JIDC | THE JOURNAL OF INFECTION IN DEVELOPING COUNTRIES

Original Article

Assessment of health care workers preparedness to epidemics: A case of Ebola virus disease preparedness in private hospitals in Kampala, Uganda

Collins Ankunda[1,2], Stuart Martin Kanyesigye[3], Susan Nakubulwa[2], Brendah Kyomuhangi[4], Jakob Cramer[5], Enrique Chacon-Cruz[1,6], Sue Ann Costa Clemens[1,7], Ralf Clemens[8]

[1] *Institute for Global Health, University of Siena, Italy*
[2] *Mildmay Research Centre Uganda, Entebbe Rd, Naziba Hill, Kampala, Uganda*
[3] *Divencha Systems, Nakawa, Kampala, Uganda*
[4] *Le Memorial Medical Services, Kigo Rd, Kampala, Uganda*
[5] *Coalition for Epidemic Preparedness (CEPI), London, United Kingdom*
[6] *Think Vaccines LLC, Houston, TX, United States*
[7] *Department of Pediatrics, University of Oxford, Oxford, United Kingdom*
[8] *International Vaccine Institute (IVI), Seoul, Republic of Korea*

Abstract

Introduction: Unrecognized Ebola Virus Disease (EVD) can lead to multiple chains of transmissions if the first caretakers are not trained and prepared. This study aimed to assess healthcare workers (HCWs) preparedness in private hospitals located in Kampala, to detect, respond and prevent EVD

Methodology: A descriptive cross-sectional study was carried out among HCWs in direct clinical care provision in four private hospitals, and in one Ebola Treatment Unit (ETU) using a self-administered questionnaire from March to June 2020.

Results: 222 HCWs agreed to participate aged from 19 to 64 years and with 6 months to 38 years of practice where most were nurses (44%). 3/5 hospitals did not have written protocols on EVD case management, and only one (ETU) had an exclusive emergency team. 59% were not sure whether contact tracing was taking place. Private hospitals were not included in EVD trainings organized by the Ministry of Health (MoH). In addition, HCWs in private hospitals were not empowered by the MoH to take part in EVD case management. Despite these shortcomings, only 66% of HCWs showed an interest to be immunized. Knowledge about potential Ebola vaccines was generally poor.

Conclusions: In Kampala, Uganda, establishment of a more comprehensive preparedness and response strategy for EVD outbreaks is imperative for HCWs in private facilities, including a wide vaccination educational program on Ebola vaccination. The findings from this study if addressed will likely improve the preparedness and management of future Ebola outbreaks in Uganda.

Key words: Ebola virus disease; epidemic preparedness; ebola vaccine; healthcare workers.

J Infect Dev Ctries 2024; 18(4):556-564. doi:10.3855/jidc.17642

(Received 05 November 2022 – Accepted 31 July 2023)

Introduction

Ebola Virus Disease (EVD) is a severe, often fatal illness affecting humans and non-human primates with an average case fatality rate of 50% up to 90%. Transmission of the Ebola virus (EBOV) - a filovirus - to people occurs from wild animals (such as fruit bats, porcupines, and non-human primates) and then spreads in the human population through direct contact with blood, secretions, organs, or other bodily fluids of infected people, and with surfaces and materials (like bedding, clothing) contaminated with these fluids [1–3].

The World Health Organization (WHO) declared Ebola Virus Disease (EVD) a Public Health Emergency of International Concern (PHEIC) in July 2019. Based on a country's risk profiles, WHO categorized four East African countries – Uganda, Rwanda, South Sudan, and Burundi as priority 1 risk countries for an EVD outbreak. This prioritization is based on both a country's capacity to manage EVD outbreaks, as well as its connections and proximity to the areas reporting EVD cases such as the Democratic Republic of Congo, DRC [1].

In Uganda, the first and largest Ebola outbreak in the year 2000 reported 425 cases and 224 deaths. Whilst these outbreaks affected mainly Northern and Western parts of Uganda, the other parts of the country including the capital Kampala were also at increased risk [4].

Importantly, unrecognized high risk of exposure to the virus most especially during an outbreak has been

noted in health facilities. HCWs who are always on the frontline are at great risk of eventually exposing themselves to EVD-infected patients. During the 2013-2015 EVD outbreak, HCWs in West Africa were 32 times more likely to be infected with EVD as compared to the general population [5]. In the 2018-2019 Ebola outbreak in DRC, infections amounting to nearly 18% were hospital-acquired infections leading to a loss of 34 HCWs [6]. As a consequence, the Public Health Emergency Operations Centre (PHEOC) under the Ugandan Ministry of Health was formed with the responsibility to coordinate information and resources (human and physical), organize, conduct, and manage all aspects of public health emergency response efforts of the country [7].

Uganda was declared by WHO Ebola epidemic-free on 11 January 2023 with 142 confirmed cases and 57 confirmed deaths including four HCWs reported in nine districts [8,9]. Given the unpredictable nature of disease outbreaks to cause public health risks, the International Health Regulations (2005) (IHR) provides an overarching legal framework that defines countries' rights and obligations in handling public health events. These events have the potential to cross borders, and the IHR requires countries to have the ability to detect, assess, report, and respond to them in a timely manner. The IHR is an instrument of international law that is legally binding on 196 countries, and Uganda is a member State [10].

Uganda is a signatory to the International Health Regulations (IHR), an evaluation of IHR core capacities using the World Health Organization (WHO) IHR Joint External Evaluation (JEE) tool was done in 2017. The goal was to assess the country's capacities under the IHR to prevent, detect, and respond to public health emergencies (PHEs). Uganda's development and implementation of the national multi-hazard public health emergency preparedness and response plan was scored at 1 out of 4 [11].

Infection control for EVD is extremely challenging to even the most skilled HCWs [12]. However, the fragile nature of health systems in some countries was noted and required a multi-sectoral approach [13]. Importantly, nurses, who are most often the first point of contact for patients, are not always included in Ministry of Health (MOH) trainings that help HCWs identify potential cases as victims of an Ebola outbreak.

Immunization is a well-known very effective preventive measure [14]. There are two approved vaccines to prevent Ebola virus disease (EVD): Ervebo®, a single-dose live attenuated vaccine that is genetically engineered to contain a protein from the Zaire ebolavirus and is licensed for adults 18 years and older; and Zabdeno® (Ad26.ZEBOV) and Mvabea® (MVA-BN-Filo), a two-dose regimen that is indicated for adults and children 1 year and older. Both vaccines have been shown to be safe, highly immunogenic, and protective [15–17]. Recently published preclinical guinea-pig data showed that Ervebo also induced cross-protects against the Ebola Sudan of close to 60% in a guinea-pig challenge model [18].

The increasing involvement of the private sector as an important source of health care and often preferred by people because of the availability of comprehensive and customer-friendly services and sometimes filling gaps where no or little public health care is available makes it mandatory that private hospitals are equally trained and equipped as public hospitals in the detection and management of EVD [19]. Bearing in mind that EVD in its early stages presents like any other tropical disease and in areas where contact tracing is not enhanced, patients with unrecognized Ebola often seek care from general healthcare facilities (both private and public) where inadequate Infection Prevention and Control of EVD is practiced leading to multiple chains of transmission amplifying the epidemic to an extent not seen in previous EVD outbreaks [20].

However, there is a lack of data on the preparedness of HCWs in private hospitals to detect and manage EVD. There is also no data available on HCWs knowledge about Ebola vaccines and their willingness to be vaccinated. Accordingly, this study aimed at identifying gaps in infrastructure, knowledge, and training to allow private HCWs efficient in-patient management whilst minimizing the infection risk to themselves and spreading to other patients who have come for treatment of other different conditions.

Methodology

Study design

A descriptive cross-sectional study among HCWs in 4 private hospitals in Kampala, Uganda was conducted with one public ETU as a comparator. The goal was to assess the preparedness in detecting, responding, and preventing EVD transmission and infection in hospitals in Uganda as well as to understand attitudes concerning vaccination.

Setting

The survey was conducted among HCWs in four private hospitals and one ETU located in Kampala. These hospitals were chosen based on the monthly outpatient reports over the three months of October, November, and December 2019 from The District

Health Information Software (DHIS2) for Uganda. Each of these hospitals had on average more than 50 patients daily. With the higher number of patients seen daily these hospitals would probably also have a greater likelihood of caring for an EVD case during an outbreak. Based on this criterion, nine hospitals qualified and were initially selected, however, five were excluded due to the COVID-19 pandemic (access restriction). Accordingly, four private hospitals were included: Case Medical Centre Hospital, Mukwaya General Hospital, Kibuli Hospital, and Lubaga Hospital. The ETU included as a comparator was Naguru Hospital - China Uganda Friendship Hospital.

Sample size determination and statistics

The sample for this study was obtained using a convenience sampling approach, which involved selecting participants based on their accessibility and willingness to participate. Convenience sampling was utilized due to practical constraints during the COVID-19 pandemic, such as time limitations and or resource availability. The target sample size was calculated at 288 participants.

Population

The study population was comprised of all accessible and consenting HCWs working in all included hospitals. All were frontline HCWs: clinicians, nurses, pharmacists, laboratory technicians, and other clinical support staff. Participation in the study was voluntary. Consent was obtained from all participants. The study was approved by the Mildmay Uganda Research Ethics Committee (#REC REF 0801-2020) Data were anonymized, and participation was signed. Reasons for rejection to participate were documented, the main reasons for not participating were lack of time to fill in and complete the questionnaire, and fear of retaliation by hospital management.

Data collection tool

The questionnaire was adopted from an 18-question survey conceived and developed by Emerging Infections Network (EIN) staff with technical assistance from the US-CDC, adjusted to fit the Ugandan healthcare context and be able to meet the study objectives [21]. The survey took an average of about 15 minutes to be filled to completion. A pilot phase of the study was conducted in Lubaga Hospital to ensure the understanding of the questionnaire and the feasibility of the tool to collect relevant information. Questions pertained to Ebola and patient care, screening protocols, personnel, PPE laboratory testing, and vaccination against Ebola.

Table 1. Study participants socio-demographic information.

Demographic characteristic	Case Hospital	Kibuli Hospital	Lubaga Hospital	Mukwaya General Hospital	Naguru Hospital-ETU	Grand Total, n (%)
Gender						
Female	24	24	31	27	20	**126 (57)**
Male	16	21	20	12	27	**96 (43)**
Grand Total	**40**	**45**	**51**	**39**	**47**	**222 (100)**
Level of Education						
Certificate	13	4	10	10	2	**39 (18)**
Diploma	11	18	29	21	9	**88 (40)**
Masters	1	2	2	0	0	**52 (2)**
Undergraduate	14	20	10	8	36	**88 (40)**
Grand Total	**39**	**44**	**51**	**39**	**47**	**220 (100)**
Profession						
Medical Officer	8	8	7	5	15	**43 (19)**
Clinical officer	1	0	3	1	7	**12 (5)**
Nurse	23	16	19	24	15	**97 (44)**
Lab Staff	5	8	13	5	0	**31 (14)**
Others*	3	13	9	4	10	**39 (18)**
Grand Total	**40**	**45**	**51**	**39**	**47**	**222 (100)**
Hospital Department						
Emergency /Treatment Room	11	4	11	14	22	**62 (28)**
In Patient	8	8	2	2	13	**33 (15)**
Out Patient	21	27	21	17	12	**98 (45)**
Lab	0	6	15	6	0	**27 (12)**
Grand Total	**40**	**45**	**49**	**39**	**47**	**220 (100)**
Time in the current Hospital						
< 1yr	7	16	19	6	22	**70 (32)**
1-5yrs	22	18	23	24	16	**103 (47)**
> 5yrs	10	10	9	9	7	**45 (21)**
Grand Total	**39**	**44**	**51**	**39**	**45**	**218 (100)**

* This category includes Reception/triage teams, pharmacy staff, and radiology staff.

Data Analysis

Analyses were done using the Statistical Package for Social Science (SPSS) IBM SPSS software program. Descriptive analysis for variables was done and presented as frequencies and percentages summarized in tables. Chi-square tests were conducted for each variable to ascertain the associations between different hospitals and implementation of policies in preparedness and practices among the hospitals.

Results

We recruited a total of 222 of the 288 planned participants because of access issues during the COVID-19 pandemic. All were included in the analysis. Results were segregated into four sections: HCWs socio-demographics; EDV detection and screening; prevention tools of EVD transmission; and vaccination against EVD.

Sociodemographic information

Sociodemographic data collection included participants' age, gender, profession, level of education, and years of hospital practice. As shown in Table 1, nurses (44%) and HCWs working in outpatient care (45%) were the predominant professions in this survey in all hospitals. The distribution of study participants by hospital and function is shown in Figure 1. Lubaga private hospital had the highest number of participants (n = 51; 23%) followed by the Naguru public hospital-ETU (n = 47; 21%). Thirty-eight percent (81/214) of the study participants had never registered an EVD case, 66/214 (31%) had registered at least 1, and 67/214 (31%) were not even sure if their hospitals had ever registered EVD cases.

EVD Screening and Detection

Only two hospitals had a well-defined, written protocol: one out of 4 private hospitals and the public ETU. Information about the existence of such protocols was inconsistent among the study interviewees and depended on function and duration of service in the hospital (Table 2).

The majority of the respondents (125/220, 57%) reported that their hospitals had written protocols available to HCWs for dealing with suspected EVD cases, 17% answered that there were none, while 26% didn't know. There was a striking difference in the knowledge about the availability of written procedures depending on the work history spent as an employee of the same hospital: 76% (94/123) of the staff who had worked more than 1 year at the same hospital compared to 24% (29/123) with a work history of less than 1 year knew about the availability of procedures. The highest knowledge of protocol availability was with HCWs working in Emergency Room settings (46/62, 74.2%).

Concerning written protocols for the management and disposal of potentially Ebola virus-contaminated waste, the staff of only one private hospital was aware of specific written guidelines, the others were not.

Half of the HCWs in both the private hospitals and the ETU were aware of the availability of screening protocols for newly admitted patients. However, the staff of all 4 private hospitals was less informed than HCWs of the public ETU about the screening procedures themselves (Figure 2). Only 21% of HCWs in private hospitals did routine screening for Ebola Virus disease on patients who came to their hospital for care and had symptoms compatible with Ebola infection when compared to 40% at ETU.

Figure 1. Study Participants - Distribution (N) of HCW by Hospital and Function.

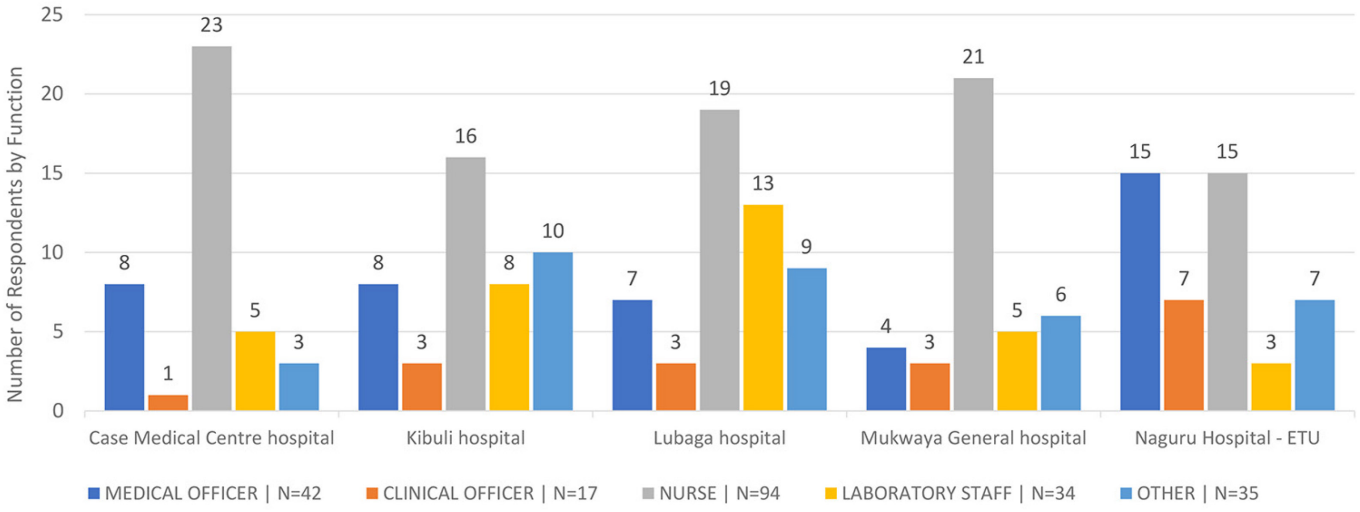
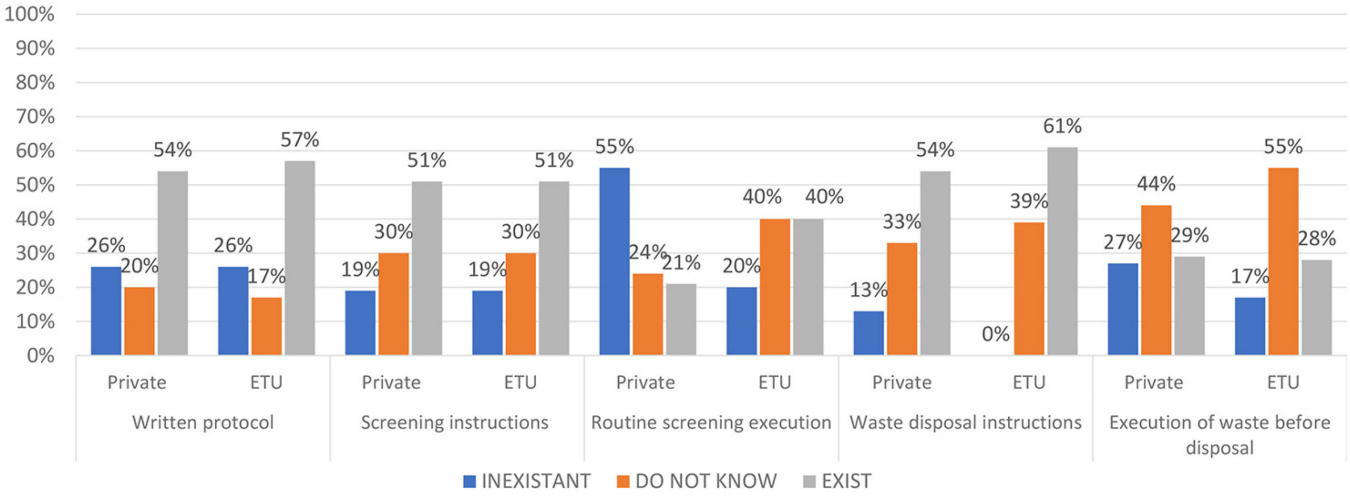


Table 2. Knowledge on specific policies for the Prevention of EVD transmission.

Variable	N/A, n (%)	NO, n (%)	UNSURE, n (%)	YES, n (%)	Total	Pearson Chi^2	*p* value
Exclusive caretaker team for EVD patients							
Hospital 1		14	17	8	39	72.05	0
Hospital 2		29	11	5	45		
Hospital 3		6	13	27	46		
Hospital 4		18	12	4	34		
ETU		4	6	29	39		
Total		71 (35)	59 (29)	73 (36)	203		
Policy to limit direct access to EVD patient							
Hospital 1		7	15	18	40	31.1599	0
Hospital 2		26	8	11	45		
Hospital 3		7	16	28	51		
Hospital 4		13	11	14	38		
ETU		9	13	25	47		
Total		62 (28)	63 (29)	96 (43)	221		
Policy limiting trainees' direct access to EVD patients							
Hospital 1	4	5	18	13	40	33.3057	0.001
Hospital 2	5	18	18	4	45		
Hospital 3	3	3	19	24	49		
Hospital 4	3	6	16	13	38		
ETU	0	12	18	17	47		
Total	15 (17)	44 (20)	89 (41)	71 (32)	219		
Consultative care without direct contact with EVD patients							
Hospital 1		2	32	6	40	57.8265	0
Hospital 2		18	20	4	42		
Hospital 3		5	34	11	50		
Hospital 4		7	27	4	38		
ETU		2	19	23	44		
Total		34 (28)	132 (28)	48 (28)	214		
Laboratory staff specifically trained for EVD diagnosis							
Hospital 1		2	32	6	40	33.3666	0
Hospital 2		18	20	4	42		
Hospital 3		5	34	11	50		
Hospital 4		7	27	4	38		
ETU		2	19	23	44		
Total		34 (16)	132 (62)	48 (22)	214		
Community HCW for EVD surveillance/ contact tracing							
Hospital 1		15	20	5	40	34.3192	0
Hospital 2		18	22	4	44		
Hospital 3		7	31	13	51		
Hospital 4		6	24	8	38		
ETU		0	33	14	47		
Total		46 (21)	130 (59)	44 (20)	220		

Figure 2. Knowledge about availability of written EDV management protocols in private hospitals and ETU.



When asked about the best timing for screening, 52% indicated that screening should be implemented immediately at the time of first interface with a patient, 21% preferred implementation of screening during primary examination whereas 27% were not sure about the best time point for screening. Likewise, responses to what should trigger the initiation of a standard screening procedure differed widely: 16% reported that regardless of symptoms a history of recent travel to endemic areas would be required; 38% reported that only signs and symptoms compatible with EVD would be required even without previous travel to risk areas, and 39% answered that both should be required. The majority of HCWs (84%) across private hospitals and ETU staff agreed that patients with signs/symptoms compatible with suspected EVD should be immediately transferred to a regional Ebola facility.

Prevention of EVD transmission

One of the cornerstones for the containment of EVD is the breaking of transmission chains in a human population. Table 2 shows responses on whether the respondents' hospital has specific policies to ensure the prevention of transmission. A high number of respondents ranging from 29% to 62% is unaware of the existence of specific transmission blocking policies. As shown in Figure 3, there were also inconsistencies in responses when asked whether the hospital had an exclusive team identified to take care of patients in case of EVD. Only one hospital had an exclusive team to take care of patients suspected to be infected with Ebola, and four hospitals did not have it, although varying proportions of respondents falsely believed their hospital had.

Over half of the respondents (55%) commented in the open-ended section about infection prevention, control and surveillance, contact tracing, and training/ sensitization of staff. Major concerns were lack of protective gear and inadequacy of physical separation of a suspected case from other patients.

Participants highlighted the importance of public-private partnerships between private hospitals and the government. Specific requests were about sufficient supplies of PPE and laboratory equipment to front-line private hospitals as well as involvement in governmental training sessions. To ensure quality, private hospitals should encourage governmental inspections.

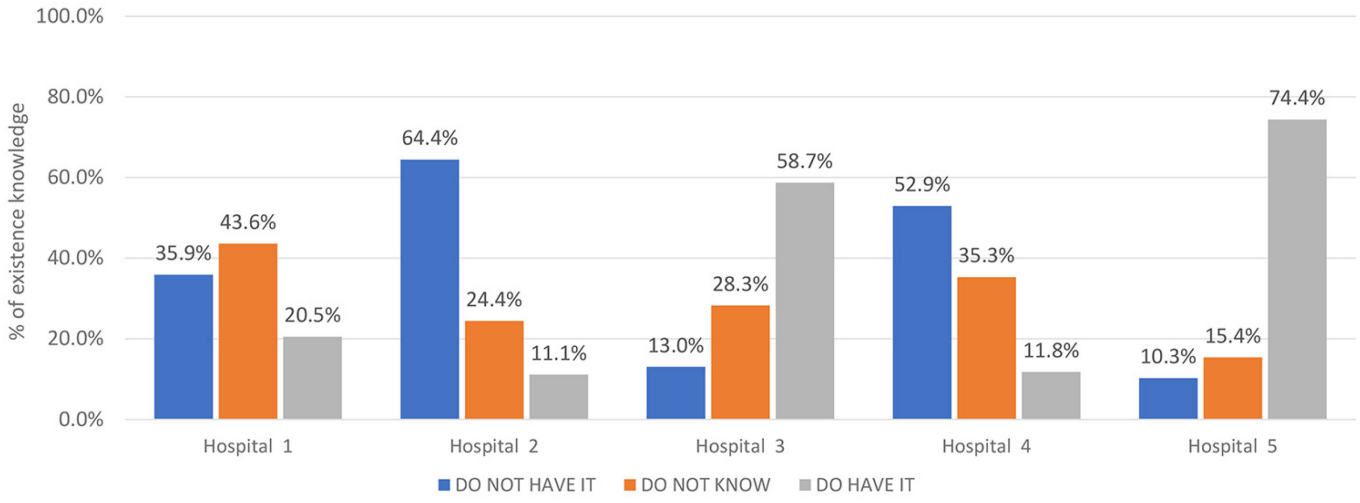
Contact tracing was another area for improvement as highlighted by about 25% (22/90) of respondents who participated in the open-ended questions. Specifically, community members need more empowerment in identifying potential cases and case reporting.

Only 22% of respondents answered that their facilities have specific training for EDV diagnosis in the lab, and 62% responded negatively. Thus, lack of training was identified as another major concern. Creating awareness through repetitive training about the disease and precautions when in contact with a suspected case was requested.

Vaccination against Ebola Virus disease

Generally, participants from both Private hospitals and ETU had similar responses with respect to having knowledge of Ebola vaccine development. HCWs knowledge about the development and availability of vaccines against Ebola was limited. Only 80 of 220

Figure 3. Existence of specific teams to identify and treat EVD.



(40%) were aware, 36% did not know, and 24% were not sure of the vaccine's availability. Knowledge was not different between ETU and private hospitals. There was a striking difference in the knowledge about Ebola vaccine development among functions: 55% of nurses, 6.3% of clinical officers, 15% of laboratory staff, 2.5% of medical officers, and 21.3% of other staff were aware of Ebola vaccine development.

Of the 215 respondents on vaccination, only 3 had been vaccinated against Ebola (1%). When asked whether a respondent would be willing to be vaccinated in case an Ebola vaccine would be available, the majority (66%) responded affirmatively and 42% were willing to be vaccinated even if they would have to pay. However, 34% were unwilling to be vaccinated even if for free. Participants were asked to choose between two potential Ebola vaccines with different profiles: (1) Vaccine A would be a single dose vaccine with close to 100% protection within 2-3 weeks and a side effects profile of 30% fever for a few days and 10% arthritis; (2) Vaccine B would be a two-dose with also an almost 100% protection but a side effects profile of 10% fever for a few days and 2% arthritis. Of the 197 responders, 157 (80%) opted for the vaccine with protection only after 2 doses but a more favorable safety profile, whereas 40 (20%) opted for the single-dose vaccine with earlier protection but less well tolerated.

Discussion

This study had as its objectives to assess the knowledge and preparedness of HCWs in detecting, responding, and preventing EDV in 4 private hospitals compared to a public Ebola Treatment Unit (ETU) in Kampala, Uganda, and secondly, to understand their attitudes towards Ebola vaccination. The outcome is worrisome: HCWs in private hospitals are inadequately prepared, trained and equipped to manage a suspected case of EVD. Major findings were the lack of written protocols, lack of or inadequate training when onboarding but also as refreshment, and exclusion of potential risk professions from training. This lack of preparedness spanned across functions and was worse in HCWs with short work experience and in those working outside emergency rooms. The public ETU in our study which should be the reference was better equipped and had written guidelines, but most other aspects of readiness were also not adequate. For a disease with such a high infectivity and mortality rate as EVD, preparedness levels including strict written policies for all HCWs with potential contacts and exposure to EVD ought to be close to 100%. This is to be encouraged irrespective of the type of health facility (public or private), HCWs function, hierarchy level, or health facility level - health center or hospital, local or regional to protect their staff but also to avoid nosocomial transmissions. For example, in the 10th EVD outbreak in DRC, nearly 18% of the total cases registered were hospital-acquired infections [6]. HCWs in Uganda are also key influencers in health policies and health-related decisions at a community level – lack of education and training of HCWs about EVD translates into less informed communities [22].

Despite evidently being at high risk, HCWs knowledge of Ebola vaccines both in the private and public hospitals was extremely low and their level of hesitancy towards Ebola vaccination was high. Even though two highly effective and safe Ebola vaccines have been available, licensed, and WHO prequalified for some time now - albeit in short supply - 99% of the frontline health workers in this study have not yet been vaccinated against Ebola.

Furthermore, only 2/3 of the interviewees were willing to be vaccinated against Ebola despite their increased exposure and infection risk. This percentage would even drop to half if they had to pay for the vaccination themselves. This hesitant attitude is a real problem for the individuals but also the Uganda health care system because it means that many of those HCW are going to die if an outbreak were to occur that involves Kampala.

To understand better attitudes towards Ebola vaccination HCWs were asked to choose between two theoretical vaccines of different profiles: a single dose vaccine which induces an earlier onset protection but is more reactogenic, or a two-dose vaccine where onset of protection is delayed but which is less reactogenic. Despite the high transmissibility and mortality of Ebola most respondents preferred the second option despite delay in protection. A potential bias with respect to Ebola vaccination attitudes was the timing of the survey which occurred when there was no current Ebola outbreak. Responses might have been different during an outbreak where immediate protection might have been considered more important. The learnings are however that if the government of Uganda were to implement Ebola vaccination in HCWs or high-risk communities, communication needs to focus on the safety of those WHO prequalified vaccines.

This study had some limitations. This study was carried out only in the central business district of the capital, Kampala. These results might therefore not be generalizable to private hospitals and ETUs which are located in the rural settings, but one could speculate that conditions out there might be even less favorable. Only

hospitals were included in this study while clinics, drug stores, pharmacies, and medical centers which also may have first contact with a suspected EVD case and where prevention knowledge is equally important were not. Because of the COVID-19 pandemic, some hospitals restricted access and did not allow the conduct of the study. This led to the exclusion of five hospitals but most likely did not introduce a selection bias as the structure of those excluded hospitals was similar to the 4 included private hospitals. In turn, the target sample size was missed by 25% but due to the mostly descriptive character of the study, the impact is minor.

Conclusions

This survey showed that 4 private hospitals that might admit potential cases of EVD but also a reference center ETU in Kampala, the capital of Uganda, had critical gaps in the detection, preparedness, response and prevention of EVD, thus putting at risk HCWs and other patients alike. The most important deficiencies were lack of written protocols, insufficient protective gear, and especially a lack of training during onboarding and as maintenance. Most of these gaps can be readily addressed without major budgetary impact but require strict supervision of implementation and discipline. The role of hospital admissions, diagnostics, and care in the spread of EDV needs to be emphasized considering that Uganda was classified as a priority 1 country for EVD control according to the WHO risk profile.

The knowledge gap of HCWs about Ebola vaccines is highly alarming. Governmental education campaigns to HCWs highlighting the existence and safety of Ebola vaccines should be a public health priority as vaccination of a HCWs does not only protect the individual but indirectly also their other patients. And vaccination of HCWs should be free of charge to ensure high coverage.

Acknowledgements

The authors are thankful to the hospital administrators and HCws from Case Medical Centre Hospital, Mukwaya General Hospital, Kibuli Hospital, Lubaga Hospital and Naguru Hospital - China Uganda Friendship Hospital for the opportunity to collect data from their facilities. This work is part of the master thesis of Collins Ankunda performed at the Institute for Global Health (IFGH) University of Siena, Siena, Italy. We thank the Board and the entire team of the IFGH "Master in Vaccinology and Drug Development" course for their support in the thesis and valuable comments to the manuscript. Special thanks to Daniele Sereni for his support in the design of the manuscript.

Authors' Contributions

CA conceived and designed the study as a lead author. BK and SMK did the data collection and interpretation. SMK, and SN participated in analysis. BK, JC, ECC, SAC-C and RC participated in the interpretation of results and writing the final manuscript. CA is responsible for the overall content as guarantor. All authors read and approved the final version of the manuscript.

Ethical statement

Approval was sought from the Mildmay Uganda Research and Ethics Committee for the protection of rights and safety of human participants in this research project. Administrative clearance was also thought from each hospital. Each HCWs agreed and signed consent from after being given information of what the study was about. Clearance was also given by the Board of the Institute for Global Health, University of Siena, Siena, Italy.

References

1. WHO (2019) Uganda simulates ebola outbreak and identifies gaps in preparedness and response. Available: https://www.afro.who.int/news/uganda-simulates-ebola-outbreak-and-identifies-gaps-preparedness-and-response. Accessed: 18 June 2020.
2. Kadanali A, Karagoz G (2015) An overview of Ebola virus disease. Northern Clinics of Istanbul 2: 81. doi: 10.14744/nci.2015.97269
3. WHO (2023) Ebola virus disease. Available: https://www.who.int/health-topics/ebola. Accessed: 25 April 2023.
4. Okware SI, Omaswa FG, Zaramba S, Opio A, Lutwama JJ, Kamugisha J, Rwaguma EB, Kagwa P, Lamunu M (2002) An outbreak of Ebola in Uganda. Trop Med Int Health 7: 1068–1075. doi: 10.1046/j.1365-3156.2002.00944.x.
5. WHO (2015) Health worker Ebola infections in Guinea, Liberia and Sierra Leone. Available: https://www.who.int/publications-detail-redirect/WHO-EVD-SDS-REPORT-2015.1. Accessed: 22 Apr 2024.
6. WHO (2020) Regional Ebola preparedness overview of needs and requirements. Available: https://www.who.int/publications/m/item/regional-ebola-preparedness-overview-of-needs-and-requirements. Accessed: 12 October 2022.
7. Kayiwa J, Homsy J, Nelson LJ, Ocom F, Kasule JN, Wetaka MM, Kyazze S, Mwanje W, Kisakye A, Nabunya D, Nyirabakunzi M, Aliddeki DM, Ojwang J, Boore A, Kasozi S, Borchert J, Shoemaker T, Nabatanzi S, Dahlke M, Brown V, Downing R, Makumbi I (2022) Establishing a public health emergency operations center in an outbreak-prone country: lessons learned in Uganda, January 2014 to December 2021. Health security 20. doi: 10.1089/hs.2022.0048.
8. WHO (2022) Ministry of Health, WHO and USAID strengthen protection of health workers during the ebola outbreak response in Uganda. Available: https://www.afro.who.int/countries/uganda/news/ministry-health-who-and-usaid-strengthen-protection-health-workers-during-ebola-outbreak-response. Accessed: 12 October 2022.

9. Ministry of Health, Republic of Uganda (2022) Ebola - Ministry of Health | Government of Uganda. Available: https://www.health.go.ug/ebola/. Accessed: 12 October 2022.
10. Standley CJ, Sorrell EM, Kornblet S, Fischer JE, Katz R (2015) Implementation of the international health regulations (2005) through cooperative bioengagement. Front Public Health 3: 1–26. doi: 10.3389/fpubh.2015.00231.
11. WHO (2017) Joint external evaluation of IHR core capacities of the Republic of Uganda. Available: https://www.who.int/publications-detail-redirect/WHO-WHE-CPI-REP-2017.49. Accessed: 22 Apr 2024.
12. Riad MH, Sekamatte M, Ocom F, Makumbi I, Scoglio CM (2019) Risk assessment of Ebola virus disease spreading in Uganda using a two-layer temporal network. Scientific Reports 9: 16060. doi: 10.1038/s41598-019-52501-1.
13. Biedron C, Lyman M, Stuckey MJ, Homsy J, Lamorde M, , Luvsansharav UO, Wilson K, Gomes D, Omuut W, Okware S, Semanda JN, Kiggundu R, Bulwadda D, Brown V, Nelson LJ, Driwale A, Fagan R, Park BJ, Smith RM (2019) Evaluation of infection prevention and control readiness at frontline health care facilities in high-risk districts bordering ebola virus disease-affected areas in the Democratic Republic of the Congo - Uganda, 2018. Morb Mortal Wkly Rep 68: 851–854. doi: 10.15585/mmwr.mm6839a4
14. Gavi, the Vaccine Alliance (2020) 5 reasons why pandemics like COVID-19 are becoming more likely. Available: https://www.gavi.org/vaccineswork/5-reasons-why-pandemics-like-covid-19-are-becoming-more-likely. Accessed: 20 June 2020.
15. Johnson & Johnson (2020) Johnson & Johnson announces European commission approval for Janssen's preventive Ebola Vaccine. Available: https://www.jnj.com/johnson-johnson-announces-european-commission-approval-for-janssens-preventive-ebola-vaccine. Accessed: 29 September 2020.
16. Milligan ID, Gibani MM, Sewell R, Clutterbuck EA, Campbell D, Plested E, Nuthall E, Voysey M, Silva-Reyes L, McElrath MJ, De Rosa SC, Frahm N, Cohen KW, Shukarev G, Orzabal N, van Duijnhoven W, Truyers C, Bachmayer N, Splinter D, Samy N, Pau MG, Schuitemaker H, Luhn K, Callendret B, Van Hoof J, Douoguih M, Ewer K, Angus B, Pollard AJ, Snape MD (2016) Safety and immunogenicity of novel adenovirus type 26– and modified vaccinia ankara–vectored Ebola Vaccines. JAMA 315: 1610. doi: 10.1001/jama.2016.4218.
17. FDA (2019) First FDA-approved vaccine for the prevention of Ebola virus disease, marking a critical milestone in public health preparedness and response. Available: https://www.fda.gov/news-events/press-announcements/first-fda-approved-vaccine-prevention-ebola-virus-disease-marking-critical-milestone-public-health. Accessed: 29 Sep 2020
18. Cao W, He S, Liu G, Schulz H, Emeterio K, Chan M, Tierney K, Azaransky K, Soule G, Tailor N, Salawudeen A, Nichols R, Fusco J, Safronetz D, Banadyga L (2023) The rVSV-EBOV vaccine provides limited cross-protection against Sudan virus in guinea pigs. NPJ Vaccines 8: 1–9. doi: 10.1038/s41541-023-00685-z.
19. Konde-Lule J, Gitta SN, Lindfors A, Okuonzi S, Onama VO, Forsberg BC (2010) Private and public health care in rural areas of Uganda. BMC Int Health Hum Rights 10: 29. doi: 10.1186/1472-698X-10-29.
20. Standley CJ, Sorrell EM, Kornblet S, Fischer JE, Katz R (2015) Implementation of the International Health Regulations (2005) Through Cooperative Bioengagement. Front Public Health 3: 1–26. doi: 10.3389/fpubh.2015.00231.
21. Polgreen PM, Santibanez S, Koonin LM, Rupp ME, Beekmann SE, del Rio C (2015) Infectious Disease Physician Assessment of Hospital Preparedness for Ebola Virus Disease. Open Forum Infect Dis 2: ofv087. doi: 10.1093/ofid/ofv087.
22. World Health Organization (2014) Hospital preparedness for epidemics. Geneva: World Health Organization. 71 p. Available: https://apps.who.int/iris/handle/10665/151281. Accessed: 13 July 2023.

Corresponding author

Mr. Collins Ankunda, M.Sc.
Clinical Research Fellow,
Mildmay Research Centre Uganda, Entebbe Rd,
Naziba Hill, Kampala, Uganda, and Institute for Global Health,
University of Siena, Italy,
Tel: +256773137473
Email: ankundacollins@gmail.com

Conflict of interests: No conflict of interests is declared.