



Assessment of healthcare waste generation rate and management practice in the case of Mizan-Tepi University Teaching Hospital Southwest, Ethiopia

Besufekad Mekonnen*, Mesfin Geremaw and Adane Asefa

Department of Public Health, College of Health Science, Mizan-Tepi University, Ethiopia
besusweet12@gmail.com

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Abstract

An institutional-based cross-sectional study design was conducted. Observational checklist, key informant interview, and weight scale were used to assess health care waste management system and generation rate in Mizan-Tepi University Teaching Hospital. Out of the total healthcare waste generated in the hospital, more than half (57.4%) was general or non-risk healthcare waste, and the remaining 42.25% was hazardous healthcare waste. The average total healthcare waste generation rate of the hospital was 6.63 kg/unit/day, 0.08kg/total patient \day and 0.306 Kg/bed/day by weight. The wastes were segregated at the source of generation in relation to their types, particularly into the following groups: sharps, infectious wastes, general waste, and pathological wastes. The hospital temporarily stored waste in open and substandard dustbins for about 12 hours. Lack of personal protective apparatus such as heavy-duty gloves, thick-soled boots, and leg protectors were identified as a resource related factor for waste segregation, storage and transportation. A large amount of general waste than pathological waste was generated during data collection time but the composition is far from the WHO recommended amount. Poor waste management practice could be attributed to the shortage of resource. Therefore, action toward proper human and material capability was recommended.

Keywords: Healthcare waste, generation rate, management practice.

Introduction

Healthcare waste (HCW) is defined as all wastes generated by health care activities which include, infectious and non-infectious waste i.e., sharps, non-sharps, blood, body parts, chemicals, pharmaceuticals, medical devices and radioactive materials¹. About 85% of hospital wastes are non-hazardous, 10% are infectious (hence, biological hazardous), and the remaining 5% are toxic chemicals, pharmaceutical and radioactive wastes².

Health care waste becomes one of important public health agenda in worldwide because of an increased amount of health wastes which coupled with population growth and expansions of health care facilities³. Health care wastes could result in unwanted damages on the environment and health of citizens. Surrender to infectious health-care waste can lead to severe health problems for waste collectors, hospital patients and healthcare workers^{4,5}. Studies revealed that about 5.2 million people (including 4 million children) die each year from waste-related diseases⁶. An open disposal of healthcare wastes results contamination soils and underground water. Similarly, incineration of healthcare waste can be the primary source of toxic pollutants like Dioxin, which is the main cause of cancer⁷.

Neglected or improper HCW management practice is a common phenomenon for most developing countries including Ethiopia. In 2002, the results of WHO assessment conducted in 22

developing countries showed that the proportion of healthcare facilities that did not use proper waste management was significant, ranging from 18% to 64%⁸. Occupational injury among health workers, nosocomial infection and environmental contamination were reported as a result poor health care management practices^{9,10}.

Quality evidence on health care waste generation rate and health care management practice is important to identify the current status of the problem and develop the solution. However, in most developing countries including Ethiopia, pieces of evidences on health care generation rate and management practice were scare or insufficient¹¹. Thus, this research was conducted to determine hospital waste generation rate and its management practice in Mizan-Tepi University Teaching Hospital.

Methodology

Study area and design: A cross-sectional study was conducted in Mizan- Tepi University Teaching Hospital (MTUTH) from February 25 – June 25/ 2019. The hospital is located in Bench Maji Zone Southern Nation Nationality and People Regional state, southwestern part of Ethiopia, at 585km from Addis Ababa. In this zone, there are 3 hospitals, 45 Health centers and 224 health posts, totally 272 health facilities are available. We were selected Mizan-Tepi Teaching Hospital among these due to it is the largest of all. Mizan-Tepi University Teaching

Hospital is a teaching hospital that provides both outpatient and inpatient services for catchment population, that come from Sheka, Kafa, Bench Majzones, and some parts of Gambella regional state. Patients get varieties of services from different units within the hospital. The inpatient's services are provided at surgical, medical, pediatrics, gynecology and obstetrics wards while the outpatient services are given at adult, pediatric, gynecology and obstetrics, emergency and surgical outpatient department. Within the hospital, there are also different specialty clinics where clients with specific need are referred for particular care.

Data collection instrument and procedures: First, inspection of health delivery units was done to identify the type of waste generated in relation to the working section of the hospital. All case teams were included for the transient observation: OPD (outpatient department), ward (inpatient), mother and child health clinic (MCH), family planning (FP), expanded program immunization (EPI) room, tuberculosis follow up the unit, the ward for emergency cases and delivery room.

Waste was collected and measured daily from Sunday to Saturday consecutively, for a week, to evaluate the amount of the waste generated. Plastic buckets of different colors were used according to the type of waste generated based on WHO guideline. Accordingly, black color for general waste, yellow color for infectious waste, red color for pathological waste and safety box for sharp waste were distributed in different sections of the hospital. The buckets, safety box, and plastic bags were labeled to indicate the different categories of healthcare waste and date of collection. The actual data was collected for seven consecutive days with plastic bags which were kept inside in the buckets. Plastic bags were removed every morning and their weights were measured every day at 8:00 A.M. using weighing scale (Baby scale, capacity range 10kg). Information about waste management status was collected by using the observational checklist and key informant interview. We made key informants interview with department leaders, hospital managers, and environmental health officer and official of the infection control unit.

Data Quality Assurance: Data quality was assured by relating the format logically to the variables measure. Weighing scale was calibrated using known 0.50kg, and 1kg objects every morning before the actual measurement started for every data collection days. Training was given for cleaner based on the aim of the study, data quality, types of health care waste, and the use of calibration of a weighing scale. Protective gloves were given for data collectors while measuring waste and the data were recorded three times (triplicate) in order to yield the most reliable data and recorded in a suitable datasheet. Data collection supervision was made by investigators at the time of data collection.

Data Processing and Analysis: To determine health care waste generation rate the raw data was entered in Microsoft Excel

computer software package and compiled by SPSS - version 20. The analysis was computed separately for each health care delivery units. The findings of hospital waste generation rate and management practices were described by using different descriptive statistics. The healthcare waste generation rates were reported on the basis of kg/bed/day, kg/patient/day and kg/outpatient/day. The average daily quantity of healthcare wastes in the hospital was computed. The annual waste generation rates were estimated based on the mean daily waste generation multiplying by the number of days in one year (365), assuming the activities related with waste generation were uniform, total HCW generation per year = Mean HCW generation in Kg per day* 365.

Ethical consideration: Ethical clearance was obtained from Mizan-Tepi University College of health science. Formal Letter of consent was given to Mizan-Tepi Teaching Hospital. Verbal consent was taken from each key informant.

Results and discussion

Healthcare waste generation rate: A total of 518 patients were in Mizan-Tepi University Teaching Hospital at the time of data collection in all health service delivery units. Out of these, 118 (22.78%) patients were admitted to inpatient department, and 400 (77.22%) was seen at OPDs.

More than half (57.34%) of the total HCW produced was general waste, and the remaining 42.25% was hazardous or risk waste. The average total HCW generation rate of the hospital was 6.63kg/unit/day, 0.08kg/total patient/day and 0.306 Kg/bed/day by weight. The average daily healthcare waste generation rate in all wards was 5.20±0.87 kg/day, and of this 2.13±0.43kg/day was general and 1.144±0.34kg/day was hazardous (Table-1). The types of hazardous waste generated from the hospital were sharps, infectious, and pathological wastes. The average generation rate of pathological waste, infectious, and sharps, was 0.094 ±0.12, 0.517±0.24, and 0.48 ±0.23 respectively (Table-2).

Healthcare waste generation rate by wards: Large amounts of waste were generated from the delivery ward, 6.7kg/day, (54.35%), whereas pediatrics ward contributed the lowest portion of total healthcare waste generated 4.28kg/day (27.7%).

Health care waste generation by working days: The largest amount of waste was generated in Tuesday and low amount was generated in Friday (Figure-1).

Estimation of annual healthcare waste generation rate: The annual healthcare waste generation rate estimation in the hospital was 13948.21kg/year. The annual flow of patients and mean healthcare waste generation rate per patient per day (the assumption was each patient who visited the hospital may generate the same amount of HCW throughout the year). The total HCW generation rate in kg per year =HCW generation rate in kg per day* 365.

Comparison between patient flow and waste generation rate: Spearman’s rank correlation coefficient (rs) was used for testing the existence of any bivariant correlation between the total numbers of patients and the total amount of healthcare waste generated. Accordingly, there was strong a positive linear relationship between amount of healthcare waste generated and total patient flow (r=0.75, p=0.052).

Healthcare waste management: Storage and segregation: The wastes were segregated at the source of generation into sharps, infectious wastes, general waste and pathological wastes in different containers. All type of container were located every area where they might needed and made from puncture resistant material and easy washable. The HCW were segregated into general waste (Black container), hazardous waste (Yellow container) and sharp material (safety box).

Table-1: Quantity of Healthcare waste generated per day by type in study unit of Mizan-Tepi University Teaching Hospital Southwest, Ethiopia 2019.

Name of case team (unit)	Total HCW in seven days (kg)	Average daily waste generated in each unit (kg)	Average daily general waste generated in each case (kg)	Average daily hazardous waste generated in each unit (kg)
OPD	36	5.14	2.08	1.9
Emergency	42	6	2.9	1.83
Surgery	33	4.31	1.9	1.76
Medical	39	5.57	2.02	1.96
Pediatrics	30	4.28	1.45	1.04
Delivery	46.9	6.7	3.03	2.09
Laboratory	31	4.43	1.5	1.04
Mean	36.84	5.20	2.13	1.14
Standard deviation	5.17	0.87	0.62	0.43

Table-2: The amount of hazardous wastes daily generation rate in each case unit of Mizan-Tepi University Teaching Hospital Southwest, Ethiopia 2019.

Name of case team (unit)	Sharp waste (kg/day)	Infectious waste (kg/day)	Pathological waste (kg/day)	Total hazardous Waste (kg/day)
OPD	0.51	0.75	0.0	1.26
Emergency	0.25	0.45	0.0	0.70
Surgery	0.29	0.31	0.10	0.60
Medical	0.78	0.87	0.00	1.65
Pediatrics	0.34	0.45	0.00	0.79
Delivery	0.32	0.91	0.56	1.79
Laboratory	0.89	0.30	0.00	1.19
Mean	0.48	0.577	0.094	1.14
Standard deviation	0.23	0.24	0.193	0.43

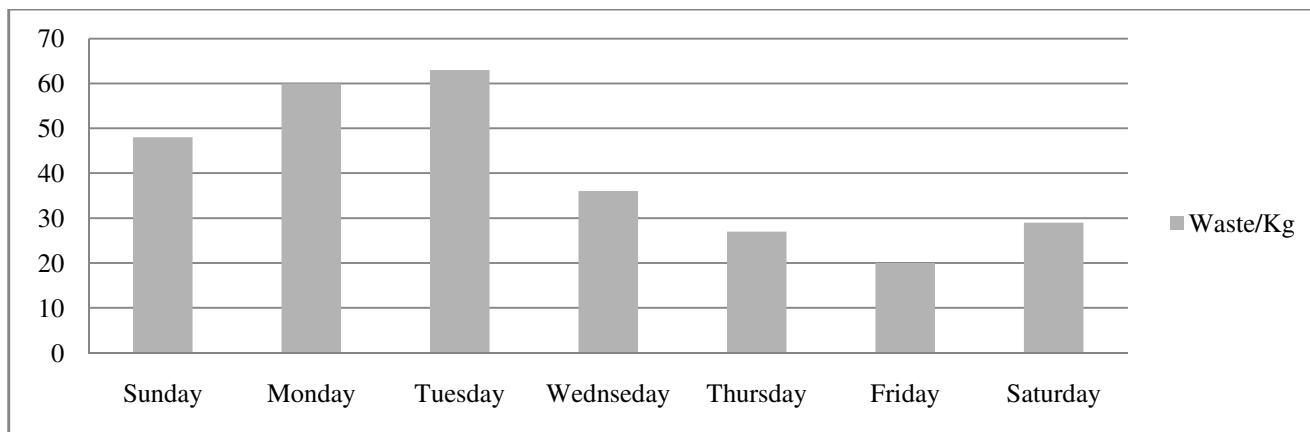


Figure-1: Daily Healthcare waste generation in Mizan-Tepi University Teaching Hospital (kg/day) Southwest, Ethiopia 2019.

Temporary storage: The hospital temporarily stored waste in open and substandard dustbins for about 12 hours. Pathological waste was stored in closed plastic containers and collected in less than 30 minutes. For sharp wastes used non-standard storages, such as carton boxes. That can be easily damaged or torn out. In the study hospitals, lack of proper waste storage areas was apparent.

Collection and transportation: The wastes that draw together had been transported to separate storage sites of different wastes. Transportation was made through wheeled trolleys that were committed solely for the waste collection and transportation. Not all waste handlers were fortified with suitable personal protective devices such as heavy-duty gloves, thick-soled boots and leg protectors during waste transportation. The hospital used both open and closed trolley for general waste and hazardous waste for transportation to on-site collection and carton boxes for contaminated sharp material collection.

Waste treatment and disposal: The waste disposal methods used by the hospital were incinerator, open-pit burning, small burial, and placenta pit. Pathological waste was collected in a non-water tight placenta pit. The incinerator was prepared by local bricks that did not have satisfactory air inlets for the enhancement of active waste combustion which was used to burn sharps waste in hospital. The other nonhazardous waste burn on open pit and general and hazardous waste were kept in separate burial. Treatment of infectious wastes prior to the final disposal was not practiced. In the hospital, there was no healthcare waste recycling or reusing mechanism.

Discussion: This study focused on the determination of healthcare waste generation rate, composition, and assessment of its management system. The average total healthcare waste generation rate was 0.07kg/patient/day, 0.306kg/bed/day. The annual hospital waste generation rate estimation in the hospital was 13948.21kg/year.

The finding of waste generation rate was higher than a study conducted in Greece which was 0.012kg/bed/day¹², Bangladesh

which was 0.934kg/bed/day¹³, but it was higher than the study conducted in Nigeria on which 0.12-0.28kg/patient/day¹⁴. The difference might be explained by study time, use of technology and geographical location. The percentage composition of non-hazardous waste in this study was 57.34%, which is lower than a study conducted in Bangladesh and Pakistan on which 77.08% and 92% were non-hazardous respectively^{12,15}. The result was similar with 52.7%, 58.69% which were conducted in Hawassa, Ethiopia 52.7% and Addis Abeba, Ethiopia^{16,17}.

Healthcare waste management practice includes all activities of healthcare waste segregation, storage, collection, transportation, treatment, disposal and other safety measures in health institutions¹⁸. The first priority among the waste management practices is on-site handling and proper separation of waste at the point of generation¹⁹. This research indicated that there was proper healthcare waste segregation practice using color code containers and labels in the study hospital. This finding is differ from the study conducted Somaliland and Kenya^{19,20} but comparable to study conducted Hawassa city SNNPR Ethiopia 2011¹⁷. The reason may be healthcare workers, administrative and waste handler staffs were adequately perceived as the health risk of handling healthcare waste.

The hospital wastes were temporarily stored in open dustbins that could attract insects, rodents, cat/dogs and they were also prone to spill over; these could potentially contaminate the environment that can cause disease and injury to those exposed to them²¹. This finding similar to the temporary storage practices in Nigeria and other parts of Ethiopia^{14,17}. This implies that in developing countries temporary healthcare waste storage practice creates a health risk to the workers as well as to the public.

In the study, hospital wastes were collected and transported by closed and open trolley without properly labeled. This finding was different from the study conducted in India (2012), which states that all containers used for the collection of hazardous wastes were standard with a proper cover and labeling²². The difference may be due to the variation on the level of awareness

of healthcare professionals, waste handlers, and decision makers. However, the finding is similar to the study conducted in Iran (2011), which reported malpractices of collection and transportation²³.

Conclusion

The solid health-care waste segregation at generation point was good but temporally storage, transportation and treatment were poor. This might create the potential for health risk and environmental pollution. Cleaners must wear personal protective devices before handling health care wastes, there should be separated transportation trolley for hazardous and none hazardous wastes. Compliance with solid waste management guideline should be a norm. Future study on perception and behavior of health workers and patients in relation to health care is recommended.

Declarations: Ethics approval and consent to participate: Ethical clearance was obtained from Ethical Review Committee of Mizan-Tepi University College of health sciences. Written informed consent was obtained from each study participants. Each study participants were briefed with objective, benefit and procedural steps of the study. Voluntary participation was assured and right to interrupt from interview was clearly stated.

List of abbreviation: ATSDR - Agency for Toxic Substances and Diseases Register, CRT - Cathode ray tube, FMOH - Federal Ministry of Health, HBV - Hepatitis B virus, HCW - Health-care waste, HCWM - Health care waste management, MTUTH - Mizan-Tepi University Teaching Hospital, TB – Tuberculosis, WHO - World Health Organization, SNNPR - Southern Nations and Nationalities and Peoples’ Region.

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Annex

Department of Public Health, College of Health Science, Mizan-Tepi University, Ethiopia

Observational checklist on the assessment of health care solid waste generation rate and management practice at Mizan-Tepi University Teaching Hospital.

Consent Form

Greeting:

Hello, my name is _____. I would like to interview you a few questions about health care waste management practice in your hospital. Therefore, your cooperation and willingness for the interview and observation is helpful in identifying problems related to the subject matter. All information that you give will be kept strictly confidential. Your participation is voluntary and you are not obliged to answer any question you do not wish to answer. Do I have your permission to continue?

1. If yes, continue to the next page
2. If no, skip to the next participant

Interviewers’ name _____

Signature _____

Date of interview _____ Time started _____

Time finished _____

Supervisors name _____ signature _____

Identification

- Checklist identification number: _____
- Address: _____
- Name of hospital _____
- Estimated population served in your hospital _____
- Number of beds the facility that have _____
- Number of inpatients _____
- Average number of outpatients per day _____
- Number of outpatients visited your hospital in the last year _____

Part I – Observation Checklist To Assess Health Care Waste Management Practice			
1. Health Care Waste Storage And Segregation			
S. No	Questions	Questions response	Skip to
01	Does HCWs segregated at the source of generation?	1. Yes 2. No	
02	Does the facility have separate containers for general, hazardous, infectious, pathological, pharmaceutical, and sharp waste?	1. Yes 2. No	If No skip to Q.No.11
04	Do you have a specific colour coding system for different containers in your hospital?	1. Yes 2. No	
05	Does all types of containers are clearly marked or labeled?	1. Yes 2. No	
06	Are all types of containers are located in every area where they might be needed?	1. Yes 2. No	
07	Are containers easily cleanable?	1. Yes 2. No	

08	Are containers made of a puncture-resistant material (cardboard, plastic, or metal)?	1. Yes 2. No	
09	Are HCW containers emptied daily or whenever they are 3/4 full?	1. Yes 2. No	
10	Are sharps containers closed securely and disposed of whenever they are 3/4 full?	1. Yes 2. No	
11	For what reasons is there absence of HCW storage bins?	1.Shortage of budget 2. Logistical 3. Others (specify)	
12	Do you have a specific temporary storage area for HCW? (Ask to be allowed to take photos of the HCW storage area place)	1. Yes 2. No	
13	Do all temporary storage sites are located in areas that are minimally accessible to staff, clients, and visitors?	1. Yes 2. No	
14	Is the health care waste stored for more than 24 hours? Before being treated / disposed of?	1. Yes 2. No	
2. Health Care Waste Collection And Transport			
15	What are the devices used for transporting HCW at onsite?	1. Open device 2. Closed device 3. Others (specify)	
16	Does hazardous / infectious health care waste and non-risk health care waste are collected on a separate trolley?	1. Yes 2. No	
17	Are there any transport services to take health care wastes to its final treatment or disposal site?	1. Yes 2. No	If No skip to Q.No.19
18	Who generally transports the HCW to its final disposal or treatment site?	1. The hospital facility 2. Municipal service 3. Private company 4. Others (specify)	
3. HCW treatment and disposal (Take photos of the treatment and disposal system available)			
19	Is HCW treated on-site or off-site?	1. On-site 2. Off-site	If off-site skip to Q.no 21
20	What are the on-site practices for HCW treatment?	1. Crushing of sharps 2. Sterilization 3. Chemical disinfection 4. Others (specify)...	
21	Which type of off-site HCW treatment system is used/ available in your hospital facility?	1. None 2. Open fire 3. Incinerator 4. Burying 5. Others (specify)	
22	Who's in charge with the off-site treatment?	1. Hospital 2. Municipality 3. Others (specify)...	
23	Is there a standard incinerator at your hospital facility?	1. Yes 2. No	If No skip to Q.no. 28
24	Is the incinerator located downwind from the hospital?	1. Yes 2. No	
26	Is the incinerator surrounded by a fence or wall to limit access?	1. Yes 2. No	
27	Where the ash from the incinerator is disposed of?	_____	
28	If you do not have incinerator, where is clinical waste incinerated?	_____	

29	Do you disposal site for wastes generated in your health care facility?	1. Yes 2. No	If No skip to Q.no. 32
30	Which type of disposal site is used for the HCW?	1. Open dump 2. Sanitary landfill 3. Small burial 4. Others (specify)	
31	Is the disposal site well protected by fence?	1. Yes 2. No	
32	Do you have a placenta pit in your health care facility (take photo)	1. Yes 2. No	
33	Can you list any HCW recycling methods if available?	_____	
34	Can you list any reusing mechanism available in your health care facility?	_____	
Part II- Key informant interview guide for Health care workers, or waste handlers			
35	Sex	1. Male 2. Female	
36	What is your educational level?	1. Elementary (grade 1-8) 2. Secondary (grade 9-10) 3. Preparatory (grade 11-12) 4. Diploma 5. Degree 6. Others (specify)	
37	What is your profession?	1. Health officer 2. Doctor 3. Nurse 4. Pharmacist 5. Laboratory staff 6. Ancillary staff (waste handlers) 7. Others (specify)	If it is waste handlers skip to Q.no. 47
38	What is your responsibility (place of work) in the hospital in this week	1. Opd, 2. Ward, 3. Delivery room, 4. MCH, 5. Laboratory, 6. others, (specify)---	
39	Do you have sufficient quantities of sharps boxes to dispose of sharps safely?	1. Yes 2. No	
40	Do you dispose needles, syringes, and sharps immediately after use in sharp containers?	1. Yes 2. No	
41	Did you take any vaccine against hepatitis B, C and tetanus?	1. Yes 2. No	
42	For how many years you worked in this health care facility?	_____	
43	Do you use protective clothing when handling clinical waste?	1. Yes 2. No	
44	What type of protective device you are using?	1. Gown 2. Glove 3. Boot 4. Others (specify)_____	
45	Have you received any training in clinical waste management	1. Yes 2. No	

Health Care Generation Rate Monitoring Tool

Mizan-Tepi University Teaching hospital _____
 Number of visitors (outpatients) _____ Number of inpatients _____

Date	Time	Ward/unit	Types of waste	No. of waste bags and sharp cont.	Weight (kg)	Brought by (full name)	Received by full name				
		OPD	General								
			Hazardous								
			Sharps								
		Surgery	General								
			Hazardous								
			Sharps								
		Medical	General								
			Hazardous								
			Sharps								
		Delivery	General								
			Hazardous								
			Sharps								
		Laboratories	General								
			Hazardous								
			Sharps								
		Pediatrics	General								
			Hazardous								
			Sharps								
		Emergency	General								
			Hazardous								
			Sharps								
		Total weight (kg)									

References

- Pépin J., Abou Chakra C.N., Pépin E., Nault V. and Valiquette L. (2014). Evolution of the global burden of viral infections from unsafe medical injections. *PLoS One*, 9(6), 2000-2010.
- World Health Organization (2000). Wastes from Healthcare Activities. WHO Fact sheet No. 253; Available from: URL: http://www.phrusa.org/campaigns/aids/who_031303/unsafe.html-99k.
- Askarian M., Vakili M. and Kabir G. (2004). Results of a hospital waste survey in private hospitals in Fars province, Iran. *Waste Management*, 24(4), 347-352.
- HabibUllah J., Ahmad K. and Khan M.A. (2010). Managing the healthcare solid waste in selected districts of Punjab, Pakistan. *Pakistan Journal of Medical Science*, 26(4), 795-799.
- World Health Organization (2006). Management of waste from injection activities at the district level: guidelines for district health managers. WHO; Geneva, Switzerland.
- World Health Organization (2007). Health care wastemanagement. Fact sheet No.1.
- Hossain M.S., Santhanam A., Norulaini N.N. and Omar A. M. (2011). Clinical solid waste management practices and its impact on human health and environment–A review. *Waste management*, 31(4), 754-766. doi:10.1016/j.wasman.2010.11.008
- Debere M.K., Gelaye K.A., Alamdo A.G. and Trifa Z.M. (2013). Assessment of the health care waste generation rates and its management system in hospitals of Addis Ababa, Ethiopia, 2011. *BMC public health*, 13(1), 28.
- Sasu S., Kummerer K. and Kranert M. (2012). Assessment of pharmaceutical waste management at selected hospitals and homes in Ghana. *Waste Manag, Res.*, 30(6), 625-630. 21.
- Sawalem M., Selic E. and Herbell J.D. (2009). Hospital waste management in Libya: a case study. *Waste Management*, 29(4), 1370-1375.
- Ruoyan G., Lingzhong X., Huijuan L., Chengchao Z., Jiangjiang H. and Yoshihisa S. (2010). Investigation of health care waste management in Binzhou District, China. *Waste Management*, 30(2), 246-250.
- Komilis D., Fouki A. and Papadopoulos D. (2012). Hazardous medical waste generation rates of different categories of health-care facilities. *Waste Management*, 32(7), 1434-1441.

13. Sarkar M.S., Haque M.A. and Khan T.A. (2006). Hospital waste management in Sylhet City. *ARPN J EngAppl Sci.*, 1(2), 32-40.
14. Basseyy B.E., BenkaCoker M.O. and Aluyi H.A. (2006). Characterization and management of solid medical wastes in the Federal Capital Territory, Abuja Nigeria. *Afr Health Sci.*, 6(1), 58-63.
15. Abdi El-Salam M.M. (2010). Hospital waste management in El-Beheira Governorate, Egypt. *J Environ Manag.*, 91(3), 618-629.
16. Haylamicheal I.D., Dalvie M.A., Yirsaw B.D. and Zegeye H.A. (2011). Assessing the management of healthcare waste in Hawassa city, Ethiopia. *Waste Management & Research*, 29(8), 854-862.
17. Debere M.K., Gelaye K.A., Alamdo A.G. and Trifa Z.M. (2013). Assessment of the healthcare waste generation rates and its management system in hospitals of Addis Ababa, Ethiopia. *J.BMC public health*, 13, 28.
18. Al-Khatib I.A. and Sato C. (2009). Solid health care waste management status at health care centers in the West Bank–Palestinian Territory. *Waste management*, 29(8), 2398-2403.
19. Engdaw D., Sulaiman H. and Leta S. (2009). Determining the generation rate and composition of solid health care waste at Gondar University Hospital. *Ethiopian Journal of Health and Biomedical Sciences*, 1, 17-21.
20. Hassan A. (2018). Assessment of medical waste disposal methods in Hargeisa public hospital–Somaliland. *International Journal of Social Science and Humanities Research (Online)*, 6(4), 1144-1167.
21. Njue P.M., Cheboi K.S. and Oiye S. (2015). Adherence to healthcare waste management guidelines among nurses and waste handlers in Thika sub-county-Kenya. *Ethiopian journal of health sciences*, 25(4), 295-304. DOI: 10.4314/ejhs.v25i4.2.
22. Singh B.P., Khan S.A., Agrawal N., Siddharth R. and Kumar L. (2012). Current biomedical waste management practices and cross-infection control procedures of dentists in India. *International dental journal*, 62(3), 111-116.
23. Askarian M., Heidarpoor P. and Assadian O. (2010). A total quality management approach to healthcare waste management in Namazi Hospital, Iran. *Waste management*, 30(11), 2321-2326.