appointed workers received a higher payment than those appointed by the City Corporations or municipalities. A septic tank cleaner earned 1000-1500 BDT (US\$ 12 – 18) from private clients per contact, whereas the street cleaners earned 2500-3500 BDT (US\$ 30 – 42) per month. Medical waste handlers/solid waste collectors appointed by NGOs earned 6000-16,000 BDT (US\$ 71 – 189). We recorded the average monthly income of all respondents at 8362 BDT (US\$ 99) (Table 1).

### *3.2 Relationship between socio-demographic characteristics with occupational safety at the workplace*

We explored the association between characteristics of the waste workers' occupational safety at their workplace (Table 2). We found no statistically significant relationship between socio-demographic characteristics such as gender, age, education or caste of the waste workers with occupational safety.

There was a significant relationship between the ethnicity and occupational safety of the workers. Among the total waste workers who worked in an unsafe workplace, around 42% of the waste workers belong to the *Harijan* ethnicity. Accommodation conditions were also

observed to have a statistically significant relationship with occupational safety- those who lived in government facilities were less likely to be in a safe category (33% vs 44%; P-value<0.05). Furthermore, those who earned over 10,000 BDT (US\$ 118) were around twice as likely to be in the safe workplace category compared to those who earned less than that.

### *3.3 Knowledge about occupational safety and COVID-19*

Waste workers who received occupational training were more likely to be considered safe (40% vs 13%; Prevalence Difference (PD): 33) (Table 3). Similarly, workers who knew about maintaining their protective gears were in safe working conditions (89% vs 49%; PD: 31). Knowledge about the spread of COVID-19 varied widely across waste workers, though it did not appear to differ substantially between the safe and unsafe group. Among these, coughing (86% safe; 83% unsafe) and sneezing (73% safe; 71% unsafe) were regarded as the prime reasons for the spread of COVID-19, followed by a social gathering (56% safe; 51% unsafe) which is more commonly known among the workers. Regarding knowledge about the prevention of COVID-19, the participants under the safe category reported wearing face masks (97%), maintaining social distance (73%) and handwashing (70%) as the prime reasons. Knowledge about the meaning of social distance also varied among the workers. Over 81% of the safe category of workers knew the meaning of social distancing as maintaining a 3-6 feet distance vs 58% in the unsafe category. Also, around 70% of workers from both the safe and unsafe workplace categories did not know how long to quarantine. On average, 85% of workers from both categories did not know how to isolate.



### *3.4 Current practices and attitudes regarding PPE, COVID-19 and maintaining occupational safety*

Almost all the workers expressed that they had government guidelines to maintain personal hygiene in the working area. Supervisors instructed the workers to follow the guidelines. However, all the workers did not follow proper hygiene protocols. They mostly argued that the nature of their work did not provide the opportunity to maintain hygiene. Another reason is that they were not provided with proper protective equipment, which often led to various occupational injuries and diseases among them. The practices include maintaining occupational safety guidelines while working, currently using PPE at their workplace, cleaning vehicles while wearing PPEs and disposing of PPEs by burning or throwing them in respected bins show a significant association with their occupational safety. Most workers reported using PPEs (92% from the safe category; 90% from the unsafe category). After returning home, over 93% from both the safe and unsafe category of workers reported taking a bath with soap. Other standard practices such as washing hands before meals (54% and 33%) and washing clothes (64% and 52%) happened less often.

Over half (54%) of the workers from the safe workplace category reported problems with PPE use, such as a feeling of discomfort which included breathing problems, sweltering problems, and improper fitting. However, over 50% of the total workers reported they were moderately satisfied with the quality of the PPE. None of the workers from the city corporation expressed strong dissatisfaction with PPE quality. However, approximately 99% of the workers from the unsafe category and 90% from the safe category reported that they did not have decent job facilities (Table 3).

### *3.5 Worker's occupational safety*

All variables within the knowledge block in the adjusted multivariate model were significantly associated with the workers' occupational safety (Table 4). Workers' practices of maintaining safety

guidelines at their workplace, current practices of using PPE while working, and practices of disposing of PPE after use were associated with having an occupationally safe working environment. Workers' attitudes towards the PPE and their types of ethnicity were found to be strongly associated with their occupational safety.

After adjusting the models in the conceptual framework, the estimates revealed that workers who received the occupational training had nearly four times higher odds (AOR= 3.77, 95% CI= 2.18-6.52) of being occupationally safe. Those who maintained protective gear were nearly nine times more likely (AOR= 8.70, 95% CI= 4.55-16.65) to have an occupationally safe environment than those who did not. Moreover, workers' occupational safety was less common among the workers who knew about communicable diseases (AOR= 0.49, 95% CI= 0.29-0.94), as well as those who wear face masks while handling waste (AOR= 0.57, 95% CI= 0.35-0.94). Workers who followed safety guidelines (AOR= 13.11, 95% CI= 6.31-27.24), wore PPE at their workplace (AOR= 10.93, 95% CI= 4.38-27.23), and disposing of PPE safely (AOR= 3.20, 95% CI= 1.59-6.44) were more likely to have the occupational safety as compared to the workers without such practices. Workers who felt some problems with their PPE had 3.5 times higher odds (AOR= 3.51, 95% CI= 2.08-5.90) of being occupationally safe at their workplace than workers who did not perceive such attitudes. Most importantly, occupational safety was more commonly associated with the workers having decent job facilities (AOR= 7.09, 95% CI= 2.17-23.09). Workers with decent job facilities were 7.09 times more likely to be exposed to a safe occupational workplace than those without. Workers from the Bengali ethnic group had nearly three times higher odds (AOR= 2.71, 95% CI= 1.06-6.94) of being in a safe occupational environment than workers from the Harijan ethnicity.

#### **4. Discussion**

The study found a strong association between waste workers' limited safety knowledge, their attitudes, hygiene practices in the

workplace, socio-demographic characteristics, and lack of job facilities with poor occupational safety. Waste workers commonly face various occupational injuries, diseases, and even deaths because they are not provided with the necessary safety measures and knowledge. In Bangladesh, from March 2020, the COVID-19 pandemic has added additional health risks to their work, which was presented in this study.

Waste workers' knowledge was identified as one of the key factors responsible for occupational safety status. We observed that only a few workers participated in any occupational training arranged by their recruiters. Similarly, a severe lack of occupational safety compliances and training for different waste workers was identified by several previous studies [32-37]. Studies also found that only 3-5% of the waste workers received institutional training in Bangladesh [5, 20]. A recent study in Bangladesh showed that 95% of the medical waste workers had experienced occupational accidents and 73% never participated in any occupational training [33]. They require a high standard of occupational training or PPE demonstration to achieve a good level of knowledge and skills towards occupational safety measures. Workers who knew how to wear and maintain protective gear and had a positive attitude toward the quality of PPE, had a better occupational safety status. However, only a few workers chose to wear PPE regularly, which indicated that the waste workers were not provided with adequate knowledge about the importance of using PPE in preventing infections. Workers' perception of various problems (fitting issues, suffocation, heat & sweat) with their PPE were associated with their occupational safety. Therefore, distributing PPEs only is not sufficient. Instead, improving knowledge and attitudes towards PPEs through training is crucial for enhancing occupational safety.

Workers who lacked the basic understanding of COVID-19 preventive measures had less occupational safety. We noted that the workers who had knowledge regarding basic hygiene practices and necessary PPE use during work increased their occupational safety at their workplace. A recent nationwide study in Bangladesh also supports this finding by concluding that regions that have people with better knowledge about COVID-19 exhibited higher rates of COVID-19

preventive behaviours [38]. This further implies that providing basic knowledge to the waste workers may increase safety in their occupation as they are directly exposed and are susceptible to infection. Providing knowledge to individuals is essential because it can motivate others to prevent spreading the virus in a community, including their family members [39]. We also found that the nature of the jobs and accommodation facilities of the waste workers often render them unable to maintain adequate distancing since they did not know whether anyone infected with COVID-19 was near them. Similar results were reported by recent assessments [40][5] .

Another significant finding from the study was that waste workers' workplaces in Bangladesh were indeed not decent, which was one of the key factors contributing to the occupational safety status. This study affirmed that all categories of waste workers manually handled various raw and harmful wastes, including biomedical wastes that severely threatened their health. A recent study in South Asian regions also indicated such health threats [41]. Study recommended the disposal of used PPEs and the separation of domestic waste from plastic-based hospital waste, suggesting that mixing these wastes raises the risk of disease transmission to waste workers [24]. Even we did not find any sterilisation system or separation of biomedical wastes exists for these worker groups. In this context, Sharma and colleagues previously indicated the urgency of these practical measures for the workers who manage solid wastes to reduce the risk of spreading the infection among them [42]. Moreover, a recent study across different municipalities of Bangladesh found that more than 80% of these worker groups were suffering from psychological distress [43].

Our study identified that workers' attitudes and scope of hygiene practices were connected with poor occupational safety status. Such connections accelerate many negative consequences like the spread of infection among them through contaminated PPEs. An exploratory study in Bangladesh supports our findings, showing that only 19% of the study participants burned PPE-related waste, while most reported using less protective disposal measures [44]. On the other hand, it is estimated that nearly 40,000 workers in Bangladesh who informally collect wastes

from households, clinics or hospitals are at a high risk of being infected by the COVID-19 virus if proper protection and disposal methods are not followed. But, it was evident that we lack proper management of the increased medical waste generated daily due to COVID-19, despite adopting the Medical Waste Regulation (Management and Processing) in 2008 [45]. A recent study also reported improper application of even newer policies and guidelines [46]. While in other countries like China, local waste management agencies arranged mobile incinerators for disposing of the atypical quantities of contaminated PPEs during the peak of the outbreak [47]. Therefore, our analysis marked a lack of necessary policies responsible for this condition. So, through this study, we want to emphasise the urgency to modify these policies that will initiate similar actions. Correspondingly, a few recent studies in Bangladesh [48] and other countries also suggested such actions could be, more resource allocation to tackle these infectious diseases [38], health promotion - mainly targeted toward COVID-19 prevention measures, and proper use and disposal of PPEs [49, 50].

Finally, we suggest key approaches to improve the occupational health and safety of waste and sanitation workers. A tailored and specifically designed intervention is needed to increase the workers' knowledge and attitude and create a culture of maintaining occupational health safety. Employers could also provide practical training that would be applicable and sustainable beyond the COVID-19 period. Training is crucial to create awareness about job-related health risks and how to mitigate them. In addition to using social and behavioural change communication (SBCC) messages designed for waste workers in the training, knowledge on the proper use of PPEs should be provided, and the importance of wearing PPEs should be emphasised. Several countries have followed these strategies to improve the health and safety of their waste workers [51]. Moreover, to ensure their access to a safe work environment, appropriate policy measures and their implications should be taken at the government level. Institutional guidelines are also required to report and monitor health behaviours at the workplace. Along with these, work benefits like payment, job security, healthcare insurance, overtime and compensation should be

improved. Lastly, it is crucial to prioritise sanitation workers in receiving vaccination to protect the safety of these frontline warriors against COVID-19 and other infectious diseases.

## **5. Limitations**

Through this study, we could not assess the rates of occupational deaths and underlying causes as Bangladesh lacks a systematic record of deaths and occupational injuries among sanitation and other waste workers. A national survey would be helpful to identify waste worker groups from various regions that are most vulnerable and the reasons for that vulnerability. In addition, despite focusing on the waste workers' physical injuries and health risks, we could not conceptualise and assess the factors impacting their mental health within the scope of this study. To ensure a decent workplace for these worker groups, the impact on their mental health is also a vital issue.

We have selected field sites purposively, so our sample might not be representative to the entire waste and sanitation worker population. However, we have selected field sites from across the country, so we have sufficiently captured variation among waste and sanitation workers in terms of socio-economic conditions, job types and facilities in our sample population.

As this was a cross-sectional study, it was not possible to directly establish causal relationships between framework variables, but clear associations noted here should provide strong hypotheses for subsequent experimental testing.

## **6. Conclusion**

Sanitation and waste workers provide essential services for cities, and so protective measures must be ensured while they work in hazardous environments that cause various injuries and diseases in addition to increased likelihood contracting COVID-19. Most sanitation and waste

worker do not have a clear understanding of proper preventive measures, and necessary protective equipment is not adequately provided to them. Infrastructural facilities are also inadequate to support preventive measures.

## **7. Recommendations**

We recommend the following measures to improve the work conditions of sanitation and waste workers:

- Provide proper protective equipment to waste workers and encouraging them to use them during work
- Ensure a regular supply of gender-specific PPEs (in terms of suitability, fitness, work type, and weather-specific comfortable materials) from the recruiting authorities
- Provide functional facilities necessary to practice personal hygiene and occupational safety such as handwashing stations, changing rooms, and disposal facilities of used PPEs at the workplace
- Introduce national institutional programs to increase awareness, training on proper use and disposal procedures for PPE, health and safety monitoring committees, committees to oversee PPE supply, quality, and disposal to ensure the sustainability of the initiatives mentioned above
- Introduce national policies to increase the salaries and benefit packages of waste workers and enable their transition to more secure and dignified jobs and work conditions.

## **Author Contributions**

MA, FS, together with TA developed the first draft of the manuscript. MZ, JBT, MR, MF, MAR, AA, DMS, SF, MH, KFT, TA critically reviewed the research design, data collection tools, and the manuscript.

DMS, SF, FS, MA, MH supervised the data collection activity. DMS, FS, MH, KFT cleaned and analysed data. MH, SF, MR was involved in data analysis and provided intellectual input. All authors provided scientific inputs and critically reviewed the manuscript. The entire study was conducted under the supervision of TA.

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## **Conflicts of interest**

The authors declare no conflicts of interest.



## References

1. World Bank, et al., *Health, Safety and Dignity of Sanitation Workers : An Initial Assessment*. 2019, World Bank: Washington, DC.
2. Maoua, M. and H. Rouis, *Occupational Rhinitis and Asthma in the Textile Sector of the Central Region of Tunisia*. *International Journal of Respiratory and Pulmonary Medicine*. International Journal of Respiratory and Pulmonary Medicine, 2018. **5**.
3. An, H., et al., *Occupational health and safety amongst municipal solid waste workers in Florida*. *Waste Management Research*, 1999. **17**(5): p. 369-377.
4. Kabir, A., et al., *Qualitative exploration of sociocultural determinants of health inequities of Dalit population in Dhaka City, Bangladesh*. *BMJ Open*, 2018. **8**(12): p. e022906.
5. WaterAid, *Risk and Vulnerability of sanitation and waste workers during Covid-19 pandemic in five major cities of Bangladesh*. 2020.
6. CWAS, CRDF, and C. University, *Improving Safety of Sanitation Workers in Wai Municipal Council* 2020.
7. Ganguly, P., *Lives Left Behind Deserve Dignity*, in *Daily Sun*. 2018.
8. Karim, A., *CITY CLEANERS Stories of those left behind*. 2017, SNV Netherlands Development Organisation: SNV.
9. Kabir, A., et al., *Sweeping practices, perceptions and knowledge about occupational safety and health hazards of street sweepers in Dhaka city, Bangladesh: a qualitative inquiry*. *Int J Community Med Public Health*, 2015. **2**(3): p. 237-243.
10. Khurana, I., T. Ojha, and B. Singh, *Burden of inheritance: Can we stop manual scavenging? Yes, but first we need to accept it exists*. 2009: New Delhi, India.

11. Practical Action, *Study on Immediate impact of coronavirus on waste workers in 10 city corporation/municipalities in Bangladesh*. 2020, Monitoring Evaluation Learning and Research Unit.
12. Hoque, S.N. *Hardship of Waste Workers in Bangladesh during Coronavirus Pandemic Revealed*. 2020; Available from: <https://practicalaction.org/news-media/2020/08/25/hardship-of-waste-workers-in-bangladesh-during-coronavirus-pandemic-revealed/>.
13. WaterAid, *Safety and wellbeing of sanitation workers during COVID-19 in South Asia*.
14. Root, R. *Sanitation workers left exposed to COVID-19*. 2020 03 September 2020; Available from: <https://www.devex.com/news/sanitation-workers-left-exposed-to-covid-19-97985>.
15. Habib, W.B. and M.A. Sujan, *Probable Vaccine Recipients: Frontliners to be first in line*, in *The Daily Star*. 2020.
16. Ali, M., et al., *Hospital waste management in developing countries: A mini review*. 2017. **35**(6): p. 581-592.
17. Behnam, B., et al., *Inadequacies in Hospital Waste and Sewerage Management in Chattogram, Bangladesh: Exploring Environmental and Occupational Health Hazards*. 2020. **12**(21): p. 9077.
18. Tsukiji, M., et al., *Waste Management during the COVID-19 Pandemic From Response to Recovery*. 2020, International Environmental Technology Centre (IETC): United Nations Environment Programme, IGES Center.
19. Syed, E.H., M. Mutahara, and M. Rahman, *Medical Waste Management (MWM) in Dhaka, Bangladesh: It's a Review*. 2012. **24**(3): p. 140-145.
20. Zaqout, M., et al., *Sustainable sanitation jobs: prospects for enhancing the livelihoods of pit-emptiers in Bangladesh*. *Third World Quarterly*, 2021. **42**(2): p. 329-347.

21. WaterAid, *Rapid Assessment of Measures on Safety of Sanitation and Waste Workers during Covid-19 in Pakistan: A Qualitative Study Report*. 2020: APEX Consulting Islamabad, Pakistan.
22. Dubey, S., et al., *Psychosocial impact of COVID-19*. Diabetes & metabolic syndrome, 2020. **14**(5): p. 779-788.
23. Sakamoto, M., S. Begum, and T. Ahmed, *Vulnerabilities to COVID-19 in Bangladesh and a Reconsideration of Sustainable Development Goals*. 2020. **12**(13): p. 5296.
24. Ma, Y., et al., *Suggested guidelines for emergency treatment of medical waste during COVID-19: Chinese experience*. Waste Disposal & Sustainable Energy, 2020. **2**(2): p. 81-84.
25. Gutberlet, J., *Waste in the City: Challenges and opportunities for Urban Agglomerations*. Urban Agglomeration, 2018: p. 191.
26. Israel, B.A., et al., *Occupational stress, safety, and health: Conceptual framework and principles for effective prevention interventions*. Journal of Occupational Health Psychology, 1996. **1**(3): p. 261-286.
27. Makin, A.M. and C. Winder, *A new conceptual framework to improve the application of occupational health and safety management systems*. Safety Science, 2008. **46**: p. 935-948.
28. Lavrakas, P.J., *Encyclopedia of Survey Research Methods*, P.J. Lavrakas, Editor. 2008, SAGE Publications, Inc: Thousand Oaks, California.
29. Tashakkori, A. and C. Teddlie, *Sage handbook of mixed methods in social and behavioral research*. 2010: SAGE publications.
30. Sorensen, G., et al., *The future of research on work, safety, health and wellbeing: A guiding conceptual framework*. Social Science & Medicine, 2021. **269**: p. 113593.
31. International Labour Organization. *Decent work*. 2015; Available from: <https://www.ilo.org/global/topics/decent-work/lang-en/index.htm>.

32. Patwary, M.M., et al., *Protecting Sanitation Workers in Low-Middle Income Countries Amid COVID-19*. *Ann Work Expo Health*, 2021. **65**(4): p. 492-493.
33. Patwary, M.A., W.T. O'Hare, and M.H. Sarker, *Occupational accident: An example of fatalistic beliefs among medical waste workers in Bangladesh*. *Safety Science*, 2012. **50**(1): p. 76-82.
34. Akram, O., *384 Occupational health and safety in Bangladesh: an important cause and consequence of extreme poverty*. 2016, BMJ Publishing Group Ltd.
35. Sarker, M.A., et al., *Evaluation of knowledge, practices, and possible barriers among healthcare providers regarding medical waste management in Dhaka, Bangladesh*. *Med Sci Monit*, 2014. **20**: p. 2590-7.
36. Uddin, S.M.N., et al., *Experiencing the Everyday of Waste Pickers: A Sustainable Livelihoods and Health Assessment in Dhaka City, Bangladesh*. 2020. **32**(6): p. 833-853.
37. Akter, K.S. and S.M.S. Reza, *Awareness on medical waste management and occupational health safety among the employees related to medical services at Upazila level in Bangladesh*. *Journal of Environmental Treatment Techniques*, 2019. **7**(3): p. 282-288.
38. Hosen, I., et al., *Knowledge and preventive behaviors regarding COVID-19 in Bangladesh: A nationwide distribution*. *PLOS ONE*, 2021. **16**(5): p. e0251151.
39. Coroiu, A., et al., *Barriers and facilitators of adherence to social distancing recommendations during COVID-19 among a large international sample of adults*. *PLOS ONE*, 2020. **15**(10): p. e0239795.
40. Paul, K. and P. Bhattacharjee, *Livelihood Status and Health Condition of Waste Pickers in Sylhet City Corporation: A Study*. *Space and Culture, India*, 2022. **9**(4): p. 16-27.

41. Islam, A., et al., *Escalating SARS-CoV-2 circulation in environment and tracking waste management in South Asia*. Environmental Science and Pollution Research, 2021. **28**(44): p. 61951-61968.
42. Sharma, H.B., et al., *Challenges, opportunities, and innovations for effective solid waste management during and post COVID-19 pandemic*. Resources, Conservation and Recycling, 2020. **162**: p. 105052.
43. Haque, M.R., et al., *Mental health status of informal waste workers during the COVID-19 pandemic in Bangladesh*. PLOS ONE, 2022. **17**(1): p. e0262141.
44. Islam, S.M.D.-U., et al., *Perception and Attitudes Toward PPE-Related Waste Disposal Amid COVID-19 in Bangladesh: An Exploratory Study*. 2020. **8**(699).
45. Rahman, M.M., et al., *Biomedical waste amid COVID-19: perspectives from Bangladesh*. The Lancet. Global health, 2020. **8**(10): p. e1262-e1262.
46. Barua, U. and D. Hossain, *A review of the medical waste management system at Covid-19 situation in Bangladesh*. Journal of Material Cycles and Waste Management, 2021. **23**(6): p. 2087-2100.
47. Singh, N., Y. Tang, and O.A. Ogunseitan, *Environmentally Sustainable Management of Used Personal Protective Equipment*. Environmental Science & Technology, 2020. **54**(14): p. 8500-8502.
48. Uddin, S.M.N., et al., *Experiencing the everyday of waste pickers: A sustainable livelihoods and health assessment in Dhaka city, Bangladesh*. Journal of International Development, 2020. **32**(6): p. 833-853.
49. Zhong, B.-L., et al., *Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey*. International journal of biological sciences, 2020. **16**(10): p. 1745.

50. Byanaku, A. and M. Ibrahim, *Knowledge, attitudes, and practices (KAP) towards COVID-19: A quick online cross-sectional survey among tanzanian residents. medRxiv-Infectious Diseases Pub Date 01.05. 2020.*
51. Kawakami, T. and T.T. Khai, *WARM: Work Adjustment for Recycling and Managing Waste.* 2010, International Labour Organization.

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**Table 1: Socio-demographic characteristics of waste and sanitation workers**

<b>Variable</b>	<b>City corporation N=153 n (%)</b>	<b>Municipality N=346 n (%)</b>	<b>Total N=499 n (%)</b>
<b>Gender</b>			
Male	127 (83)	276 (80)	403 (81)
Female	26 (17)	70 (20)	96 (19)
<b>Age (years)</b>			
< 25	42 (27)	55 (16)	97 (19)
25 – 40	85 (56)	173 (50)	258 (52)
>40	26 (17)	118 (34)	144 (29)
<b>Age</b>			
Mean ( $\pm$ SD)	31.6 (10.5)	37.5 (12.9)	35.7 (12.5)
<b>Religion</b>			
Islam	61 (40)	189 (55)	250 (50)
Hinduism	92 (60)	156 (45)	248 (50)
Other	0 (0.0)	1 (0.3)	1 (0.2)
<b>Caste</b>			
	<b>N=92</b>	<b>N=154</b>	<b>N=246</b>
Shudras	0 (0.0)	14 (9.1)	14 (5.7)
Vaishyas	0 (0.0)	2 (1.3)	2 (0.8)
Kshatriyas	0 (0.0)	4 (2.6)	4 (1.6)
Brahmins	0 (0.0)	2 (1.3)	2 (0.8)
Bashfor	0 (0.0)	3 (2.0)	3 (1.2)
Das	0 (0.0)	4 (2.6)	4 (1.6)
Dhor	0 (0.0)	2 (1.3)	2 (0.8)
Harijan/ Dalit	92 (100)	114 (74)	206 (84)
Kaishto	0 (0.0)	9 (5.8)	9 (3.7)
<b>Education</b>			
No Formal education	19 (12)	62 (18)	81 (16)
Can sign only	51 (33)	107 (31)	158 (32)
1-8th class	71 (47)	155 (45)	226 (45)
Above 8th class	12 (8)	22 (6)	34 (7)
<b>Income</b>			
$\leq$ 5000 tk	56 (37)	76 (22)	132 (26)
5001-10000 tk	61 (40)	182 (53)	243 (49)
>10000 tk	36 (23)	88 (25)	124 (25)
<b>Monthly income</b>			
Mean ( $\pm$ SD)	8057 (5389)	8497 (5190)	8362 (5250)
<b>Ethnicity</b>			
Bengali	60 (39)	246 (71)	306 (61)
Harijan	93 (61)	100 (29)	193 (39)
<b>Accommodation</b>			
Government facilities	91 (60)	116 (34)	207 (41)
Own facilities	30 (20)	80 (23)	110 (22)
Rent	32 (21)	150 (43)	182 (36)
<b>Listed-non listed status</b>			

Listed (muster role)	85 (56)	181 (52)	266 (53)
Listed (non muster role)	25 (16)	128 (37)	153 (31)
Non listed	43 (28)	37 (11)	80 (16)

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**Table 2: Bi-variate relationship between socio-demographic and socio-economic variables with the occupational safety of workers at workplace**

Variables	Occupational safety						P-value
	City N=153	corporation	Municipalities N=346		Total N=499		
	Safe n (%)	Unsafe n (%)	Safe n (%)	Unsafe n (%)	Safe n (%)	Unsafe n (%)	
<b>Gender</b>							
Male	17 (85)	110 (83)	83 (78)	193 (80)	100 (79)	303(81)	0.646
Female	3 (15)	23 (17.29)	23 (22)	47 (20)	26 (21)	70 (19)	
<b>Age</b>							
< 25 yr	7 (35)	35 (26)	17 (16)	38 (16)	24 (19)	73 (19)	0.412
25 – 40 yr	10 (50)	75 (56)	61 (58)	112 (47)	71 (56)	187 (50)	
>40 yr	3 (15)	23 (18)	28 (26)	90 (37)	31 (25)	113 (30)	
<b>Education</b>							
No Formal education	2 (10)	17 (13)	20 (19)	42 (17)	22 (17)	59 (16)	0.065
Can sign only	5 (25)	46 (34)	23 (22)	84 (35)	28 (22)	130 (35)	
1-8th class	10 (50)	61 (46)	57 (54)	98 (41)	67 (53)	159 (42)	
Above 8th class	3 (15)	9 (7)	6 (5)	16 (7)	9 (8)	25 (7)	
<b>Caste</b>							
Harijan/ Dalit	8 (40)	84 (63)	36 (34)	78 (32)	44 (35)	162 (43)	0.093
Others	12 (60)	49 (37)	70 (66)	162 (68)	82 (65)	211 (57)	
<b>Ethnicity</b>							
Bengali	12 (60)	48 (36)	78 (74)	168 (70)	90 (71)	216 (58)	<b>0.007</b>
Harijan	8 (40)	85 (64)	28 (26)	72 (30)	36 (29)	157 (42)	
<b>Accommodation</b>							
Government facilities	7 (35)	84 (63)	35 (33)	81 (34)	42 (33)	165 (44)	<b>0.020</b>
Own facilities	7 (35)	23 (17)	18 (17)	62 (26)	25 (20)	85 (23)	
Rent	6 (30)	26 (20)	53 (50)	97 (40)	59 (47)	123 (33)	
<b>Income</b>							
<= 5000 tk	7 (35)	49 (37)	17 (16)	59 (25)	24 (19)	108 (29)	<b>0.001</b>
5001-10000 tk	4 (20)	57 (43)	52 (49)	130 (54)	56 (44)	187 (50)	
>10000 tk	9 (45)	27 (20)	37 (35)	51 (21)	46 (37)	78 (21)	

**Table 3: Association between workers knowledge, attitude, practice and other factors with their occupational safety at workplace**

Variables	Occupational safety						Prevalence Difference % (P-value)
	City corporation N=153		Municipalities N=346		Total N=499		
	Safe n (%)	Unsafe n (%)	Safe n (%)	Unsafe n (%)	Safe n (%)	Unsafe n (%)	
<b>Knowledge</b>							
<b>Received occupational training</b>							
Yes	10 (50)	11(8) 122 (92)	41 (39) 65 (61)	37 (15) 203 (85)	51 (40) 75 (60)	48 (13) 325 (87)	32.7 (0.00)
No	10 (50)						
<b>Knowledge of maintaining protective gears</b>							
Yes	17 (85)	57 (43) 76 (57)	95 (90) 11 (10)	124 (52) 116 (48)	112 (89) 14 (11)	181 (49) 192 (51)	31.4 (0.00)
No	3 (15)						
<b>Heard about communicable diseases</b>							
Yes	16 (80)	89 (67) 44 (33)	39 (37) 67 (63)	107 (45) 133 (55)	55 (44) 71 (56)	196 (53) 177 (47)	-6.7 (0.084)
No	4 (20)						
<b>Knowledge about wearing mask when handling waste</b>							
Yes	10 (50)	64 (48) 69 (52)	57 (54) 49 (46)	124 (52) 116 (48)	67 (53) 59 (47)	188 (50) 185 (50)	2.09 (0.59)
No	10 (50)						
<b>Knowledge about spreading COVID-19?</b>							
Coughing (yes)	18 (90)	104 (79) 20 (20)	75 (85) 10 (11)	195 (85) 34 (15)	93 (86) 15 (14)	299 (83) 51 (14)	
Sneezing (yes)	16 (80)	101 (77) 20 (20)	63 (71) 10 (11)	154 (67) 34 (15)	79 (73) 15 (14)	255 (71) 51 (14)	
Spittle (yes)	5 (25)	37 (28) 20 (20)	29 (33) 10 (11)	63 (28) 34 (15)	34 (31) 15 (14)	100 (28) 51 (14)	
Used utensils (yes)	5 (25)	17 (13) 20 (20)	10 (11) 10 (11)	34 (15) 34 (15)	15 (14) 15 (14)	51 (14) 51 (14)	
Social gathering (yes)	18 (90)	72 (55) 20 (20)	42 (48) 10 (11)	111 (49) 34 (15)	60 (55) 15 (14)	183 (51) 51 (14)	
Air (yes)	1 (5)	2 (1.5) 20 (20)	4 (4.6) 10 (11)	7 (3.1) 34 (15)	5 (4.6) 15 (14)	9 (2.5) 28 (7.8)	
Don't know (yes)	0 (0)	13 (9.9) 20 (20)	4 (4.6) 10 (11)	15 (6.6) 34 (15)	4 (3.7) 15 (14)	28 (7.8) 28 (7.8)	
Others	0 (0)	1 (0.8) 20 (20)	2 (2.3) 10 (11)	3 (1.32) 34 (15)	2 (1.9) 15 (14)	4 (1.1) 51 (14)	
<b>Knowledge of spreading COVID-19 by Coughing, Sneezing, Social gathering</b>							
Yes	14 (70)	58 (44) 75 (56)	30 (28) 76 (72)	78 (32) 162 (67)	44 (35) 82 (65)	136 (36) 237 (64)	-1.26 (0.756)
No	6 (30)						
<b>Knowledge about prevention of COVID-19?</b>							
Wearing face mask (yes)	18 (90)	119 (89) 20 (20)	104 (98) 10 (11)	222 (92) 34 (15)	122 (97) 15 (14)	341 (91) 51 (14)	

Face shield (yes)	4 (20)	6 (4.5)	5 (4.7)	5 (2.1)	9 (7.1)	11 (2.9)	
Using hand gloves (yes)	10 (50)	51 (38)	34 (32)	97 (40)	44 (35)	148 (40)	
Hand washing (yes)	16 (80)	106 (80)	72 (68)	156 (65)	88 (70)	262 (70)	
Not touching eye, nose, face (yes)	8 (40)	33 (25)	33 (31)	47 (19)	41 (32)	80 (21)	
Maintaining social distance (yes)	18 (90)	76 (57)	74 (70)	107 (44)	92 (73)	183 (49)	
Washing cloths (yes)	8 (40)	36 (27)	21 (20)	38 (16)	29 (23)	74 (20)	
Cleaning fruits and vegetables (yes)	1 (5)	7 (5.3)	3 (2.8)	21 (8.7)	4 (3.2)	28 (7.5)	
Using elbow while coughing or sneezing (yes)	6 (30)	25 (19)	4 (3.8)	16 (6.67)	10 (7.9)	41 (11)	
Cleaning toilets (yes)	1 (5)	9 (6.8)	2 (1.9)	10 (4.2)	3 (2.4)	19 (5.1)	
Washing shoes or other equipment (yes)	3 (15)	9 (6.8)	2 (1.9)	11 (4.6)	5 (3.9)	20 (5.4)	
Medicine (yes)	0 (0)	1 (0.8)	1 (0.9)	6 (2.5)	1 (0.8)	7 (1.9)	
Vaccination (yes)	0 (0)	1 (0.8)	0 (0)	1 (0.4)	0 (0)	2 (0.5)	
Cleanliness (yes)	0 (0)	2 (91)	2 (1.9)	16 (6.7)	2 (1.6)	18 (4.9)	
Don't know (yes)	1 (5)	7 (5.3)	0 (0)	10 (4.2)	1 (0.8)	17 (4.6)	
Other	1 (5)	1 (0.8)	1 (0.9)	10 (4.2)	2 (1.6)	11 (2.9)	
<b>Knowledge of preventing COVID-19 by Wearing face mask, Hand washing, Maintaining social distance</b>	14 (70)	64 (48) 69 (52)	47 (44) 59 (56)	75 (31) 165 (69)	61 (48) 65 (52)	139 (37) 234 (63)	8.7 (0.027)
Yes	6 (30)						
No							
<b>Knowledge about meaning of social-distancing?</b>	(N= 133)	20	(N= 240)	106	(N= 373)	126	
Avoiding handshake (yes)	5 (25)	38 (28)	17 (16)	30 (12)	22 (17)	68 (18)	
Avoiding crowded place (yes)	9 (45)	44 (33)	46 (43)	113 (47)	55 (44)	157 (42)	
Avoiding hugs (yes)	5 (25)	35 (26)	11 (10)	20 (8.3)	16 (13)	55 (15)	
Maintaining 3-6 ft distance (yes)	16 (80)	95 (71)	86 (81)	121 (50)	102 (81)	216 (58)	
Stay in Quarantine (yes)	2 (10)	5 (3.8)	2 (1.9)	10 (4.2)	4 (3.2)	15 (4.0)	
Don't know (yes)	4 (20)	27 (20)	8 (7.5)	66 (27)	12 (9.5)	93 (25)	
Other	0	0	0	3 (1.3)	0	3 (0.8)	
<b>Knowledge about meaning of social-distancing as avoiding crowded place, maintaining 3-6 ft distance</b>	8 (40) 12 (60)	33 (25) 100 (75)	34 (32) 72 (68)	65 (27) 175 (73)	42 (33) 84 (67)	98 (27) 275 (73)	6.6 (0.127)
Yes							
No							

<b>Have knowledge about quarantine?</b>	11	43 (32)	28 (26)	64 (27)	39 (31)	107	2.06
Yes	(55)	90 (68)	78 (74)	176	87 (69)	(29)	(0.629)
No	9 (45)			(73)		266	
						(71)	
<b>Have knowledge about isolation?</b>	4 (20)	21 (16)	16 (15)	29 (12)	20 (16)	50 (13)	
Yes	16	112	90 (85)	211	106	323	3.86
No	(80)	(84)		(88)	(84)	(87)	(0.49)
<b>Practice</b>							
<b>Maintain occupational safety guidelines while working?</b>	(N=15)		(N=96)		(N=111)		
	(N=19)		(N=37)		(N=56)		
Yes	12	16 (84)	53 (55)	24 (65)	65 (59)	40 (71)	-12.3
No	(80)	3 (16)	43 (45)	13 (35)	46 (41)	16 (29)	<b>(0.000)</b>
	3 (20)						
<b>Currently using PPE?</b>	(N=20)		(N=106)		(N=126)		
Yes	(N=38)		(N=118)		(N=156)		6.85
No	16	32 (84)	100	108	116	140	<b>(0.000)</b>
	(80)	6 (16)	(94)	(92)	(92)	(90)	
	4 (20)		6 (6)	10 (8)	10 (8)	16 (10)	
<b>Frequency of cleaning mask</b>	(N=11)	3)	(N=6)		(N=9)		
1 day	1 (33)	6 (54)	1 (17)	12 (43)	2 (22)	18 (46)	12.22
2 to 4 days	0	3 (27)	4 (67)	11 (39)	4 (44)	14 (36)	6.66
5 to 7 days	1 (33)	0	0	5 (18)	1 (11)	5 (13)	40 (0.249)
8 or more days	1 (34)	2 (18)	1 (16)	0	2 (22)	2 (5)	
<b>Wear PPEs while cleaning vehicle</b>	(N=20)		(N=99)		(N=119)		
Yes	(N=121)		(N=226)		(N=347)		
No	3 (15)	1 (0.8)	12 (12)	7 (3)	15 (13)	8 (2)	41.74
	17	120	87 (88)	219	104	339	<b>(0.000)</b>
	(85)	(99)		(97)	(87)	(98)	
<b>Practices during COVID-19 after returning home</b>	(N=20)		(N=106)		(N=126)		
Forbid family members to come close (yes)	(N=133)		(N=240)		(N=373)		
Wash hand first (yes)	7 (35)	44 (33)	32 (30)	52 (22)	39 (31)	96 (26)	
Wash cloths (yes)	13	70 (53)	55 (52)	54 (22)	68 (54)	124	
	(65)					(33)	
Taking bath with soap (yes)	15	76 (57)	66 (62)	119	81 (64)	195	
	(75.00)			(49)		(52)	
Do nothing (yes)	19	127	100	220	119	347	
Others	(95)	(95)	(94)	(92)	(94)	(93)	
	0	1 (0.8)	0	2 (0.8)	0	3 (0.8)	
	0	2 (1.5)	0	4 (1.7)	0	6 (1.6)	
<b>Practices during COVID-19 after returning home by making distance from family, washing hand, cloth, taking bath</b>	4 (20)	23 (17)	11 (10)	19 (8)	15 (12)	42 (11)	1.2
Yes	16	110	95 (90)	221	111	331	(0.844)
No	(80)	(83)		(92)	(88)	(89)	
<b>Disposal of PPE after use</b>	(N=20)		(N=106)		(N=126)		
Burn (yes)	(N=38)		(N=118)		(N=156)		
Throw away (yes)	2 (10)	1 (2.6)	15 (14)	16 (14)	17 (13)	17 (11)	
	15	23 (60)	45 (42)	61 (52)	60 (48)	84 (54)	
	(75)						

Throw in respected bin (yes)	3 (15)	11 (29)	68 (64)	53 (45)	71 (56)	64 (41)	
Can't remember (yes)	0	2 (5.3)	1 (0.9)	2 (1.7)	1 (0.8)	4 (2.6)	
Return to office (yes)	0	0	3 (2.8)	6 (5.1)	3 (2.4)	6 (3.9)	
Others	0	3 (7.9)	2 (1.9)	6 (5.1)	2 (1.6)	9 (5.8)	
<b>Practices of disposing PPE by burning, throwing in designated bin</b>	(N= 133)	(N= 20)	(N= 240)	(N= 106)	(N= 373)	(N= 126)	
Yes	5 (25)	12 (9)	77 (73)	63 (26)	82 (65)	75 (20)	39.36
No	15 (75)	121 (91)	29 (27)	177 (74)	44 (35)	298 (80)	<b>(0.001)</b>
<b>Attitude</b>							
<b>Perceived problems with PPE</b>	(N= 38)	(N= 20)	(N= 118)	(N= 106)	(N= 156)	(N= 126)	
Yes	4 (20)	10 (26)	64 (60)	64 (54)	68 (54)	74 (47)	6.45
No	16 (80)	28 (74)	42 (40)	54 (46)	58 (46)	82 (53)	(0.275)
<b>Satisfaction level with the quality of PPE</b>	(N= 38)	(N= 20)	(N= 118)	(N= 106)	(N= 156)	(N= 126)	
Very satisfied	3 (15)	9 (24)	28 (26)	21 (18)	31(25)	30 (19)	-15.85
Moderately satisfied	13 (65)	24 (63)	53 (50)	56 (47)	66(52)	80 (51)	(0.368)
Neutral	2 (10)	5 (13)	12 (11)	22 (19)	14(1)	27 (17)	
Dis-satisfied	2 (10)	0	9 (8)	17 (14)	11 (9)	17 (11)	
Very dissatisfied	0	0	4 (4)	2 (2)	4 (3)	2 (1)	
<b>Job facilities</b>							
Yes	3 (15)	0 (0)	9 (8.49)	4 (1.67)	12 (9.52)	4 (1.07)	51.4
No	17 (85)	133 (100)	97 (92)	236 (98)	114 (90)	369 (99)	<b>(0.000)</b>

**Table 4: Results of multivariate logistic regression analysis within each of the Knowledge, practices, and attitude factors with the workers occupational safety**

Variables	Crude			Adjusted <sup>1</sup>		
	OR	P-value	95% CI	OR	P-value	95% CI
<b>Knowledge</b>						
Knowledge of occupational training	3.84	0.000	2.28 - 6.45	3.77	0.000	2.18 - 6.52
Maintaining protective gear	8.09	0.000	4.28 - 15.32	8.70	0.000	4.55 - 16.65
Knowledge about communicable disease	0.40	0.001	0.24 - 0.67	0.49	0.007	0.29 - 0.94
Wear mask while handle waste	0.59	0.036	0.36 - 0.97	0.57	0.027	0.35 - 0.94
Knowledge about prevention of covid-19	1.53	0.107	0.91 - 2.58			
Knowledge about social distancing	1.02	0.930	0.60 - 1.75			
<b>Practice</b>						
Practice of maintaining safety guideline	13.35	0.000	6.89 - 25.88	13.11	0.000	6.31 - 27.24
Practice of currently using PPE	10.89	0.000	4.84 - 24.49	10.93	0.000	4.38 - 27.23
Cleaning wash vehicles wearing PPE's	5.14	0.010	1.49 - 17.74	3.11	0.085	0.85 - 11.35
Practice of disposing PPE	4.57	0.000	2.47 - 8.45	3.20	0.001	1.59 - 6.44
<b>Attitude</b>						
Feeling problems with PPE	4.74	0.000	3.07 - 7.30	3.51	0.000	2.08 - 5.90
<b>Job facilities</b>						
	9.71	0.000	3.07 - 30.69	7.09	0.001	2.17 - 23.09
<b>Socio-economic condition</b>						
Caste	2.24	0.093	0.87 - 5.77	2.13	0.118	0.82 - 5.53
Ethnicity	2.99	0.022	1.17 - 7.63	2.71	0.037	1.06 - 6.94
Accommodation						
Government facilities	Ref					
Own facilities	1.13	0.722	0.58 - 2.17	1.22	0.556	0.62 - 2.42
Rent	1.60	0.105	0.91 - 2.82	1.83	0.043	1.02 - 3.29
Income						
<5000 tk	Ref					
5000-10000 tk	1.06	0.843	0.59 - 1.88	1.42	0.325	0.70 - 2.87
>10000 tk	2.12	0.013	1.17 - 3.85	2.54	0.011	1.24 - 5.23

<sup>1</sup> Significant variables adjusted according to conceptual framework relationship

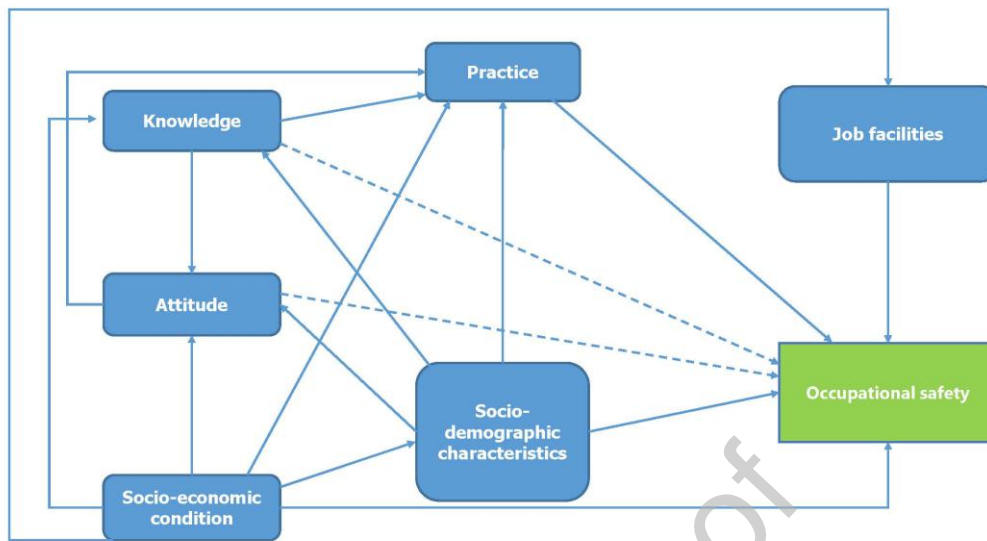


Figure 1