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Assessment of knowledge, attitude and practice about biomedical waste management among healthcare staff of Fasa educational hospitals in COVID-19 pandemic

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1. Introduction

Biomedical waste (BMW) refers to the waste produced by medical centers, research centers, and laboratories during diagnosis, treatment or immunization of human or animal. Hazardous wastes are considered a major threat to health and the environment [1]. The incidence of the SARS-CoV-2 virus, which accounts for COVID-19 disease, has attracted global attention since December 2019. The acute respiratory syndrome began in Wuhan, in Hubei Province, China. It soon spread all over the world [2]. The world health organization (WHO) and the disease control and prevention center (CDC) called for an urgent quarantine and the use of personal protective equipment (PPE) such as facemask, gloves, gown, and face shield [3]. Due to the highly contagious nature of the disease, BMW is a spot point of the virus residing and spreading [4,5]. Improper management and exposure to produced infectious waste from positive patients can easily infect healthcare staff such as, doctors, nurses, waste pickers, and visitors [6].

BMW composition during the pandemic, except for the production of large quantities of plastic in PPE, was more or less the same as the pre-pandemic era. Yet, BMW production was significantly increased [7]. In Indian hospitals, the quantity of BMW increased from 25 to 349 tons/day during May–July, and it is predicted to have doubled during August–October [8]. A local council in Sydney reported increasing a 35% in biomedical waste due to the COVID-19 pandemic [9]. The massive production of BMW during the pandemic has become a new threat to public health and environment [10]. Managing the BMW produced during the pandemic needs special attention because BMW acts as a vector for SARS-CoV-2 and it can enhance spreading of this virus. In fact, the novel SARS-CoV-2 can survive for 72 h outside of its host organism on the surface of a facemask [11,12]. Hospitals, as one of

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the important centers for curing patients in this period, need special attention. Knowing whether the healthcare staff is sufficiently aware about the generated COVID-waste or not? How do they react when faced to this waste? Therefore, investigating of BMW management for controlling the pandemic spread during COVID-19 in hospitals is essential.

The health staff’s satisfactory knowledge, attitude, and practice about the nature of the generated waste can be effective in managing waste safely [13]. BMW sustainable management requires establishing a waste management unit, allocating financial resources and manpower, holding regular trainings, monitoring, evaluating, and continuously improving conditions [6]. Installation of marked and lined collection containers for infectious wastes with trained workers were the main method that used in many countries. In order to disinfect wastes, using disinfectants and sorting the waste for 9 days is necessary [6]. In South Korea, the foremost principle for maintaining the healthcare staff’s safety and health is familiarity with waste management, especially BMW, which reduces the infection risk [14]. A proper waste management has managed to reduce costs in healthcare facilities and increase profitability in German hospitals [15]. Wuhan has improved its management process by closing up the municipal waste disposal site and investing more in disinfecting the waste produced during the pandemic [16]. BMW is collected from marked containers, transported, and disposed of by specially designed vehicles and well-trained workers [17].

Healthcare staff should become environmentally sensitive; they should advocate positive changes for managing the waste produced in the pandemic. In other words, maintaining quality patient care and worker safety should be considered in parallel to waste management. Producing exclusively educational videos or publicly available videos about proper waste management in the COVID-19 and holding webinars by environmental experts can help improve the healthcare staff’s knowledge, attitude, and practice [18]. Regularly monitoring, putting up visual guides on proper separation and handling COVID patient’s wastes can improve the practice of the health staff as well as patients’ visitors. Intense educational interventions, interactive discussions, and brainstorming in Saudi Arabia managed to improve the healthcare staff’s knowledge and attitudes during the MERS CoV outbreak [19]. Using popular social networks such as WhatsApp as the dissemination platform can be useful for waste training courses. Zarepour et al. [20] reported that educational interventions were necessary to explore the determinants of waste management and improve the health staff’s knowledge and practice. The findings reported by Mousavi et al. [21] showed a statistically significant association between the hospital staff’s knowledge and practice of BMW management with demographic variables. The knowledge and practice showed to be better and higher in female participants than the male. The findings reported by Abdul Salam [22] in Egypt showed that a major problem in waste management was misconceptions about the nature of BMW.

Fasa is the third-largest city in Fars Province in Iran, with a population of 110,835. Fasa is the fourth most populated city in this province. The city has two hospitals affiliated with Fasa University of Medical Sciences named Valiasr and Shariati hospitals with 980 staff in different wards. As there had been no research on the health staff’s knowledge, attitude, and practice about BMW management, we decided to conduct the present study during the COVID-19 pandemic to explore the health staff’s knowledge, attitude, and practice in the two hospitals about managing the BMW generated in the pandemic. The study hypothesis was that the knowledge, attitude, and practice of the healthcare staff of educational hospitals of Fasa about BMW management during the COVID-19 era is satisfactory. In the end, several solutions were suggested to manage the waste produced during the COVID-19 pandemic properly.

2. Materials and methods

2.1. Setting and sample size

The present descriptive-analytical study was cross-sectional in type. It was conducted in autumn 2021 on 251 medical staff in two hospitals affiliated with Fasa University of Medical Sciences. After the required permissions were gained from the research deputy at Tarbiat Modares University of Medical Sciences, an ethical code (IR.MODARES.REC.1400.225) was assigned to the project. In the target hospitals, 980 people worked as the healthcare staff. The inclusion criteria were working in either Valiasr or Shariati hospitals affiliated with Fasa University of Medical Sciences, having at least one year of work experience, and providing an informed consent to participate in the research. The sampling was convenient in type. At first, the purpose of study was explained to the participants (see the objective of study in supplementary files). The questionnaire was created using Google forms, and the hyperlink was sent to the social networks. We did not have any information about the participants because the questionnaires were anonymous. The participants were assured of the confidentiality of the information they provided. They were provided with the online version of the questionnaire survey. Cochran’s formula (Eq. (1)) was used to estimate the required sample size.

\[
n = \frac{Z^2 \cdot p \cdot q}{d^2}
\]

\[
+ \frac{p \cdot q}{n} = 1
\]

Which, n is the sample size, Z is the statistics for a level of confidence (1.96 at 95% confidence interval), d is the margin of error (0.05), N is the population size (980), P is expected prevalence (0.5), and q is 1-p (0.5). The sample size was eventually estimated at 275. After posting the questionnaire to the social network, 282 persons sent over their responses. We reviewed the submitted questionnaires, and only 251 provided complete answers, and the rest were omitted because the return rate was lower than 40%. The responses were not reliable. Therefore, we conducted the analysis using 251 completed questionnaires in the following.

2.2. Data collection instrument and procedure

For data collection, a questionnaire survey was used with 4 sections (supplementary file). The first section consisted of 8 demographic information questions (age, gender, education, work experience, employment type, position, workplace, and history of infection with the virus). Knowledge, attitude, and practice as the three main sections of the questionnaire were divided into 4 parts. Knowledge questions were divided into 4 categories: BMW classification and acronym (7 questions), waste separation and color-coding system (4 questions), waste storage and collection scheme (8 questions), and waste disposal management (9 questions). The 20 questions for attitude were categorized into: BMW classification and acronym (1 question), waste separation and color-coding (4 questions), waste management (11 questions), and waste training and their role (4 questions). The 32 questions for the practice section were divided into: waste color-coding and separation (8 questions), waste collection and transportation (7 questions), waste management, especially in the COVID-19 outbreak (6 questions), and waste training plan in the COVID-19 outbreak (12 questions).

For the knowledge section, a correct answer received 2 points, and an incorrect answer received 0. If the no comment answer was selected, 1 point was assigned. The attitude section enquired about the waste team management, waste container color-coding, segregation, holding the waste management training program, and the role of hospital environmental health, which were scored on a five-point Likert scale (ranging from strongly agree (5) to strongly disagree (1)). The practice section investigated waste segregation, container labeling, waste
transportation, container color-coding system, use of separation guide posters, waste collection programs, waste storage, and waste disposal. The scoring of the practice section was similar to the knowledge section. The maximum knowledge, attitude, and practice scores were 54.0, 97.0, and 64.0, respectively (if all the questions were answered correctly). In order to explore the healthcare staff’s knowledge, attitude, and practice of BMW, the total score of each section was categorized as follows. If the sum of knowledge and practice scores ranged between 0.0 and 15.0, the overall level was interpreted as very poor; if it ranged between 16.0 and 30.0, it was interpreted as poor to moderate. If the score was between 31.0 and 45.0, it was considered average to satisfactory; if the score was over 46.0, it was taken as satisfactory to excellent. If the sum of attitude score was between 0.0 and 25.0, the overall level was interpreted as very poor; if it ranged between 25.0 and 50.0, it was interpreted as poor to moderate. If the score was between 50.0 and 75.0, it was considered average to satisfactory; if the score was over 75.0, it was taken as satisfactory to excellent.

This researcher-made questionnaire was developed based on a review of the related literature [23]. 10 environmental health experts (Ph. D. degree) reviewed the questionnaire to test the validity. It was submitted to 20 healthcare staff and environmental health experts in hospitals to substantiate the reliability, and the results were obtained. The reliability coefficient was assessed by Cronbach’s alpha method. Cronbach’s alpha coefficients of the demographic section, knowledge, attitude, and practice were 0.99, 0.93, 0.95, and 0.94, respectively. The overall Cronbach’s alpha coefficient of the questionnaire was 0.953. As the value was above 0.7, the measurement instrument was perceived as highly reliable.

2.3. Data analysis

The data were analyzed in SPSS24. At first, the normality of data was tested using Kolmogorov-Smirnov and Shapiro-Wilk tests. The results showed that the data distribution was normal and, therefore, parametric tests could test the relationship between variables. To test the relationship of two-level demographic variables with knowledge, attitude, and practice, T-test analysis was used, and for multi-level variables, one-way analysis of variance (ANOVA) was run. The significance level was set at $p < 0.05$.

3. Results

3.1. Participants’ demographic information

Table 1 summarizes the participants’ demographic information. The results show that out of 251 participants in the study, 56.2% were female ($n = 141$), and 43.8% were male ($n = 110$). In terms of age, the largest group of participants in this study belonged to the two age-groups of 20–30 and 31–40 with a frequency of 41.0% and 48.2%, respectively. The majority of participants held a Bachelor’s degree (49%). Next stood the diploma, associate degree, Ph.D., Master’s degree, and others, with percentages of 27.9, 7.2, 6, 4.8, and 5.2, respectively. In terms of employment, 31.5% worked on a fixed term (being employed temporarily); 23.9% were employed on a permanent basis, and 44.6% held other part-time jobs. As for work experience, most participants had either 1–5 or 6–10 years’ work experience with a frequency of 57% and 23.1%, respectively. About 89.2% of the participants were working in hospitals affiliated with Fasa University of Medical Sciences. 50.6% of the participants were working in the non-COVID ward, while 49.4% were working in the COVID ward. Concerning their position, most of the participants (32.3%) were service workers. Next stood the other miscellaneous work positions held in hospitals (26.7%). Nurses ranked third (25.1%), and radiologists ranked fourth (24.0%). About 50.2% of the participants had a history of SARS-CoV-2 virus infection, and about 90.2% claimed they had been vaccinated against COVID-19.

Table 1

| Variable          | Level          | Frequency | Frequency percent |
|-------------------|----------------|-----------|-------------------|
| Gender            | Female         | 141       | 56.2              |
|                   | Male           | 110       | 43.8              |
| Age               | 20–30          | 103       | 41.0              |
|                   | 31–40          | 121       | 48.2              |
|                   | 41–50          | 26        | 10.4              |
|                   | 51–60          | 1         | 0.4               |
| Education         | Diploma        | 70        | 27.9              |
|                   | Associate degree | 18       | 7.2               |
|                   | Bachelor’s degree | 123     | 49.0              |
|                   | Master’s degree | 12        | 4.8               |
|                   | Ph.D.          | 15        | 6.0               |
|                   | Other          | 13        | 5.2               |
| Employment        | Permanent      | 60        | 23.9              |
|                   | Fixed term     | 70        | 27.5              |
|                   | Other          | 112       | 44.6              |
| Work experience   | 1–5            | 143       | 57.0              |
|                   | 6–10           | 58        | 23.1              |
|                   | 11–15          | 31        | 12.4              |
|                   | 16–20          | 7         | 2.8               |
|                   | 21–25          | 10        | 4.0               |
|                   | 26–30          | 2         | 0.8               |
| Workplace         | Educational hospital | 227   | 89.2             |
|                   | Clinic affiliated with university | 24 | 10.8 |
| Ward              | COVID          | 124       | 49.4              |
|                   | Non-COVID      | 127       | 50.6              |
| Work position     | Physician      | 7         | 2.8               |
|                   | Nurse          | 63        | 25.1              |
|                   | Lab work       | 7         | 2.8               |
|                   | Radiologist    | 24        | 9.6               |
|                   | Intern         | 2         | 0.8               |
|                   | Maintenance worker | 81    | 32.3              |
|                   | Other          | 67        | 26.7              |
| COVID-19 infection| Yes            | 128       | 50.2              |
|                   | No             | 125       | 49.8              |
| COVID-19 vaccination| Yes          | 228       | 90.8              |
|                   | No             | 23        | 9.2               |

3.2. The health staff’s knowledge, attitude and practice

The minimum, maximum, and mean scores of knowledge were 16.0, 54.0, and 38.8 ± 6.1, respectively. For attitude, these scores were 55.0, 97.0, and 83.0 ± 8.8, respectively. For practice, these were 13.0, 64.0, and 47.5 ± 14.5. The participants’ mean knowledge, attitude, and practice scores were 38.8 ± 6.1, 83.0 ± 8.8, and 47.5 ± 14.5, respectively. It shows that the participants enjoy a moderate to satisfactory level of knowledge and satisfactory to the excellent level of practice. The test results showed that the study hypothesis was accepted. According to Table 2, the lowest knowledge score was in BMW classification and acronyms, and waste disposal management (6.5 out of 14 and 11.4 out of 16). The lowest attitude score was that of BMW classification and acronyms, and waste disposal management (2.5 out of 5 and 45.7 out of 54). The lowest practice score was that of waste management and plans, especially in COVID-19 (6.9 out of 12 and 15.1 out of 24).

Based on the T-test results in Table 3, it can be observed that there is a significant relationship between gender and knowledge ($p = 0.006$). It shows that female and male health staff differ significantly in their knowledge of BMW management, with the mean scores of 37.6 and 33.9, respectively. Statistically significant relationships were also found between the health staff’s knowledge and the ward and their workplace ($p = 0.001$ and $p = 0.001$, respectively). Those who were working in the COVID ward in educational hospitals showed to have a better knowledge of waste management. There was also a statistically significant association between knowledge and the history of COVID-19 infection ($p = 0.015$). Those with no history of COVID-19 infection had a better knowledge of waste management.

As for attitude, T-test results showed statistically significant
results show that women, those working in COVID ward, and workplaces (p = 0.007, p = 0.011, and p = 0.043, respectively). These results show that women, those working in COVID ward, and in educational hospitals had a higher attitude towards BMW management.

However, there was no statistically significant difference between the attitudes of the staff with and without a history of COVID-19 infection (p = 0.831). The practice-related results showed statistically significant relationships between demographic variables such as gender, ward, and workplace and the participants’ practice (p = 0.023, p = 0.000, and p = 0.001, respectively). Therefore, women, the staff working in the non-COVID ward, and those working in educational hospitals did better in waste management during the pandemic.

Table 4 shows the ANOVA results of comparing knowledge, attitude, and practice across demographic values with more than two levels. As it can be observed, statistically significant differences were found in the healthcare staff’s knowledge of BMW management across different levels of education (p = 0.000). Those with a Ph.D. and a Master’s degree had significantly higher mean scores of knowledge. As for the type of employment, those who worked on a fixed term (i.e., being employed

| Domain | Variable | Level | Mean score | SD | P |
|--------|----------|-------|------------|----|---|
| Knowledge | Education | Diploma | 35.8 | 8.8 | 0.000 |
|          |          | Associate degree | 42.5 | 10.7 | |
|          |          | Bachelor’s degree | 37.9 | 12.4 | |
|          |          | Master’s degree | 50.8 | 11.8 | |
|          |          | Ph.D. | 53.3 | 7.7 | |
|          |          | Other | 32.3 | 6.4 | |
|          | Type of employment | Permanent | 36.0 | 10.3 | 0.001 |
|          |          | Fixed term | 41.1 | 12.3 | |
|          |          | Other | 38.6 | 11.4 | |
|          | Position | Physician | 52.4 | 3.2 | 0.000 |
|          |          | Nurse | 35.6 | 9.5 | |
|          |          | Lab work | 42.1 | 11.2 | |
|          |          | Radiologist | 36.1 | 10.8 | |
|          |          | Intern | 48.7 | 9.9 | |
|          |          | Maintenance worker | 34.5 | 7.3 | |
|          |          | Other | 45.0 | 13.5 | |
|          | Attitude | Education | 62.8 | 8.8 | 0.049 |
|          |          | Associate degree | 74.1 | 7.8 | |
|          |          | Bachelor’s degree | 76.3 | 10.1 | |
|          |          | Master’s degree | 84.8 | 11.4 | |
|          |          | Ph.D. | 89.8 | 7.0 | |
|          |          | Other | 69.8 | 4.8 | |
|          | Type of employment | Permanent | 63.0 | 8.9 | 0.000 |
|          |          | Fixed term | 84.2 | 10.9 | |
|          |          | Other | 80.8 | 8.2 | |
|          | Position | Physician | 92.3 | 2.1 | 0.047 |
|          |          | Nurse | 84.1 | 10.5 | |
|          |          | Lab work | 79.3 | 10.6 | |
|          |          | Radiologist | 86.2 | 5.7 | |
|          |          | Intern | 89.4 | 3.0 | |
|          |          | Maintenance worker | 63.3 | 8.3 | |
|          |          | Other | 69.6 | 9.9 | |
|          | Practice | Education | 44.1 | 12.6 | 0.000 |
|          |          | Associate degree | 50.2 | 17.3 | |
|          |          | Bachelor’s degree | 54.4 | 18.4 | |
|          |          | Master’s degree | 58.2 | 17.9 | |
|          |          | Ph.D. | 60.5 | 10.1 | |
|          |          | Other | 39.9 | 9.6 | |
|          | Type of employment | Permanent | 49.0 | 17.2 | 0.000 |
|          |          | Fixed term | 57.3 | 19.7 | |
|          |          | Other | 47.1 | 16.1 | |
|          | Position | Physician | 60.1 | 10.1 | 0.000 |
|          |          | Nurse | 54.3 | 15.2 | |
|          |          | Lab work | 52.1 | 15.9 | |
|          |          | Radiologist | 53.5 | 12.8 | |
|          |          | Intern | 57.7 | 11.3 | |
|          |          | Maintenance worker | 45.6 | 11.9 | |
|          |          | Other | 40.4 | 20.8 | |
temporarily) showed to have a significantly higher knowledge than others ($p = 0.001$). Concerning one’s position, physicians and medical interns showed significantly higher knowledge scores than others ($p = 0.000$). The healthcare staff’s attitude showed to diverge significantly across education levels, position, and type of employment ($p = 0.049$, $p = 0.000$, and $p = 0.047$, respectively). Similarly, the practice scores were significantly different in education levels, employment types, and positions ($p = 0.000$). Those with a Master’s and Ph.D. degrees, those working on a fixed term, physicians, and interns did waste management better than others.

Pearson correlation coefficient test was run to explore the correlation between the healthcare staff’s knowledge, attitude and practice (Table 5). As it can be observed, there is a statistically significant relationship between these three variables about BMW management ($p = 0.000$). As for the strength of association, the findings showed a very strong positive relationship between knowledge and practice ($r = 0.725$) and a strong positive relationship between attitude and practice ($r = 0.547$). The relationship between knowledge and attitude was positive and moderate ($r = 0.471$).

4. Discussion

4.1. The healthcare staff’s knowledge, attitude and practice about BMW

COVID-19-related waste needs special attention, as this disease has prevailed globally since 2019 in an unprecedented manner. Its unknown dimensions and many mutations ever since have increased the risk of infection. Thus, the infected waste, which can largely transmit the disease, needs special care. Studies have shown that the virus can survive on solid surfaces for long: for example, 72 h on plastic, 48 h on stainless steel, and 24 h on paper and cardboard [24]. Therefore, a delay of more than 72 h in collecting the infectious waste can increase the chances of virus transmission, especially to waste collection workers. The quality of infectious waste has changed due to the widespread use of PPE, especially masks and gloves by patients, visitors, and the medical staff [25].

Our findings showed that women’s knowledge, attitude, and practice about BMW management were higher and better than males. The female’s knowledge, attitude, and practice scores against males were 37.6 vs. 33.9, 84.2 vs. 80.9, and 49.4 vs. 44.8. The results showed that females are in a better situation in all three dimensions. The results are consistent with the findings reported by Zarepour et al. [20]. This difference between males and females can be due to women’s higher responsibilities in the family, more obsession with the surrounding environment [26]. The highest participation rate was in younger people with less than 5 years’ work experience. Based on the results, people in the age range of 20–40 years were made up more than 89.2% of the participants, and people with a work experience of 1–5 years had the highest participation rate. Increasing age was accompanied by a decreasing level of knowledge, which can be due to the less use of the Internet and social networks to acquire information. Jalal et al. [27] showed that the knowledge of BMW management was greater in young people, 20–30 years of age, with one year of work experience during the COVID-19 pandemic. The greater participation of young people in the study is due to their interest and familiarity with filling the electronic forms. Also, people with lower work experience are more inclined to participate in various job-related courses due to improving their resume status for employment. It seems that most of the participation of these two groups in the present study is due to these two reasons.

The present findings showed that those working in educational hospitals had higher knowledge, attitude, and practice about BMW management than those working in the clinics. This is due to the greater susceptibility of employees working in the educational hospitals than the clinics and the more availability of waste management equipment [28]. The other reason is related to environmental health experts in educational hospitals. Also, those working in the COVID ward have higher knowledge and attitude about BMW management than the non-COVID ward, but there is no significant difference between their practices. This matter may be related to the lack of infrastructure for waste management facilities in the investigated hospitals. Jalal et al. [27] also showed that the highest level of knowledge was found in the medical staff working in public hospitals. The results also showed that participants without a history of COVID infection were more aware of the BMW generated, indicating that they took more care of themselves and paid more attention to virus transmission. Education is an influential factor in health-promotion behaviors, and employees with a Ph.D. and Master’s degrees had better BMW management. Considering that the maximum scores of knowledge, attitude, and practice were 54.0, 97.0, and 64.0, respectively, in people with Ph.D. and master’s degrees, their average scores of knowledge were 53.3 vs. 50.8, for attitude were 89.8 vs. 84.8, and in the case of practice were 60.5 vs. 58.2. These results indicate that these two groups were in a good position in three aspects. It can be due to their having passed HSE courses during their academic life [29].

Regarding the type of employment and job position, the study results showed that fixed-term individuals were better in knowledge, attitude, and practice than permanently employed persons. Their knowledge, attitude, and practice scores in fixed-term people compared to permanently employed persons were 41.1 vs. 36.0, 84.2 vs. 63.0, and 57.3 vs. 49.0, respectively. As those working on fixed terms are younger, they may pay more attention to BMW management. The lower participation rate of employees with permanent jobs or those with more work experience can be because these people are more assured of their job position. Emdadifar et al. [30] showed that the type of employment, due to its effect on employee accountability, can significantly affect the success of organizational programs. Sepahvand et al. [31] also stated that people with permanent jobs, due to more work pressures, felt more stress at work than those working on a fixed term. Physicians and medical interns were in a higher position than other occupational groups in three aspects of knowledge, attitude, and practice. For example, physicians’ knowledge, attitude, and practice scores were 52.4, 92.3, and 60.1 out of maximum 54.0, 97.0, and 64.0, respectively. As reported by Sengodan and Amruth [32] in India, physicians showed to have a satisfactory level of knowledge and practice in waste management. Physicians’ higher knowledge and practice are related to having biomedical waste management courses in their curriculum. Also, they spent more time in the practical field than other occupational groups.

The Pearson correlation coefficient showed a strong positive relationship between the staff’s knowledge and practice about BMW management. It shows that participants who had a good knowledge of waste management also had a good practice; and those who had a good attitude toward BMW also had a good practice. In other words, knowledge and attitude had significantly influenced BMW management. This finding is consistent with Akkajit et al. [33]. Their research findings showed there were positive and significant correlations between knowledge and attitude ($r = 0.464$), knowledge and practice ($r = 0.396$), and practice and attitude ($r = 0.519$). They concluded that a higher knowledge is related to a positive attitude and good practice about BMW. Dulai et al. [23] showed that 43.2% and 35.8% of the healthcare staff had excellent and good knowledge about BMW, respectively. Studies in Saudi Arabia [19] showed that the majority of healthcare staff had sufficient knowledge of the control measures of COVID-19, which
may be related to the training they received to highlight their role in this field. Pazokinejad and Salehi [34] showed that healthcare workers have a lower level of knowledge, attitude, and practice. Differences in sample selection, the prevalence of COVID-19, cultures, and geographical environments can be the reasons for divergent findings.

Despite the satisfactory level of staff’s knowledge, attitude, and practice, there are certain issues with waste management in the long-term. Instances are unfamiliarity with BMW acronyms and waste management plans and also a lack of training courses during the pandemic. If the health staff can properly distinguish between the types of generated waste and know the BMW acronyms, they can show a better waste separation and management behavior. More than half of the staff considered waste management as a waste of time and reckoned neither they nor their colleagues played any significant role in waste management. It can be concluded that the healthcare staff should be trained to accept their role in waste management. In light of the present findings, it is deemed necessary to hold training courses on waste management, especially in the COVID-19 pandemic. These courses should regularly assess the healthcare staff’s knowledge, attitude, and practice about BMW management.

4.2. International measures to manage COVID-19 wastes

Due to the threatening nature of the SARS-CoV-2 virus, different countries have taken different measures to manage the BMW generated during the pandemic. Fasa hospitals represent healthcare providing centers in Iran, and how these hospitals manage BMW is not unlike other healthcare centers in the world. Thus, they are expected to have similar problems managing the generated waste. According to the results and field visits, the above-mentioned hospitals face several problems in waste management, especially during the COVID-19 pandemic. Due to the contagious nature of this virus and the possibility of its transmission through contaminated waste, exclusive collection bins are necessary. There were no separate bins in Fasa hospitals to collect PPE waste of visitors and healthcare staff. A well-organized training and awareness-raising course can improve waste management too. According to surveys, this course was not held for the health staff. The pictorial posters were not installed near the waste containers to guide people for waste separation. The waste produced in different wards was not labeled. Measures and strategies taken in other parts of the world for hospital waste management can be an appropriate guide for developing countries, as presented below.

Using separate bins is recommended for collecting contaminated masks and gloves in different parts of healthcare centers. Medical centers currently have a number of trash bins marked exclusively and put in certain places in hospitals to dispose of masks only [35]. Bangkok, for example, has placed special red bins labeled as “Used for face masks only” in clearly visible areas to prevent the theft of used or re-used face masks [36]. Using two-layered garbage bags is recommended to pack contaminated masks. These wastes are managed and disposed of as public BMW by a special personnel and a special waste management unit. These workers are required to use PPE such as long-sleeved robes, gloves, boots, masks, or shields [1,13].

It is recommended to label COVID-19 infectious waste generated by clinics, wards, examination rooms, and laboratories as “COVID Infectious Waste” [13]. It is necessary to disinfect COVID-19 waste at 121 °C for 110 min or store it at a high temperature (above 70 °C) for more than 5 minutes [37]. This process has been reported to be very effective in inactivating SARS-CoV-2. The disinfected bags should then be incinerated in less than 24 h [3]. It is suggested to collect and transfer hospital waste off-site using trained workers and special vehicles. The vehicle ID number or chassis number must be recorded for future controls [14]. A safe disposal of SARS-CoV-2 wastes is recommended in an environmentally-friendly manner. Priority goes to incineration at high temperatures because the virus will be extinguished at 100 °C for 3 min [38].

Due to the concurrence of the study with the COVID-19 outbreak, some of the limitations of this study are presented here. As the title of the manuscript shows, which lies in the scope of waste management, gathering data through an internet-based questionnaire instead of a paper-based survey is a measure of reducing waste. However, uploading the questionnaire link in the social network made it hard for older and more experienced staff to fill out the online survey. This is one reason for the low participation rate. The prevalence of COVID-19 and the involvement of healthcare staff in treating patients cause some staff to forget to complete the questionnaire. Thus, the authors had to remind the participants frequently. There were also initial strictures for coordination to obtain a license for questionnaire distribution. Many staff also affirmed that they had completed the questionnaire but had did not submit it because they had not experienced any online survey before. The lacking cooperation of social network administrators in pinning the survey hyperlink in groups and reminding members to complete it was another limitation of this study.

In addition to proper management of biomedical waste, control measures such as vaccination with approved and available vaccines, as well as division of the cities and countries into red and green zones, diagnostic tests such as real-time PCR, trained workers, and logistics are helpful for improving conditions [39,40].

5. Conclusion

The present study assessed the health staff’s knowledge, attitude, and practice about BMW in the COVID-19 pandemic in Fasa hospitals. The results showed statistically significant differences between the healthcare staff’s knowledge, attitude, and practice across demographic variables including gender, wards, workplaces, education, type of employment, and position. The general level of employees’ knowledge, attitude, and practice was moderate to satisfactory. However, several deficiencies were observed due to the lacking infrastructure and cohesive training courses. The results showed some deficiencies in waste acronyms, waste management, and training course related to the BMW during the pandemic. Due to the possibility of an epidemic in the future and the problems in the current waste management in Fasa hospitals, it is necessary to update the waste management program for emergencies. It is also necessary to hold systematic training courses to become familiar with the concepts of waste management for all healthcare staff.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cscee.2022.100207.

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