



Health concerns among waste collectors during pandemic crisis

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Abstract

The COVID-19 pandemic has negatively affected the economic, social, and psychological aspects globally. COVID-19 can possibly spread through municipal solid waste (MSW) if it is collected, bagged, transported, and disposed inappropriately. Such situation has posed significant challenges to MSW management (MSWM), which has led waste personnel under massive pressure. This study aims to examine the health-protective behavior of sanitation workers/MSW collectors (MSWCs) during the COVID-19 crisis. Quantitative data were collected by using a self-administered survey from 418 MSWCs working in Mainland China. The study extended the traditional health–belief model and proposed education and training as a facet of the behavioral model. Result showed that education and training were a significant predictor of health-protective behavior. Moreover, the moderating incremental influence of regulative assistance significantly affected the behavioral mapping of MSWCs. This study contributes to the literature by mapping the concerns, risks, and challenges experienced by MSWCs in times of a health crisis. Policymakers should specially consider the safety and hygiene concerns of frontline workforce in the whole chain of waste management (including the outsourced operations of MSWM). Lastly, the adoption of smart communication with the frontline workforce (i.e., MSWCs) is in dire need to maintain trust and avoid rumors and misconceptions during the time of a pandemic situation.

Keywords Waste collector · COVID-19 · China · Health belief model · Education and training · Task self-efficacy

Introduction

A respiratory system infection caused by coronavirus, which was officially named coronavirus disease 2019 (COVID-19) on February 11, 2020, by the WHO (2020), has posed a global crisis. Many countries have been forced to mandate lockdown as a measure to prevent the spread of COVID-19 (Haque et al.

2021). The negative consequences of COVID-19 have spread across economic, social, and psychological aspects globally (Ahorsu et al. 2020). These consequences have a tremendous negative effect on human lives, financial markets, and the global economy (Hassan et al. 2021). One huge challenge that is relevant to people's lives is a sharp increase in the quantity and composition of municipal solid waste (MSW; Hantoko et al. 2021; Torkashvand et al. 2021).

Recently, the public concern on health has significantly overwhelmed people's attention on environmental carefulness around the world, which has led to environmental deteriorating effects to be ignored temporarily. First, the public have to use personal protective equipment (PPE), such as facemasks, to prevent infection and transmission of the COVID-19 effectively; however, millions of potentially contaminated masks are discarded every day around the world (Penteado and Marco 2021). Second, people have adapted the new normal with the spread of the COVID-19 pandemic, which has caused the complexities and difficulties of waste management (Torkashvand et al. 2021). The amount of online shopping and in-home cooking have increased sharply, which, in turn, have increased the amount of MSW (Yousefi et al. 2021). The increased demand for plastic-packaged food and groceries and

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the heavy usage of disposable supplies have also dramatically raised the amount of MSW, especially of plastic waste (Valizadeh and Mozafari 2021). In addition, people who are infected of the virus require home isolation rather than hospitalization, which produces hazardous waste daily (Penteado and Marco 2021). Haque et al. (2021) stated that one infected person produces 3.40 kg of generated hazardous waste daily. Municipal waste collection systems may not be able to handle a sudden increase in infectious waste. Lastly, the radical increase of medical waste has also brought heavy pressure on MSW management (MSWM). Consequently, the possibility of the transmission of COVID-19 has been intensified by the change of the quantity and composition of MSW.

The source of MSW basically consists of household solid waste (HSW; Hussein Abdel-Shafy and Mansour 2018), mainly including food, recyclable, and hazardous wastes and other solid waste (Wang et al. 2018). The MSWM system is composed of many key processes, such as waste production, collection, transportation, management, and disposal, which are strongly linked with socioeconomic aspects (Valizadeh and Mozafari 2021). However, the world has commonly faced environmental problems concerning MSWM (Tasi et al. 2020), especially in the most of the populous countries (Zolnikov et al. 2018). In addition to less systematic disposal dumping practices, administrative will and financial capacity are lacking, and the complex multidimensional system of MSWM is poorly handled in developing countries (Tasi et al. 2020). Although waste collectors (sanitation workers) have held an important role for protecting public health (Shin et al. 2019); they are potentially exposed to high risk of various occupational injuries and illnesses (Zolnikov et al. 2018; Ziaei et al. 2019). Penteado and Marco (2021) summarized that the potential occupational risks of waste workers include mechanical, ergonomic, chemical, biological, and social aspects. In comparison with developed countries, waste collectors have faced higher risk of occupational injuries in many developing regions. The reasons are as follows: high illiteracy rate of workers (Thakur et al. 2018), lack of standards and norms (Eskezia et al. 2016), shortage of protective gears (Ziaei et al. 2018), and lack of basic facilitating conditions (Salve et al. 2020). Moreover, Mol et al. (2017) argued that the factors that affect the rates of waste workers' accidents include lack of proper training, negligence of normal work routine, and informality of the profession. The advent of COVID-19 has aggravated the tension in MSWM, especially for waste workers. Research has reported that coronaviruses persist on different media and surfaces (e.g., metal, plastic, paper, ceramic, and glass) from 2 h to 9 days (Kampf et al. 2020), as well as 3 h in aerosols and 3–4 days in solid feces (Nghiem et al. 2020). Coronaviruses may exist on the whole spectrum of the MSW industry's activities. MSW must be collected, bagged, transported, and disposed appropriately to prevent the possible spread of COVID-19 through it. Such

situation has posed significant challenges to MSWM, which has led to waste personnel being under massive pressure. The International Solid Waste Association (ISWA) emphasized that all governments should recognize the key role of waste workers and the waste sector in the period of epidemic. Waste workers are the second most important human shield to coronavirus, after health workers (ISWA 2020). Consequently, many governments have adopted socioeconomic support to waste workers. For example, workers involved in waste disposal sectors have been given the status of key workers to ensure safe schooling and care provision for their children and families by the government in the UK (Cabinet Office 2021).

However, ISWA highlighted that waste collection workers, as one of the most vulnerable parts of the population, have already been exposed in several health risks, including infections (ISWA 2020). Acharya et al. (2021) claimed that waste workers, as one of the frontline workers during the pandemic, have faced an alarming challenge of exposure to virus. Yousefi et al. (2021) also indicated that taking reasonable precautions and safety training for waste service personnel is necessary, especially the collection department in the COVID-19 situation. During the COVID-19 outbreak, most governments and authorities' priorities have shifted toward public health protection from the viral infection rather than societal and environmental aspects (Haque et al. 2021). The situation is worse in developing countries because they lack personal protection equipment and clear guidelines to MSWM employees (Vaverková et al. 2021), awareness and campaign programs from the government (Acharya et al. 2021), and timely and effective training (Ganguly and Chakraborty 2021).

In the perspective of Mainland China, MSWM has continuously reformed at the local and national levels for addressing the clean collection, transportation, and disposal of MSW (The brief list of reforms and reports in Mainland China is listed in Appendix A.). The Chinese government began to be concerned about waste collectors (sanitation workers) in 1992 when the State Council of the People's Republic of China launched a proposal to improve their working conditions, improve their wages and benefits, and solve their housing difficulties. However, waste collectors have been labeled as the crowd of low income, low education, and low skills under dangerous and poor working conditions (Wei 2017). Alarmingly, the role of MSW collectors (MSWCs) has been overlooked. Particularly, the authors collected 22 reports and reforms published by different governing institutions in Mainland China in the last 30 years. Among the 22, only eight documents addressed the role and concerns of waste collectors. However, none of them addressed the challenges related to the pandemic situation. Moreover, MSWM faces several problems because it is still reforming. According to a survey (Tencent 2020), there exists chaos in employee identity in

MSWM, that is, the employment contract of respondents (waste collectors) includes dispatched workers (57.5%), formal staff (22.5%), temporary workers (10%), and contract workers (5%). They came from 20 sanitation companies, and many of them could not accurately tell the name of their companies. Moreover, as discussed above, the Chinese government also adopted strict martial laws to the public to prevent the spread of COVID-19 (Fanelli and Piazza 2020), which derived a large amount of MSW. Several studies have addressed COVID-19 and waste as a new challenge (Hantoko et al. 2021; Richter et al. 2021; Capoor and Parida 2021; Behera 2021). However, works on health-protective behavior of MSWCs in Mainland China are unavailable. Thus, the present study aims to underline the health-protective behaviors of MSWCs in Mainland China during the ongoing pandemic crisis and map MSWCs' concerns while being on the frontline and collecting waste. To achieve the current objective, we adapted the health belief model (HBM) and proposed its extension by including task/performance self-efficacy and the role of *education and training* as a construct. Moreover, institutional theory (regulative and normative assistance) was applied as a moderator variable to create a unique framework. The objective of this study is to propose implications that can help academicians, administrative authority, and policymakers to understand the stance of waste collectors and possible contributions while proposing any reform related to MSWM, especially in the case of a pandemic situation.

Theoretical background and hypothesis building

HBM

HBM originated from the perception or belief about diseases (Kocoglu-Tanyer et al. 2020), which was modified and revised through the psychological theories of motivation, cognition, and value expectation (Janz and Becker 1984; Rosenstock 1974). HBM indicates that individuals' health behaviors will be positively affected by subjective assessment (Straub and Leahy 2014). Investigation on HBM dated from Rosenstock's research (1966), who developed the model that explored why and under what circumstances individuals will take action to prevent illnesses (Carpenter 2010). In the classic view of HBM, it consists of four basic components, namely, perceived susceptibility and severity, barriers, and benefits (Jones et al. 2015). Rosenstock et al. (1988) argued that self-efficacy can play a critical role in HBM. However, Carpenter (2010) underlined that it has been ignored in the previous pool of HBM-related literature. Similar influential power of cues to action, which can have an internal or external influential role (i.e., normative and regulative, as suggested by Urban and

Kujinga (2017)), was also underlined by Champion and Skinner (2008).

The intensive use of HBM in recent times signifies its significance and meaningfulness in depicting public health-protective behavior (Keren et al. 2021). It has been one of the most effective models for explaining disease prevention, symptom responses, and other health-related behaviors (Del Villar et al. 2017). HBM has also been applied in investigating diverse health-related behaviors (Mo et al. 2019), such as breast self-examination (Didarloo et al. 2017), dietary behaviors (Khoramabadi et al. 2016), predictors of adherence with home quarantine (Al-Sabbagh et al. 2021), and public perception and preparedness for COVID-19 (Jose et al. 2021). Therefore, the current study adopted HBM because of the following inter-construct relationships. First, a strong relationship exists between individuals' preventive or protective behaviors and their perceived sense of exposure. Second, the study extended the traditional HBM and proposed education and training as a facet of the behavioral model. Last, the current study adopted the moderating role of regulative and normative assistance instead of cues to action, as they can affect individuals' final action. In the context of traditional HBM, hypotheses of perceived exposure, perceived threat, barriers of being protected, benefits of being protected, and modified self-efficacy (task/performance self-efficacy) were adopted in the case to map the perceived health-protective behavior of MSWCs.

Perceived exposure

MSWCs always try to protect their health, but they are exposed to a dangerous working environment. Madsen et al. (2016) found that exposure to microorganisms has been a serious health problem for garbage collectors. Some authors have indicated that exposure to air pollution harms the public's health (Radisic et al. 2016; Mirzaei-Alavijeh et al. 2020). Travaglio et al. (2021) identified that long-term exposure to poor air quality increases the risks of COVID-19 infection and mortality.

The current study applied *perceived exposure* adapted from *perceived susceptibility*. *Perceived exposure* can be defined as individuals subjectively assessing the risk and seriousness of disease or health problems. Somville et al. (2021) found that *perceived exposure* is generally high (88%) in physicians in the time of COVID-19. MSWCs who are conscious of risk of exposure will adopt preventive measures actively. Therefore, this study indicates that MSWCs' health-protective behaviors are affected by their *perceived exposure*.

Perceived threat

Perceived threat defines individuals' perceived possible negative result caused by not observing healthy behaviors (Kwon

and Ahn 2019), which are preliminary driven by the influence of perceived exposure and further lead to health-related behaviors, especially for increasing the motivation of taking precautionary measures (Jeong and Ham 2018; Tajeri Moghadam et al. 2020; Carico Jr et al. 2021). Thus, higher perceived threat indicates a higher likelihood of engagement in health-promoting behaviors (Jose et al. 2021). Siddiqui et al. (2016) found a higher level of preventive practices on dengue among people who have *perceived threat* on dengue. Yuen et al. (2020) also argued that individuals' perception of threat defines their protective behavior. Workers will act more actively to avoid possible negative results because of a higher perceived threat. Hence, the current study proposes that MSWCs' health-protective behaviors depend on their perception of threat.

Barriers of being protected

Barriers of being protected (perceived barriers) indicate that individuals subjectively assess the costs or obstacles of given health behaviors. In some context, the possibility of participation of individuals' health-promoting behaviors is obstructed by *perceived barriers* (Kwon and Ahn 2019). Simply stated, higher individuals' likelihood of engagement in behavior decreases because of higher perceived barriers (Carico Jr et al. 2021). *Perceived barriers* have been adopted as a key variable for forecasting wide health behaviors, which involve customers' use of menu labels (Jeong and Ham 2018), injury prevention (Gabriel et al. 2019), influenza vaccine acceptance (Hu et al. 2017), and home quarantine (Al-Sabbagh et al. 2021). Generally, although MSWCs recognize the necessity of given health behaviors, they have to give up or not take action because of the costs or obstacles of given health behaviors. For example, people cannot wear standard masks when the masks are unavailable or when they cannot afford them at an exorbitant price. Thus, waste collectors' perception of the barriers of being protected concludes their health-protective behaviors.

Benefits of being protected

Benefits of being protected (perceived benefits) refer to individuals' perception of the positive consequences or benefits by engaging in given health behaviors (Carico Jr et al. 2021). *Perceived benefits* have been commonly applied to study individuals' health-related behaviors in cases of breast self-examination behavior (Didarloo et al. 2017), injury prevention (Gabriel et al. 2019), acceptance of vaccination (Hu et al. 2017; Mo et al. 2019; Kocoglu-Tanyer et al. 2020), and waste management (Khan et al. 2019). Moreover, Jose et al. (2021) indicated that perceived benefits in HBM show a significant association with behavioral changes. Notably, almost all people are enthusiastic about receiving benefits. In other words,

people are willing to adopt special behaviors if they can perceive positive consequences or benefits by participating. Thus, we infer that MSWCs' health-protective behaviors depend on their *perceived benefits*.

Task performance self-efficacy

Self-efficacy is individuals' confidence concerning their ability to achieve a particular goal (Bandura 1978; Taylor and Betz 1983). It is an important factor when individuals assess and achieve goals, tasks, and challenges (Kröninger-Jungaberle and Grevenstein 2013). Carico Jr et al. 2021 indicated that perceived self-efficacy is crucial because people do not start what they feel they cannot achieve. Moreover, various extensions of basis requests have been required by many specialists; thus, the concept of *self-efficacy* has been extensively extended. Many of these extensions are related to individuals' health behaviors, such as *preventive service use self-efficacy* (Jacob et al. 2016), *self-care self-efficacy* (Eller et al. 2016), *alcohol-refusal self-efficacy* (Lee et al. 2020), and *pain self-efficacy* (Larowe et al. 2020). Wen et al. (2021) suggested that *self-efficacy* buffers students' stress during COVID-19. In the current study, the influence of task self-efficacy among MSWCs' health-protective behaviors is a novel contribution to the literature. Specifically, frontline workers' health-protective behaviors in case of any pandemic situation (or crisis) have never been researched before.

To address the remaining constructs of traditional HBM, the extension of the existing HBM has also been proposed by addressing the construct of education and training, especially in the context of MSWCs' health-protective behaviors while working on the frontline in the time of the ongoing pandemic situation. Furthermore, the current study adopted institutional theory to elaborate the effectiveness of cues on institutional and social grounds instead of generalizing cues only for support. The related hypotheses will be discussed in the following subsections.

Proposed extension of HBM (education and training)

The definition of education can be understood as transmission processes in which accumulated information, knowledge, understanding, attitudes, values, skills, competencies, and behaviors are transmitted (ISCED 2011). Education and training can be formal or informal. Informal education and training include any organized and sustained learning activities that can be performed within and outside educational institutions and cater to people of all ages, such as adult literacy and work skills (UNESCO-UIS 2016) i.e. it can be done by using digital technologies and new media. From another perspective, learning can be defined as a change in behavior caused by an experience (De Houwer et al. 2013). Education and training seem to be an experience provider. Such condition, education,

and training offer new experiences to learners that affect their behaviors. Research shows that education level had significantly affected the awareness of the A(H1N1) pdm09 pandemic, wherein women who had attended college were 77.8 times as likely as women with no formal education (Kouassi et al. 2012).

Moreover, 98.5% of community residents think that performing universal education of the prevention and treatment of public health emergencies is necessary (Zheng et al. 2020). Li et al. (2020) highlighted that health education and training are urgently required during the COVID-19 outbreak. Zhong et al. (2020) indicated that health education related to improving COVID-19 knowledge can contribute to community's optimistic attitudes and appropriate behaviors. Yue et al. (2020) emphasized that education programs about COVID-19 knowledge are extremely urgent for the general population, particularly for rural and undereducated residents. Educational interventions should be an important part of future outbreak responses (Kaim et al. 2020). The effect and value of education and training have been explored by many experts from different disciplines. Morony et al. (2018) presented that health education and training can empower adults' health management. Mackert et al. (2011) suggested that healthcare workers' health literacy and associated communication challenges can be enhanced by education and training. In addition, the role of education and training has been studied while mapping radiation protection (Higley 2017). Therefore, on the basis of the above literature in the "HBM" section and the "Proposed extension of HBM (education and training)" section, the following lists of hypotheses are considered in the current study.

H1(a and b): *Perceived exposure* influences the perceived *task self-efficacy* and *perceived threat* among MSWCs during the pandemic.

H2(a and b): MSWCs' *education and training* influence their perceived *task self-efficacy* and *perceived threat* during the pandemic.

H3 and H4: *Perceived threat* and *task self-efficacy* among MSWCs influence their *health-protective behavior* during the pandemic.

H5 and H6: *Benefits* and *barriers of being protected* while collecting waste during the pandemic influence the *health-protective behavior* of MSWCs.

Role of perceived threat and task self-efficacy as mediators

The literature has examined *perceived threat/risk* as a moderator (Champion and Skinner 2003) and a mediator (Jones et al. 2015) in the context of HBM. In the current study, the extension of HBM is distinctively proposed by adding the role of

education and training. Moreover, it depicts a socio-psychological behavioral mapping in the time of the pandemic. In the same manner, *self-efficacy* has been tested as a mediator while mapping persuasive behavior modeling (Chen et al. 2015) and understanding self-regulated learning behaviors (Alghamdi et al. 2020). Furthermore, studies in organizational settings have underlined the role of *task self-efficacy* on performance (Wang and Hsu 2014). Thus, on the basis of the supporting constructs' behavior in the literature, we examine the mediating role of *perceived threat* and *task self-efficacy* on the *health-protective behavior* of MSWCs during the ongoing pandemic crisis. Particularly, we propose the following related hypotheses.

H7: As constructs, perceived *task self-efficacy* and *perceived threat* mediate the relationship between *education and training* and perceived *health-protective behavior* of MSWCs during the pandemic.

H8: As constructs, perceived *task self-efficacy* and *perceived threat* mediate the relationship between *perceived exposure* and perceived *health-protective behavior* of MSWCs during the pandemic.

Regulatory and normative assistance

Institutions regulate the society (North 1990); they can be a formal set of rules, regulations, norms, values, and taken-for-granted assumptions (Scott 2002; Bruton et al. 2010). Institutional environment/pressure can considerably affect organizational (DiMaggio and Powell 1991) and individual behaviors (Griffiths et al. 2013). Institutional theory has been used as a key factor in predicting organizational and individual behaviors in several studies. Seelos et al. (2011) explained that the *regulatory environment* is the formal rules and regulations that conduct individual behaviors. Such an environment includes rewards and punishments (Valdez and Richardson 2013). Urban and Kujinga (2017) found that the *regulatory environment* considerably affects workforce's intentions. Furthermore, the *regulatory environment* has been confirmed as a positive factor for individuals' responsible and conscious behaviors (Zhang et al. 2019; Ye et al. 2020a, 2020b) and has remarkably played its role in HSW-related studies (Ye et al. 2020b).

Conversely, *normative environment* can be defined as the individuals' perception of social pressure that normalizes their behavior (Ma et al. 2018). Such an environment includes normative beliefs. Normative beliefs conduct individuals' given behaviors, which are based on the approval or disapproval of important referent individuals or groups (Ajzen 1991). Wu et al. (2019) indicated that individuals' intention and behavior are significantly affected by the *normative environment*. Bruton et al. (2010) reported that the *normative*

environment establishes the social value that guides individuals' behavior. Particularly, a significant relationship exists between normative beliefs with individuals' intention and behavior in a collectivist society (Furnham et al. 2012; Wu and Chen 2014; Shi et al. 2017). Therefore, in the current research setting, the following hypotheses are proposed for the study.

- H9: *Regulatory assistance* moderates the relationship of exogenous factors (*perceived threat* and *task self-efficacy*) with the endogenous factor (*perceived health-protective behavior*) in the case of MSWCs during the pandemic.
- H10: *Normative assistance* moderates the relationship of exogenous factors (*perceived threat* and *task self-efficacy*) with the endogenous factor (*perceived health-protective behavior*) in the case of MSWCs during the pandemic.

The graphical representation of the proposed model of the research is shown in Fig. 1.

Methodology

Sample and procedure

We conducted a questionnaire-based online survey and collected responses from frontline MSWCs. To access the potential respondents, we contacted the concerned public office and gained necessary approval. The public office helped us approach the frontline MSWCs who are affiliated with two private cleaning companies, namely, Anhui Hongyang Environmental Greening Management Co., Ltd. and Hubei Jiashicheng Environmental Protection Technology Co., Ltd. We requested the representatives of both enterprises to help in

collecting data from Anhui and Henan Provinces (in Mainland China). The involvement of enterprises (private firms) for frontline MSW collection is the part of national policy for MSWM since 2004, as listed in Appendix A. The principal researcher physically visited each participating organization multiple times to meet the potential participants and requested them to participate in the online survey (through www.wjx.cn). Ethical and health-related clearances were obtained from multiple institutions involved. First, ethical clearance was requested from the affiliated institution (Department of Science and Technology of Communication, University of Science and Technology of China) to assure data anonymity and adopt all concerned standard operating procedures. Second, we requested permission and assistance from the concerned representative of the "Urban Management and Law Enforcement" (UMALE) to collect data for the academic research. After the ethical approval, UMALE forwarded and helped us coordinate with the two concerned private cleaning companies stated above. After having the ethical approval from each of the involved public and private institutions, data were collected officially.

To increase the response rate, we kept revisiting the concerned offices. To maximize the response rate, a lucky draw (red envelope) was offered to respondents who completed the survey, which helped create a shared "buzz" about participating. Data collection was performed from the first week of March 2020 until the end of the second week of August 2020. Each questionnaire included a cover page that explained the brief objective of the study, the voluntary nature of the survey, and assurance of anonymity and confidentiality. We also provided the contact details of the principal researcher in case the respondents have any questions or inquiries about the study. We approached nearly 700 frontline workforce

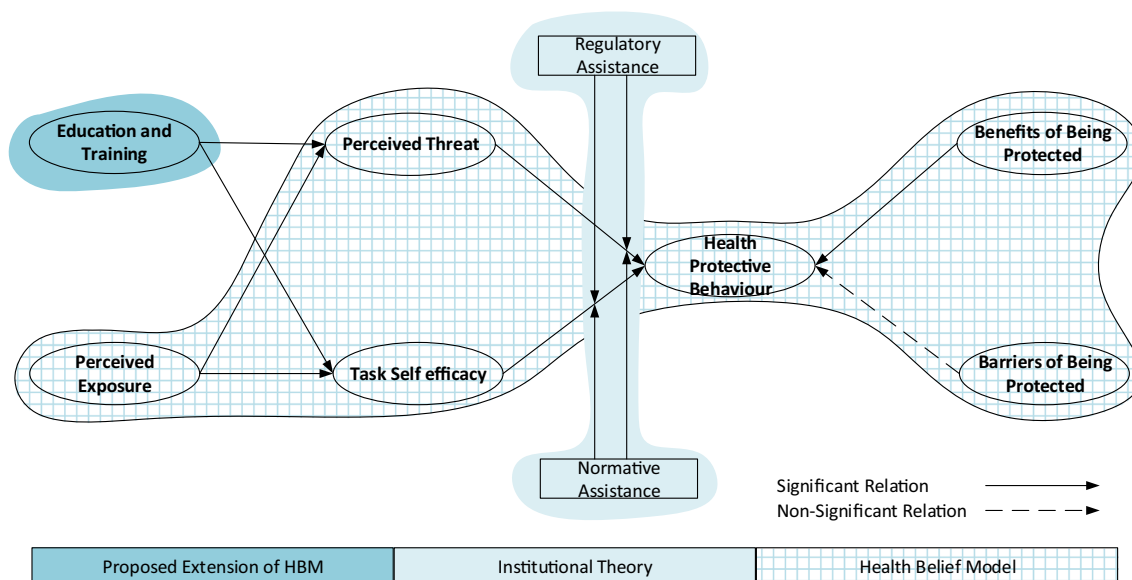


Fig. 1 Graphical representation of the proposed model

(MSWCs) associated with the waste management firms and received 418 completed and usable questionnaires, making an overall response rate of 59.71%. We discarded 37 questionnaires because of invalid or incomplete responses. We examined the nonresponse bias in our dataset by comparing the personal and professional attributes of early respondents (those who participated in March 2020) versus late respondents. Using *t*-test, we did not find any significant differences between both sets of respondents (early versus late respondents).

Measurement instrument

We used well-established scales to measure the primary constructs of the study. The questionnaire had two sections. The first section comprised of all items measuring independent, mediating, moderating, and dependent variables. The second section captured personal and professional attributes of the participants, including age, gender, employment status, and years of work experience. The questionnaires were conducted in the Chinese language for the ease of the participants' understanding. However, to confirm the validity and reliability of the questionnaire, we used a back-translation method, as suggested by Brislin (1970). In this method, we initially translated the English version of the questionnaire to the Chinese version via a professional language translator. Then, we translated the Chinese version of the questionnaire back to the English version by using the services of a different language expert. The two English versions of the questionnaire were then compared by a native English speaker, who confirmed the equivalence of both versions. Finally, the Chinese version of the questionnaire was pretested on a diverse group of individuals belonging to different age, gender, education, and employment categories. We identified small glitches and performed minor modifications to the wording, content, and overall structure of the questionnaire and cover letter. Thus, we confirmed that all items were appropriate and relevant to the corresponding variables, ensuring content validity and reliability. Table 1 presents the English and Chinese versions of the measurement items. All items were rated by the respondents on a 5-point scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Common method bias

Although the objective was to assess the perception of MSWCs, we collected data from a single source. To assess whether common method bias would be a significant issue in our collected sample, we used the well-established and robust Harman's single-factor test. We performed exploratory factor analysis on our data, which indicated that the largest single factor explained 29.67% of the total variance. No single factor captured the major proportion of the total variance. To verify

the external validity of the collected data, common latent factor was also computed, following Keren et al. (2021). Particularly, no significant difference was found in the standard regression scores above the upper cutoff of 0.200 recorded in the cases of absence and presence of CLF. Thus, the research eliminated the risk of common method bias. In terms of age, approximately 17% of the participants were under 25 years old, 23% were between 25 and 35 years old, 38% were between 35 and 45 years old, and 22% were above 45 years old. Approximately 87% of the respondents were male, whereas 13% were female. In terms of work experience, approximately 21% of the respondents had less than 1 year of work experience, 36% had 1–3 years of work experience, 27% had 3–5 years of work experience, and 16% had more than 5 years of work experience. Overall, our sample presents a satisfactory representation of employees with diverse personal and professional attributes. Table 2 presents the descriptive profile of the respondents.

The table shows the sample distribution of 418 waste collectors investigated in this study.

Findings

Measurement model

In the next step, we assessed the quality of data in the measurement model. We used four robust criteria to evaluate the measurement model: (i) construct reliability, (ii) convergent validity, (iii) discriminant validity, and (iv) nomological validity. The tabular representation of the measurement model is listed in Appendix C. Specifically, all four criteria were used to assess the measurement model. First, construct reliability was evaluated using conventional and established Cronbach's α . All constructs showed satisfactory reliability with the values above the minimum cutoff criteria of 0.70. Among all constructs, health-protective behavior showed the highest reliability with $\alpha = 0.95$, whereas normative environment demonstrated the lowest but acceptable reliability with $\alpha = 0.71$. The convergent, discriminant, and nomological validities were further examined for construct validity. Regarding convergent validity, we found satisfactory results for composite reliability (CR) and average variance extracted (AVE) of all the surveyed constructs. The CR of all constructs were beyond the threshold value of 0.70, with health-protective behavior having the highest CR (0.95) and normative environment varying the low but acceptable CR (0.79). The standard loadings of all items were higher than the desired threshold of 0.7 and significant at 0.001, which indicated a good convergent validity, as listed in Appendix C-1.

Regarding discriminant and nomological validities, we estimated the AVE and Dijkstra–Henseler's rho ρ_A

Table 1 Instruments adapted in the current study (English version).

Constructs	Items	Sources
Education and training	In the context of waste sorting and collecting process 1. Education and training gave me confidence 2. Education and training improved my performance 3. Education and training are knowledgeable and assist me in understanding new tasks	Zulfiqar and Asmi (2019)
Perceived exposure	1. I will likely be infected with COVID-19 2. I believe that COVID-19 is a severe health problem 3. I feel that I will get COVID-19 sometime during the pandemic	Champion (1999)
Perceived threat	1. My chance of getting exposed to COVID-19 is high if I do not perform safety behavior 2. I will be more likely to be exposed to COVID-19 if I do not perform safety behavior 3. The thought of being exposed to COVID-19 scares me	Yuen et al. (2020)
Performance/task self-efficacy	1. I am sure that I can learn about any new task in my job 2. I have high self-confidence when it comes to understanding new tasks 3. Even before I begin to listen or get involved in any new task on the job, I feel confident that I can understand it	Nietfeld et al. (2006); White et al. (2019)
Health-protective behavior while collecting waste	1. I follow all safety procedures (which are necessary or advised by the health and safety department) at any cost 2. I follow safety rules that I think are necessary or advised by the health and safety department 3. I try my best to get every information necessary to protect myself	Yuen et al. (2020)
Regulatory assistance	Relevant government departments actively... 1. ... emphasized that safety precautions are important to be taken while dealing with COVID-19 during waste collection 2. ... communicated about the advantages of adopting safety measures (i.e., by sharing best practices). 3. ... working to control the spread of COVID-19	Tajeri Moghadam et al. (2020)
Normative assistance	While communicating with my colleagues, I have heard about the... 1. ... important safety precautions to be taken while dealing with the current emergency 2. ... advantages of adopting safety measures while dealing with the current emergency 3. ... encouragements to adopt precautionary measures	Tajeri Moghadam et al. (2020)
Barriers of being protected	1. To stay at safe enough space keeps me restricted to perform effectively 2. To stay at safe enough space brings me psychological pressure 3. It is very hard for me to perform standard operation procedures with precautionary measures	Champion (1999)
Benefits of being protected	1. I believe that by taking precautionary measures, as suggested by health experts, can prevent serious outcomes 2. In the case of collecting and sorting waste, adopting safety measures (i.e., using mask and gloves) would protect me from COVID-19	Fallah Zavareh et al. (2018); Tajeri Moghadam et al. (2020)

Table 2 Descriptive profile of the respondents.

Descriptive	Detail	Frequency	Percentage
Age	Under 25	71	16.99%
	25–35	96	22.96%
	35–45	158	37.80%
	Above 45	93	22.25%
Gender	Male	363	86.84%
	Female	55	13.16%
Work experience	Less than 1 year	87	20.81%
	1–3 years	149	35.65%
	3–5 years	113	27.03%
	More than 5 years	69	16.51%

of the study constructs. All primary constructs showed AVE above the recommended cutoff criteria of 0.50. Discriminant validity was evaluated in two steps. The Fornell and Larcker criterion was calculated, in which the square root of the AVEs noted was greater than the inter-construct correlations (Hair et al. 2010). The results in the tabular format are listed in Appendix C-2. The values of the heterotrait–monotrait ratio of correlations were also calculated, considering the threshold of 0.90, as listed in Appendix C-2 (Henseler et al. 2014). These results provided sufficient evidence of discriminant validity for these constructs. Multi-collinearity was also calculated by variance inflation among items of each of the constructs. All VIF scores were below the

upper cutoff value of 3 (Hair et al. 2010). The tabular output is listed in Appendix C-3.

Structural model: direct and indirect effects

The structured model was tested using partial least squares (PLS), as a technique in ADANCO 2.0.1. The model fitness scores for the saturated and estimated models, which satisfy the cutoff suggested by Henseler (2017), are shown in Table 3.

SRMR standardized root mean square residual, dULS unweighted least squares discrepancy, dG geodesic discrepancy, HI95 95% percentile, HI99 99% percentile

Direct effects In the next step, we used ADANCO 2.0.1 with bootstrapping to test the direct effect hypothesis in the proposed model. Moreover, the effect size of each of the hypotheses was calculated to measure its significance. Particularly, the effect size of each hypothesis scored as weak, moderate, or high at cutoff values of 0.02, 0.15, and 0.35, respectively, as suggested by Hanel and Mehler (2019). Only the hypotheses addressing the influence of education and training on task self-efficacy were recorded with a weak effect and noted as insignificant. The tabular outcome with direct path analysis and effect size is listed in Appendix C-4. The variance explained (R^2) by perceived threat, task self-efficacy, and perceived health-protective behavior was calculated as 0.823, 0.741, and 0.885, respectively.

The results of direct effect hypothesis are as follows. Regarding H1(a and b), *education and training* had a positive and significant link with *task self-efficacy* ($\beta = 0.31, p \leq 0.01$) and *perceived threat* ($\beta = 0.17, p \leq 0.01$). A similar trend of findings has also been noted in the existing pool of literature (Boswell et al. 2019; Shin et al. 2019). Thus, H1(a and b) were accepted. Regarding H2(a and b), *perceived exposure* was positively and significantly associated with *task self-efficacy* ($\beta = 0.62, p \leq 0.01$) and *perceived threat* ($\beta = 0.78, p \leq 0.01$). This trend of relationship has also been observed in the literature (Janmaimool 2017; Yuen et al. 2020). Therefore, H2(a and b) were supported. Regarding H3 and H4, a positive and significant direct relationship was observed between *perceived threat* and *health-protective behavior* ($\beta = 0.72, p \leq 0.01$) and between *task self-efficacy* and *health-protective behavior* ($\beta = 0.24, p \leq 0.01$). Hence, H3 and H4 were accepted. The mapping of the potential inference of *perceived*

benefits (H5) and *perceived barriers* (H6) of being protective showed a positive and significant direct association between *perceived benefits* of being protective and *health-protective behavior* ($\beta = 0.11, p \leq 0.05$). However, in the case of *perceived barriers* (H6), an insignificant relationship was observed ($\beta = 0.004, p \geq 0.05$). Similar trend of research findings have also been observed in the literature (Hu et al. 2017; Razmara et al. 2018; Tajeri Moghadam et al. 2020). Moreover, the control variables (i.e., age, gender, and experience) were noted as insignificant in the current study. Specifically, in terms of elder age (above 45), the relationship from BaBP to HPB was observed as significant ($\beta = 0.204$); in the case of the overall model, it is nearly neglectable. BeBP was also recorded as strengthened ($\beta = 0.251$); in the case of the overall model, it was recorded as weak. Thus, among elder people (above 45), BaBP and BeBP were recorded as dominating constructs to define HPB in comparison with the response trends from the overall population.

Mediation (indirect effects) and moderation We used two complementary approaches to test the mediating effects of *perceived threat* and *task self-efficacy* among MSWCs in the relationship between exogenous factors (*education and training* and *perceived exposure*) and endogenous factor (*health-protective behavior*). Particularly, the method recommended by Preacher and Hayes (2008) was adopted, followed by that of Baron and Kenny (1986), to compute the mediation effect. The tabular and narrative detail of the mediation process conducted is presented in Appendix C-5. The findings concluded that *perceived threat* and *task self-efficacy* partially mediate (in serial mediation) the proposed exogenous factors (*education and training* and *perceived exposure*) and endogenous factor (*health-protective behavior*). Overall, the empirical results largely support our theoretical propositions.

In the final step, we tested the moderating role of *regulatory* and *normative assistance* in the relationship of the proposed mediators (*perceived threat* and *task self-efficacy*) with the endogenous factor (*health-protective behavior*), which are noted as H9a, H9b, H10a, and H10b. We used hierarchical regression to test the moderation hypothesis, as suggested by Qing et al. (2020). The tabular and narrative explanation of the moderation analysis is listed in Appendix C-6. Figure 2 shows the interaction plot for each of the moderation effect, as proposed in the “Theoretical

Table 3 Fitness measured through PLS (in ADANCO 2.0.1).

	Saturated	Score	HI95	HI99	Estimated	Score	HI95	HI99
SRMR		0.039	0.048	0.053		0.042	0.052	0.058
dULS		0.688	0.809	0.993		0.766	0.950	1.188
dG		0.403	0.618	0.785		0.551	0.664	.0821

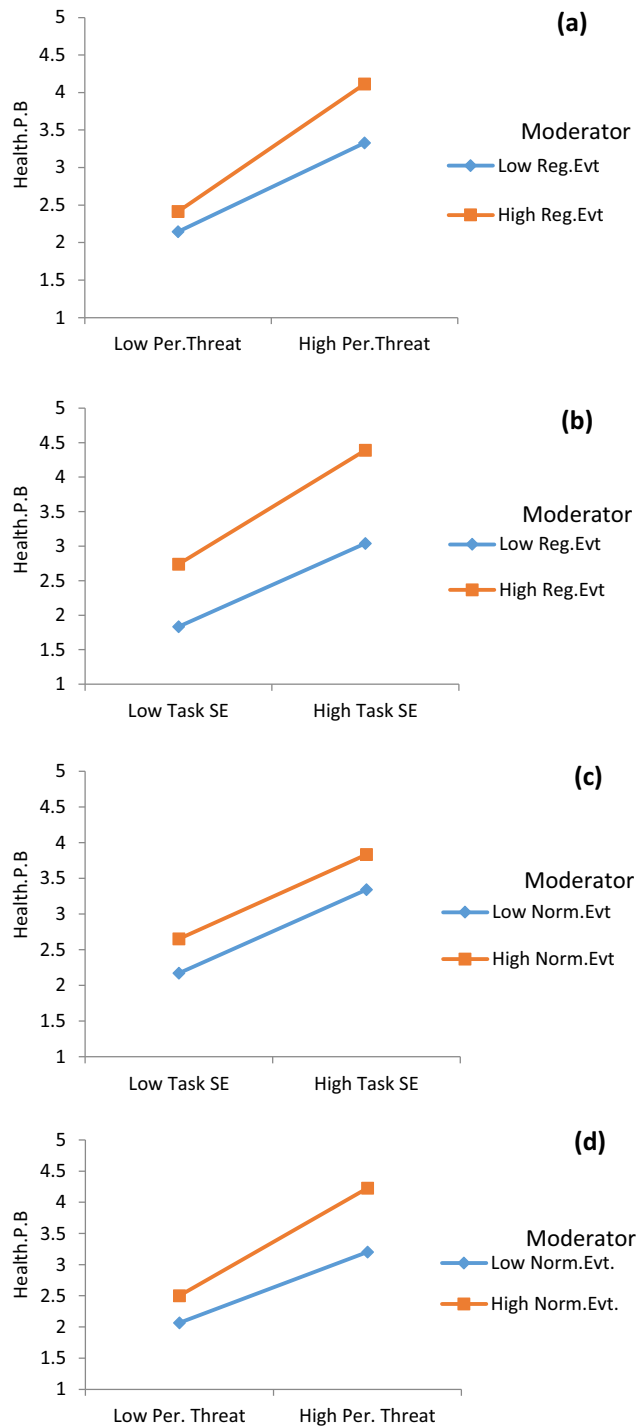


Fig. 2 a Interaction plots examining the moderating effect of H9(a) (regulatory assistance while mapping perceived threat over health-protective behavior); b H9(b) (regulatory assistance while mapping task self-efficacy over health-protective behavior); c H10(a) (normative assistance while mapping perceived threat over health-protective behavior); and d H10(b) (normative assistance while mapping task self-efficacy over health-protective behavior).

background and hypothesis building” section. The findings conclude that the role of *regulatory assistance* is a more

influential moderator than the role of *normative assistance*. Findings further highlighted the insignificant effect of *normative assistance* in the case of the relationship between *task self-efficacy* and *health-protective behavior* (in the time of pandemic), which can be an interesting finding.

Discussion

The current study extended HBM with the new variation of self-efficacy by proposing *task/performance self-efficacy* and proposed the extension by adding the role of *education and training*, which hold a significant explanatory power in the setting of the proposed model. Moreover, the strategic role of *regulatory assistance* was observed. The theoretical and practical implications of this study will be discussed in the following subsections.

Theoretical implications

The first theoretical contribution is that the study used *education and training* as an exogenous factor while mapping health-protected behavior in the perspective of *HBM*. Education can be considered information, knowledge, skills, competencies, and transitions. It includes not only formal *education and training* offered by formal educational institutions but also informal forms consisting of any organized and sustained learning activities on the job. The findings of our study are also supported by Davis et al. (2018), who highlighted that individuals’ environmental health skills are significantly enhanced by *education and training*. Furthermore, *education and training* have been confirmed as a positive factor for preventing and reducing occupational injuries and illnesses among MSWCs (Bogale et al. 2014; Zolnikov et al. 2018; Shin et al. 2019; Kaim et al. 2020). As Li et al. (2020) indicated, health education and training are urgently required during the COVID-19 outbreak. Therefore, *education and training* should be applied as an exogenous factor to *HBM* while studying any organizational setting to measure *health-protective behavior* during a pandemic situation. Particularly, the exogenous effect of *education and training* in the case of *HBM* can be noted as a unique contribution in terms of understanding (1) MSWCs’ behavior, (2) circumstances in Mainland China, and (3) pandemic situations.

Second, *HBM* is one of the most useful theories that predict individuals’ *health-protective behaviors* (Tajeri Moghadam et al. 2020), which has also been supported by the current study. The institutional theory has been adapted by emphasizing two principal pillars, *regulative and normative pillars* (Scott 2008), which significantly affect organizational (DiMaggio and Powell 1991) and individual (Griffiths et al. 2013) behaviors. The current study concluded that in

comparison with *normative assistance*, the role of *regulatory assistance* is more significant and prominent while mapping MSWCs' *health-protective behavior*, which is accordance with the research of Al-sabbagh et al. (2021). In other words, the study concludes that the use of regulatory reform should be used more efficiently and effectively during the pandemic situation while understanding the *health-protective behaviors* of frontline workers (i.e., MSWCs). According to a press conference held on April 12, 2020 (SCIO 2020), the performance of MSWCs has excellently been acclaimed. The group has played an extremely critical role in epidemic prevention and control in China. They have not only performed their normal tasks well but have also undertaken emergency tasks, such as disinfection and sterilization on related places, management of public toilets in mobile cabin hospitals and transportation, and disposal of medical waste. The press conference also emphasized that a series of measures will be launched to look after and improve MSWCs' facilitating conditions, including physical and psychological health and welfare treatment and salary. The signal has been responded by governments at all levels and societies at all sectors. The current findings can predict the relatedness of the aforementioned secondary source of information.

Third, the reform, which outsources (marketization) public services, has been widely practiced by the Chinese government; one typical example is urban sanitation service. Sanitation enterprises have been established at Shenzhen in 1984. In 2017, most cities conducted outsourcing (marketization) of municipal sanitation (Li 2019). Notably, a landmark policy was implemented, namely, Guidelines of the General Office of the State Council on the Government's Purchase of Services from Social Forces (General Office of the State Council 2013), which accelerated the outsourcing (marketization) of municipal sanitation services. Municipal sanitation services have reformed more than 30 years; however, many problems have not been resolved, including the absence of public service responsibility, inefficiency of governmental supervision and contract (Huang 2012), incomplete contract signing system, and negative influence on the interests of sanitation workers (Li 2014). For example, an incomplete contract signing system has caused messy employment approaches, formal workers, contract workers, temporary workers, and dispatch laborers (leased workers) in one mechanism. In conclusion, local governments act as regulators, and sanitation enterprises perform tasks of municipal sanitations at most cities. This study suggests that the institution (government) must implement all health-related concerns and policies even for outsourced (marketization) firms. Thus, in case of any pandemic crisis, the workforce can gain confidence and support from the government in terms of accurate and reliable facilitating conditions.

Fourth, the study can also be noted as a valuable finding, because it can help formulate future strategies in case of any

pandemic situation and design strategies for other frontline workers (including medical staff and law enforcement agencies). The study's conclusion of the weak role of the normative environment as a moderator also highlights the urgency to address the dynamics of the normative environment by academicians and policymakers, with the intention to transform this weak link into a valuable game changer by addressing stakeholders' interests and dynamics.

Lastly, in the current study, the influence of *task self-efficacy* among MSWCs' *health-protective behavior* is a novel contribution to the literature. Specifically, the *health-protective behavior* of frontline MSWCs in case of any pandemic situation (or crisis) has never been researched. This study is the first to use the mediating role of *perceived threat* and *perceived task self-efficacy* simultaneously in case of defining *health-protective behavior* while taking *perceived exposure* and workforce's *education and training* as exogenous factors. The partial mediating role of the proposed mediators signifies the role of proposed mediators in the case of examining MSWCs' *health-protective behavior*. Previously, health-related studies have mentioned the significant role of *education and training* to define *perceived threat* and *self-efficacy*. Similarly, *perceived exposure* has been studied to understand *perceived threat* and *self-efficacy*. However, none of the literature has taken both mediators simultaneously (in a serial or parallel manner). Thus, the current study is valuable as its underlining role of *perceived threat* and *task self-efficacy* as mediators and signifies its role in the time of crisis and future pandemic situation.

Practical implications

The first practical contribution of the study is mapping the stance and conditions of MSWCs under a pandemic situation. Notably, MSWCs are responsible for collecting, transporting, and processing of MSW. They have been a key part of protecting public health (Shin et al. 2019). The situation during COVID-19 can worsen; as a result, MSWCs have faced inconceivable dangers. The COVID-19 pandemic has caused an increase in the quantity and composition of MSW (Hantoko et al. 2021), which possibly leads to risk of spreading the virus in the process of waste management (Torkashvand et al. 2021). Therefore, the current initiative mapped the stance and condition of MSWCs during the pandemic, which is first of its kind.

Second, the result of the current study showed that during the COVID-19 outbreak, the influence of the normative environment is relatively weak among MSWCs. In other words, this study underlined the anxiety and fear among MSWCs, which were triggered by the workforce's perception of risks during the epidemic. The widespread outbreak of COVID-19 has led to psychological distress and mental illness of the public (Rajkumar 2020). The myths and misinformation

related to COVID-19 have negatively affected epidemic prevention and control (Bao et al. 2020; Zandifar and Badrfam 2020). Fake news (incorrect news) on social media also negatively affect public health (Mian and Khan 2020). The current research findings suggest that governing institutions should have an official mode of communication with the workforce, which can provide authentic and reliable information communication. It can improve the trust of MSWCs over the institution. It can further provide two-way communication mode for the workforce, which indirectly improves the sense of social responsibility, sense of affection, and recover from distrust among stakeholders.

The last suggestion is to expand the role of governing institutions by providing adequate protective resources and equipment to adopt health-protective behavior among MSWCs. The integration of public and private organizations is evident in current practices. However, the outsourcing practice still places more emphasis on the efficacy and results. MSWM should be reformed, where private organizations should strictly adopt the economic and hygienic concerns of the workforce as recommended by governing institutions. For instance, the role of economic institutions is strongly correlated with the current pandemic crisis (Kinatered et al. 2021; Hassan et al. 2021). This recommendation can be achieved by adding strict requirements for private firms (enterprises) to train and provide facilitating conditions to each frontline MSWC for achieving each task. As indicated in Appendix A, reforms and reports addressing MSWCs' rights and facilitating conditions are limited and must thus be addressed in future policies and reforms by the governing institutions in Mainland China.

Conclusion and future studies

The environmental problem driven from MSWM is a global issue, especially in most of the developing countries. The COVID-19 pandemic has worsened the situation. The government and public concern on health has significantly overwhelmed people's attention on environmental carefulness around the world, which has led to environmental deteriorating effects to be ignored temporarily. As a result, the situation has caused in the complexities and difficulties of waste management. Especially, sanitation workers/MSWCs who are the second most important human shield to COVID-19 not only have faced work overload but have also been exposed to several health risks, including high risk of infections in the current pandemic situation.

The result showed that the moderating incremental influence of regulative assistance significantly affected the behavioral mapping of MSWCs. All governments should recognize the key role of waste workers and the waste sector in the period of an epidemic. Particularly, governing institutions

should supply adequate PPE, offer professional training, and provide socioeconomic support (including for their children and families), such that MSWCs can adopt health-protective behaviors. In the case of China, MSWM includes public and private organizations (outsourcing), in which outsourcing practices still place more emphasis on efficacy and profit. In a time of pandemic, private organizations should strictly adopt economic and hygienic concerns on the workforce as recommended by governing institutions.

The persuasive behavioral psychological model of stimulus–organism–response can be adopted in future studies to underline the stressors and concerns of MSWCs. It can be further revised and improved by underlining the role of MSWCs' anxiety and dissatisfaction during a pandemic. The current study's initiative emphasized the role of task self-efficacy. The role of health self-efficacy and literacy can be adopted in future studies. The present study contacted the UMALE to request for permission and assistance to collect data for academic research. Future studies can underline the concerns and challenges of managerial staff and mid-level human resources to understand the challenges of MSW collection and management. Moreover, data collection was conducted using an online survey because of the requirements of epidemic prevention and control, which may have caused the older group of MSWCs to be overlooked. The demographic characteristics and primary goal of future studies can be set to underline the trend in behavior change in case of different age groups during any pandemic crisis. Lastly, hygiene and safety concerns can be compared between private and public sector stakeholders, given that frontline MSWCs are associated with enterprises (private firms).

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Declarations Not applicable

Ethics approval Ethical clearance from the ethical committee from the Department of Science and Technology of Communication, University of Science and Technology of China was provided.

Consent to participate Informed consent was obtained from all individual participants included in the study (included in the cover letter of the questionnaire).

Consent for publication The authors affirm that respondents for the questionnaire survey provided informed consent for publication (included in the cover letter, and authors assured their identity to keep anonymous).

Conflict of interest The authors declare no competing interests.

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