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WASTE MANAGEMENT FROM VACCINATION AND ASSOCIATED FACTORS IN THE YALEKO HEALTH ZONE, THE DEMOCRATIC REPUBLIC OF CONGO

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ABSTRACT

Introduction: The management of waste generated from vaccination activities (DIV) is a major public health challenge in the DRC. This study aimed to assess the DIV management system in the Yaleko Health Zone (HZ) and identify associated factors.

Materials and Methods: This cross-sectional analytical study was conducted from April to September 2024, involving 398 providers in 63 facilities in the Yaleko HZ. Data were collected through interviews, observations, and document reviews and analyzed using STATA 13.1. Statistical inference was performed using Pearson's chi-square test and odds ratios (OR) with a 5% confidence interval.

Waste sorting was performed in 58.3% of cases, and the collection of waste from sharp, cutting, and piercing objects (OPCT) was performed entirely in receptacles. Waste storage bins were properly used in 55% of cases, proper disposal occurred in 40% of cases, and the average duration of DIV storage was 13.8±5.9. Of the facilities, 96.5% lacked means of transport for DIV, incinerators were operational in 21% of health facilities, and DIV disposal was done by open-air burning (34.5%) and burial (32.6%). Analysis of factors associated with good waste management showed a significant association with the professional category of physician and staff training on DIV management (OR=8.8, 95% CI: 4.98-10.7). The main suggestion for improving DIV management was training (70%).

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Conclusion: The management of DIV in Yaleko is largely deficient and is mainly associated with staff training, along with the need to strengthen waste management infrastructure and equipment. It is urgent to invest in compliant incinerators and waste bins and strengthen the capacities of providers to protect the community and the environment.

KEYWORDS: Waste management, Vaccination, Associated factors, Biomedical waste, Yaleko, DRC

I. INTRODUCTION

Vaccination activities generate large quantities of waste, including vaccine vials, sharp waste, and other auxiliary waste. This presents a challenge for countries with limited resources and capacities to safely manage and treat waste for final disposal in a way that does not endanger the population and environment. Waste disposal must follow the same procedures established for other healthcare-related waste in accordance with national policies, guidelines, and standards [1].

According to a WHO report, 30% of healthcare facilities (60% in the least developed countries) are not equipped to manage existing waste volumes, let alone the additional waste related to vaccination. This situation potentially exposes healthcare workers to accidental needle-stick injuries, burns, and exposure to pathogenic microorganisms. It also affects populations living near landfills and poorly managed waste disposal sites due to air pollution from burning waste, poor water quality, and the presence of disease-carrying pests [2].

Secure medical waste management practices also support several of the United Nations' Sustainable Development Goals (SDGs), including Goal 3 on health, Goal 6 on safe water management and sanitation, Goal 7 on climate change, and Goal 12 on sustainable consumption and production. According to new global data published by the WHO and UNICEF in 2019, secure management of medical waste is non-existent or extremely limited in a large proportion of facilities [3].

Data representing more than 560,000 facilities in 125 countries indicate that 40% of healthcare facilities do not separate waste. In the least developed countries, the situation is far worse, with only 27% of countries providing basic services (safe waste separation and destruction) [4]. The WHO has defined standards for the correct collection and disposal of waste, such as the use of auto-disable syringes and safety receptacles (safety boxes) for all vaccination activities, not recapping used needles, immediately collecting used syringes and needles in safety boxes, transporting the containers via methods protected from contamination, incinerating waste at 800°C using a Montfort-type incinerator as close as possible to the point of use and as soon as possible after a vaccination session, supervising vaccination activities at least twice a year, and continuously supplying injection materials and safety boxes according to estimated

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needs and a well-defined schedule [5].

The WHO estimates that more than 12 million injections are administered annually worldwide. Of these injections, 95% are for therapeutic purposes and 5% are for preventive purposes, of which 3% are for vaccination [6]. According to the WHO, needles and syringes are not disposed of appropriately, representing a significant risk of injury and infection. An additional danger lies in scavenging at public dumps where waste is usually deposited, the presence of waste in the immediate vicinity of health centers, and the reuse of disposable syringes by some individuals [6].

Biomedical waste from care activities and biomedical analysis (categories B and C waste) according to the WHO classification roughly corresponds to infectious risk healthcare waste (DASRI) [7].

A study conducted in Bamako (Mali) observed that providers had good knowledge of the risks of contamination from vaccination waste, and the management plan was available and compliant with WHO guidelines; however, there were weaknesses, notably the lack of adequate means to transport waste and the absence of ash pits at waste incineration sites [8].

As in all other developing countries, problems related to hospital waste management exist in Algeria, where they are more acute due to the sharp increase in waste, especially in light of the Covid-19 pandemic. In the city of M'sila, the quantity of hospital waste has tripled; this increase also requires a special strategy different from the usual practice and the cooperation of all concerned facilities [9].

The failure of the biomedical waste management system in healthcare establishments in the DRC is a reality. A study conducted in Kinshasa showed that healthcare facilities are the main sources of medical waste. The main finding was that healthcare staff were minimally involved in the daily management of waste generated by vaccination, even though they should play a central role in the operation of a sustainable waste management system [10].

In 2016, the Ministry of Public Health and the World Health Organization (WHO) supervised the final destruction of 10,540 tons of waste, corresponding to 13,532 safety boxes, at a temperature of 800°C, and then calcined in the rotary kiln section of the oven. It was crucial for the WHO to support the national authorities of the DRC in gathering all necessary safety measures so that this sharp waste, which may be contaminated, could be completely eliminated in an adequate treatment facility, such as the Lukala Cement Plant, to preserve the environment and population health [10].

In a study conducted in Kisangani on hospital waste management, the results showed that the sorting of

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healthcare waste was inadequate in 53.3% of departments, and the color-coding system was used in only 10.0% of departments; the transportation of healthcare waste was done by hand in 73.3% of departments, with carts or trolleys in 10.0%, and with wheelbarrows in 16.7%. Knowledge about healthcare waste management was considered insufficient by 61.6% of the workers surveyed, while 84.7% of them were aware of the health risks related to healthcare waste [11]. Despite the existence of standards for the management of vaccination-related waste, information on compliance with these precautions is less documented in the Tshopo Province.

Given the numerous vaccination sessions organized each month in all health centers and periodically during mass vaccination campaigns, we are increasingly concerned about the environmental aspects associated with the large volume of infectious waste generated by these activities and their consequences. Therefore, the objective of this study was to evaluate the waste management system resulting from the vaccination activities in the YALEKO Health Zone.

II. MATERIALS AND METHODS

Study setting: The Yaleko Health Zone (HZ), the setting for this study, is located in Tshopo Province in the Democratic Republic of the Congo (DRC), specifically within the territory of Opala. Covering an area of 8,746 km², the Yaleko HZ has a total population of 198,648 inhabitants, representing a population density of 23 inhabitants/km ². In terms of health service organization, the health zone encompasses 21 operational health areas (HA), including two (2) Reference Health Centers (RHC).

Study Population: The study population consisted of all providers involved in organizing vaccination activities, namely nurses, pharmacists, laboratory technicians, community health workers, and maintenance staff in healthcare facilities that organize vaccination. Second, it included all healthcare facilities that conducted vaccination activities in the Yaleko HZ (general referral hospitals, health centers, reference health centers, and health posts).

Type and Period of Study: This was a cross-sectional descriptive study covering the period from April 1 to September 30, 2024. This period was chosen to cover the evaluation of waste management resulting from vaccination in a dynamic context marked by two phases of the polio vaccination campaigns.

Sampling

The sample size was calculated using the Schwartz formula:

where ***n*** is the minimum sample size, ***Z is*** the confidence level (1.96 for a 95% confidence level), and ***p*** is the estimated proportion of the population at 50% by default in the absence of prior estimation. With an estimated margin of error of 5%, the sample size was 384.

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We conducted exhaustive sampling of 63 healthcare facilities in the Yaleko HZ responsible for vaccination activities and then carried out simple random sampling of seven providers in each healthcare facility involved in waste management. Providers were progressively enrolled based on the criteria described below, up to the seventh criterion.

Inclusion criteria: Any provider involved in the management of vaccination waste in the targeted healthcare facilities, present on the day of data collection, and available to respond to our questionnaire was included in this study.

Variables of interest

Dependent variable: management of vaccination waste (adequate or inadequate)

Independent variables: Characteristics of vaccination staff: qualifications, years of experience, training completed under the EPI, and knowledge of infection risks associated with improper waste management.

- Characteristics of individuals responsible for vaccination waste management: qualifications, years of experience, training completed under the EPI, available PPE, and knowledge of infection risks associated with improper waste management.
- Waste management guidelines: available and posted
- Existence of a waste management plan (yes or no)
- Waste disposal location: on-site or off-site
- Waste management facilities and equipment: incinerators, containers (number), means of waste transportation
- Waste disposal methods: incineration, landfilling, and others.

Operational definitions

- Knowledge of the risks associated with poor waste management was considered good when the respondent could correctly define biomedical waste, knew the steps involved in managing vaccination waste, and understood the risks associated with its improper management.
- Management practices: An effective (i.e., producing results in line with set objectives) and efficient (i.e., using the right resources at the right time, in the right place, and at optimal cost) approach to carrying out an activity or process within an organization or business.
- Vaccination waste: All biomedical waste resulting from vaccination activities.

Data collection techniques: Data were collected using a combination of interviews, observations, and literature reviews. Guided interviews using a pretested questionnaire were conducted with providers

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responsible for organizing vaccination sessions and staff assigned to vaccination waste management. Observation using an observation grid focused on provider behavior, the vaccination waste management process, and waste management facilities and equipment. The literature review verified the existence of guidelines for vaccination waste management.

Analysis Techniques and Data Processing Plan

The collected data were entered into Excel and exported to STATA 13.1 for analysis. Categorical data were described using proportions, and quantitative data were described using the mean (SD) or median (IQR), depending on whether the distribution was symmetric. The analysis of factors associated with waste management was performed using Fisher's exact test for non-binary variables and odds ratios (OR) with 95% confidence intervals for dichotomous or dichotomized variables.

Overall knowledge of IWM was classified as good when the respondent provided a correct definition of IWM, knew the stages of IWM, and cited at least one risk associated with poor IWM knowledge.

Administrative and Ethical Considerations

The research protocol was approved by the Ethics Committee of the University of Kisangani. Participation in the study was voluntary and required informed consent from all participants. Anonymity was guaranteed from data collection to dissemination.

III. RESULTS

3.1. Sociodemographic Characteristics of Respondents

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Table I. Sociodemographic Characteristics of Respondents

VARIABLE (n=398)	Categories	Frequency	Percentage
Age (Mean ± SD)	38 ± 10 years		
Length of Service (Median; IQR)	6 (11 – 4)		
Type of Facility	BCZ	10	2,51
	HGR	6	1,51
	CSR	49	12,31
	CS	242	60,80
	PS	91	22,81
Respondent's Qualification	Physician	7	1,76
	Nurse	303	76,13
	Pharmacist	4	1,01
	Biologist	13	3,27
	Cleaning staff	43	10,80
	Others (RECO)	28	7,04
Level of education	Elementary	19	4,77
	Secondary	194	48,74
	Higher / University	129	32,41
	No education	56	14,07

This table shows that the average age of respondents was 38 ± 10 years, and the median length of service was 6 years (IQR: 4–11 years). The majority of respondents were from community health centers (CS) and were nurses with secondary education.

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Table 2. Collection of vaccination waste

Variables (n=398)	Categories	Frequency	Percentage
Sorting performed	Yes	232	58,29
	No	166	41,71
Types of containers used for OPCT and other types of waste			
	Safety box	398	100
	Plastic bags	164	41,21
Nombre de bacs de stockage des DIV (N=20)	0,32 ± 0,86		
Number of DIV storage bins (n=20) No waste around the bins, no overflowing waste)	Yes	11	55,00
	No	9	45,00
Emptying of sharps storage bins (n=20)	Yes	8	40,00
	No	12	60,00
Storage duration		**13,77 ± 5,88**	

This table shows that vaccination waste was sorted in only approximately half of the cases, and safety boxes were used exclusively for waste collection. The average number of VDP storage bins per healthcare facility was nearly one; the majority were used correctly, and the average waste storage duration was 13.8 ± 6 days

Table 3. Transportation, PPE, and Waste Disposal

VARIABLE n= 398	Categories	Frequency	Percentage
Means of transporting medical waste	No means of transport	384	96,48
	Manual cart	7	1,76
	Motorized cart	7	1,76
Sufficient PPE	Yes	100	25,13
	No	93	23,37
Types of PPE available	Gloves	293	73,62
	Jackets	126	31,66

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	Boots	131	32,91
	Masks	332	83,42
	goggles	138	34,67
	Hats	179	44,97
Waste disposal pit at the healthcare facility	Yes	288	72,36
	No	110	27,64
Functional incinerator	Yes	85	21,36
	No	313	78,64
Disposal methods for used vaccination waste (VW) when not incinerated (n=313)	Landfilling	102	32,59
	Open-air burning	108	34,50
	Disposal in the open	85	27,16
	Don't know	18	5,75

The table reveals a lack of transportation resources for vaccination waste (VW) at nearly all health facilities. Most respondents reported that sufficient PPE was available. Although most facilities had a trash pit, only one-fifth had a functional incinerator and regularly incinerated the VW. The most commonly used waste disposal method was open-air burning of waste.

Table 4. Analysis of factors associated with VWF management

Variables	VWF Management		OR	CI 95%	P value
	Correct n=5	Incorrect n=393			
Length of service					
[1-10 years]	4 (1)	291 (99)			*0,992**
[11-20 years]	1 (1)	83 (99)			
[> 20 years]	0 (0)	19 (100)			
Occupational categories					
Physician	2 (12)	15 (88)			
Biologist	0 (0)	13 (100)			

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Pharmacist	0 (0)	4 (100)			
Nurse	2 (1)	291 (99)			0,005*
Cleaning staff	1 (2)	42 (98)			
Others	0 (0)	28 (100)			
Waste Management Training					
Yes	3 (5)	57 (95)			
No	2 (1)	336 (99)	*8,84*	[4,98-10,7]	*0,026*
Incinerator					
Present	2 (2)	83 (98)			
Absent	3 (1)	310 (99)	2,49	[0,20 -22,04]	0,306
Overall knowledge of waste management					
Good	2 (2)	146 (146)			
Poor	3 (3)	247 (247)	*1,13*	[0,60 -2,24]	*0,89*

**Fisher's Exact Test*

The occupational category of physicians and training in medical waste management were significantly associated with good waste management.

IV. DISCUSSION

4.1 Sociodemographic Characteristics of the Respondents

The results of our study revealed that the mean age of the healthcare providers was 38 ± 10 years, with a median length of service of 6 years. The majority (76.13%) of the participants were nurses who worked primarily in health centers (60.80%). This profile of healthcare providers is representative of peripheral healthcare facilities in the Democratic Republic of the Congo (DRC) and is consistent with other African studies in which nurses constitute the bulk of the workforce involved in primary care and vaccination [12-13]. In Burkina Faso, a study conducted in primary healthcare facilities showed that 68% of the staff responsible for biomedical waste were nurses [14].

This staff composition, dominated by nurses, implies that they are at the forefront of vaccination waste management (VWM). A lack of knowledge or skills among this group would have direct repercussions on the entire VWM system in the province. Therefore, it is essential to prioritize nurses in capacity-building programs and biomedical waste management policies, including VWM.

4.2. Collection of Vaccination Waste

The collection of VWF remained suboptimal: sorting was performed in 58.29% of cases; safety boxes

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were used exclusively for collecting OPCT waste; and plastic bags were used in 41.21% of cases for non-OPCT waste. OPCT waste collection is appropriate given the availability of safety boxes, which, in principle, should contain all combustible waste; however, sorting is inadequate, preventing proper waste disposal using appropriate techniques [15].

The prolonged storage of waste (13.77 days on average) is a particular cause for concern, far exceeding WHO recommendations, which advocate for storage of less than 7 days in tropical areas [16]. By way of comparison, in Senegal, the median storage duration was 5 days in peripheral facilities [17].

The low availability of IWB storage bins (0.32 storage bins per facility) reflects a structural problem that makes it difficult to comply with the collection standards. Prolonged storage increases the risk of pathogen proliferation, production of foul odors, and attraction of vectors such as rodents or insects [18]. It is essential to increase the supply of collection equipment to healthcare facilities, enforce strict removal schedules, and raise awareness about compliance with storage time limits.

4.3. Transportation, PPE, and Waste Disposal

Transportation of medical waste is nonexistent in 96.48% of cases, leading to waste accumulation within healthcare facilities. The lack of personal protective equipment (PPE) (only 31.41% of facilities are equipped) exposes staff to an increased risk of injury and infection. These findings are consistent with a study in Tanzania, where 30% of facilities lacked appropriate PPE [19].

Regarding waste disposal, the absence of functional incinerators in 78.64% of the facilities forced the use of hazardous methods: open-air burning (34.50%), shallow burial (32.59%), or waste abandonment (27.16%). These practices are known to release environmental pollutants (dioxins and furans) and promote the spread of infectious agents [20]. In Nepal, 85% of centers had functional incinerators, thanks to support from technical partners [21].

This situation calls for urgent investment in safe waste disposal infrastructure. It is imperative to equip PHCs with incinerators that comply with environmental standards and ensure their maintenance. The establishment of shared community waste disposal systems should be explored for small-scale facilities.

4.4. Analysis of Factors Associated with Proper Waste Management

Medical profession and training in IWM were significantly associated with proper waste management. These results are consistent with those of studies conducted in India [22] and Kenya [23], where regular training significantly improved medical waste management practices. Provider qualifications were also a determining factor ($p = 0.005$), illustrating the importance of technical competence in practice quality.

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These results reinforce the importance of integrating training in medical waste management into providers' ongoing professional development. Certain grants or accreditations should also be contingent on meeting targets for the safe management of medical waste.

4.5. Limitations of the Study

Data collected through interviews may have been subject to recall bias, as participants may have had difficulty recalling past events or providing accurate information. Participants may have been tempted to provide socially acceptable answers rather than their true opinions or practices, which may skew the results.

CONCLUSION

This study highlighted significant shortcomings in the knowledge, practices, and infrastructure dedicated to the management of IVDs. Despite the central role of nurses, who account for more than three-quarters of healthcare providers, and the widespread implementation of vaccination activities, the management of IVDs remains largely deficient, characterized by a low level of knowledge, lack of training, and inadequate collection, storage, and disposal practices.

These findings underscore the urgent need to strengthen provider capacity and infrastructure (incinerators), equip facilities with appropriate equipment, and establish sustainable and secure sharp management systems to prevent risks to healthcare workers, the community, and the environment.

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