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Solid health care waste management practice in Ethiopia, a convergent mixed method study

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Abstract

Introduction Healthcare waste is any waste generated by healthcare facilities that is considered potentially hazardous to health. Solid healthcare waste is categorized into infectious and non-infectious wastes. Infectious waste is material suspected of containing pathogens and potentially causing disease. Non-infectious waste includes wastes that have not been in contact with infectious agents, hazardous chemicals, or radioactive substances, similar to household waste, i.e. plastic, papers and leftover foods.

This study aimed to investigate solid healthcare waste management practices and develop guidelines to improve solid healthcare waste management practices in Ethiopia. The setting was all health facilities found in Hossaena town.

Method A mixed-method study design was used. For the qualitative phase of this study, eight FGDs were conducted from 4 government health facilities, one FGD from each private health facility (which is 37 in number), and forty-five FGDs were conducted. Four FGDs were executed with cleaners; another four were only health care providers because using homogeneous groups promotes discussion. The remaining 37 FGDs in private health facilities were mixed from health professionals and cleaners because of the number of workers in the private facilities. For the quantitative phase, all health facilities and health facility workers who have direct contact with healthcare waste management practice participated in this study. Both qualitative and quantitative study participants were taken from the health facilities found in Hossaena town.

Result Seventeen (3.1%) health facility workers have hand washing facilities. Three hundred ninety-two (72.6%) of the participants agree on the availability of one or more personal protective equipment (PPE) in the facility "*the reason for the absence of some of the PPEs, like boots and goggles, and the shortage of disposable gloves owes to cost inflation from time to time and sometimes absent from the market". The observational finding shows that colour-coded waste bins are available in 23 (9.6%) rooms.* 90% of the sharp containers were reusable, and 100% of the waste storage bins were plastic buckets that were easily cleanable. In 40 (97.56%) health facilities, infectious wastes were collected daily from the waste generation areas to the final disposal points. Two hundred seventy-one (50.2%) of the respondents were satisfied or agreed that satisfactory procedures are available in case of an accident. Only 220 (40.8%) respondents were vaccinated for the Hepatitis B virus.

Conclusion Hand washing facilities, personal protective equipment and preventive vaccinations are not readily available for health workers. Solid waste segregation practices are poor and showed that solid waste management practices (SWMP) are below the acceptable level.

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Keywords Health care waste, Waste management, Disposal, Private health facilities

Introduction

Healthcare waste (HCW) encompasses all types of waste generated while providing health-related services, spanning activities such as diagnosis, immunization, treatment, and research. It constitutes a diverse array of materials, each presenting potential hazards to health and the environment. Within the realm of HCW, one finds secretions and excretions from humans, cultures, and waste containing a stock of infectious agents. Discarded plastic materials contaminated with blood or other bodily fluids, pathological wastes, and discarded medical equipment are classified as healthcare waste. Sharps, including needles, scalpels, and other waste materials generated during any healthcare service provision, are also considered potentially hazardous to health [1].

Healthcare waste in solid form (HCW) is commonly divided into two primary groups: infectious and non-infectious. The existence of pathogens in concentrations identifies infectious waste or amounts significant enough to induce diseases in vulnerable hosts [1] If healthcare facility waste is free from any combination with infectious agents, nearly 85% is categorized as non-hazardous waste, exhibiting characteristics similar to conventional solid waste found in households [2]. World Health Organization (WHO) recommends that appropriate colour-coded waste receptacles be available in all medical and other waste-producing areas [3].

Solid waste produced in the course of healthcare activities carries a higher potential for infection and injury than any other type of waste. Improper disposal of sharps waste increases the risk of disease transmission among health facility workers and general populations [1]. Inadequate and inappropriate handling of healthcare waste may have serious public health consequences and a significant environmental impact. The World Health Organization (2014) guidelines also include the following guidance for hand washing and the use of alcohol-based hand rubs: Wash hands before starting work, before entering an operating theatre, before eating, after touching contaminated objects, after using a toilet, and in all cases where hands are visibly soiled [4].

Among the infectious waste category, sharps waste is the most hazardous waste because of its ability to puncture the skin and cause infection [3]. Accidents or occurrences, such as near misses, spills, container damage, improper waste segregation, and incidents involving sharps, must be reported promptly to the waste management officer or an assigned representative [5].

Africa is facing a growing waste management crisis. While the volumes of waste generated in Africa are relatively small compared to developed regions, the mismanagement of waste in Africa already impacts human and environmental health. Infectious waste management has always remained a neglected public health problem in developing countries, resulting in a high burden of environmental pollution affecting the general masses. In Ethiopia, there is no updated separate regulation specific to healthcare waste management in the country to enforce the proper management of solid HCW [6].

In Ethiopia, like other developing countries, healthcare waste segregation practice was not given attention and did not meet the minimum HCWM standards, and it is still not jumped from paper. Previous study reveals that healthcare waste generation rates are significantly higher than the World Health Organization threshold, which ranges from 29.5–53.12% [7, 8]. In Meneilk II Hospital, the proportion of infectious waste was 53.73%, and in the southern and northern parts of Ethiopia, it was 34.3 and 53%, respectively. Generally, this figure shows a value 3 to 4 times greater than the threshold value recommended by the World Health Organization [7].

Except for sharp wastes, segregation practice was poor, and all solid wastes were collected without respecting the colour-coded waste disposal system [9]. The median waste generation rate was found to vary from 0.361- 0.669 kg/patient/day, comprising 58.69% non-hazardous and 41.31% hazardous wastes. The amount of waste generated increased as the number of patients flow increased. Public hospitals generated a high proportion of total healthcare waste (59.22%) in comparison with private hospitals (40.48) [10]. The primary SHCW treatment and disposal mechanism was incineration, open burning, burring into unprotected pits and open dumping on municipal dumping sites as well as in the hospital backyard. Carelessness, negligence of the health workers, patients and cleaners, and poor commitment of the facility leaders were among the major causes of poor HCWM practice in Ethiopia [9]. This study aimed to investigate solid healthcare waste management practices and develop guidelines to improve solid healthcare waste management practices in Ethiopia.

Method

The setting for this study was all health facilities found in Hossaena town, which is situated 232 kms from the capital city of Ethiopia, Addis Ababa, and 165 kms from the regional municipality of Hawasa. The health facilities found

in the town were one university hospital, one private surgical centre, three government health centres, 17 medium clinics, and 19 small clinics were available in the city and; health facility workers who have direct contact with generating and disposal of HCW and those who are responsible as a manager of health facilities found in Hossaena town are the study settings. All health facilities except drug stores and health facility workers who have direct contact with healthcare waste generation participated in this study.

Design

A mixed-method study design was used. For the quantitative part of this study, all healthcare workers who have direct contact with healthcare waste management practice participated in this study, and one focus group discussion from each health facility was used. Both of the study participants were taken from the same population. All health facility workers who have a role in healthcare waste management practice were included in the quantitative part of this study. The qualitative data collection phase used open-ended interviews, focus group discussions, and visual material analysis like posters and written materials. All FGDs were conducted by the principal investigator, one moderator, and one note-taker, and it took 50 to 75 min. 4–6 participants participated in each FGD.

According to Elizabeth (2018: 5), cited by Creswell and Plano (2007: 147), the mixed method is one of the research designs with philosophical assumptions as well as methods of inquiry. As a method, it focuses on collecting, analyzing, and mixing both quantitative and qualitative data in a single study. As a methodology, it involves philosophical assumptions guiding the direction of the collection and analysis and combining qualitative and quantitative approaches in many phases of the research project. The central premise is that using qualitative and quantitative approaches together provides a better understanding of the research problems than either approach alone.

The critical assumption of the concurrent mixed methods approach in this study is that quantitative and qualitative data provide different types of information, often detailed views of participants' solid waste management practice qualitatively and scores on instruments quantitatively, and together, they yield results that should be the same. In this approach, the researcher collected quantitative and qualitative data almost simultaneously and analyzed them separately to cross-validate or compare whether the findings were similar or different between the qualitative and quantitative information. Concurrent approaches to the data collection process are less time-consuming than other types of mixed methods studies because both data collection processes are conducted on time and at the same visit to the field [11].

Data collection

The data collection involves collecting both quantitative and qualitative data simultaneously. The quantitative phase of this study assessed three components. Health care waste segregation practice, the availability of waste segregation equipment for HCW segregation, temporary storage facilities, transportation for final disposal, and disposal facilities data were collected using a structured questionnaire and observation of HCW generation. Recycling or re-using practice, waste treatment, the availability of the HCWM committee, and training data were collected.

Qualitative data collection

The qualitative phase of the data collection for this study was employed by using focus group discussions and semi-structured interviews about SHCWMP. Two focus group discussions (FGD) from each health facility were conducted in the government health facilities, one at the administrative level and one at the technical worker level, and one FGD was conducted for all private health facilities because of the number of available health facility workers. Each focus group has 4–6 individuals.

In this study, the qualitative and the quantitative data provide different information, and it is suitable for this study to compare and contrast the findings of the two results to obtain the best understanding of this research problem.

Quantitative data collection

The quantitative data were entered into Epi data version 3.1 to minimize the data entry mistakes and exported to the statistical package for social science SPSS window version 27.0 for analysis. A numeric value was assigned to each response in a database, cleaning the data, recoding, establishing a codebook, and visually inspecting the trends to check whether the data were typically distributed.

Data analysis

Data were analyzed quantitatively by using relevant statistical tools, such as SPSS. Descriptive statistics and the Pearson correlation test were used for the bivariate associations and analysis of variance (ANOVA) to compare the HCW generation rate between private and government health facilities and between clinics, health centres and hospitals in the town. Normality tests were performed to determine whether the sample data were drawn from a normally distributed population.

The Shapiro–Wilk normality tests were used to calculate a test statistic based on the sample data and compare it to critical values. The Shapiro–Wilk test is a statistical

test used to assess whether a given sample comes from a normally distributed population. The P value greater than the significance level of 0.05 fails to reject the null hypothesis. It concludes that there is not enough evidence to suggest that the data does not follow the normal distribution. Visual inspection of a histogram, Q-Q plot, and P-P plot (probability-probability plot) was assessed.

Bivariate (correlation) analysis assessed the relationships between independent and dependent variables. Then, multiple linear regression analysis was used to establish the simple correlation matrices between different variables for investigating the strength relationships of the study variables in the analysis. In most variables, percentages and means were used to report the findings with a 95% confidence interval. Open-ended responses and focused group findings were undertaken by quantifying and coding the data to provide a thematic narrative explanation.

Appropriate and scientific care was taken to maintain the data quality before, during, and after data collection by preparing the proper data collection tools, pretesting the data collection tools, providing training for data collectors, and proper data entry practice. Data were cleaned on a daily basis during data collection practice, during data entry, and before analysis of its completeness and consistency.

Data analysis in a concurrent design consists of three phases. First, analyze the quantitative database in terms of statistical results. Second, analyze the qualitative database by coding the data and collapsing the codes into broad themes. Third comes the mixed-method data analysis. This is the analysis that consists of integrating the two databases. This integration consists of merging the results from both the qualitative and the quantitative findings.

Descriptive analysis was conducted to describe and summarise the data obtained from the samples used for this study. Reliability statistics for constructs, means and modes of each item, frequencies and percentage distributions, chi-square test of association, and correlations (Spearman rho) were used to portray the respondents' responses.

All patient care-providing health facilities were included in this study, and the generation rate of healthcare waste and composition assessed the practice of segregation, collection, transportation, and disposal system was observed quantitatively using adopted and adapted structured questionnaires. To ensure representativeness, various levels of health facilities like hospitals, health centres, medium clinics, small clinics and surgical centres were considered from the town. All levels of health facilities are diagnosing, providing first aid services and treating patients accordingly.

The hospital and surgical centre found in the town provide advanced surgical service, inpatient service and food for the patients that other health facilities do not. The HCW generation rate was proportional to the number of patients who visited the health facilities and the type of service provided. The highest number of patients who visited the health facilities was in NEMMCSH; the service provided was diverse, and the waste generation rate was higher than that of other health facilities. About 272, 18, 15, 17, and 20 average patients visited the health facilities daily in NEMMCSH: government health centres, medium clinics, small clinics, and surgical centres. Paper and cardboard (141.65 kg), leftover food (81.71 kg), and contaminated gloves (42.96 kg) are the leading HCWs generated per day.

Result

A total of 556 individual respondents from sampled health facilities were interviewed to complete the questionnaire. The total number of filled questionnaires was 540 (97.1) from individuals representing these 41 health facilities.

The principal investigator observed the availability of handwashing facilities near SHCW generation sites. 17(3.1%) of health facility workers had hand washing facilities near the health care waste generation and disposal site. Furthermore,10 (3.87%), 2 (2.1%), 2 (2.53%), 2 (2.1%), 1 (6.6%) of health facility workers had the facility of hand washing near the health care waste generation site in Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital (NEMMCSH), government health centres, medium clinics, small clinics, and surgical centre respectively. This finding was nearly the same as the study findings conducted in Myanmar; the availability of hand washing facilities near the solid health care waste generation was absent in all service areas [12]. The observational result was convergent with the response of facility workers' response regarding the availabilities of hand washing facilities near to the solid health care waste generation sites.

The observational result was concurrent with the response of facility workers regarding the availability of hand-washing facilities near the solid health care waste generation sites.

The availability of personal protective equipment (PPE) was checked in this study. Three hundred ninety-two (72.6%) of the respondents agree on the facility's availability of one or more personal protective equipment (PPE). The availability of PPEs in different levels of health facilities shows 392 (72.6%), 212 (82.2%), 56 (58.9%), 52 (65.8%), 60 (65.2%), 12 (75%) health facility workers in NEMMCSH, government health centres, medium clinics, small clinics, and surgical centres respectively agree

to the presence of personal protective equipment in their department. The analysis further shows that the availability of masks for healthcare workers was above the mean in NEMMCSH and surgical centres.

Focus group participants indicated that health facilities did not volunteer to supply Personal protective equipment (PPEs) for the cleaning staff.

"We cannot purchase PPE by ourselves because of the salary paid for the cleaning staff."

Cost inflation and the high cost of purchasing PPEs like gloves and boots are complained about by all (41) health facility owners.

"the reason for the absence of some of the PPEs like boots, goggles, and shortage of disposable gloves are owing to cost inflation from time to time and sometimes absent from the market is the reason why we do not supply PPE to our workers."

Using essential personal protective equipment (PPEs) based on the risk (if the risk is a splash of blood or body fluid, use a mask and goggles; if the risk is on foot, use appropriate shoes) is recommended by the World Health Organization [13]. The mean availability of gloves in health facilities was 343 (63.5% (95% CI: 59.3–67.4). Private health institutions are better at providing gloves for their workers, 67.1%, 72.8%, and 62.5% in medium clinics, small clinics, and surgical centres, respectively, which is above the mean.

Research participants agree that.

"there is a shortage of gloves to give service in Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital (NEMMCSH) and government health centres."

Masks are the most available personal protective equipment for health facility workers compared to others. 65.4%, 55.6%, and 38% of the staff are available with gloves, plastic aprons and boots, respectively.

The mean availability of masks, heavy-duty gloves, boots, and aprons was 71.1%, 65.4%, 38%, and 44.4% in the study health facilities. Health facility workers were asked about the availability of different personal protective equipment, and 38% of the respondents agreed with the presence of boots in the facility. Still, the qualitative observational findings of this study show that all health facility workers have no shoes or footwear during solid health care waste management practice.

SHCW segregation practice was checked by observing the availability of SHCW collection bins in each patient care room. Only 4 (1.7%) of the room's SHCW bins are collected segregated (non-infectious wastes segregated in black bins and infectious wastes segregated in yellow bins) based on the World Health Organization standard. Colour-coded waste bins, black for non-infectious and yellow for infectious wastes, were available in 23 (9.6%) rooms. 90% of the sharp containers were reusable, and 100% of the waste storage bins were plastic buckets that were easily cleanable. Only 6.7% of the waste bins were pedal operated and adequately covered, and the rest were fully opened, or a tiny hole was prepared on the container's cover. All of the healthcare waste disposal bins in each health facility and at all service areas were away from the arm's reach distance of the waste generation places, and this is contrary to World Health Organization SHCWM guidelines [13]. The observation result reveals that the reason for the above result was that medication trolleys were not used during medication or while healthcare providers provided any health services to patients.

Most medical wastes are incinerated. Burning solid and regulated medical waste generated by health care creates many problems. Medical waste incinerators emit toxic air pollutants and ash residues that are the primary source of environmental dioxins. Public concerns about incinerator emissions and the creation of federal regulations for medical waste incinerators are causing many healthcare facilities to rethink their choices in medical waste treatment. Health Care Without Harm [14], states that non-incineration treatment technologies are a growing and developing field. The U.S. National Academy of Science 2000 argued that the emission of pollutants during incineration is a potential risk to human health, and living or working near an incineration facility can have social, economic, and psychological effects [15].

The incineration of solid healthcare waste technology has been accepted and adopted as an effective method in Ethiopia. Incineration of healthcare waste can produce secondary waste and pollutants if the treatment facilities are not appropriately constructed, designed, and operated. It can be one of the significant sources of toxic substances, such as polychlorinated dibenzo-dioxins/dibenzofurans (PCDD/ PCDF), polyvinyl chloride (PVC), hexachlorobenzenes and polychlorinated biphenyls, and dioxins and furans that are known as hazardous pollutants. These pollutants may have undesirable environmental impacts on human and animal health, such as liver failure and cancer [15, 16].

All government health facilities (4 in number) used incineration to dispose of solid waste. 88.4% and 100% of the wastes are incinerated in WUNEMMCSH and government health centres. This finding contradicts the study findings in the United States of America and Malaysia, in which 49–60% and 59–60 were incinerated, respectively, and the rest were treated using other technologies [15, 16].

World Health Organization (2014:45) highlighted those critical elements of the appropriate operation of incinerators include effective waste reduction and waste segregation, placing incinerators away from populated areas, satisfactory engineered design, construction following appropriate dimensional plans, proper operation, periodic maintenance, and staff training and management are mandatory.

Solid waste collection times should be fixed and appropriate to the quantity of waste produced in each area of the health care facility. General waste should not be collected simultaneously or in the same trolley as infectious or hazardous wastes. The collection should be done daily for most wastes, with collection timed to match the pattern of waste generation during the day [13].

SHCW segregation practices were observed for 240 rooms in 41 health facilities that provide health services in the town. In government health centres, medium clinics, small clinics, and surgical centres, SHCW segregation practice was not based on the World Health Organization standard. All types of solid waste were collected in a single container near the generation area, and there were no colour-coded SHCW storage dust bins. Still, in NEMMCSH, in most of the service areas, colour-coded waste bins are available, and the segregation practice was not based on the standard. Only 3 (10%) of the dust bins collected the appropriate wastes according to the World Health Organization standard, and the rest were mixed with infectious and non-infectious SHCW.

Table 1 below shows health facility managers were asked about healthcare waste segregation practices, and 9 (22%) of the facility leaders responded that there is an appropriate solid healthcare waste segregation practice in their health facilities. Still, during observation, only 4 (1.7%) of the rooms in two (4.87%) of the facilities, SHCW bins collected the segregated wastes (non-infectious wastes segregated at the black bin and infectious wastes segregated at yellow bin) based on the world health organization standard. The findings of this study show there is a poor segregation practice, and all kinds of solid wastes are collected together.

In 40 (97.56%) health facilities, infectious wastes were collected daily from the waste generation areas to the final disposal points. During observation in one of the study health facilities, infectious wastes were not collected daily and left for days. Utility gloves, boots, and aprons are not available for cleaning staff to collect and transport solid healthcare wastes in all study health facilities. 29.26% of the facilities' cleaning staff have a face mask, and 36.5% of the facilities remove waste bins from the service area when 3/4 full, and the rest were not removed or replaced with new ones. There is a separate container only in 2 health facilities for infectious and non-infectious waste segregation practice, and the rest were segregated and collected using single and non-colour coded containers.

At all of the facilities in the study area, SHCW was transported from the service areas to the disposal site were transported manually by carrying the collection container and there is no trolley for transportation. This finding was contrary to the study findings conducted in India, which show segregated waste from the generation site was being transported through the chute to the carts placed at various points on the hospital premises by skilled sanitary workers [17].

Only 2 out of 41 health facilities have temporary solid waste storage points at the facility. One of the temporary storage places was clean, and the other needed to be properly cleaned and unsightly. Two (100%) of the temporary storage areas are not fenced and have no restriction to an authorized person. Temporary storage areas are available only in two health facilities that are away from the service provision areas.

Observational findings revealed that pre-treatment of SHCW before disposal was not practised at all study health facilities. 95% of the facilities have no water supply for hand washing during and after solid healthcare waste generation, collection, and disposal.

The United States Agency estimated sharp injuries from medical wastes to health professionals and sanitary service personnel for toxic substances and disease registry. Most of the injuries are caused during the recapping of hypodermic needles before disposal into sharps containers [13]. Nearly half of the respondents, 245 (51.5%), are recapping needles after providing an injection to the patient. Recapping was more practised in NEMMCSH and surgical centres, which is 57.5% and 57.5%, respectively. In government health centres, medium clinics, and surgical centres, the recapping of used needles was practised below the mean, which is 47.9%, 48, and 43.8%, respectively. This finding was reasonable compared to the study findings of Doylo et al. [18] in western Ethiopia, where 91% of the health workers are recapping needles after injection [18]. The research finding shows that there is no significant association P-value of 0.82 between the training and recapping of needles after injection.

Focus group participants' response for appropriate SHCWMP regarding patients' and visitors' lack of knowledge on SHCW segregation practice

"The personal responsibilities of patients and visitors on solid HCW disposal should be explained to help

Table 1 Health facility manager response to solid health care waste management practice ($n=41$)

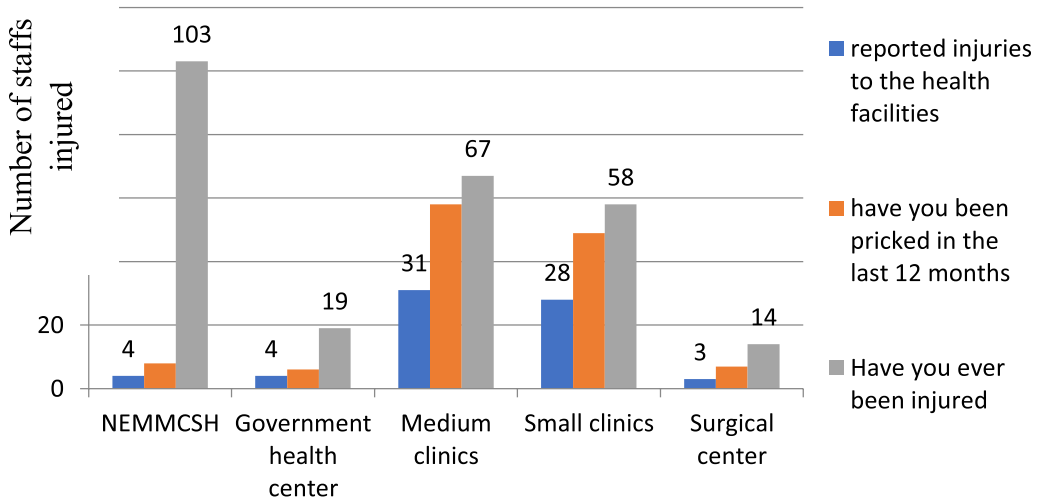
Variable	Response			
	Yes		No	
	Number	%	Number	%
Health care waste generation rate assessment done last year?	0	0	41	100
Does the facility reuse waste?	1	2.43	40	97.57
If yes, how many kilograms of solid health care waste reused?	50.6 kg			
If yes, which type of waste reused?	plastic bottle			
Is there a waste segregation practice?	9	22	32	78
Does the facility have onsite sterilization of waste?	0	0	41	100
Does the facility have a waste reduction policy /strategy?	0	0	41	100
Does the facility have a mercury elimination strategy?	0	0	41	100
Do you have a waste management policy?	8	19.5	33	80.5
Do you have a program for purchasing mercury alternative materials?	0	0	41	100
Does the facility have a waste recycling policy?	0	0	41	100
Is the waste volume tracked?	0	0	41	100
Has the facility performed a waste audit in the last year?	0	0	41	100
Is the committee formed to investigate waste management?	4	9.8	37	90.2
Does the committee have a plan for performance monitoring?	1	25	4	75
Does the committee meet at least monthly?	0	0	4	100
Does your facility provide waste management training?	3	7.3	38	92.7
Does the facility have an operational standard of waste management?	3	7.3	38	92.7
Is there a health care waste trainer in this institution?	1	2.4	40	97.6
Do you have an environmental purchasing policy to encourage waste reduction?	0	0	41	100
Do you have a procedure for the safe handling of cytotoxic waste?	1	2.4	40	97.6
Is there an operating budget for labour?	41	100	0	0
Is the budget available for consumables?	30	73.2	11	26.8
Is there an adequate program for immunization of hepatitis B, and hepatitis C?	4	9.8	37	90.2
Does this facility have an environmental management office?	2	4.9	39	95.1
Is there a written training plan for a refresher training?	1	2.4	40	97.6
Are you aware of any legislation on HCWM?	5	12.2	36	87.8
Does waste management include in the employment job description?	1	2.4	40	97.6
Do you have a record of waste management injury?	1	2.4	40	97.6
Do you incinerate waste in your facility?	41	100	0	0
Do you have a plan to eliminate incineration?	1	2.4	40	97.6
Do you think current practice needs improvement?	41	100	0	0
Do you have a policy for PPE to be used by the worker?	5	12.2	36	87.8

appropriate safe waste management practice and maintain good hygiene."
"Providing waste management training and creating awareness are the two aspects of improving SHCW segregation practice."
"Training upgrades and creates awareness on hygiene for all workers."

Sharp waste collection practices were observed in 240 rooms in the study health facilities, and 9.2% of the rooms used disposable sharp containers.

Sixty per cent (60%), 13.3%, 8.24%, and 15.71% of the sharps containers in NEMMCSH, government health centres, medium clinics, and small clinics, respectively, were using disposable sharps containers; sharps were disposed together with the sharps container, and surgical centre was using reusable sharp collection container. All disposable sharps containers in medium and small clinics used non-puncture-resistant or simple packaging carton boxes. 60% and 13.3% of the disposable sharps containers in NEMMCSH and the government health centre use purposefully manufactured disposable safety boxes.

Needle sticks injury reporting and occurrence



A total of 70 injuries were reported to the health facility manager in the last one year, and 44 of the injuries were reported by health professionals. The rest of the injuries were reported by supportive staff. These injuries were reported from 35 health facilities, and the remaining six health facilities did not report any cases of injury related to work; see Tables 2 and 3 below.

Accidents or incidents, including near misses, spillages, damaged containers, inappropriate segregation, and any incidents involving sharps, should be reported to the waste-management officer. Accidental contamination must be notified using a standard-format document. The cause of the accident or incident should be investigated by the waste-management officer (in case of waste) or another responsible officer, who should also take action to prevent a recurrence [13]. Two hundred seventy-one (50.2% (CI: 45.7–54.6) of the respondents agree that satisfactory procedures are available in case of an accident, while the remaining 269 (49.8%(CI: 45.4–54.3) of respondents do not agree on the availability of satisfactory procedures in case of an accident, see Table 4 below. The availability of satisfactory procedures in case of an accident is above the mean in medium clinics, which is 60.8%. 132(24.4%) of the staff are pricked by needle stick injury while providing health services. Nearly half of the respondents, 269 (49.8%), who have been exposed to needle stick injury do not get satisfactory procedures after being pricked by a needle, and those who have not been stung by a needle stick injury for the last year. 204 (37.8%) disagree with the presence of satisfactory procedures in the case of a needle stick injury. In NEMMCSH, 30.2% of the research participants were pricked by needle stick injury within one year of period, and 48.8% of those who were stung by needle stick injuries did not agree upon the presence of satisfactory procedures in case of needle stick injuries in the study hospital. 17.9% and 49.5%, 24.1% and 60.8%, 7.6% and 50% of the respondents are pricked by needle sticks, and they disagree on the availability of satisfactory procedures in case of accidents, respectively, in government health centres, medium clinics, small clinics, and surgical centre respectively.

One hundred seventy-seven (32.7% (CI:29.1–37) respondents were exposed to needle stick injury while working in the current health facilities. One hundred three (58.1%) and 26 (32.9%) needle stick injuries were reported from WUNEMMCSH and medium clinics, which is above the mean. One hundred thirty-two(24.7% (95%CI:20.7–28.1) of the respondents are exposed to needle stick injury within one year of the period. Seventy-eight(30.2%), 17 (17.9%), 19 (24.1%), 15 (16.3%), 3 (18.8%) of the staff are injured by needle sticks from NEMMCSH, government health centres, medium clinics, small clinics, and surgical centre staffs respectively within one year of service.

The mean availabilities of satisfactory procedures in case of accidents were 321 (59.4% (CI:55.4–63.7). Out of this, 13.7% of the staff is injured by needle sticks within one year before the survey. Except in NEMMCSH, the mean availabilities of satisfactory procedures were above the mean, which is 50%, 60%, 77.2%, 66.3%, and 81.3% in NEMMCSH, government health centres, medium clinics, small clinics, and surgical centres respectively.

Table 5 below shows that Hepatitis B, COVID-19, and tetanus toxoid vaccinations are the responses of

Table 2 Needle sticks injury and the presence of satisfactory procedures in case of an accident (*n*= 540)

Variable		Has a needle pricked you last 12 months?				
Satisfactory procedures are present in case of an accident				No	Yes	Total
	Hospital	No	Count	91	41	132
			% of Total	35.3%	15.9%	51.2%
		Yes	Count	89	37	126
			% of Total	34.5%	14.3%	48.8%
		Total	Count	180	78	258
			% of Total	69.8%	30.2%	100.0%
	Government health centre	No	Count	40	8	48
			% of Total	42.1%	8.4%	50.5%
		Yes	Count	38	9	47
			% of Total	40.0%	9.5%	49.5%
		Total	Count	78	17	95
			% of Total	82.1%	17.9%	100.0%
	Medium clinics	No	Count	23	8	31
			% of Total	29.1%	10.1%	39.2%
		yes	Count	37	11	48
			% of Total	46.8%	13.9%	60.8%
		Total	Count	60	19	79
			% of Total	75.9%	24.1%	100.0%
	Small clinics	No	Count	42	8	50
			% of Total	45.7%	8.7%	54.3%
		Yes	Count	35	7	42
			% of Total	38.0%	7.6%	45.7%
		Total	Count	77	15	92
			% of Total	83.7%	16.3%	100.0%
	Surgical centre	No	Count	8	0	8
			% of Total	50.0%	0.0%	50.0%
		Yes	Count	5	3	8
			% of Total	31.3%	18.8%	50.0%
		Total	Count	13	3	16
			% of Total	81.3%	18.8%	100.0%
	Mean/ average	No	Count	204	65	269
			% of Total	37.8%	12.0%	49.8%
		Yes	Count	204	67	271
			% of Total	37.8%	12.4%	50.2%
		Total	Count	408	132	540
			% of Total	75.6%	24.4%	100.0%

the research participants to an open-ended question on which vaccine they took. The finding shows that 220 (40.8%) of the respondents were vaccinated to prevent themselves from health facility-acquired infection. One hundred fifty-six (70.9%) of the respondents are vaccinated to avoid themselves from Hep B infection. Fifty-nine (26%0.8) of the respondents were vaccinated to protect themselves from two diseases that are Hep B and COVID-19.

Appropriate health care waste management practice was assessed by using 12 questions: availability of colour-coded waste bins, foot-operated dust bins, elbow or foot-operated hand washing basin, personal protective equipment, training, role and responsibility of the worker, the presence of satisfactory procedures in case of an accident, incinerator, vaccination, guideline, onsite treatment, and the availability of poster. The mean of appropriate healthcare waste management practice was 55.58%. The mean of solid health care waste management practice based on the level of health facilities was summed and divided into 12 variables to get each health facility's level of waste management practice. 64.9%,

Table 3 The presence of satisfactory procedures in case of an accident ($n=540$)

Variable	Health facilities	Response	n	% (95%CI)
Satisfactory procedures are present in case of an accident?	NEMMCSH	Yes	126	48.8 (CI:42.2–56)
		No	132	51.2 (CI:44–57.8)
		I don't know	0	0
		Total	**258**	**100**
	Health centres	Yes	47	49.5 (CI:40.6–59.4)
		No	48	50.5 (CI:40.6–59.4)
		I don't know	0	0
		Total	**95**	**100**
	Medium clinics	Yes	48	60.8 (CI:50.6–72.2)
		No	31	39.2(CI: 27.8–49.4)
		I don't know	0	**0**
		Total	**79**	**100**
	Small clinics	Yes	42	45.7 (CI:34.8–55.4)
		No	50	54.3 (CI:44.6–65.2)
		I don't know	0	0
		Total	**92**	**100**
	Surgical centres	Yes	8	50(CI:25–75)
		No	8	50 (CI:25–75)
		I don't know	0	0
		Total	**16**	**100**
	The mean knowledge of the availability of policy regarding health care waste management policy	**Yes**	**271**	**50.2%(CI:45.7–54.6)**
		No	**269**	**49.8%(CI:45.4–54.3)**
		I don't know	**17**	**3.1%(CI:1.7–4.6)**
		Total	**540**	**100**

45.58%, 49%, 46.9%, and 51.8% are the mean appropriate health care waste management practices in NEMMCSH, government health centres, medium clinics, small clinics, and surgical centres, respectively. In NEMMCSH, the practice of solid healthcare waste management shows above the mean, and the rest was below the mean of solid healthcare waste management practice.

Healthcare waste treatment and disposal practice

Solid waste treatment before disposal was not practised at all study health facilities. There is an incineration practice at all of the study health facilities, and the World Health Organization 2014 recommended three types of incineration practice for solid health care waste management: dual-chamber starved-air incinerators, multiple chamber incinerators, and rotary kilns incinerators. Single-chamber, drum, and brick incinerators do not meet the best available technique requirements of the Stockholm Convention guidelines [13]. The findings of this study show that none of the incinerators found in the study health facilities meet the minimum standards of solid healthcare waste incineration practice, and they need an air inlet to facilitate combustion. Eleven (26.82%) of the health facilities have an ash pit to dispose of burned SHCW; the majority, 30 (73.17%), dispose of the incinerated ash and burned needles in the municipal

Table 4 Vaccination status of health facility workers ($n=540$)

Variable	Response	Frequency	Percent	95% Confidence Interval	
				Lower	Upper
Did you receive any protective vaccination to prevent infection?	no	319	59.2	54.6	63.3
	yes	220	40.8	36.7	45.4
	Total	540	100.0	100.0	100.0

Table 5 Solid health care waste disposal practice in the different labels of health facilities (*n*= 540)

Variable	Response	NEMMCSH		Government health centres		Medium clinics		Small clinics		Surgical centre	
		n	%	n	%	n	%	n	%	n	%
Does the facility have an ash pit for incinerated SHCW?	Yes	1	100	2	66.6	4	23.52	5	26.31	1	100
	No	0	0	1	33.33	13	76.47	14	73.6	0	0
	Total	1	100	3	100	17	100	19	100	1	100

waste disposal site. In one out of 11 health facilities with an ash pit, one of the incinerators was built on the ash pit, and the incinerated ashes were disposed of in the ash pit directly. Pre-treatment of SHCW before disposal was not practised at all health facilities; see Table 6 below.

All government health facilities use incineration to dispose of solid waste. 88.4% and 100% of the solid wastes are incinerated in WUNEMMCS Hospital and government health centres, respectively. This finding was not similar to the other studies because other technologies like autoclave microwave and incineration were used for 59–60% of the waste [15]. Forty-one (100%) of the study facilities were using incinerators, and only 5 (12.19%) of the incinerators were constructed by using brick and more or less promising than others for incinerating the generated solid wastes without considering the emitting gases into the atmosphere and the residue chemicals and minerals in the ashes.

Research participants' understanding of the environmental friendliness of health care waste management practice was assessed, and the result shows that more than half, 312(57%) of the research participants do not agree on the environmental friendliness of the waste disposal practices in the health facilities. The most disagreement regarding environmental friendliness was observed in NEMMCSH; 100 (38.8%) of the participants only agreed the practice was environmentally friendly of the service. Forty-four (46.3%), 37 (46.8%), 40 (43.5%), and 7 (43.8%) of the participants agree on the environmental friendliness of healthcare waste management practice in government health centres, medium clinics, small clinics, and surgical centres, respectively.

One hundred twenty-five (48.4%) and 39(42.4%) staff are trained in solid health care waste management practice in NEMMCSH and small clinic staff, respectively; this result shows above the mean. Twenty-seven (28.4%), 30 (38%), and 4 (25%) of the staff are trained in health care waste management practice in Government health centres, medium clinics, and surgical centres, respectively. The training has been significantly associated with needle stick injury, and the more trained staff are, the less exposed to needle stick injury. One hundred ninety-six (36.4%) of the participants answered yes to the question about the availability of trainers in the institution. 43.8% of the NEMMCSH staff agreed on the availability of trainers on solid health care waste management, which is above the mean, and 26.3%, 31.6%, 31.5%, and 25% for the government health centres, medium clinics, small clinics, and surgical centre respectively, which is below the mean.

Trained health professionals are more compliant with SHCWM standards, and the self-reported study findings of this study show that 41.7% (95%CI:37.7–46) of the research participants are trained in health care waste management practice. This finding was higher compared to the study findings of Sahiledengle in 2019 in the southeast of Ethiopia, shows 13.0% of healthcare workers received training related to HCWM in the past one year preceding the study period and significantly lower when compared to the study findings in Egypt which is 71% of the study participants were trained on SHCWM [8, 19, 20].

Three out of four government health facility leaders, 17 (45.94%) of private health facility leaders/owners of the clinic and 141 FGD participants complain about the absence of some PPEs like boots and aprons to protect themselves from infectious agents.

"Masks, disposable gloves, and changing gowns are a critical shortage at all health facilities."

Table 6 The availability of guidelines and instructive posters (*n* = 540)

Variables	Response	Frequency	Percent	95% Confidence Interval	
				Lower	Upper
Do you have the guidelines on HCWM	No	247	45.7	41.4	49.8
	Yes	265	49.1	45.1	53.4
	I don't know	28	5.2	3.4	6.9
	Total	540	100.0	100.0	100.0
Do you have instructive posters on HCWM	No	289	53.5	49.4	57.4
	Yes	251	46.5	42.6	50.6
	Total	540	100.0	100.0	100.0

Cleaners in private health facilities are more exposed to infectious agents because of the absence of personal protective equipment. Except for the cleaning staff working in the private surgical centre, all cleaning staff 40 (97.56) of the health facilities complain about the absence of changing gowns and the fact that there are no boots in the facilities.

Cost inflation and the high cost of purchasing PPEs like gloves and boots are complained by all of (41) the health facility owners and the reason for the absence of some of the PPEs like boots, goggles, and shortage of disposable gloves. Sometimes, absence from the market is the reason why we do not supply PPE to our workers.

Thirty-four (82.92%) of the facility leaders are forwarded, and there is a high expense and even unavailability of some of the PPEs, which are the reasons for not providing PPEs for the workers.

> *"Medical equipment and consumables importers and whole sellers are selective for importing health supplies, and because of a small number of importers in the country and specifically, in the locality, we can't get materials used for health care waste management practice even disposable gloves."*

One of the facility leaders from a private clinic forwarded that before the advent of COVID-19 -19) personal protective equipment was more or less chip-and-get without difficulty. Still, after the advent of the first Japanese COVID-19 patient in Ethiopia, people outside the health facilities collect PPEs like gloves and masks and storing privately in their homes.

> *"PPEs were getting expensive and unavailable in the market. Incinerator construction materials cost inflation, and the ownership of the facility building are other problems for private health facilities to construct standard incinerators."*

For all of the focus group discussion participants except in NEMMCSH and two private health facilities, covered and foot-operated dust bins were absent or in a critical shortage compared to the needed ones.

> *"Waste bins are open and not colour-coded. The practice attracts flies and other insects. Empty waste bins are replaced without cleaning and disinfecting by using chlorine solution."*
> *"HCW containers are not colour-coded, but we are trying to label infectious and non-infectious in Amharic languages."*

Another issue raised during focus group discussions is incineration is not the final disposal method. It needs additional disposal sites, lacks technology, is costly to construct a brick incinerator, lacks knowledge for health facility workers, shortage of man powers /cleaners, absence of environmental health professionals in health centres and all private clinics, and continues exposure to the staff for needle stick injury, foully smell, human scavengers, unsightly, fire hazard, and lack of water supply in the town are the major teams that FGD participants raise and forwarded the above issue as a problem to improve SHCWMP.

Focus group participants, during the discussion, raised issues that could be more comfortable managing SHCWs properly in their institution. Two of the 37 private health facilities are working in their own compound, and the remaining 35 are rented; because of this, they have difficulty constructing incinerators and ash removal pits and are not confident about investing in SHCWM systems. Staff negligence and involuntary abiding by the rules of the facilities were raised by four of the government health facilities, and it was difficult to punish those who violated the healthcare waste management rules because the health facility leaders were not giving appropriate attention to the problem.

Focus group participants forwarded recommendations on which interventions can improve the management of SHCW, and recommendations are summarised as follows:

> *"PPE should be available in quality and quantity for all health facility workers who have direct contact with SHCW."*
> *"Scientific-based waste management technologies should be availed for health facilities."*
> *"Continuous induction HCW management training should be provided to the workers. Law enforcement should be strengthened."*
> *"Communal HCW management sites should be availed, especially for private health facilities."*
> *"HCWM committee should be strengthened."*
> *"Non-infectious wastes should be collected communally and transported to the municipal SHCW disposal places."*
> *"Leaders should be knowledgeable on the SHCWM system and supervise the practice continuously."*
> *"Patient and client should be oriented daily about HCW segregation practice."*
> *"Regulatory bodies should supervise the health facilities before commencing and periodically between services."*

The above are the themes that FGD participants discussed and forwarded for the future improvements of SHAWMP in the study areas.

Lack of water supply in the town

Other issues raised during FGDs were health facilities' lack of water supply. World Health Organization (2014: 89) highlights that water supply for the appropriate waste management system should be mandatory at any time in all health service delivery points.

Thirty-nine (95.12%) of the health facilities complain about the absence of water supply to improve HCW management practices and infection prevention and control practices in the facilities.

> *"We get water once per week, and most of the time, the water is available at night, and if we are not fetching as scheduled, we can't get water the whole week".*

In this research, only those who have direct contact have participated in this study, and 434 (80.4%) of the respondents agree they have roles and responsibilities for appropriate solid health care waste management practice. The rest, 19.6%, do not agree with their commitment to manage health care wastes properly, even though they are responsible. Health facility workers in NEMMCSH and medium clinics know their responsibilities better than others, and their results show above the mean. 84.5%, 74.5%, 81%, 73.9% and 75% in NEMMCSH, Government health centres, medium clinics, small clinics, and surgical centres, respectively.

Establishing a policy and a legal framework, training personnel, and raising public awareness are essential elements of successful healthcare waste management. A policy can be viewed as a blueprint that drives decision-making at a political level and should mobilize government effort and resources to create the conditions to make changes in healthcare facilities. Three hundred and seventy-four (69.3%) of the respondents agree with the presence of any solid healthcare waste management policy in Ethiopia. The more knowledge above the mean (72.9%) on the presence of the policy is reported from NEMMCSH.

Self-reported level of knowledge on what to do in case of an accident revealed that 438 (81.1% CI: 77.6–84.3%) of the respondents knew what to do in case of an accident. Government health centre staff and medium clinic staff's knowledge about what to do in case of an accident was above the mean (88.4% and 82.3%), respectively, and the rest were below the mean. The action performed after an occupational accident revealed that 56 (35.7%) of the respondents did nothing after any exposure to an accident. Out of 56 respondents who have done nothing after exposure, 47 (83.92%) of the respondents answered yes to their knowledge about what to do in case of an accident. Out of 157 respondents who have been exposed to occupational accidents, only 59 (37.6%) of the respondents performed the appropriate measures, 18 (11.5%), 9 (5.7%), 26 (16.6%), 6 (3.8%) of the respondents are taking prophylaxis, linked to the incident officer, consult the available doctors near to the department, and test the status of the patient (source of infection) respectively and the rest were not performing the scientific measures, that is only practising one of the following practices washing the affected part, squeezing the affected part to remove blood, cleaning the affected part with alcohol.

Health facility workers' understanding of solid health care waste management practices was assessed by asking whether the current SHCWM practice needs improvement. Four hundred forty-nine (83.1%) health facility workers are unsatisfied with the current solid waste management practice at the different health facility levels, and they recommend changing it to a scientific one. 82.6%, 87.4%, 89.9%, 75%, and 81.3% of the respondents are uncomfortable or need to improve solid health care waste management practices in NEMMCSH, government health centres, medium clinics, small clinics, and surgical centres, respectively.

Lack of safety box, lack of colour-coded waste bins, lack of training, and no problems are the responses to the question problems encountered in managing SHCWMP. Two Hundred and Fifty (46.92%) and 232 (42.96%) of the respondents recommend the availability of safety boxes and training, respectively.

Four or 9.8% of the facilities have infection prevention and control (IPC) teams in the study health facilities. This finding differed from the study in Pakistan, where thirty per cent (30%) of the study hospitals had HCWM or infection control teams [21]. This study's findings were similar to those conducted in Pakistan by Khan et al. [21], which confirmed that the teams were almost absent at the secondary and primary healthcare levels [20].

The availability of health care waste management policy report reveals that 69.3% (95% CI: 65.4–73) of the staff are aware of the presence of solid health care waste management policy in the institution. Availability of health care waste management policy was 188 (72.9%), 66 (69.5%), 53 (677.1%), 57 (62%), 10 (62.5%) in NEMMCSH, Government health centres, medium clinics, small clinics, and surgical centre respectively. Healthcare waste management policy availability was above the mean in NEMMCSH and government health centres; see Table 6 below.

Open-ended responses on the SHCWM practice of health facility workers were collected using the prepared interview guide, and the responses were analyzed using thematic analysis. All the answered questions were tallied on the paper and exported to Excel software for thematic analysis.

The study participants recommend.

"appropriate segregation practice at the point of generation"
"health facility must avail all the necessary supplies that used for SHCWMP, punishment for those violating the rule of SHCWMP",

and

"waste management technologies should be included in solid waste management guidelines, and enforcement should be strengthened."

The availability of written national or adopted/adapted SHCWM policies was observed at all study health facilities. Twenty eight (11.66%) of the rooms have either a poster or a written document of the national policy document. However, all staff working in the observed rooms have yet to see the inside content of the policy. The presence of the policy alone cannot bring change to SHCWMP. This finding shows that the presence of policy in the institution was reasonable compared to the study findings in Menelik II hospital in Addis Ababa, showing that HCWM regulations and any applicable facility-based policy and strategy were not found [22]. The findings of this study were less compared to the study findings in Pakistan; 41% of the health facilities had the policy document or internal rules for the HCWM [21].

Focus group participants have forwarded recommendations on which interventions can improve the management of SHCW, and recommendations are summarised as follows.

"Supplies should be available in quality and quantity for all health facility workers with direct contact with SHCW. Scientific-based waste management technologies should be available for health facilities. Continues and induction health care waste management training should be provided to the workers. Law enforcement should be strengthened. Community healthcare waste management sites should be available, especially for private health facilities. HCWM committee should be strengthened. Non-infectious wastes should be collected communally and transported to the municipal SHCW disposal places. Leaders should be knowledgeable about the SHCWM system and supervise the practice continuously. Patients and clients should be oriented daily about health care waste segregation practices. Regulatory bodies should supervise the health facilities before commencing and periodically in between the service are the themes those FGD participants discussed and forward for the future improvements of SHCWMP in the study areas."

Discussion

The availability of PPEs in different levels of health facilities shows 392 (72.6%), 212 (82.2%), 56 (58.9%), 52 (65.8%), 60 (65.2%), 12 (75%) health facility workers in NEMMCSH, government health centres, medium clinics, small clinics, and surgical centres respectively agree to the presence of personal protective equipment in their department. The availability of PPEs in this study was nearly two-fold when compared to the study findings in Myanmar, where 37.6% of the staff have PPEs [12].

The mean availability of masks, heavy-duty gloves, boots, and aprons was 71.1%, 65.4%, 38%, and 44.4% in the study health facilities. This finding shows masks are less available in the study health facilities compared to other studies. The availability of utility gloves, boots, and plastic aprons is good in this study compared to the study conducted by Banstola, D in Pokhara Sub-Metropolitan City [23].

The findings of this study show there is a poor segregation practice, and all kinds of solid wastes were collected together. This finding was similar to the study findings conducted in Addis Ababa, Ethiopia, by Debere et al. [24] and contrary to the study findings conducted in Nepal and India, which shows 50% and 65–75% of the surveyed health facilities were practising proper waste segregation systems at the point of generation without mixing general wastes with hazardous wastes respectively [9, 17].

Ninety percent of private health facilities collect and transport SHCW generated in every service area and transport it to the disposal place by the collection container (no separate container to collect and transport the waste to the final disposal site). This finding was similar to the study findings of Debre Markos's town [25]. At all of the facilities in the study area, SHCW was transported from the service areas to the disposal site manually by carrying the collection container, and there was no trolley for transportation. This finding was contrary to the study findings conducted in India, which show segregated waste from the generation site was being transported through the chute to the carts placed at various points on the hospital premises by skilled sanitary workers [17].

Observational findings revealed that pre-treatment of SHCW before disposal was not practised at all study health facilities. This study was contrary to the findings of Pullishery et al. [26], conducted in Mangalore, India, which depicted pre-treatment of the waste in 46% of the hospitals [26]. 95% of the facilities have no water supply for handwashing during and after solid healthcare waste generation, collection, and disposal. This finding was contrary to the study findings in Pakistan hospitals, which show all health facilities have an adequate water supply near the health care waste management sites [27].

Questionnaire data collection tools show that 129 (23.8%) of the staff needle stick injuries have occurred on health facility workers within one year of the period before the data collection. This finding was slightly smaller than the study findings of Deress et al. [25] in Debre Markos town, North East Ethiopia, where 30.9% of the workers had been exposed to needle stick injury one year prior to the study [25]. Reported and registered needle stick injuries in health facilities are less reported, and only 70 (54.2%) of the injuries are reported to the health facilities. This finding shows an underestimation of the risk and the problem, which was supported by the study conducted in Menilik II hospitals in Addis Ababa [22]. 50%, 33.4%, 48%, 52%, and 62.5% of needle stick injuries were not reported in NEMMCSH, Government health centres, medium clinics, small clinics, and surgical centres, respectively, to the health facility manager.

Nearly 1/3 (177 or 32.7%) of the staff are exposed to needle stick injuries. Needle stick injuries in health facilities are less reported, and only 73 (41.24%) of the injuries are reported to the health facilities within 12 months of the data collection. This finding is slightly higher than the study finding of Deress et al. [25] in Debere Markos, Ethiopia, in which 23.3% of the study participants had encountered needle stick/sharps injuries preceding 12 months of the data collection period [25].

Seventy-three injuries were reported to the health facility manager in the last one year, 44 of the injuries were reported by health professionals, and the rest were reported by supportive staff. These injuries were reported from 35(85.3%) health facilities; the remaining six have no report. These study findings were better than the findings of Khan et al. [21], in which one-third of the facilities had a reporting system for an incident, and almost the same percentage of the facilities had post-exposure procedures in both public and private sectors [21].

Within one year of the study period, 129 (23.88%) needle stick injuries occurred. However, needle stick injuries in health facilities are less reported, and only 70 (39.5%) of the injuries are reported to the health facilities. These findings were reasonable compared to the study findings of the southwest region of Cameroon, in which 50.9% (110/216) of all participants had at least one occupational exposure [28, 29]. This result report shows a very high exposure to needle stick injury compared to the study findings in Brazil, which shows 6.1% of the research participants were injured [27].

The finding shows that 220 (40.8%) of the respondents were vaccinated to prevent themselves from health facility-acquired infection. One Hundred Fifty-six (70.9%) of the respondents are vaccinated in order to avoid themselves from Hep B infection. Fifty-nine (26%0.8) of the respondents were vaccinated to protect themselves from two diseases that are Hep B and COVID-19. This finding was nearly the same as the study findings of Deress et al. [7],in Ethiopia, 30.7% were vaccinated, and very low compared to the study findings of Qadir et al. [30] in Pakistan and Saha & Bhattacharjya India which is 66.67% and 66.17% respectively [25, 30, 31].

The incineration of solid healthcare waste technology has been accepted and adopted as an effective method in Ethiopia. These pollutants may have undesirable environmental impacts on human and animal health, such as liver failure and cancer [15, 16]. All government health facilities use incineration to dispose of solid waste. 88.4% and 100% of the wastes are incinerated in WUNEM-MCSH and government health centres, respectively. This finding contradicts the study findings in the United States of America and Malaysia, which are 49–60% and 59–60 are incinerated, respectively, and the rest are treated using other technologies [15, 16].

All study health facilities used a brick or barrel type of incinerator. The incinerators found in the study health facilities need to meet the minimum standards of solid health care waste incineration practice. These findings were similar to the study findings of Nepal and Pakistan [32]. The health care waste treatment system in health facilities was found to be very unsystematic and unscientific, which cannot guarantee that there is no risk to the environment and public health, as well as safety for personnel involved in health care waste treatment. Most incinerators are not properly operated and maintained, resulting in poor performance.

All government health facilities use incineration to dispose of solid waste. All the generated sharp wastes are incinerated using brick or barrel incinerators, as shown in Fig. 1 above. This finding was consistent with the findings of Veilla and Samwel [33], who depicted that sharp waste generation is the same as sharps waste incinerated [33]. All brick incinerators were constructed without appropriate air inlets to facilitate combustion except in NEMMCSH, which is built at a 4-m height. These findings were similar to the findings of Tadese and Kumie at Addis Ababa [34].

Strengths and limitations

This is a mixed-method study; both qualitative and quantitative study design, data collection and analysis techniques were used to understand the problem better. The setting for this study was one town, which is found in the southern part of the country. It only represents some of the country's health facilities, and it is difficult to generalize the findings to other hospitals and health centres. Another limitation of this study was that private drug stores and private pharmacies were not incorporated.

Fig. 1 Barrel and brick incinerators used in private clinic

Conclusions

In the study, health facilities' foot-operated solid waste dust bins are not available for healthcare workers and patients to dispose of the generated wastes. Health facility managers in government and private health institutions should pay more attention to the availability of colour-coded dust bins. Most containers are opened, and insects and rodents can access them anytime. Some of them are even closed (not foot-operated), leading to contamination of hands when trying to open them.

Healthcare waste management training is mandatory for appropriate healthcare waste disposal. Healthcare-associated exposure should be appropriately managed, and infection prevention and control training should be provided to all staff working in the health facilities.

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Authors' contributions
Dr. Yeshanew Ayele Tiruneh is a researcher of this study; the principal investigator does all the proposal preparation, methodology, data collection, result and discussion, and manuscript writing. Professor LM Modiba and Dr. SM Zuma are supervisors for this study. They participated in the topic selection and modification to the final manuscript preparation by commenting on and correcting the study. Finally, the three authors read and approved the final version of the manuscript and agreed to submit the manuscript for publication.

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Availability of data and materials
The authors declare that data for this work are available upon request to the first author.

Declarations

Ethics approval and consent to participate
Before the data collection, all research participants were asked to participate in this study, and oral informed consent was taken from all health facilities and healthcare workers. Ethical approval was obtained from the University of South Africa Department of Health Studies with reference number HSHDC/1002/2020, the Hadiya Zone Health Department with reference number UHMD/35/699 and the hospital medical ethical and research ethics review committee. All experiments were performed in accordance with relevant guidelines and regulations, such as the Declaration of Helsinki.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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