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Infectious medical waste management during the COVID-19 pandemic in public hospitals of West Guji zone, southern Ethiopia

Hailu Lemma*, Lechisa Asefa, Tesfaye Gemedà, Degefa Dhengesu

Department of Environmental Health Science, Institute of Health, Bule Hora University, P.O.Box 144, Bule Hora, Ethiopia

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ABSTRACT

Introduction: COVID-19 has swept through the world in a very short period; large volumes of medical waste are being generated in response to the pandemic. Hence, it is imperative to plan and develop evidence-based additional waste management systems.

Objective: To assess infectious medical waste management system during the COVID-19 pandemic in public hospitals of the West Guji zone, southern Ethiopia, 2020.

Methods: Institution-based cross-sectional study design was conducted from November 05-25/2020. To determine infectious medical waste generation rate, different color plastic buckets and bags was distributed to each ward of the hospitals. Then, its quantity was measured by using a calibrated weighing balance for seven consecutive days. An interviewer-administered questionnaire and an observational checklist were used to collect data related to the existing waste management system, and the knowledge, attitude and practice of waste handlers.

Result: The average infectious medical waste generation rate was determined to be 2.1 kg/bed/day and/or 0.57kg/patient/day. Besides, there was limited segregation of infectious medical waste at the point of generation. Mixed medical waste was collected and transported by using open plastic bin and burned in a brick incinerator or/and dumped in an open field. Moreover, about 42%, 44.6% and 64.8% of the waste handlers had adequate knowledge; a positive attitude and adequate practice respectively.

Conclusion: The average infectious medical waste generation rate is above the threshold value (0.2kg/bed/day) set by the WHO. Besides, its management was limited. There was also a gap in the knowledge and attitude of waste handlers towards infectious medical waste management during the COVID-19 pandemic.

1. Introduction

COVID-19 has swept through the world in a very short period, causing widespread concern for many countries.¹ Large volumes of medical wastes, such as personal protective equipment, are being generated in response to the pandemic.²

The study conducted in Hubei Province, People’s Republic of China, showed that the infectious medical waste generation was increased by 600% from 4 tons per day to 240 tons per day during the COVID-19 outbreak.³ This quickly overwhelmed existing medical waste transport and disposal infrastructure around hospitals.⁴ Especially in least developed countries, where there is no or very limited safe management of health care waste⁵; the outbreak of COVID-19 further exacerbates the already growing waste management challenges.⁶

In Ethiopia, as in many developing countries COVID-19 transmission and the number of COVID-19 patients were rising sharply within the past few months; and thus increasing demand for health services. These combined trends increase the amount of medical waste generated in the country.⁷

However, waste management across health institutions is still inadequate and received less attention.⁸ At the same time, there is very low attention is given to healthcare waste management (HCW) by healthcare administrators. So that, the impact of improper medical waste management on the health of healthcare waste collectors is assumed to be very high.⁹ Hence, it is imperative to plan and develop evidence-based additional waste management systems,¹⁰ to reduce the risk of COVID-19 transmission.

Therefore, this study will be aimed at filling this gap by providing important information on the amount of infectious medical waste generated, identify the gap in existing infectious medical management...
practices as well as knowledge, attitude and practice of healthcare waste handlers towards infectious medical waste management during the COVID-19 pandemic.

2. Methods and materials

2.1. Study area and period

This study was conducted in public hospitals of the West Guji zone, southern Ethiopia from November 5–25/2020. West Guji zone is one of the zones found in the Oromia regional state; which has one general hospital (Bule Hora general hospital), two primary hospitals (Melka Soda primary hospital and Kercha primary hospital) (Fig. 1), 42 health centers and 166 health posts. In these health institutions, there are about 860 health care providers and 478 health extension workers; that giving the service to the population of the catchment area.

2.2. Study design

Institutional-based cross-sectional study design was used to assess the infectious medical waste management system in public hospitals of West Guji zone.

2.3. Population

2.3.1. Source Population

The source populations were all public hospitals and their healthcare waste handlers found in the West Guji zone.

2.3.2. Study population

The study population was all public hospitals and their healthcare waste handlers found in the West Guji zone.

2.4. Inclusion and exclusion criteria

2.4.1. Inclusion criteria

☞ Health care waste handlers, who stayed in the study area for six months and above
☞ All specialty wards and medical-related departments including intensive care units will be included in the study

2.4.2. Exclusion criteria

☞ The study was excluded all administrative offices, kitchens and cafeterias because they do not give patient care services and infectious medical waste generation is not expected from this areas.

2.5. Data Collection Tools and Procedure

First, a walk-through inspection of all wards of the hospitals was conducted by the investigators to identify the type of waste generated with the different departments of the hospitals. To determine infectious medical waste generation rate, plastic buckets and plastic bags of different colors that meet WHO guidelines,4 were distributed to the different wards of each hospital. The buckets, safety box and plastic bags were labeled to indicate the different categories of infectious medical waste, the place of generation, date and time of collection. The waste characterization was done in following the national guidelines. Then, the quantity of infectious medical waste generated from each ward was measured using a calibrated weight balance for seven consecutive days. During data collection, data collectors were used gloves, masks, gowns and antiseptics to prevent infection.

The existing infectious medical waste management system practiced in each hospital and the knowledge, attitude and practice of healthcare waste handlers towards infectious medical waste management during the COVID-19 pandemic was investigated by using a pretested interviewer-administered questionnaire and observational checklist adapted from the United Nations Environmental Program (UNEP).13

The questionnaire of knowledge, attitude and practice domains
The weighing scale was calibrated before the actual measurements. Knowledge and practice responses were scored as either 1 or 0 points for correct and incorrect responses, respectively. Whereas, attitude questions responses were indicated with the three-point Likert type scale of measurement as “disagree”, “neutral” and “agree” and numerical values of 1, 2, and 3, respectively. Then, the mean scores were calculated and used as a cut of a point to categorize the knowledge, attitude and practice of the study participants as adequate knowledge, positive attitude, and adequate practice scores.

2.6. Study variables

2.6.1. Dependent variables

- Infectious medical waste generation rate
- Existing infectious medical waste management practice

2.6.2. Independent variables

- Socio-demographic factor
- Number of Patients
- Knowledge, attitude and practice of healthcare waste handlers

2.7. Data Analysis

The raw quantitative data of waste generation rate was edited, coded and entered into Epi-Data version 3.1. After the screening and correction of the data entry errors, the data was exported to Statistical Package for Social Science (SPSS) version 25 for analysis. The correlation analysis between infectious medical waste generation rate in each hospital and their total number of patient flow was tested by Pearson correlation coefficient (r).

Qualitative data from key informant interviews and observation was analyzed by theme. Thematic analyses of the data were conducted manually, by sorting and organizing information according to their thematic similarities and differences. Then, the information was categorized and studied to understand their relationships in the overall context of the study.

2.8. Data Quality Assurance

To assure the data quality, training was given to data collectors on how to use personal protective equipment and on data collection tools. The weighing scale was calibrated before the actual measurements started. An interview-administered questionnaire was pretested with a pilot survey of a similar study population at Yabello general hospital started. An interview-administered questionnaire was pretested with a pilot survey of a similar study population at Yabello general hospital before the actual data collection period. In addition, daily on-site supervision was made by the supervisors during the actual waste measurements.

2.9. Operational definitions

Basic infectious medical waste management service: Waste is safely segregated into at least three bins, and sharps and infectious waste are treated and disposed of safely.

Limited infectious medical waste management service: There is limited separation and/or treatment and disposal of sharps and infectious waste, but not all requirements for basic service are met.

No infectious medical waste management service: There are no separate bins for sharps or infectious waste, and sharps and/or infectious waste are not treated/disposed of safely.

Adequate knowledge: participants who correctly answered the knowledge-based questions greater than or equal to the mean knowledge score were considered as having adequate knowledge.

Inadequate knowledge: participants who answered the knowledge-related questions correctly less the mean knowledge score were considered as having inadequate knowledge.

Positive attitude: those participants who correctly responded to the attitude-related questions greater than or equal to the mean score were considered as having a positive attitude.

Negative attitude: those participants who answered the attitude-based questions less than the mean attitude score were considered as having a negative attitude.

Adequate practice: those participants who correctly answered greater than or equal to the mean score of the practice-related questions were considered as having an adequate practice.

Inadequate practice: those participants who correctly answered less than the mean score of the questions were considered as having an inadequate practice.

2.10. Ethical consideration

Ethical permission to undertake the study was obtained from Bule Hora University Research and Community Service Directorate. An official letter of cooperation was given to west Guji zone hospitals. Informed consent to participate in the study was obtained before conducting the interview.

3. Result

Patient flow: A total of 3101 patients visited all wards and outpatient departments of all public hospitals within a week, of which 840 (27.08%) of patients were admitted to the inpatient department and the remaining 2261 (72.9%) were seen at the outpatient department. The average daily total patient flow at inpatients, outpatients and overall in all hospitals were 119.99 ± 12.11, 323.12 ± 63.94 and 443.09 ± 75.36 respectively. More patients were visited at Bule Hora general hospital (215.14 patients/day) and fewer of patients was found in the Kercha (124.85 patients/day) and the Melka Soda primary hospitals (103.1 patients/day).

Infectious medical waste generation rate: The average infectious medical waste generation rate in all public hospitals of the west Guji zone was determined to be 0.57 kg/patient/day and/or 2.1 kg/bed/day. It was identified that a high amount of infectious medical waste was generated from Bule Hora general hospital (0.26 kg/patient/day), while the least amount was recorded at Melka Soda primary hospital (0.15 kg/patient/day) (Table 1).

Infectious medical waste generation rate by type of waste: The compositions of infectious medical waste generated in public hospitals of West Guji Zone were: infectious waste, sharps and pathological wastes (Table 1). The majority of these was infectious wastes (212.57 ± 10.95 kg/day (84.93%)), while the rests were a pathological waste (30.71 ± 38.89 kg/day (2.8%)), sharp wastes (8.71 ± 0.83 kg/day (1.6%)) (Fig. 2).

Comparison of infectious medical waste generation rate and patient flow: Pearson’s correlation coefficient (r) was used to test the existence of any bivariate correlation between the total number of patients and the amount of infectious medical waste generated from the public hospitals. Accordingly, there was a strong positive correlation between the total amount of infectious medical waste generated and total patient flow in the public hospitals (r = 0.91, p = 0.004).

3.1. Infectious medical waste management practices

Segregation practice: In all public hospitals, there was limited segregation of infectious medical waste into different categories by use of waste containers with a standard color coding and labeling at the point of generation. It was observed, different categories of medical wastes were deposited together in a non-standard color-coded plastic buckets and/or thrown away on the floor nearby the container (medical unit of Kercha primary hospital) (Fig. 3A). Moreover, a perforated plastic
Collection and transportation of waste: There was no structured and separated collection and transportation system for infectious medical waste in all public hospitals. It was observed; the mixed medical waste was collected and transported to the disposal place by using open plastic bucket (Fig. 4A). In addition, the waste was scattered on the floor in wards and on the road to disposal sites in all public hospitals (Fig. 4B and C).

Treatment and disposal practice: All public hospitals used a single chamber brick incinerator to dispose of the infectious medical waste without pre-treatment. In Bule Hora general hospital the incinerator was damaged and not functional (Fig. 5A), and the waste generated was disposed and burned in an open field (Fig. 5B). In addition, a placenta pit was used for the disposal of pathological waste in all public hospitals. But, it was not securely covered in Bule Hora general hospital and Kercha primary hospital (Fig. 5C).

Waste management guidelines and budget: Ethiopian Federal Ministry of Health prepared the National Healthcare Waste Management Guideline in 2008. But none of the hospitals used this guideline. In addition, there was no separate budget allocated for healthcare waste management in all public hospitals.

Training and safety device: In all public hospitals training was not given for healthcare waste handlers on healthcare waste management during this COVID-19 pandemic. It was observed that there were instances when waste collectors were cleaning the room without wearing personal protective equipment’s (i.e., safety boot, apron, etc) (Fig. 6A) and others were using surgical gloves for handling medical waste because of the unavailability of heavy-duty gloves (Fig. 6B). In addition, some of the waste handlers were not wearing masks and gloves while

| Hospitals                          | Infectious medical waste generation rate kg/patient/day | Infectious medical waste generation rate kg/bed/day |
|-----------------------------------|--------------------------------------------------------|-----------------------------------------------|
|                                  | Infectious waste | Sharps | Pathological waste | Total | Infectious waste | Sharps | Pathological waste | Total |
| Bule Hora General Hospital        | 0.22            | 0.0077 | 0.033            | 0.26  | 0.8              | 0.028 | 0.12             | 0.95  |
| Kercha Primary Hospital           | 0.14            | 0.0061 | 0.017            | 0.16  | 0.54             | 0.022 | 0.06             | 0.59  |
| Melka Soda Primary Hospital       | 0.123           | 0.006  | 0.021            | 0.15  | 0.457            | 0.021 | 0.07             | 0.55  |
| Total                             | 0.48            | 0.02   | 0.07             | 0.57  | 1.77             | 0.072 | 0.25             | 2.1   |
handling the waste (Fig. 6 C).

3.2. Knowledge, attitude, and practice of healthcare waste handlers

Socio-demographic characteristics of healthcare waste handlers: A total of 74 healthcare waste handlers that work in public hospitals of West Guji zone were participated in this study. Majority of the study participants (87.84%) were females and the left were males. From this 34 (45.9%) of them were married and 35.15% of them were single. Regarding the educational status of study participants, majority of them were learned only up to a secondary (9–12) educational level; while a few participants (8.1%) have a college diploma. The detail of the socio-demographic characteristics of the study participants is showed in Table 2.

Knowledge of healthcare waste handlers: In this study, only 31 (42%) of the healthcare waste handlers had adequate knowledge of infectious medical waste management during the COVID-19 pandemic. Even though most of them know that the hospitals were generating infectious medical wastes; about 29(39.2%) of them do not know whether the infectious medical waste was hazardous and also about 25(33.78%) of them do not identify the biohazard symbol. Details of the knowledge score of the study participants were showed in Table 3.

Attitude of study participants: Regarding the attitude of study participants, 33 (44.6%) of healthcare waste handlers have a positive attitude towards infectious medical waste management during the COVID-19 pandemic. About 16.2% of healthcare waste handlers were not agreed that infectious medical wastes can transmit COVID-19 infection and about 18.9% of healthcare waste handlers were not agreed that labeling waste containers can add any value to infectious medical waste management. The detail was indicated in Table 4.

The practice of waste handlers: In this study, majority 48 (64.86%) of the healthcare waste handlers had adequate practice scores. About 65 (87.8%) and 63 (85.13%) were always wearing heavy-duty gloves and face mask when handling waste respectively. In addition, the majority of the study participants 66 (89.2%), 57 (77.02%), and 52 (70.02%) used closed containers to transport different types of waste in separate way using the trolley/wheeled bin respectively. However, only 34 (45.9%) of them regularly clean reusable waste containers with disinfectant, and none of them used safety boots during handling waste and hand sanitizer.

![Fig. 5. The photo showing nonfunctional brick incinerator (figure A) and open dumping of mixed medical waste near incinerator in Bule Hora general hospital (figure B) and placenta pit with unsecure cover (figure C) of the West Guji zone, November 2020.](image1)

![Fig. 6. The photo shows the healthcare waste handlers cleaning the room without wearing the apron/gown and safety boot (figure A), using latex glove (figure B) and without wearing mask (figure B and C) in public hospitals of the West Guji zone, November 2020.](image2)

Table 2

| Socio demographic variables | Variable category | Number of study participants (%) |
|-----------------------------|-------------------|---------------------------------|
| Gender                      | Male              | 9 (12.16%)                     |
|                             | Female            | 65 (87.84%)                    |
| Age of respondents          | <25               | 19 (25.67%)                    |
|                             | 25–30             | 35 (47.3%)                     |
|                             | 30–35             | 14 (18.9%)                     |
|                             | >35               | 6 (8.1%)                       |
| Religion                    | Orthodox          | 26 (35.13%)                    |
|                             | Protestant        | 34 (45.9%)                     |
|                             | Muslim            | 14 (18.91%)                    |
| Marital status              | Single            | 26 (35.15%)                    |
|                             | Married           | 34 (45.9%)                     |
|                             | Divorced          | 14 (18.91%)                    |
| Educational level           | Primary (1–8)     | 18 (24.3%)                     |
|                             | Secondary (9–12)  | 50 (67.56%)                    |
|                             | Diploma/Certificate | 6 (8.1%)                |
| Work hours/day              | Less than 8 h/day | 18 (24.3%)                     |
|                             | 8 h/day           | 56 (75.67%)                    |
| Work experience             | 1–3               | 42 (56.76%)                    |
|                             | 3–5               | 20 (27.02%)                    |
|                             | >5                | 12 (16.21%)                    |
compared with a study conducted in the USA (2.79 kg/bed/day) and another study conducted in public hospitals of in the USA, which reported that most of the hospitals are segregating infectious waste from other medical waste. But similar non-compliance had been reported by different national studies conducted in public hospitals of Addis Ababa, Referral Hospital of Hawassa University, and Mizan Tepi University Teaching Hospital. This indicated that the implementation of medical waste segregation is a challenge in different healthcare facilities of Ethiopia.

Besides, there was no structured and separated collection and transportation system for infectious medical waste. It was observed; the mixed medical waste was collected and transported in an open and substandard waste container and the waste was scattered on the road to disposal sites. This may contribute to the risk of injury and infection for waste handlers, healthcare providers, patients and visitors.

In all public hospitals, a single chamber brick incinerator and/or dumping in an open pit, and burning in an open field were used to dispose mixed medical waste together without pretreatment. This was against the WHO and national guidelines, which recommended the infectious medical waste incineration at above 850 °C, for complete destruction of infectious agents and limit the risk of exposures waste workers, health workers, patients, and the community in general.

Thus, the current practices of infectious medical waste treatment and disposal technologies that found in all of the public healthcare facilities in the west Guji zone are not incorporate any air pollution control devices. This practice of infectious medical waste treatment and disposal system can result in the release of a wide variety of pollutants such as metals, acid gases, and suspended particulate matters; that poses a significant threat to public health and the environment.

### Table 3
The frequency distribution of healthcare waste handlers among each knowledge item question at the West Guji zone public hospitals, southern Ethiopia, November 2020.

| Variables                                                                 | Response options |
|--------------------------------------------------------------------------|------------------|
| Awareness regarding the generation of infectious medical waste from the hospital | Yes (91.8%) | No (6.7%) | Not sure (1.35%) |
| Aware of infectious medical waste need proper management                 | 73 (98.6%)       | 0         | 1 (1.35%)        |
| Aware of infectious medical waste cause health hazard                     | 62 (83.7%)       | 8 (10.8%) | 4 (5.4%)         |
| Aware of needle-stick or sharp injury is a concern                         | 64 (86.5%)       | 3 (4.05%) | 7 (9.45%)        |
| Knows that wearing personal protective equipment and hand washing can reduce the risk of COVID-19 infection | 65 (87.8%)   | 4 (5.4%) | 6 (8.75%)        |
| Aware of all infectious medical wastes are biologically hazardous         | 45 (60.8%)       | 2 (2.7%) | 20 (12.2%)       |
| Knows that the items that are potentially contaminated with body fluids are considered as infectious medical waste | 69 (93.2%)       | 3 (4.05%) | 2 (2.7%)         |
| Identification of color coding system for infectious medical wastes       | 56 (75.6%)       | 6 (8.1%) | 12 (16.2%)       |
| Recognize the label of biohazard symbol                                   | 49 (66.2%)       | 15 (20.3%) | 10 (13.5%) |
| Knows that the infectious medical wastes should be segregated into a different categories at the point of generation | 70 (94.6%)       | 3 (4.05%) | 1 (1.35%)        |
| Knows that the disinfection of infectious medical wastes can decrease the risk of COVID-19 transmission | 65 (87.8%)       | 2 (2.7%) | 7 (9.45%)        |
| Awareness regarding the transportation of infectious medical waste in a closed containers | 60 (81.1%)  | 4 (5.4%) | 10 (13.5%)       |
| Awareness regarding the storage of infectious medical wastes in a secured place before disposal | 53 (71.6%)       | 2 (2.7%) | 19 (25.6%)       |
| Aware of infectious medical waste disposal methods                        | 73 (98.6%)       | 0         | 1 (1.35%)        |

and/or alcohol after finished their work rather they only clean their hand with water.

### 4. Discussion
The average infectious medical waste generation rate in public hospitals of the West Guji zone was determined to be 2.1 kg/bed/day and 0.57 kg/patient/day. The result of this study was lower when compared with a study conducted in the USA (2.79 kg/bed/day) as mentioned in the WHO report and the study conducted in Bahrain 1.177 kg/patient/day. The higher infectious medical waste generation rate in developed countries may be due to the higher the per capita gross domestic product (GDP), the developed nation’s lifestyle needs a high supply and the provision of healthcare services tend to generate a higher amount of waste in healthcare facilities. But it was higher when compared with the WHO report of hazardous health care waste generation rate in low-income countries which is 0.2 kg/bed/day and another study conducted in public healthcare facilities in Bujumbura, Burundi 0.22 kg/patient/day, Municipal hospital of Ghana 0.39 kg/patient/day, and the local study conducted in public hospitals of Amara Regional State, 0.67 ± 0.13 kg/bed/day and 0.22 ± 0.13 kg/patient/day. The higher in average value of waste generation rate in this study could be speculated to the increase in transmission of the COVID-19 virus, which makes the use of personal protection equipment vital for healthcare workers, patients and visitors that may have possibility to increase the infectious medical waste generation rate.

Moreover, the study identified that there was limited segregation of infectious medical waste into different categories. This finding is inconsistent with the study conducted in different hospitals of the West Guji zone were not incorporate any air pollution control devices. This practice of infectious medical waste incineration at above 850 °C, for complete destruction of infectious agents and limit the risk of exposures waste workers, health workers, patients, and the community in general.

Thus, the current practices of infectious medical waste treatment and disposal technologies that found in all of the public healthcare facilities in the west Guji zone are not incorporate any air pollution control devices. This practice of infectious medical waste treatment and disposal system can result in the release of a wide variety of pollutants such as metals, acid gases, and suspended particulate matters; that poses a significant threat to public health and the environment.

### Table 4
Frequency distribution of study participants among each Likert item of infectious medical waste management during the COVID-19 pandemic in public hospitals of the West Guji zone, southern Ethiopia, November 2020.

| Variables                                                                 | Response options |
|--------------------------------------------------------------------------|------------------|
| Proper medical waste handling is an issue of concern during COVID-19 pandemic. | Agree (83.7%)    | Neutral (6.75%) | disagree (9.5%) |
| Safe infectious medical waste management needs a teamwork                | 61 (85.1%)       | 9 (12.16%)  | 4 (5.4%)        |
| COVID-19 can be transmitted through infectious medical wastes             | 62 (83.78%)      | 7 (9.45%)  | 6 (6.75%)       |
| HIV and HBV can be transmitted through infectious medical wastes          | 52 (70.2%)       | 12 (16.2%) | 10 (13.5%)      |
| Infectious medical wastes do not transmit any infectious disease          | 60 (81%)         | 9 (12.16%) | 6 (8.75%)       |
| Infectious medical waste should be segregated at the point of generation | 63 (85.13%)      | 3 (4.05%)  | 8 (12.2%)       |
| Infectious medical waste segregation can facilitate safe handling.       | 67 (90.5%)       | 0         | 7 (9.45%)       |
| Labeling waste containers do not add any value to safe infectious medical waste management | 14 (18.9%)  | 2 (2.7%) | 58 (78.4%)      |
| Safe disposal of infectious medical waste can prevent COVID-19 infection transmission | 71 (95.9%) | 0         | 3 (4.05%)       |
| Infectious medical waste disinfection can reduce the chance of contracting the COVID-19 infection | 59 (79.7%) | 7 (9.45%) | 8 (10.8%)       |
| Wearing PPE help to reduce the risk of COVID-19 infection.                | 72 (97.3%)       | 2 (2.7%)  | 0               |
| COVID-19 pandemic adds the extra burden of work on infectious medical waste management | 64 (86.5%) | 8 (10.8%) | 2 (2.7%)       |
| Infectious medical waste should be disinfected before disposal           | 61 (85.1%)       | 6 (8.1%)  | 8 (9.45%)       |
environment.

Furthermore, the medical waste handling is a hazardous activity that requires a high standard of training and skill especially during the COVID-19 pandemic. However, in this study it was identified that all public hospitals of West Guji zone doesn’t give any training for healthcare waste handlers on infectious medical waste management and safety measures during the COVID-19 pandemic. This may result a gap in knowledge among healthcare waste handlers toward a safe management of infectious medical waste. Besides, it was confirmed by this study that, only 42% of the healthcare waste handlers have adequate knowledge towards infectious medical waste management system. The result of this study was in line with the finding from Karnataka, India which reported that merely, 43% of the participants correctly knew the categorization of biomedical waste and its disposal in proper color-coded bins/bags. Similarly, the result of finding from the mentioned research showed that the inadequate level of knowledge is due to a low level of training particularly for the cleaning staff.

5. Conclusion

The infectious medical waste generation rate during the COVID-19 pandemic (2.1 kg/bed/day and/or 0.57 kg/patient/day) is above the threshold value of hazardous health care waste generation rate in low-income countries, as reported by the WHO, and its management was poor. There is also a gap in the knowledge and attitude of healthcare waste handlers towards infectious medical waste management systems. Thus, in order to prevent and control the transmission of coronavirus; all public hospitals of West Guji zone needs for further planning and improvement of the current infectious medical waste management system following the national and international guidelines.

Authors statement

Hailu Lemma: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Resources, Software, Validation, Writing - original draft, Writing - review & editing. Lechisa Asefa: Investigation, Resources, Supervision, Writing - review & editing. Tesfaye Gemeda and Degefa Dhengesu: Resources, Supervision, Writing - review & editing.

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Declaration of competing interest

None.

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References

1 Ed O, Ym A. Covid-19 and Challenges of Management of Infectious Medical Waste in Nigeria. A Case of Taraba State; 2020.
2 Ugom M. Managing Medical Wastes during the Covid-19 Pandemic in Nigeria. 2020:1–7.
3 Asian Development Bank A. Managing Infectious Medical Waste during the COVID-19 Pandemic. 2020:2019–2020.
4 Emmanuel J, Pierper U, Rusbrook P, et al. Safe Management of Wastes from Health-Care Activities. 2014.
5 WHO/UNICEF. Water, Sanitation and Hygiene in Health Care Facilities: Status in Low- and Middle-Income Countries. Geneva: World Health Organization; 2019.
6 Saadat S, Rawtani D, Mustanar C. Science of the total environment environmental perspective of COVID-19 [Internet] Sci Total Environ. 2020/728, 138870. https://doi.org/10.1016/j.scitotenv.2020.138870. Available from:.
7 Abebe MA. Study of Hazardous Biomedical Waste Management Practices and Development of Hazardous Biomedical Waste Management Guidelines in Addis Ababa. vol. 1. 2017:19–32, 8.
8 Yaze Teshiwal Deress, T MG, C KA. Healthcare waste management current status and potential challenges in Ethiopia : a systematic review [Internet] BMC Res Notes. 2019:1–7, https://doi.org/10.1186/s13104-019-4316-y. Available from:.
9 Martins MA, Pataca LCM, Santos E d S, et al. Generation of infectious waste during the COVID-19 pandemic: the case of a Brazilian hospital. Waste Manag Res. 2021:39 (10):1245–1255.
10 Alenayebu T, Worku A, Ansefa N. imedPub Journals Medical Waste Collectors in Eastern Ethiopia Are Exposed to High Sharp Injury and Blood and Body Fluids Contamination. 2016:1–10.
11 Schenckba CG, Wooldridge A, Humer N, Mavropoulos A, Silva C. COVID-19 PANDEMIC ISW A’S Recommendations. 2020. April.
12 Araz M, Meleko A, Tesfay T, Henok A. Araz Meleko, Abebe Adane. Assessment of health care waste generation rate and Evaluation of its management system in Mizan Tepi University Teaching hospital (MTUTh), Bench Maji zone, South west Ethiopia. Ann Rev Res. 2018;1(4), 555556, 2018,.
13 WHO. Overview of Technologies for the Treatment of Infectious and Sharp Waste from Health Care Facilities. 2019. ISBN 978-92-4-151622-8.
14 Torres AL. Practical Guideline for the Handling, Storage and Disposal of Covid-19 Infected Wastes, Including Personnel Protective Equipment. 2020:1–8.
15 Deres T, Jemal M, Girma M, Adane K. Knowledge , attitude , and practice of waste handlers about medical waste management in Debre Marks town healthcare facilities, northwest Ethiopia [Internet] BMC Res Notes. 2019:1–7, https://doi.org/10.1186/s13104-019-4174-7. Available from:.
16 Mohamed LF, Ebrahim SA, Al-thukair AA. Hazardous healthcare waste management in the Kingdom of Bahrain [Internet] Waste Manag. 2009;29(8):2404–2409. https://doi.org/10.1016/j.wasman.2009.02.015. Available from:.
17 Windfeld ES, Brooks MS. Medical waste management e A review. J Environ Manage [Internet]. 2015;163:98–108. https://doi.org/10.1016/j.jenvman.2015.08.013. Available from:.
18 WHO. WHO. Waste from health care Activities [Online], [cited 8 February 2018. Available from: http://www.who.int/mediacentre/factsheets/fs625/en/; 2016, 2016;(March).
19 Niyonzabo E, Chul Y, Daeseok J, Kijune K. Generation , management practices and rapid risk assessment of solid medical wastes : a case study in Burundi [Internet] J Mater Cycles Waste Manag. 2019. https://doi.org/10.1007/s10163-019-00854-0, 0 (0):0. Available from:.
20 Wiatte S, Nooni IK, Nianta MS, Diaba SKF SK. Assessing Clinical solid waste management Strategies in Sunyani Municipality, Ghana- evidence from three healthcare facilities. Int J Environ Pollut Res. 2015;3(3):32–52.
21 Tesfahun E. Healthcare Waste in Ethiopia a Study of Waste Generation , Composition and Management in the Amhara National Regional State. 2015. Ethiopia.
22 Klangpin P, Harding AK, Harding AK. Medical Waste Treatment and Disposal Methods Used by Hospitals in Oregon , Washington , and Idaho Medical Waste Treatment and Disposal Methods Used by Hospitals in Oregon. 2011:2247. Washington , and Idaho.
23 Debere MK, Gelaye KA, Alamdo AG, Trifa ZM. Assessment of the health care waste generation rates and its management system in hospitals of Addis Ababa, Ethiopia, 2011. BMC Publ Health. 2013:13(1):1–9.
24 Abebe S. Health Care Solid Waste Generation and its Management in Hawassa Referral Hospital of Hawassa University , Southern , Ethiopia. vol. 6. 2017:126–132, 5.