



Assessing Human and Animal Healthcare Personnel's Knowledge, Attitudes, and Practices toward Medical Waste Management at Health Centers and Communities in Kampot Province, Cambodia

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Received September 04, 2023; revised September 18, 2023; accepted October 03, 2023

ABSTRACT

Introduction

Poor management of medical waste at health facilities has contributed to detrimental impacts on the environmental, human, and animal health in developing countries. Despite the availability of national policy and guidelines on medical waste management in Cambodia, understanding medical waste management at service delivery points remains a gap. Our study aims to assess the human and animal health personnel's knowledge, attitudes, and practices toward medical waste management at the selected health centers, animal clinics, and communities in Kampot province, Cambodia.

Methods

The data collection was conducted in Kampot province from 18 to 20 August, 2022 with twelve participants from health centers, four from animal clinics and four from community. The participatory epidemiology approach using various data collection methods, which included focus group discussion, proportional piling, and mapping exercises, was executed. Thematic analysis was applied to identify the key themes. The data from transect walks and key informant interviews were triangulated with other findings.

Results

Almost all participants had favorable attitudes toward enhancing the best medical waste management practices. While animal health personnel had lower knowledge and poor management practice, human health personnel had already initiated medical waste management at their facilities. Nevertheless, there were still more opportunities to improve off-site transportation, on-site storage, treatment plans, and disposal practice.

Conclusion

Medical waste management at health centers and communities in Cambodia merits more serious attention. More training and coaching programs are needed to build the capacities of human and animal healthcare personnel and enhance the standardized practice in complement with more financial and technical support.

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Citation: Ngor C, Invong W, Man D, Ly P, Chuon M, Ban N, Khieu K. Assessing human and animal healthcare personnel's knowledge, attitudes, and practices toward medical waste management at health centers and communities in Kampot province, Cambodia, *CJPH* (2023) 04:04.

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Keywords: Knowledge, attitudes, practices, medical waste management, participatory epidemiology

Introduction

Over the last decades, the increase in the number of health facilities (HFs) with the advancement of medical sciences and technologies has contributed to the rising amount of medical waste globally [1]. Medical waste can significantly impact the progress toward achieving the United Nations Sustainable Development Goals (SDGs) [2]. While there is no universal definition, the World Health Organization (WHO) defines medical waste as "waste that is generated in the diagnosis, treatment, or immunization of human beings or animals from healthcare facilities, research centers, and laboratories related to medical procedures" [3].

The WHO estimated that 15% of medical waste could be hazardous (infectious, toxic, or radioactive substances), and the other 85% was non-hazardous. Nevertheless, poor practice in separating hazardous from non-hazardous waste made the number of hazardous wastes much higher in developing nations [4]. The increase in medical waste, especially personal protective equipment (PPE) and vaccines, exacerbated the challenges in waste management at HFs and thus resulted in significant public health problems amid the Covid-19 pandemic [5].

In Cambodia, the MWM Unit under Red Cross Cambodia, the largest humanitarian organization, has overseen MWM from collection to disposal only in the capital city of Phnom Penh [6]. However, medical waste in the provinces has been managed locally at the service delivery points (SDPs) [7]. This practice of handling, segregating, storing, treating, and disposing of medical waste at SDPs in the provinces has thus been a serious concern [6].

The optimum practice of MWM relies on adequate knowledge, the favorable attitude of healthcare workers and waste handlers, and other enabling factors [8, 9]. Despite the grave public health concerns about inefficient MWM, fewer studies on medical waste, particularly the awareness and the practice of MWM at SDPs, have been conducted in Cambodia [10, 11]. Therefore, our study aimed to assess human and animal health personnel's knowledge, attitude, and practices (KAP) toward MWM at health centers (HCs), animal clinics, and communities in Kampot province, Cambodia. Understanding this will help inform policy improvement and proper MWM practice at the SDP level.

Materials and Methods

A. Study setting and design

The data collection was conducted in Kampot province from 18 to 20 August, 2022. This province comprises four operational districts and 64 HCs in 488 villages [12]. The qualitative method was applied to collect and triangulate the data from the participatory epidemiology (PE) approach, transect walks, and key informant interviews (KIIs). The PE activities were held at the Kampot Diamond Hotel.

B. Study participants and sites

In the initial step, 12 HCs were purposely selected from the list of HCs in four operational districts. Then, personnel working to manage medical waste in each selected HC was invited to participate in the PE activities. At the same time, four animal health personnel (two from private and two from non-governmental clinics) and four village animal health workers were invited to participate in the study. Therefore, 20 participants were selected and invited to attend the PE activities at Kampot Diamond Hotel. In the second step, the research team conducted the transect walk and KIIs at six locations (four HCs and two animal clinics). Transect walk is a direct observation method in participatory action research for collecting spatial data and identify problem by asking and listening people and observing inhabitants and surrounding environment while walking around their areas and communities [13].

C. Study materials

A semi-structured questionnaire was used for focus group discussion (FGD), proportional piling, and mapping exercises during PE activities. During the transect walk and KII activities, the data collectors used a checklist for direct observation, an unstructured questionnaire to interview key informants, and visual aid to capture some pictures. The semi-structured questionnaire and the transect walk checklist were established based on the theoretical framework of human and animal healthcare personnel's KAP toward MWM adapted that of Deress [14] (**See appendix 1**).

D. Data collection training and procedures

Our research team hired four research volunteers to assist with the data collection. The research team and volunteers attended a one-day data collection and management training. The data collectors also pre-tested the questionnaire and approach to adjust, modify, and correct.

The data collection was administered in two phases. In the first phase, the 12 inviting participants attended PE activities, including FGD, proportional piling, and mapping exercises. Before starting PE activities, the research team requested consent and

provided instructions to the participants. In the second phase, the research team and volunteers interviewed some key informants and conducted the transect walk activities to observe the MWM practices at the selected facilities.

E. Data management and analysis

Qualitative data obtained from PE activities were entered into an Excel® spreadsheet for analysis. The thematic analysis was applied to identify the key themes based on the conceptual framework. Relevant quotes were defined and extracted to support the findings. The analytical results were then triangulated with the outputs from the transect walk and KIIs [15]. Furthermore, the findings were compared between those collected from human and animal healthcare personnel.

F. Ethical consideration

The study protocol was reviewed and approved by the National Ethics Committee for Health Research (NECHR), Cambodia's Ministry of Health, on July 21, 2022 (No. 205 NECHR) and UC Davis Institutional Review Board (IRB 1980311-1) on December 6, 2022. All study participants provided informed written consent prior to their participation in the study. A unique code is assigned to replace the name of each participant to protect the confidentiality and anonymity of the data during and after the research.

Results

A. Basic socio-demographic characteristics of the study participants

Of the 20 participants, thirteen were males, and seven were females. The average age of participants was 36.3 years (Median = 32.0 years), ranging from 25 to 60 years. Five participants graduated with a bachelor's degree, ten with an associate's degree, one with a primary's degree, and four finished grade 12 or lower. Regarding their current occupation, twelve participants were HC personnel, four were clinic veterinarians, and six were village animal health workers (**Table 1**).

B. Knowledge of the participants on MWM

Table 2 summarizes the assessment of the participant's MWM knowledge.

Overall, HC personnel had higher MWM knowledge than the clinic animal personnel and village animal workers. However, their knowledge was limited to segregating medical waste. Most HC

participants defined medical waste as waste from hospitals and HCs, and they categorized medical waste into different types, such as general, infectious, toxic, sharp, pathological (placenta pit), laboratory, and radioactive wastes. Most animal personnel could not well define medical waste.

Table 1: Basic socio-demographic characteristics of the study participants

| Basic characteristics | N = 20 | |
|--|--------|--------|
| | Freq. | % |
| Sex | | |
| Male | 13 | 65 |
| Female | 7 | 35 |
| Average age of participants in years (Median) | 36.3 | (32.0) |
| Range | 25-60 | |
| Occupation | | |
| Health center personnel | 12 | 60 |
| Animal health personnel | 4 | 20 |
| Village animal health workers | 4 | 20 |
| Highest education level of participants | | |
| Bachelor's degree in nursing | 1 | 5 |
| Bachelor's degree in midwifery | 1 | 5 |
| Bachelor's degree in animal science and Veterinary medicine | 3 | 15 |
| Associate's degree in nursing | 7 | 35 |
| Associate's degree in animal science and Veterinary medicine | 1 | 5 |
| Associate's degree in midwifery | 2 | 10 |
| Primary's degree in midwifery | 1 | 5 |
| Less or equal to grade 12 | 4 | 20 |

“Medical wastes are wastes from medical treatment, including syringes, needles, serums, and animal organs.” (An animal clinic personnel-R13)

“Medical wastes are serum bottles, infusion sets, needles and syringes, and sanitary tissues and cotton.” (A village animal worker-R18).

Even though some participants had seen the biohazard symbols, nearly all participants were uncertain about the meaning of this warning sign. Many respondents acknowledged that improper MWM could increase the risk of disease infections and transmission from humans to animals. Fewer participants expressed concerns about the unhealthy environment caused by medical waste.

“Blood and cotton from infectious waste, for example, can cause infectious diseases such as HIV/AIDS, STD, Hepatitis B, Hepatitis C, and Covid-19.” (A HC personnel-R8)

“...If wastes are buried, they can cause a contaminated and polluted environment.” (A village animal worker-R13).

Table 2: Knowledge of participants on MWM

| Measures of knowledge | Health center personnel | Animal clinic personnel | Village animal workers |
|--|--|--|---|
| Identification of medical waste | Waste from hospitals and health centers including general, infectious, toxic, sharp, pathological (placenta pit), laboratory, and radioactive waste | Waste from medical treatment such as syringes, needles, serums, and animal organs | Medical waste such as serum bottles, infusion sets, needles, syringes, sanitary tissues, cotton.... |
| Recognition of the biohazard symbol | Have ever seen it but are uncertain about its specific warning sign | Have ever seen it but are uncertain about its specific warning sign | Have never seen or recognized the biohazard symbol |
| Health and environmental hazards of medical waste | Improper MWM can increase the risk of infectious disease and cancer, affect the beautiful and hygienic surroundings | Improper MWM results in the transmission of infectious diseases from animals to humans. | Improper MWM can transmit infectious diseases between humans and animals and cause an unhealthy environment |
| MWM procedures | Separate different types of waste in plastic bags in different color-coded bins and stored them in the on-site incinerators for disposal. Storing pathological waste and glass waste in a separate well. Use safety boxes for sharp waste. | Some medical waste can be open-burned while needles and medical bottles are loaded in safety boxes or plastic bags to be collected by the waste collection firm for disposal with general waste. | Open burning or burying of medical waste depending on the types of waste |
| Importance of PPE | Protective from infection | Protective from infection | NA |

* Abbreviation: MWM: medical waste management; NA: not available; PPE: personal protection equipment

C. Attitudes of the study participants toward MWM

The result from proportional pilling activities and further discussion showed that nearly all participants consented to a favorable attitude toward MWM regarding the personnel's responsibilities, the proper MWM procedures, the health and environmental hazards, reporting systems, and PPE use (**Table 3**). However, there were a few controversial statements on treating medical waste, reporting systems, and the required teamwork for MWM.

Two participants strongly disagreed that medical waste should be appropriately treated before disposal. They believed the disposal practice would get rid of negative consequences.

“Treating or non-treating [medical waste] has no difference.” (A village animal worker-R14).

“Treating medical waste is unnecessary because burning is considered disinfection.” (Two village animal workers-R13 and R15).

Five argued that waste management recording was unnecessary.

“I felt neutral since our private clinic does not require a management record, but it would be better if we had one.” (A clinic animal personnel-R21)

“...No need to have a management record because the private waste collection firm will collect and dispose of that [medical waste]. It is manageable.” (A clinic animal personnel-R20)

“The report is not useful.” (A village animal worker-R16)

“It is unnecessary to report this [medical waste record] since it is manageable.” (A village animal worker-R13).

A few respondents disagreed with the required teamwork to manage safe medical waste.

“It is not easy to get the team involved.” (A village animal worker-R13)

“It is the waste under our management. If we need support from others, it might be inappropriate.” (A village animal worker-R14).

Table 3: Attitude of the study participants toward MWM

| Statements for assessing the participant's attitude toward MWM | Number of participants | | | | |
|---|------------------------|----------|---------|--------|----------------|
| | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
| | N (%) | N (%) | N (%) | N (%) | N (%) |
| Improperly managed medical waste may cause infection | 0 | 0 | 0 | 7 (35) | 13 (65) |
| Proper segregation of medical waste facilitates safe handling | 0 | 0 | 0 | 3 (15) | 17 (85) |
| Labelling containers of medical waste has no significance | 17 (85) | 3 (15) | 0 | 0 | 0 |
| A well-designated waste storage facility is important for medical waste management | 0 | 0 | 0 | 7 (35) | 13 (65) |
| Medical waste needs to be properly treated before disposal | 2 (10) | 0 | 2 (10) | 9 (45) | 7 (35) |
| Proper medical waste disposal is important to prevent infection transmissions such as HIV, HBV, HCV, and others | 0 | 0 | 0 | 8 (40) | 12 (60) |
| Wearing personal protective equipment during managing medical waste properly helps to reduce the risk of infection | 0 | 0 | 0 | 6 (30) | 14 (70) |
| It is less important to have waste management records at different stages of medical waste management | 3 (15) | 11 (55) | 1 (5) | 2 (10) | 3 (15) |
| Safe medical waste management involves a teamwork | 3 (15) | 1 (5) | 0 | 7 (35) | 9 (45) |
| Medical waste management adds extra burden work for you | 4 (20) | 14 (70) | 1 (5) | 0 | 1 (5) |

* Abbreviation: HBV: hepatitis B virus; HCV: hepatitis C virus; HIV: human immunodeficiency virus; MWM: medical waste management

Table 4: Practice of the study participants in MWM

| Practice of MWM | Health center personnel | Animal clinic personnel | Village animal workers |
|--|---|---|--|
| MWM procedures | <p>Preparing and collecting: Three or four different color-coded bins for various types of waste</p> <p>Storing: Very few HCs have a storage facility for medical waste, mostly stored in the on-site cinerator. Safety boxes are used for sharp waste. Storing timeframe for medical waste varies from two to three days, except for sharp waste for two weeks. The temporary store will be longer during raining season. Pathological waste for immediate disposal.</p> <p>Segregating and treating: None</p> <p>Disposal: General and medical waste are disposed of in an on-site incinerator. A concrete well for pathological waste, ashes, and glass waste separately</p> | <p>Preparing and collecting: Only separate medical waste from other general waste</p> <p>Storing: All types of medical waste are put together in plastic bags and bins, except sharp waste</p> <p>Segregating and treating: None</p> <p>Disposal: Open burning or burying</p> | <p>Preparing and collecting: Only separate medical waste from other general waste</p> <p>Storing: All types of medical waste in plastic bags at home from the reach of others and animals</p> <p>Segregating and treating: None</p> <p>Disposal: Open burning or burying</p> |
| Frequency of medical waste disposal | Medical waste, except sharp waste, is disposed of on-site once every few days depending on the amount of medical waste but could be delayed during the rainy season. Sharp waste is disposed of every two weeks at the referral hospital. | Every week | Randomly depending on the available time |
| Use of PPE | Only cleaners use gloves, boots, and facial masks. | Only facial masks and gloves are used for MWM. The gown is reported as unnecessary. | No PPE is used for MWM |

* Abbreviation: HC: health center; MWM: medical waste management; PPE: personal protection equipment

D. Practices of the study participants in MWM

The assessment of MWM practice in different stages during the FGD and mapping activities was reported in **Table 4**.

(1) Preparation, collection, and segregation

Preparing medical waste at HCs was mainly to segregate different types of medical waste in three or four color-coded bins and sharp waste in safety boxes. The animal health personnel reported only separating their medical waste from general waste and putting different types of medical waste, except syringes and needles, in plastic bags and bins.

(2) Storage and off-site transportation

All types of medical wastes, except sharp and pathological waste, were often stored impermanently for two to three days before disposal in the on-site cinerators beside the HCs. These wastes were stored longer during the rainy season as the outdoor disposal sites got wet or flooded. All HCs transported their

safety boxes to referral hospitals (RHs). The animal clinic personnel and village animal workers stored medical waste in plastic bags and bins for several days without knowing the storage timeframe.

(3) Treatments

There were no practical procedures and plan for treating medical waste before on-site disposal at HCs, animal clinics, and communities.

(4) Disposal

Medical wastes, excluding sharp waste, glasses, and placenta, were burned in on-site incinerators. Interestingly, the medical wastes, such as glasses and pathologies, were kept permanently in the concrete well rings. The modern incinerators at nearby RHs were employed to dispose of the sharp waste. Dissimilarly, personnel at the animal clinics and communities practiced traditional methods such as open burning or landfilling for disposing of medical waste.

(5) Hygiene and sanitation

When handling medical waste, the waste handlers or cleaners at HCs used gloves, boots, and surgical masks. Animal clinic personnel used only surgical masks and gloves. Surprisingly, village animal workers asserted that they used only gloves.

E. External factors influencing participants' KAP toward MWM

The information from FGD affirmed that there was neither structure nor a specific committee for MWM at HCs, animal clinics, and communities. Animal health personnel reported the lack of budget, guidelines, assessment, and reporting systems at their working facilities. HC personnel claimed the availability of the technical guidelines on healthcare waste management and infection, prevention, and control at HC at their facilities [16, 17]. They also included the roles of a focal person but not the MWM reporting system, in their annual operational plan. The fund from Cambodia's Health Equity and Quality Improvement Project (H-EQIP) and national budget were available for managing waste at HCs. All the participants in our study had never received proper training on MWM.

F. Triangulation of information from transect walk at facilities

The transect walks at HCs observed the collection of medical wastes by their types but the mixture at the storage and disposal sites. The on-site disposal facilities were close to the service delivery centers. Some were likely to be flooded during the rainy season. The on-site waste treatment plan and reporting system were unavailable in place.

At the observed nearby RH, some syringes and needles spilling out from safety boxes mixed up with other wastes. One of the two electronic incinerators had been out of order for three to four months. Many safety boxes placed outdoors were likely to be ruined and decayed by sunlight and rainwater (**Figure 1**).

There were inadequate waste bins, safety boxes, and plastic bags for distinguishing different kinds of medical waste at the observed animal clinics. There was neither a waste collection schedule nor an MWM reporting system. The key informants reported the lack of an on-site treatment plan, storage, and disposal facility. Medical waste was collected with general waste by the garbage collection company.



Figure 1: Improper storage of sharp waste for incineration in one referral hospital (Transect walk on August 19, 2022)

Discussion

The results from the triangulation of various data sources were consistent. Our findings of favorable attitudes toward enhancing the best practices of MWM among participants were consistent with those in a recent systematic review assessing the healthcare personnel's KAP regarding biomedical waste management [18].

Our assessment found that animal health personnel had lower knowledge of MWM than HC personnel. The unavailability of policy and infrastructure, standard guidelines, and proper training might explain the limited knowledge of animal health personnel.

Although HC personnel had better MWM practices than animal health personnel, the on-site storage, off-site transportation, treatment plans, and unstandardized incinerators remained a gap. The use of outdoor disposal facilities for temporary storage and the longer storing duration than recommended were grave concerns. According to Articles 13 and 14 of the regulation on Healthcare Waste Management in Cambodia and WHO guideline, healthcare waste is recommended to store in proper facilities not exceeding 48 hours in summer and 72 hours in winter [19, 20]. This improper storage with a mixture of different types of waste and the long storing duration

was likely to increase the hazardous effect and high treatment cost [21].

Despite its usefulness in minimizing the hazardous effects of medical waste and protecting the environment [22], none of the simple and efficient on-site treatment plans was available at the observed facilities in our study. The limited technical support and attention to the necessity of waste treatment before disposal found in the proportional piling exercise in our assessment might explain the lack of an on-treatment modality.

All HCs commonly burned all medical waste, excluding placenta, glasses, and sharp waste, in the non-standard outdoor incinerators. Utterly, traditional open burning or burying executed for medical waste disposal among animal clinic personnel and village animal workers found in our study was even critical. Article 18 of the 2008 Prakas on Healthcare Waste Management in Cambodia states various standard techniques for medical waste disposal as consistently recommended by the WHO [19, 22]. This malpractice of incineration leads to more hazardous environmental problems, including air, water, and soil pollution [23-25].

Personal protection equipment such as masks, gloves, aprons, eye protection or face shields, and safety boots are required for managing medical waste [16]. In our study, some participants, especially animal health personnel, poorly used PPE. The lack of budget, PPE supply, and less attention to waste handlers possibly explain the inappropriate use of PPE among these groups [9].

The animal health personnel experienced a lack of policy and environmental support. At HCs, there was neither a standard operating procedure nor a standard reporting system for MWM activities despite the availability of national policy, technical guidelines, and some funds for MWM activities. Previous studies indicated the availability of policy, MWM plans, and budget for MWM as one of the key drivers for better waste management practice and sustainability assurance [26].

Almost all respondents reported never receiving any MMW training. MWM activities at HCs relied heavily on waste handlers who appeared to be less educated. Consistently, the Indian study found the substantial roles of waste handlers and their potential health risks [27]. Many studies found adequate training a successful intervention for effective MWM [18, 28-30].

Strengths and limitations

Our study is the first to use the PE approach to assess human and animal personnel's KAP toward MWM at HCs, animal clinics, and communities in Cambodia. The study triangulates the findings using different data collection approaches. Data triangulation helps reduce information bias and enhance the validity of the research findings. A limitation of our data collection method was that the transect walk during fieldwork was not a direct observation of the personnel managing and disposing of medical waste. However, using a standard checklist for observing the facilities and KII during the transect walk made the information less prone to subjective interpretation.

Conclusion

There was a substantial variation in KAP toward MWM between human and animal health personnel. HC personnel had higher knowledge and better practices toward MWM than the clinic animal personnel and village animal workers. Nevertheless, there were still more opportunities for improvement, particularly the off-site transportation, treatment plan, on-site storage, disposal facility, and disposal practice. More training and coaching programs are needed to build the capacities of human and animal health personnel in both the public and private sectors. Financial and technical support is urgently required to optimize standardized MWM and waste management technology to promote sound healthcare waste management.

List of abbreviations

| | |
|-----|-------------------------------------|
| FGD | Focus Group Discussion |
| HC | Health Centre |
| HF | Health Facility |
| KAP | Knowledge, Attitudes, and Practices |
| KII | Key Informant Interview |
| MWM | Medical Waste Management |
| PE | Participatory Epidemiology |
| PPE | Personal Protection Equipment |
| RH | Referral Hospital |
| SDP | Service Delivery Point |
| WHO | World Health Organization |

Authors' contribution

NC, IW, and LP conceived and designed the study. NC, MD, and BN oversaw the data management. NC was responsible for conducting the qualitative analyses and data interpretation. Other co-authors participated in interpreting and providing technical inputs. NC wrote the early draft of the manuscript. KK provided feedback and edited the manuscript. All authors read and approved the final manuscript.

Acknowledgments

We are immensely grateful to the Provincial Health Department and the Provincial Department of Agriculture, Forestry, and Fisheries in Kampot province for their administrative support. We thank all the research volunteers for their partial support in logistics arrangement and contribution to the data collection and entry. We also would like to thank the participants and other staff from the public and private sectors for their voluntary participation in the data collection activities.

Funding

This work was funded by the SEAHOUN Small Grant Program with the generous support of the American people through the United States Agency for International Development (USAID) One Health Workforce - Next Generation (OHW-NG) Award 7200AA19CA00018. The contents and associated materials are the responsibility of the authors and do not necessarily reflect the views of USAID, the US Government.

Competing interest

The authors declare that they have no competing interests.

References

- [1] Visvanathan C: Medical waste management issues in Asia. In: Asia 3R Conference, Tokyo, Japan: 2006; 2006.
- [2] Nor Faiza MT, Noor Artika H, Yusof MZ: Health care waste management and sustainable development goals in Malaysia. *Journal of Wastes and Biomass Management* 2019, 1(1):18-20.
- [3] Windfeld ES, Brooks MS: Medical waste management - A review. *Journal of Environmental Management* 2015, 163:98-108.
- [4] World Health Organization [online factsheet]: Health-care waste. In.; 2018.
- [5] World Health Organization: Global analysis of healthcare waste in the context of COVID-19: status, impacts, and recommendations. In.; 2022.
- [6] Singh RK, Gamaralalage PJD, Yagasa R, Onogawa K: State of waste management in Phnom Penh, Cambodia. 2018.
- [7] Siru D: Technical guidelines on healthcare waste management in Cambodia In.; 2011.
- [8] Adogu P, Ubajaka C, Nebuwa J: Knowledge and practice of medical waste management among health workers in a Nigerian general hospital. *Asian Journal of Science and Technology* 2014, 5(12):833-838.
- [9] Deress T, Jemal M, Girma M, Adane K: Knowledge, attitude, and practice of waste handlers about medical waste management in Debre Markos town healthcare facilities, northwest Ethiopia. *BMC Res Notes* 2019, 12(1):146.
- [10] Hess J, Frumkin H: The international trade in toxic waste: the case of Sihanoukville, Cambodia. *International Journal of Occupational and Environmental Health* 2000, 6(4):331-344.
- [11] Sangkham S: Face mask and medical waste disposal during the novel COVID-19 pandemic in Asia. *Case Studies in Chemical and Environmental Engineering* 2020, 2:100052.
- [12] National Institute of Statistics: Cambodia intercensal population survey 2013. Phnom Penh: Ministry of Planning 2013.
- [13] Omer K: Rethinking transect walk and community mapping process. *The methodology and Techniques DOI* 2017, 10.
- [14] Deress T, Hassen F, Adane K, Tsegaye A: Assessment of knowledge, attitude, and practice about biomedical waste management and associated factors among the healthcare professionals at Debre Markos town healthcare facilities, northwest Ethiopia. *Journal of environmental and public health* 2018, 2018:7672981.
- [15] Greene JC, Caracelli VJ, Graham WF: Toward a conceptual framework for mixed-method evaluation designs. *Educational Evaluation and Policy Analysis* 1989, 11(3):255-274.
- [16] Ministry of Health Cambodia: National guidelines for IPC in health facilities. Phnom Penh; 2017.
- [17] Ministry of Health Cambodia: Technical guidelines on healthcare waste management. Phnom Penh; 2011.
- [18] Mannocci A, di Bella O, Barbato D, Castellani F, La Torre G, De Giusti M, Cimmuto AD: Assessing knowledge, attitude, and practice of healthcare personnel regarding biomedical waste management: a systematic review of available tools. *Waste Management & Research* 2020, 38(7):717-725.
- [19] Ministry of Health Cambodia: Prakas on healthcare waste management in Cambodia. Phnom Penh; 2008.
- [20] World Health Organization: Safe management of wastes from health-care activities: a summary. In.: World Health Organization; 2017.
- [21] Vumase SB: An evaluation of operational and administrative procedures for health care waste management in public district hospitals of South Africa. 2009.
- [22] Chartier Y: Safe management of wastes from health-care activities: World Health Organization; 2014.
- [23] Manzoor J, Sharma M: Impact of biomedical waste on environment and human health. *Environmental Claims Journal* 2019, 31(4):311-334.
- [24] Emmanuel J, Hrdinka D, Gluszynski P: Non-incineration medical waste treatment technologies in Europe; 2004.
- [25] Insa E, Zamorano M, Lopez R: Critical review of medical waste legislation in Spain. *Resources, Conservation and Recycling* 2010, 54(12):1048-1059.
- [26] Akum FA: An assessment of medical waste management in Bawku Presbyterian hospital of the upper east region of Ghana. *Merit research journal of environmental science and toxicology* 2014, 2(2):27-38.
- [27] Mane V, Nimbannavar S, Yuvaraj B: Knowledge, attitude, and practices on biomedical waste and its management among health care workers at a tertiary care hospital in Koppal, Karnataka, India. *International Journal Of Community Medicine And Public Health* 2016, 3(10):2953-2957.
- [28] Gihan H, Shima S, Rania E: An intervention study on safety climate among health care medical waste handling workers in some hospitals of Alexandria, Egypt. *Sci-Afric J Sci Issues Res Essays* 2017, 5:23-33.

- [30] David NO, Alex C, Ndubuisi U: Waste management options for health care wastes in Nigeria: A case study of Port Harcourt hospitals. *Journal of public health and Epidemiology* 2012, 4(6):156-169.
- [31] Ashtari A, Sadegh Tabrizi J, Rezapour R, Rashidian Maleki M, Azami-Aghdash S: Health care waste management improvement interventions specifications and results: A systematic review and meta-analysis. *Iranian journal of public health* 2020, 49(9):1611-1621.

Appendices

Appendix 1: Theoretical framework of KAP regarding MWM (*adapted from a conceptual framework developed by Teshiwal Deress for his thesis entitled "Assessment of knowledge, attitude, and practice about bio-medical waste management and associated factors among health care workers at Debre Markos Town Health Facilities Northwest Ethiopia"*)

