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Research article

Public perception towards medical waste generated in the environment during the COVID-19 pandemic in Eastern Province, Saudi Arabia

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ABSTRACT

Airborne droplets and contaminated surfaces are the main routes for the epidemic virus outbreak that causes the novel coronavirus. To reduce virus spread, people wear face masks and gloves daily, which massively increases the amount of waste generated in the environment. Also, the inappropriate disposal of used masks and gloves in communities may boost the spread of the novel coronavirus. However, no studies have been conducted to evaluate a public perception regarding the management of generated masks and gloves during the global health threat. Therefore, this paper proposes a study of public awareness, attitudes, and practices towards gloves and masks generated during the novel coronavirus pandemic in Saudi Arabia. The study showed that most of the participants (74%) have adequate awareness regarding the proper way to dispose of used masks and gloves, with 76% showing positive attitudes toward waste management. Gender shows a significant correlation with the regulations of medical waste collection and disposal ($r = 0.169$, $p = 0.0001$), and the consideration of the effective disposal of COVID-19 waste management as a collective responsibility of the community ($r = 0.158$, $p = 0.0001$). Also, the study shows that the majority of participants were aware on the availability of regulations for the collection and disposal of biomedical waste. Moreover, it demonstrates that public awareness regarding the attitude and measures taken by regional municipalities to reduce the spread of coronavirus has a significant positive correlation ($r = 0.279$, $p = 0.0001$). The study further recognized that the effective management of contagious wastes significantly protects the public against the improper practices of wastes disposal generated during the novel coronavirus pandemic.

1. Introduction

During the last two decades, pieces of evidence have shown the ability of Coronaviruses (CoVs) to infect humans in addition to mammals (Weiss and Leibowitz 2011; Schoeman and Fielding 2019). CoVs can infect humans' gastrointestinal, respiratory, hepatic, and central nervous systems (Chen and Guo 2016). On 11 March 2020, the World Health Organization (WHO) declared novel coronavirus (COVID-19) a global pandemic after the virus spread rapidly in many countries, including the Kingdom of Saudi Arabia (KSA). As of 30 September, 2021, WHO data showed that there have been 233,201,667 confirmed cases of COVID-19, including 4,772, 958 deaths in 216 affected countries and territories. In KSA, particularly, there have been 543,028 confirmed cases and 8,709 deaths.

Due to the fact that contaminated hands will in all likelihood transmit the virus once they get in contact with the eyes, nose, and mouth (WHO 2020), an unusual amount of personal protective equipment (PPE) like gloves and facemasks have been produced with people all over the world wearing them in hopes that they will serve as protection from the virus. A study conducted on 4,305 participants in Saudi Arabia found that 86.4% of the respondents had a good attitude on the proper wear of masks while also exhibiting appropriate practice, with 98.3% regularly wearing them to prevent the spread of the virus (Alnasser et al., 2021). According to the projected population in General Authority for Statistics of KSA, the predicted usage of the mask is 33,250,00 masks/day, given that about 95% of the KSA's population wears a mask.

Studies have investigated whether PPE may be considered useful or detrimental to the environment. It was discovered that due to the increased production, consumption, inappropriate disposal, and poor waste management of PPE, it was proven to be harmful to the environment across several countries in the world (Parashar and Hait 2021). Till

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March 2020, in Wuhan City, China, the capacity of medical waste (MW) treatment incinerators was more than 260 tons/day, with an increment of 215 tons/day during COVID-19 pandemic. In Barcelona, Spain, MW, including facemasks and gloves, increased by 350% (1200 tons) compared to the usual waste of ~275 tons. Also, in Thailand, MW amount has increased from 1500 to 6300 tons daily, whereas the UK witnessed a 300% rise in MW disposal during the pandemic. In France and the Netherlands, PPE resulted in a 10% and 5% increment in the daily generation of MW during lockdown (Yu et al., 2020; Sarkodie and Owusu 2020; Das et al., 2021). The number of used masks and COVID-19 related MW has increased rapidly in South Korea, with about 295 tons generated from early February till early March 2020 to reach 20 tons daily in April (Rhee 2020).

With the massive amount of MW, the possibility of further spreading COVID-19 is heightened, especially between the public, more specifically with inadequate MW management (MWM) (Mol and Caldas 2020; Nzediegwu and Chang 2020; Peng et al., 2020). Other people, including trash collectors, cleaners, and public space workers, are at a higher risk of being infected by the contact of MW (Saadat et al., 2020). This, combined with several other concerns from a health and environmental perspective, increases the need for effective management of MW (Cesaro and Pirozzi 2020; Klemeš et al., 2020; Ouhsine et al., 2020) with some research groups have had already suggested ways to manage MW during COVID-19 pandemic (Ma et al., 2020; Peng et al., 2020; Wang et al., 2020; Yu et al., 2020).

Several studies showed the essentiality for the public to have the knowledge, a positive attitude, and acceptable practices when MWM is concerned pre COVID-19; however, limited researchers investigated PPE-related waste disposal during COVID-19. A study conducted by a research group in Bangladesh used a pre-designed survey that targeted 1,303 locals to test whether they possessed the knowledge, attitudes, and practices essential for MWM during COVID-19. Results demonstrated that masks and gloves were the dominant protective equipment used with only half of the participants (49.35%) properly disposing of their masks and gloves in bins that were set apart from trash cans found at home and common areas (54.56 and 75.6%, respectively) (Islam et al., 2020). Researchers in Nepal investigated the satisfaction level of household waste management in Nepalese homes through a survey. Results found that a majority of the 512 participants (62.3%) were dissatisfied with the current waste management system (Acharya et al., 2021).

Although it is widely known that healthcare facilities produce a large amount of MW, the waste produced by the public is overlooked. The management of contagious waste in hospitals is different from that in public places managed by municipalities. The public usage of masks and gloves during daily activities goes to trash bins as municipal wastes. Municipal waste is the waste generated from households as a result of all stages of human activities whilst medical waste is any solid waste that is produced from healthcare facilities, including syringes, human tissues, chemicals, plastics, disposable devices, radioactive waste, blood, and urine samples (Pruss et al., 1999; OECD/Eurostat 2017). The inappropriate management of either municipal or medical waste impacts human health and the environment through soil and water contamination, air quality, climate, land use, and landscape.

It is important to note that the municipality has no dedicated collection and disposal of masks and gloves in the study area. Moreover, the infectious wastes from daily public usage are generally discarded in trash bins and containers. This mixed with municipal waste will find its final destination in the landfill. However, the contagious garbage (masks and gloves from medical workers and COVID-19 patients' daily usage) is collected as infectious waste by the MWM companies, ultimately incinerated or autoclaved and landfilled. Since there are limited studies carried out to assess AAP of the public towards COVID-19 waste management (COVWM), a study aimed at assessing the AAP toward COVWM among the public is urgently needed. This is necessary for taking additional steps in making MWM a social and ethical responsibility of the public to collect, store, manage, and dispose of the COVW safely and effectively to reduce the risk of spreading COVID-19 and protect the environment.

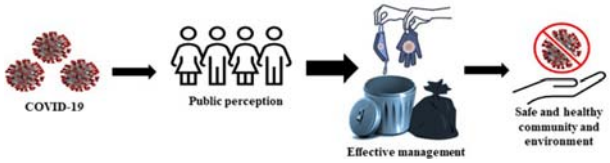

Figure 1. Graphical illustration of the public perception regarding the wastes generated during COVID-19 pandemic.

In KSA, the transportation, handling, and disposal of MW being managed by licensed, contracted companies. Some of these companies are Saudi Gulf Company for Environmental Protection (SEPCO), Enjaz Company, and Saad Trading and Construction (Department of Medical Waste Management). The current practices for disposal include incineration or autoclave disinfection and landfill. The status of MWM was previously assessed in a novel study conducted in Eastern Province hospitals and healthcare centers, in which it was found that the average generation rate of MW for hospitals and healthcare centers was 640.74 (±0.59), and 0.598 (±0.119) tons/year respectively. Also, results showed that the average MW generation rate was 0.51 kg/bed/day and 1.66 kg/patient/day (Alagha et al., 2018).

During the partial and full lockdowns, there were discrepant attitudes among the public on how to discard the mask and gloves after daily activities. Therefore, the present study aims to assess AAP regarding gloves and face masks generated in the environment during the COVID-19 pandemic in Eastern Province, KSA as shown in Figure 1. The other goal is to determine the correlation between perception and attitude regarding contagious waste management. The current study targets neither healthcare nor municipal workers, but the community attitude towards MWM. Other studies targeting healthcare and municipal workers are under preparation by our research group.

The paper is organized as follows: Section 2 illustrates the methods used in this study. Section 3 shows the results and discussion of the study. Finally, section 4 concludes this study. This research was carried out in the Eastern Province of KSA during the period of 15 July 2020 to 17 August 2020.

2. Methods

2.1. Design of study

A cross-sectional study was conducted amongst 572 respondents of the public community of the Eastern Province region in the KSA. Several studies across the world have concluded that a correlation exists between perception and attitude with contagious waste management; therefore, the primary goal of this study is to prove that this correlation is also present during COVID-19 in the Eastern Province of KSA. The study was conducted in a period of one week from 24 June to 1 July, 2020, using a pre-constructed survey that was shared using various online platforms, including social media. The survey was designed based on literature, available national and international guidelines, including WHO guidelines for medical waste management (Chhabra et al., 2019; Karki et al., 2020; Ma et al., 2020; WHO 2020, 2020a). The survey was self-administered and conducted using QuestionPro® with an option for the respondents to choose either Arabic or English language due to the diversity of the community in the Eastern region of the KSA. The survey consisted of two parts, the first of which contained questions concerned with the socio-demographic characteristics of the participants (age, gender, marital status, education level, profession), while the second part focused on the AAP of participants regarding COVW. The results were then collected and performed using Statistical Package 25 for the Social Sciences SPSS® (IBM®, SPSS® Statistics, Armonk, NY, USA).

Table 1. Demographic profile of participants (N = 572).

Characteristics	Categories	Frequency (N)	Percentage (%)
Age (years)[1]	<18	5	0.87
	18–24	144	25.17
	25–34	134	23.43
	35–44	134	23.43
	45–54	90	15.73
	55–64	60	10.49
	>65	5	0.87
Gender	Male	258	45.03
	Female	314	54.97
Marital Status	Single	202	35.25
	Married	342	59.86
	Divorced	15	2.62
	Widowed	6	1.05
	Prefer not to say	7	1.22
Educational Level	High School	76	13.26
	Diploma	40	6.98
	Bachelor	352	61.61
	Master	67	11.69
	Doctorate	37	6.46
Profession	Education	110	19.2
	Engineering	193	33.68
	Banking	5	0.87
	Health worker	28	4.89
	Medical doctor	6	1.05
	Management	95	16.58
	Others	135	23.73

[1] Mean age in years ±SD = 36.123 ± 1.357.

2.2. Statistical analysis

SPSS was utilized to analyze, elucidate, and explain the variation and trends in the collected data. In the current study, mean, median, standard deviation, and variance, together with Kurtosis and Skewness, were obtained for the data collected from the customized questionnaire. In addition to that, the correlation matrix is obtained using Pearson correlation analysis, where a two-tailed test for the survey results is performed.

2.3. Ethical approval

This article does not contain any studies with human participants performed by any of the authors. The approval of the participants was taken before the start of data collection.

3. Results and discussions

Up until the day of submitting this work, there has not been any published study that addresses the assessment of AAP of the public regarding COVW, even though the effective management of used gloves, face masks, and disposable handkerchiefs in communities play a vital role in preventing the spread of COVID-19. Also, the assessment of AAP will dramatically support governments to successfully cope with the unexpected massive number of generated wastes resulting from the community use of personal preventive equipment, thus suggesting efficient and safe guidelines for crisis treatment of such wastes. Table 1 shows the sociodemographic profiles of 572 participants with a 100% response rate which is statistically sufficient to reach the study goals.

3.1. Awareness of the participants regarding COVID-19 wastes

The awareness of participants was assessed based on six categories, AW1 to AW6 as shown in Table 2. Results revealed that the mean and median are identical with a value of 2 for AW1 which is related to the definition of biomedical waste, while the Skewness value is zero and the Kurtosis has a high value of 29.10. This indicates that the correspondent answers are divided consistently into the options provided, and their responses showed a typical Gaussian distribution, where 510 (97%) of the participants were aware of the definition of biomedical waste, which is the waste generated from hospital activities, including prevention, treatment, and diagnostic items. However, 9 (2%) of the participants believed that biomedical waste is the waste generated from households, and 8 (2%) were unaware of the correct definition.

A similar trend is observed regarding the most appropriate way to dispose of biomedical waste (AW5), where 501 (95%) of the participants responded that biomedical waste should be disposed of by collection in special bins and handed to certified hazardous-waste-management-companies or specialists. 12 (2%) responded that biomedical waste should be treated as municipal wastes and sent to landfills. Also, among all, 14 (3%) did not know the proper method of disposing of biomedical wastes. It is clear from the results that this study presented a high level of public awareness regarding general biomedical waste and its method of disposal. Results obtained from this study contrast those recently reported when the knowledge and attitude of the community people of Kathmandu, Nepal were assessed where 26.3% of community people had inadequate knowledge regarding healthcare waste (Karki et al., 2020). The results also disagreed with those in (Sidhu and Kaur, 2016) where a below-average level of knowledge regarding biomedical waste management was observed. One possible reason for that is the noticeable difference between the educational levels of respondents in both studies.

When comparing the awareness of participants regarding the existence of well-known, accessible, published regulations and guidelines for collection and disposal of general biomedical waste, the 75th percentile of the responses fall below the answer 3 “do not know” for question AW2. In contrast, the 25th and 5th percentile of the responses fall below answer 1, which shows the shift of answers towards answer 3. Here, there were 212 (32%) of the participants did not know if there are regulations for the collection and disposal of biomedical waste in their regions. However, 315 (59%) selected answer 1, which indicated that there were well-known, accessible, and published regulations for the collection and disposal of MW, while 45 (9%) of the participants believed that no regulations exist.

Table 2. Awareness about COVID-19 wastes management (N = 572).

Awareness about	Mean	Median	Standard Deviation	Variance	Skewness	Kurtosis	Percentiles		
							25	50	75
AW1. The definition of MW	2.000	2.000	0.177	0.031	0.000	29.097	2	2	2
AW2. The regulations of MW collection and disposal	1.72	1.00	0.913	0.833	0.573	-1.557	1	1	3
AW3. The applicability of MW management rules, guidelines, and technologies for COVID-19 wastes in hospitals and medical centers	3.58	4.00	0.916	0.839	-0.499	0.303	3	4	4
AW4. The procedures followed to dispose COVID-19 wastes	3.49	4.00	1.086	1.180	-0.611	-0.123	3	4	4
AW5. The most appropriate way to dispose biomedical waste	2.00	2.00	0.221	0.049	0.277	17.619	2	2	2
AW6. The proper ways to dispose COVID-19 wastes	1.33	1.00	0.606	0.367	1.684	1.646	1	1	2

With regards to COVID-19 waste management AW3 and AW4, only 74 (14%) of all participants strongly agreed that the hospitals and medical centers in the region are equipped with the necessary information, guidelines, and technologies to manage the wastes produced during COVID-19 pandemic (AW3), where 223 (42%) agreed, while 177 (34%) were neutral. Also, there were only 16% among all participants who strongly agreed that they were aware of the procedures followed to discard used gloves, masks, and disposable handkerchiefs during COVID-19 pandemic (AW4), with 39% agreeing, 29% neutral, 9% disagreeing, and only 7% strongly disagreeing. The histogram distributions for AW3 and AW4 of study participants are shown in Figure 2 (a) and (b), respectively. Both distributions show a similar trend where the mean values are 3.49 and 3.58, respectively, with both curves being a little skewed right with skewness values of 0.49 and 0.61, respectively.

For the proper way of disposing of used masks, gloves, and disposable handkerchiefs during COVID-19 pandemic (AW6), 388 (74%) choose to separately collect those gloves, masks, and handkerchiefs in dedicated containers and manage them as MW. 100 (19%) of the participants have chosen to dispose of them in municipal waste bins (75th percentile), while 39 (7%) of the respondents were not sure how they should be properly disposed of. Figure 3 shows the distribution for the study responses regarding the proper way of disposing of used masks, gloves, and disposable handkerchiefs generated during COVID-19 in the environment. As noted, the responses are skewed left toward collecting the COVW in a dedicated container and managing them as biomedical waste.

The high level of awareness regarding COVWM may result from the fact that most of the study participants considered that the waste produced from used gloves, face masks, and disposable handkerchiefs during COVID-19 is MW Figure 3. In the same vein, WHO has reported that the masks used in communities, in areas that have reported cases of COVID-19 should be treated as infectious wastes. On the other hand, before the COVID-19 pandemic, previous studies conducted among nursing and healthcare workers staff have shown an appreciable lack of knowledge regarding MW rules (Chawla et al., 2016; Panneerselvam 2016; Chhabra et al., 2019), the appropriate storage, segregation, and management (Ramokate and Basu 2009; Chhabra et al., 2019).

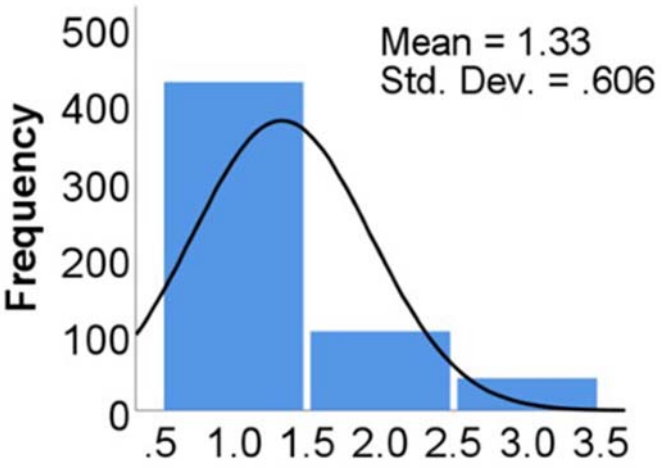

Figure 3. Distribution of participants perceptions regarding the proper way to dispose used masks, gloves, and disposable handkerchiefs generated during COVID-19 pandemic (Mean = 1.33, Median = 1.00, and Skewness = 1.684).

3.2. The attitude of the participants toward COVID-19 wastes

The attitude of the participants towards COVWM was positive in this study. On assessing participants' attitude towards the classification of COVW (AT1), Table 3 shows that the 25th, 50th, and 75th percentile of the responses fall below to answer 1, which indicates that the gloves, masks, and disposable handkerchiefs generated during COVID-19 pandemic are considered MW. 64 (13%), and 61 (12%) have classified COVW as municipal waste (second answer) and do not know (third answer), respectively.

The position of the study population towards the sufficiency and efficiency of COVWM measures taken by municipalities to prevent the spread of COVID-19 (AT2) showed that 107 (19%), 214 (38%), 129 (22%), 91 (16%), and 31 (5%) of the participants respectively strongly agreed, agreed, were neutral, disagreed, and strongly disagreed that COVWM measures taken by the municipalities to protect public health during the pandemic were sufficient and efficient. In response to the public attitude regarding the inappropriate disposal of COVW in the environment (AT3), 225 (39%) of the participants agreed, 110 (19%) strongly agreed, 99 (17%) do not know, 99 (18%) disagreed, and 39 (7%) strongly disagreed on the question whether they have usually faced people who inappropriately disposed of used gloves and masks in the environment.

Table 3 shows that the responses for AT2 and AT3 follow a similar trend where the mean values are 3.48 and 3.47, respectively, and variance values are 1.259 and 1.393 while both distributions are skewed right. This demonstrates that most of the participants have shown a negative attitude regarding the inappropriate disposal of COVW in the environment. Other studies conducted on general MWM showed that the attitude towards MWM was positive as most participants considered that poor waste management is a critical health issue (Ramokate and Basu 2009; Gursangeet and Amandeep, 2016; Chhabra et al., 2019). Most recent studies showed negative (Karki et al., 2020) or unfavorable (Woromogo et al., 2020) attitudes of respondents towards MWM.

The less acceptable attitude was noticed regarding the attitude of the participants toward attending training courses (AT4) on COVWM as there were only 243 (46%) of the overall participants who agreed and showed their eagerness to attend such training courses. Also, among all participants, a low percentage (15%) strongly agreed that the medical waste from hospitals and medical centers is being managed by trained people in the region (AT5), while 36% agreed, 39% did not know, 6%

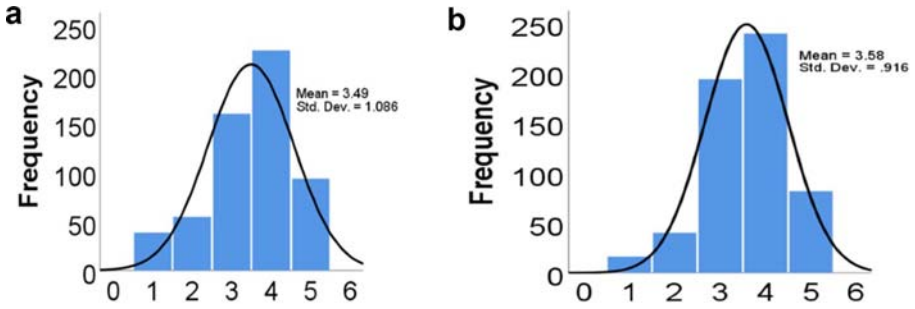

Figure 2. (a) Distribution of participants perceptions regarding the procedures followed to dispose COVID-19 wastes (Mean = 3.49, Median = 4, and Skewness = -0.611). (b) Distribution of the participants perceptions regarding the applicability of MW management rules, guidelines, and technologies for COVID-19 wastes in hospitals and medical centers (Mean = 3.58, Median = 4.00, and Skewness = -0.499).

Table 3. Attitude towards COVID-19 wastes management (N = 572).

Attitude towards	Mean	Median	Standard Deviation	Variance	Skewness	Kurtosis	Percentiles		
							25	50	75
AT1. The classifications of COVID-19 pandemic wastes	1.34	1.00	0.667	0.445	1.725	1.443	1	1	1
AT2. The sufficiency and efficiency of CWM measures taken by municipalities to prevent the spread of COVID-19	3.48	4.00	1.122	1.259	-0.462	-0.592	3	4	4
AT3. The inappropriate disposal of COVID-19 wastes	3.47	4.00	1.180	1.393	-0.511	-0.706	3	4	4
AT4. The importance of participating in a special dedicated training on COVID-19 wastes management	1.88	2.00	0.894	0.799	0.228	-1.713	1	2	3
AT5. The level of experience and training of the healthcare workers that manage medical wastes in hospitals and training centers	3.53	4.00	0.947	0.896	-0.464	0.319	3	4	4
AT6. The consideration of the effective disposal of COVW as a collective responsibility of the community	4.46	5.00	0.794	0.630	-1.949	4.843	4	5	5

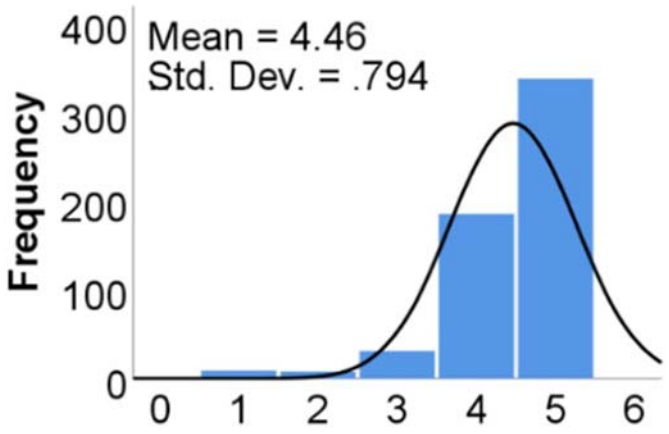

Figure 4. Distribution of the community attitudes towards the consideration of effective disposal of COVW as a collective responsibility of the community, responses were skewed right towards strongly agree with Mean = 4.46, Median = 5.00, and Skewness = -1.949).

disagreed, and 4% strongly disagreed. This may be a result of most participants (56%) believing that they can obtain information regarding COVWM wastes management through news and online resources.

One of the most encouraging results was the participants' attitude (59% strongly agreed, 32% agreed) towards considering the effective disposal of COVW, including used face masks, gloves, and disposal handkerchiefs as a collective responsibility for every person of the community (AT6). As noticed in Figure 4, the distribution curve for study population responses is skewed right where the 50th and 75th percentile of the participants' answers were below 5, meaning that majority of responses were skewed towards and strongly agreed with the effective disposal of wastes generated from COVID-19 pandemic including used masks, gloves, and disposal handkerchiefs, and thus protecting the environment as a collective responsibility for every person in the community. This positive attitude is shown to be significantly correlated with the high level of awareness among the study population regarding the hazardous issues associated with the inappropriate disposal of COVW.

3.3. The practice of the participants regarding COVID-19 wastes

Table 4 shows the results for the assessment of practices of participants regarding COVWM. Results revealed that most of the respondents, 402 (76%), have disposed of used gloves, masks, or disposable handkerchiefs in cars or household bins (PR1). When the public practices were assessed regarding the disposal of COVW in a special garbage bag (PR2), the 50th and 75th percentile of the responses fall below the option 4 "agree", where there were only 22% who strongly agreed, option 5, that they usually dispose of their used masks, gloves and disposable handkerchiefs generated during COVID-19 pandemic in a special or separate garbage bag. However, other responses were distributed as 35% agreed (option 4), 12% were neutral (option 3), 20% disagreed (option 2), and 11% strongly disagreed (option 1). This practice shows that many of the participants were completely aware of the proper way to dispose of COVW according to WHO (2020) guidelines which state that the generated wastes form COVID-19 should be disposed of in strong and closed black bags before the final disposal through municipal waste. Despite this good practice, there was a somewhat negative practice wherein PR1, 76% of the participants have thrown gloves or faced masks in their cars or in household trash bins which is significantly correlated ($r = 0.258$, $p = 0.000$) with that 44% of the participants did not normally find dedicated places in public to dispose of used gloves and face masks (PR3), while they were outside their homes during the allowed time to roam. Table 4 shows that the public responses regarding the attendance of special training for COVWM (PR4) have shown a high positive Skewness value of 2.73, which indicates that the answers are shifted right towards response "No", while 51 (10%) participants only have experienced a special training on COVWM.

3.4. Correlation analysis between AAP of participants regarding COVID-19 wastes

Table 5 show the correlation analysis between AAP of the community towards used face masks, gloves, and disposable handkerchiefs generated in the environment during COVID-19. Results showed a significant correlation ($r = 0.293$, $p < 0.0001$) between the public awareness regarding the regulations of MW collection and disposal (AW2) and their attitude regarding the level of experience and training

Table 4. Practice regarding COVID-19 wastes management (N = 572).

Practice regarding	Mean	Median	Standard Deviation	Variance	Skewness	Kurtosis	Percentiles		
							25	50	75
PR1. The disposal of COVID-19 wastes in cars or household bins	1.24	1.00	0.430	0.185	1.193	-0.578	1	1	1
PR2. The disposal of COVID-19 wastes in a special garbage bag	3.36	4.00	1.320	1.741	-0.390	-1.105	2	4	4
PR3. The disposal of COVID-19 wastes in dedicated containers in public places	2.78	3.00	1.255	1.575	0.100	-1.080	2	3	4
PR4. The attendance of a special training for COVID-19 wastes management	1.90	2.00	0.297	0.088	-2.713	5.380	2	2	2

Table 5. Two-tailed Pearson Correlation between public attitude, awareness and practices.

		AW1	AW2	AW3	AW4	AW5	AW6	AT1	AT2	AT3	AT4	AT5	AT6	PR1	PR2	PR3	PR4
AW1	*r*	1	-0.032	.097*	-0.027	.089*	-0.016	-0.030	0.070	0.033	0.055	-0.042	0.050	-0.046	0.067	-0.016	-0.033
	p		0.439	0.020	0.516	0.033	0.698	0.480	0.093	0.425	0.188	0.320	0.235	0.273	0.108	0.708	0.429
AW2	*r*	-0.032	1	-.092*	-.093*	0.065	.125**	0.076	-0.049	-0.046	.107*	-.189**	0.019	-0.064	-0.058	-0.046	.100*
	p	0.439		0.028	0.026	0.118	0.003	0.069	0.248	0.271	0.011	0.000	0.642	0.125	0.163	0.274	0.017
AW3	*r*	.097*	-.092*	1	.210**	0.033	-0.046	-.085*	.279**	.154**	-0.014	.293**	.096*	0.057	.140**	.196**	-.106*
	p	0.020	0.028		0.000	0.429	0.274	0.043	0.000	0.000	0.733	0.000	0.022	0.176	0.001	0.000	0.011
AW4	*r*	-0.027	-.093*	.210**	1	0.015	-.123**	-.127**	.214**	.331**	-0.023	.113**	.104*	.242**	.438**	.187**	-.149**
	p	0.516	0.026	0.000		0.725	0.003	0.002	0.000	0.000	0.585	0.007	0.012	0.000	0.000	0.000	0.000
AW5	*r*	.089*	0.065	0.033	0.015	1	-0.022	-0.008	0.057	-0.060	-0.016	-0.009	-0.039	0.009	0.002	0.015	-0.048
	p	0.033	0.118	0.429	0.725		0.607	0.848	0.176	0.153	0.709	0.831	0.350	0.822	0.968	0.713	0.252
AW6	*r*	-0.016	.125**	-0.046	-.123**	-0.022	1	.328**	0.015	-0.032	.141**	-0.021	-0.045	-.099*	-.103*	0.024	.100*
	p	0.698	0.003	0.274	0.003	0.607		0.000	0.722	0.443	0.001	0.617	0.278	0.018	0.013	0.566	0.017
AT1	*r*	-0.030	0.076	-.085*	-.127**	-0.008	.328**	1	0.048	-0.005	.083*	-0.068	-.088*	-0.033	-0.037	0.029	.115**
	p	0.480	0.069	0.043	0.002	0.848	0.000		0.254	0.899	0.046	0.103	0.035	0.432	0.373	0.485	0.006
AT2	*r*	0.070	-0.049	.279**	.214**	0.057	0.015	0.048	1	.101*	0.061	.143**	.095*	0.067	.203**	.321**	0.079
	p	0.093	0.248	0.000	0.000	0.176	0.722	0.254		0.015	0.146	0.001	0.024	0.110	0.000	0.000	0.060
AT3	*r*	0.033	-0.046	.154**	.331**	-0.060	-0.032	-0.005	.101*	1	-0.075	.107*	.132**	.120**	.281**	.203**	-.153**
	p	0.425	0.271	0.000	0.000	0.153	0.443	0.899	0.015		0.074	0.010	0.002	0.004	0.000	0.000	0.000
AT4	*r*	0.055	.107*	-0.014	-0.023	-0.016	.141**	.083*	0.061	-0.075	1	0.048	-0.046	0.014	0.002	0.021	.188**
	p	0.188	0.011	0.733	0.585	0.709	0.001	0.046	0.146	0.074		0.250	0.275	0.732	0.957	0.613	0.000
AT5	*r*	-0.042	-.189**	.293**	.113**	-0.009	-0.021	-0.068	.143**	.107*	0.048	1	0.017	0.053	.109**	.110**	0.025
	p	0.320	0.000	0.000	0.007	0.831	0.617	0.103	0.001	0.010	0.250		0.678	0.209	0.009	0.008	0.557
AT6	*r*	0.050	0.019	.096*	.104*	-0.039	-0.045	-.088*	.095*	.132**	-0.046	0.017	1	0.053	.198**	0.050	0.021
	p	0.235	0.642	0.022	0.012	0.350	0.278	0.035	0.024	0.002	0.275	0.678		0.209	0.000	0.228	0.615
PR1	*r*	-0.046	-0.064	0.057	.242**	0.009	-.099*	-0.033	0.067	.120**	0.014	0.053	0.053	1	.239**	.169**	-.141**
	p	0.273	0.125	0.176	0.000	0.822	0.018	0.432	0.110	0.004	0.732	0.209	0.209		0.000	0.000	0.001
PR2	*r*	0.067	-0.058	.140**	.438**	0.002	-.103*	-0.037	.203**	.281**	0.002	.109**	.198**	.239**	1	.258**	-0.072
	p	0.108	0.163	0.001	0.000	0.968	0.013	0.373	0.000	0.000	0.957	0.009	0.000	0.000		0.000	0.087
PR3	*r*	-0.016	-0.046	.196**	.187**	0.015	0.024	0.029	.321**	.203**	0.021	.110**	0.050	.169**	.258**	1	-0.039
	p	0.708	0.274	0.000	0.000	0.713	0.566	0.485	0.000	0.000	0.613	0.008	0.228	0.000	0.000		0.356
PR4	*r*	-0.033	.100*	-.106*	-.149**	-0.048	.100*	.115**	0.079	-.153**	.188**	0.025	0.021	-.141**	-0.072	-0.039	1
	p	0.429	0.017	0.011	0.000	0.252	0.017	0.006	0.060	0.000	0.000	0.557	0.615	0.001	0.087	0.356	

*Correlation is significant at the 0.05 level (2-tailed, **. Correlation is significant at the 0.01 level (2-tailed), ***r***: Pearson Correlation, ***p***: Sig. (2-tailed).

of the healthcare workers that manage medical wastes (AT5) in hospitals medical centers in the region. All parameters were tested using Pearson correlation at 0.05 two-tailed significant level. Some of the correlations were found to be significantly correlated at the 0.01 significant level as shown in Table 5.

These encouraging results show that the public is aware of the procedures for COVW disposal, and they are following the proper practice for disposal. The awareness of the public regarding the applicability of MWM rules, guidelines, and technologies for COVW in hospitals and medical centers has shown an extremely strong correlation with many attitudes and practices, including; the sufficiency and efficiency of COVWM measures taken by municipalities to prevent the spread of COVID-19, the inappropriate disposal of COVW, the level of experience and training of the healthcare workers that manage medical wastes in hospitals and training centers, the disposal of COVW in a special garbage bag, and the disposal of COVW wastes in dedicated containers in public places.

This significant correlation ($r = 0.279$, $p < 0.0001$) also indicates that the public had a positive attitude (AT2) regarding those measures taken by regional municipalities (AW3) to reduce the spread of coronavirus.

Also, the awareness and knowledge of the community regarding the procedures followed to dispose of COVW has shown an extremely strong correlation with the sufficiency and efficiency of COVWM measures taken by municipalities to prevent the spread of COVID-19, the inappropriate disposal of COVW, where this affects their practices towards the disposal of COVW in cars or household bins, the disposal of COVW in a special garbage bags, the disposal of COVW in dedicated containers in public places, and their eagerness to the attendance of special training for COVWM. Another extremely strong correlation was noticed between the awareness of the community members regarding the proper ways to dispose of used face masks, gloves, and handkerchiefs generated during COVID-19 and their attitudes and practices towards the classifications of such wastes as a MW that should be separately collected in dedicated containers and managed as MW.

Moreover, the community attitudes towards the sufficiency and efficiency of COVWM measures taken by municipalities to prevent the spread of COVID-19 was extremely correlated with their practice regarding the disposal of COVW, including; used gloves, masks, and disposable handkerchiefs in a special garbage bags and the availability of dedicated containers in public places to dispose of COVW. Moreover, the community's attitudes regarding the inappropriate disposal of used gloves and masks in the environment have a significant effect on their practices and eagerness to join a special training course on COVWM.

3.5. Correlation analysis between AAP and participants' characteristics

Multi-correlational analysis (Table 6 and Table S1) between participants demographics (gender, educational level, and profession) vs. awareness, attitude, and practice have been analyzed.

Gender shows a significant correlation with AW2 ($r = 0.169$, $p = 0.0001$), AW6 ($r = 0.158$, $p = 0.0001$). This indicates that the majority of participants have no idea of the availability of regulations for the collection and disposal of biomedical waste in their region. In addition to that, it shows a significant correlation with AT1 ($r = 0.081$, $p = 0.053$), AT2 ($r = 0.108$, $p = 0.01$), and AT4 ($r = 0.084$, $p = 0.046$). Furthermore, gender also appears to have a significant correlation with PR4 ($r = 0.115$, $p = 0.006$). The percentile analysis shows that the 25th quartile corresponds to males, whereas 50th and 75th quartile refers to female participants. This indicates that there is a correlation between female participants and getting special training for COVID-19's BWM.

A significant but negative correlation trend has been found between education level (high school, diploma, bachelors, masters, doctorate) and various survey questions of awareness, attributes, and practice. For instance, practice shows negative correlation with PR2 ($r = -0.164$, $p = 0.0001$) and PR3 ($r = -0.138$, $p = 0.001$). This may indicate an inverse proportional relation between education level and practice of disposal of masks, gloves during COVID-19 pandemic in a special/separate garbage bag. That means as the educational level goes to a higher degree, the disposal of medical waste goes too strongly disagrees with practice (PR2).

Table 6. Gender, educational level, and profession correlations with awareness, attitude, and practice.

	Study Questions	Correlation/ Significance	Gender	Education Level	Profession
Awareness	AW1	*r*	0.04	-0.06	.106*
		p	0.344	0.151	0.011
	AW2	*r*	.169**	-.166**	0.078
		p	0.0001	0.0001	0.062
	AW3	*r*	-0.055	-0.042	0.071
		p	0.191	0.322	0.091
	AW4	*r*	-0.019	-0.028	0.047
		p	0.647	0.505	0.265
	AW5	*r*	0.062	-0.015	0.001
		p	0.139	0.727	0.975
	AW6	*r*	.158**	-.177**	.135**
		p	0.0001	0.0001	0.001
Attitude	AT1	*r*	0.081	-.116**	.099*
		p	0.053	0.005	0.018
	AT2	*r*	.108**	-.174**	.101*
		p	0.01	0.0001	0.016
	AT3	*r*	-0.047	-0.036	0.076
		p	0.262	0.384	0.071
	AT4	*r*	.084*	-0.069	.110**
		p	0.046	0.098	0.009
	AT5	*r*	0.018	0.002	0.003
		p	0.672	0.956	0.949
	AT6	*r*	0.01	0.024	-0.011
		p	0.806	0.572	0.796
Practice	PR1	*r*	-0.024	0.068	-0.023
		p	0.563	0.104	0.591
	PR2	*r*	0.069	-.164**	.134**
		p	0.101	0.0001	0.001
	PR3	*r*	0.041	-.138**	.083*
		p	0.322	0.001	0.047
	PR4	*r*	.115**	-0.054	0.033
		p	0.006	0.199	0.425

*Correlation is significant at the 0.05 level two-tailed. **. Correlation is significant at the 0.01 level two-tailed. N: 572, ***r***: Pearson Correlation, ***p***: Sig. two-tailed.

The participant profession (such as education, engineering, banking, health worker, or medical doctor) shows a significant correlation with awareness such as AW1 ($r = 0.006$, $p = 0.011$) with the majority of participants do not know a specific definition of BMW. This indicates that more awareness campaigns are needed to improve community awareness on this matter. It also shows a significant correlation with AT4 ($r = 0.110$, $p = 0.009$), which indicates that the majority of participants are willing to attend training on COVID-19 biomedical waste management.

There is very limited research in the literature that investigates public perception and attitude towards PPE waste disposal. However, the results of this study are consistent with the few papers available. As is the case with our study, an investigation in Bangladesh (Islam et al., 2020) found that residents and citizens had to the proper awareness, attitude, and practice of proper PPE disposal. Women were also found to have better practices than the male respondents. On the contrary, when education and profession were involved, our results were inconsistent with the study as education proved to have an inversely proportional relationship with proper disposal, while despite the profession, individuals did not exhibit a proper knowledge of what BMW is.

The results also do not corroborate with those found in Guyana and Nigeria (Nzediegwu and Chang 2020). The respondents in this study

exhibited good awareness and practice for proper disposal of PPE; however, in 60.9% and 71.5% of households in Guyana and Nigeria, respectively, PPE was found to be mixed with general solid wastes indicating poor disposal of PPE.

4. Conclusion

This paper brings a novel study of community members' awareness, attitudes, and practices regarding managing used face masks, gloves, and disposal handkerchiefs generated in the environment during the COVID-19 pandemic. It is recognized that the effective management of such obtrusive wastes will significantly protect the community against the indirect infection and protect the environment against a substantial amount of long-lasting, plastic-based, or infectious trash including used masks, gloves, and disposable handkerchiefs which may end up in ocean or landfill once inappropriately discarded. The current study shows that the adequate level of community perception is associated with their favorable attitudes and thus resulted in proper and environmentally friendly practices to dispose of wastes generated during COVID-19 pandemic, and thus save the environment against such parasitical wastes. Also, it is an inspiring community attitude that most participants considered the effective disposal of wastes generated during COVID-19 as teamwork and collective responsibility for every person of the community. However, some undesirable practices still exist, including throwing used face masks and gloves in cars and household trash bins and the inappropriate disposal of COVID-19 wastes in public places where the current study participants condemned this practice. As only a small number of participants have strongly agreed that trained people manage the COVID-19 wastes in hospitals and medical centers, community education and training programs on the available policies and guidelines of COVWM are urgently required.

Declarations

Author contribution statement

Abdul-Hakeem Alomari: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Omer Aga: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Wrote the paper.

Lola El Sahmarany: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Mariam Hegazi: Contributed reagents, materials, analysis tools or data; Wrote the paper.

Latifah Almulla: Performed the experiments.

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Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

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