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Dear Reader,

We take great pleasure in welcoming you to Issue 3, Volume 8 of the Uganda Public Health Bulletin.

We aim to inform the district, national, and global stake-holders on disease outbreak investigations, public health surveillance, and interventions undertaken in detecting, preventing, and responding to public health events in Uganda.

In this issue, we present a variety of articles including; Stigma among Ebola Survivors, the Role of Community Beliefs and Practices in the Spread of Ebola in Uganda, KAP of traditional healers about Ebola, Anthrax Outbreaks, Measles Outbreak in Kiryandongo, Meningitis Outbreak in Obongi District, Effect of ambient Air pollution during pregnancy on pre-term births, Factors associated with severe pneumonia, Exclusive breastfeeding among HIV exposed infants, and Increasing stock outs of critical malaria commodities in public health facilities

Should you have any questions or require additional information related to articles in this bulletin please contact us on: ltumusiime@uniph.ac.ug, bkibwika@uniph.ac.ug, enamulondo@uniph.go.ug, lnaluwagga@uniph.ac.ug OR lbulage@uniph.go.ug

We hope you find this information valuable and we shall appreciate any feedback from you.

Thank You

Inside this issue:

Stigma among Ebola Disease Survivors in Mubende and Kassanda Districts, Uganda, 2022

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Summary

Background: On September 20, 2022, Uganda declared a Sudan Ebola Virus Disease (SUVD) outbreak after a case was detected in Mubende District. The outbreak eventually spread to 8 other districts during September-November 2022. Ebola survivors often experience stigma in multiple formats, including felt (perceived) stigma, enacted (action-based) stigma, and structural (institutional) stigma. We examined the types of stigma experienced by survivors and their household members and its effect on their well-being to inform ongoing interventions.
Methods: We conducted a qualitative study during January 2023 in Mubende and Kassanda Districts. We conducted in-depths and key informant interviews with ten SUDV survivors, ten household members of SUDV survivors, and ten key informants (district officials and health workers in the affected communities). Interviews were recorded, translated, transcribed, and analyzed thematically.
Results: Survivors reported experiencing isolation and rejection by most community members, as well as loss of business or their jobs. They reported being denied goods at shops and, when their purchases were accepted, having their money collected in a basket and disinfected (enacted Stigma). Due to this enacted stigma, survivors resorted to self-isolation (felt stigma). Educational institutions denied some students from affected homes access to school, while some parents stopped sending children to school due to verbal abuse from students and teachers (structural stigma). Prolonged EVD symptoms as well as additional attention to survivors, including home visits by health workers, public distribution of support items, and conspicuous transport from home to the survivor's clinic aggravated both felt and enacted stigma. Despite a number of community engagement activities by the response team to reduce stigma, survivors felt they were still considered a threat to the community.
Conclusion: Survivors experienced felt stigma, enacted stigma, and structural stigma that persisted even after implementation of control measures. Strengthening community engagement to counteract stigma, rethinking response activities that aggravate stigma, management of long-term SUDV symptoms for survivors, integrated response interventions by partners, private distribution of support items, and increasing awareness and sensitization through video messages could reduce stigma among the SUDV survivors.

Introduction

Ebola disease (EBOD) is a severe and frequently lethal disease caused by Ebola virus. EBOD outbreaks typically start from a single case of probable zoonotic transmission, followed by human-to-human transmission via contact with infected bodily fluids or contaminated fomites [1]. There are 6 species of Ebola virus: *Bundibugyo ebolavirus*, *Zaire ebolavirus*, *Sudan virus*, *Reston ebolavirus*, *Bombali ebolavirus*, and *Taï Forest ebolavirus*. Three species, Bundibugyo ebolavirus, Zaire ebolavirus, and Sudan virus, cause epidemics in Africa, resulting in severe hemorrhagic diseases with high case fatality rates (CFR) [2]. Zaire ebolavirus has an average case fatality rate (CFR) of 60–90%, while the Sudan virus has a CRF of 40-60%, the Bundibugyo ebolavirus has caused only one outbreak to date with a CFR of 25% [3]. Several Ebola outbreaks have been registered in Africa in the last three decades [4], of these Uganda has registered five Ebola outbreaks since 2000, with the largest being the Gulu Outbreak in 2000 [5,6].
Despite the high fatality rates, Ebola usually records a high number of survivors; based on the 2014–2016 West African Ebola outbreak, 35% of the recorded 28,646 cases survived while during the Gulu Uganda outbreak in 2000,

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47% of the 425 clinical cases survived [5]. Despite the scary Ebola disease experience for all patients, many EVD survivors are known to suffer from short - and long-term physical symptoms and mental complications. Psychosocial consequences of EVD survivorship can be traumatic due to experiences during infection, treatment, and post-discharge. These may include but are not limited to depression, anxiety, grief, and stigma [7]. According to a study in West Africa, shame or disgrace was felt by people who had any association with EVD, regardless of whether they themselves had been sick or not [8], while in another study, survivors felt supported through engagement in religious faith activities and in Ebola response [9].

Addressing disease-associated stigma early in an epidemic has been identified as an important intervention in the containment of epidemics and pandemics because it affects the willingness of affected communities to seek care and their acceptance of prevention and case management packages [6]. The stigma attached to Ebola survivors largely stems from fear of contagion and has led to evictions, intimate partnership dissolution, termination of employment, abandonment, and physical violence [10]. Ebola survivors need comprehensive support for the medical and psychosocial challenges they face and to minimize the risk of continued Ebola virus transmission [6]. The support given to survivors has been linked to better coping, faster restoration of their dignity and quick recovery to full potential following discharge [11].

On September 20, 2022, Uganda declared an EBOD outbreak (Sudan virus) that started from Mubende District and spread to Kassanda, Kampala, Wakiso, Kyegegwa, Bunyangabu, Kagadi, Masaka, and Jinja Districts, with Mubende and Kassanda being the most affected. The outbreak led to 142 cases, 55 confirmed deaths, 22 probable deaths, and 87 survivors [12]. Due to the anticipated stigma, the Uganda ministry of health and a number of partners invested in community engagement dialogues to control stigma and quicken reintegration of survivors in the communities, four meetings had been held in each district by the time of the study. Furthermore, implementing partners supported survivors with cash and household items like mattresses, clothes, and food which were issued out at the subcounty headquarters which is a public place. Additional support included: psychosocial support at the survivor's clinic and in the community. To the survivor's clinic, survivors were picked and returned to their homes by branded organization vehicles while in the community, various stakeholders visited survivor's homes for psychosocial support. To ascertain the effectiveness of the stigma control measures and to promote the well-being of EVD survivors in Uganda, we examined the types of stigma experienced by EBOD survivors and their household members, how it affected their lives and the possible drivers to inform stigma control measures for improved epidemic response and survivor support.

Methods

Study design and setting

We conducted a qualitative study to explore the perceptions and experiences of survivors and their household members. We focused on Mubende and Kassanda Districts since these were the most affected areas with a significant number of Ebola survivors. Important to note is that these districts had never experienced an EBOD outbreak before.

Study population

Participants for this study were Ebola disease survivors, members of the same household as the survivor above the age of 18 years. However, an exception was made to include emancipated minors (Children above 16 years living independently). Children living with their parents or guardians and individuals whose physical and psychological health limits them from providing information through the interview process were excluded from this study. While the experiences of these groups are valuable and worthy of study, they required specially developed and tested data collection methods that would go beyond the resources available. We identified survivors using a discharge list from the ETU and located them in the communities with the help of community health workers (CHW).

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Sample size considerations

We recruited survivors and household members from each district for in-depths interviews (IDI). Similarly, household members were recruited from each district, only one survivor or household member was recruited per household for IDIs to increase the variability of findings. We also engaged district local government leaders from each district as key informants on how stigma could be reduced for improved wellbeing of the Ebola survivors. These included health workers attached to health facilities in Ebola affected communities, the District Health Officer (DHO), Resident District Commissioner (RDC), and the District Surveillance focal person (DSFP). Saturation was reached with 20 in depth interviews; 10 survivors, 5 from each district and 10 household members and with 10 key informant interviews.

Study variables and data collection

Using an interview guide, we conducted in-depth interviews in the local language (Luganda) with the EVD survivors and their household members. We also used an interview guide to interview the key informants. Variables explored for IDIs included: experiences of stigma, possible stigma instigating factors or actions, how stigma affected their lives, possible suggestions for the control of stigma and any additional support required. In addition, we collected data on age, sex, place of residence, EVD status (survivor or household member), number of EVD patients in household, presence of EVD death in household from the survivor and household members. Key informant interviews explored community perceptions and actions towards EBOD survivors and their household members, health concerns of EBOD survivors, and recommendations for improvement. Information from the interviews was recorded in electronic form using audio digital recorders. Data was collected from participants in both districts concurrently until saturation was attained.

Data analysis

Recordings were translated to English and transcribed at the end of each data collection day and stored safely by the project PI in soft copies in a password protected computer. Participants were identified based on the type of interview, an example is SKR1, SMR2…. for survivors, HHM1, HHK1 …. for household members and KIIK1, KIIM2…. for key informants. This code was applied for both transcripts and demographic forms. After data collection, transcripts were reviewed by the PHFP fellows, coded and analyzed thematically using the CDC Excel tool for thematic analysis Ver. 10.18.22. to bring out the story of lived experiences and recommendations.

Ethical considerations

Before starting the project, a non-research determination form was submitted to the US Centers for Disease Control and Prevention (CDC) as a requirement. The Office of the Associate Director for Science at the CDC determined that the project did not involve human subjects research. This determination was made because the project aimed to address a public health problem and had the primary intent of public health practice. Further administrative approval to conduct this study was obtained from Mubende and Kassanda District offices, Mubende Regional Referral Hospital case management team, the Uganda National Institute of Public Health, and Ministry of Health. Before data collection, written informed consent was sought from respondents, they were informed that their participation was voluntary and their refusal would not result in any negative consequences. To protect the confidentiality of the respondents, each was assigned a unique identifier which was used instead of their names. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy. § §See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

Results

Type of stigma experienced by Ebola disease survivors and their household members, Mubende and Kassanda Districts, Uganda, September 2022-January 2023

Ebola virus survivors experienced various forms of stigma.

Enacted Stigma

All Ebola survivors experienced enacted stigma in the first 2 months after discharge most

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especially those that were discharged during the peak of the outbreak. The stigma was mainly from community members and this made the survivors feel so terrible.

"….. I was treated so badly, people feared and isolated me, when I would go to the shop, they could not touch the money, they put a basket where we would drop the money and they later washed it…" a survivor from Kassanda District.

"……they treated us very badly, the shop attendants would refuse to hold our money, we were ignored by everyone. At the borehole we always fetched water last because no one wanted to pump water after we had pumped….". Another survivor from Mubende District.

However, it was noted that survivors discharged in the early stages of the epidemic were less likely to be stigmatized, this was related to the limited knowledge about the seriousness of the disease by the community members.

"…. I was welcomed well by the community and I integrated well, it was still early and the community was not yet tired of ambulances. My boss offered my job back but I could not do it because I was weak…." a survivor in Mubende District

Despite the support provided to survivors to control stigma like the community engagements for acceptance, survivors were still considered a threat to the community and some families had not yet fully accepted their survivors, this was most times not said but implied.

"…. survivors are still stigmatized in the communities although people cannot openly come out to talk about it but it is implied in how they relate to them…" a key informant in Kassanda District

"…. we are still rejected, it will take several months because now it's been 3 months. Maybe after 6 months they will be free with us…." A survivor in Mubende District

"….to date some people still fear and discriminate us, some times when you come where they are they don't offer you a seat so you automatically understand they still fear you…." a survivor in Mubende District.

Institutional stigma

Survivors further experienced institutional stigma with the educational institutions being the most involved. Respondents reported that children from Ebola survivors home steads were denied access to schools while others were stopped from attending school by their parents due to the immense rejection and verbal abuse from the teachers and fellow students.

"….. we received reports that some students from affected homesteads were denied end of term promotion exams, teachers fear to touch their books and fellow students also stigmatize them….." a key informant from Mubende district

"….my children were discriminated by their friends; a time came when they did not want to go to school so they stayed home until examination period …" revealed a household member in Kassanda District

Felt Stigma

Following the intense stigma from the community, survivors felt it was best to keep to themselves. A survivor from Mubende district revealed that:

"…. I have not started going to the mosque, I fear to scare people when they see me coming, it's better not to go until when the situation is better…."

In Kassanda District, survivors kept to themselves and developed a very strong bond because they frequently spent time together due to the rejection from the community. This helped them console each other in case of any form of abuse. However, for a few survivors, felt stigma started from discharge due to the long EVD signs and

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symptoms, they felt unwell and thought they could still be infectious.

> *"….. after discharge I was so happy but I feared to go home because I was still weak and thought maybe the disease was still there. I didn't want to go home because my body was still swollen …." a survivor from Mubende District*

Reasons for the aggravated stigma among Ebola disease survivors and their household members in Mubende and Kassanda Districts, Uganda, September 2022-January 2023

Prolonged EVD symptoms

Stigma among EVD survivors was aggravated by the prolonged EVD symptoms and the fear for the disease due to its high fatality rate. Sickly survivors were perceived as "still infectious".

> *"……many of them still have health problems like: scrotal swelling and pain, hearing problems, back pain mainly for the women, headache and easy irritability. The residual symptoms confirm the community's myths that Ebola cannot heal further increasing the stigma among Ebola survivors…." a key informant in Mubende District*
>
> *"……..it was hard to explain to the children why their father was still weak following discharge, so any sign like vomiting or coughing they would run away from him...." a household member from Kassanda District*

Extra attention to the survivors

Partners provided a number of services to the EVD survivors and majority of these were considered extra attention that aggravated both felt and enacted stigma among EVD survivors and their household members. The frequent community visits by supporting partner organizations with so many cars raised the attention of the community, the pickups from the community to the survivor's clinic. Other services provided included public distribution of support items (public in-kind and monetary support issued at subcounty offices) and conspicuous transport from home to the survivor's clinic.

> *"……use of ambulances to pick survivors for review, people in the community think they are still sick. It is making it hard for the community to accept them as survivors...." a key informant from Kassanda District*
>
> *"…. visiting their homes with so many cars, the neighbors wonder if somebody has become sick again, the frequent visits, frequent clinic reviews, the special attention with support, there is some level of stigma we bring ...." a key informant from Kassanda District*

Public monetary and in-kind support

Various partners supported survivors with cash and house hold items like mattresses, clothes, and food. All these were provided in public at the respective sub county offices. It was noted that publicizing support aggravated stigma to the survivors as reported by some respondents.

> *"…. giving them material and monetary support in public…. the community segregates them because they assume they have more than other members in the …." a key informant Kassanda District.*

Risk communication

During health education and community sensitization, it was noted that a lot of information was provided to the community which they could not comprehend. This included messages like the presence of the virus in the body fluids of survivors for 1 year after discharge.

> *"……. a lot of stigma which was promoted during health education……. the message that these are survivors but they still have a risk, they still have the virus in their semen and tears…." a key*

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informant in Kassanda District

Furthermore, the mode of sensitization was considered ineffective to the community. The moving mobile vehicles were not audible and the information was not well received.

"……I can remember the education I received as a youth about prevention of HIV because they were showed in video form in the community squares but I cannot remember all that was said a few months back when the Ebola treatment unit was opened…." - A key informant in Mubende District

***Effects of stigma to the* Ebola disease survivors and their household members in Mubende and Kassanda Districts, Uganda, September 2022-January 2023**

Economic effects

Stigma mainly affected the economic aspect of the survivors and their household members lives. A household member in Mubende revealed that:

"……. the herdsman was not allowed to cross the compound to take the cows for grazing so he run away and the cows died……".

While a key informant from Mubende revealed that:

"……most of them have lost their jobs, for the few that maintained their jobs, their physical health is limiting their engagement in day to day activities….".

Effects on education

Additionally, stigma affected the education of school going household members to EVD survivors as noted by respondents.

"….. we received reports that some students from affected homesteads were denied end of term promotion exams, teachers fear to touch their books and fellow students also stigmatize them….." A key informant from Mubende district

"….my children were discriminated by their friends; a time came when they did not want to go to school so they stayed home until examination period and so my children did not perform well this last term…". A report from a household member in Kassanda District

Social effects

Families broke down due to stigma, in polygamous families where only one family was affected, the heads of family have refused to go back and denied them support. For other families where one parent died, the other divorced and refused to return home for fear of getting infected resulting in child headed homes and elderly headed homes where children were left with their grandparents.

For such homes, the subcounty in Mubende has tried to offer some support.

"…. some families are now headed by children, the father died, the mother divorced and has refused to return in fear of getting infected…." a key informant in Mubende District

"…. the subcounty has taken on support for child headed homes and homes headed by the elderly. we plan to pay the little school fees for them in government schools using the subcounty budget… for child headed homes we have identified a relative or neighbor to watch out for them…" a key informant in Mubende District.

Additionally, there was an increase in marital conflict caused by the close interaction among survivors. Wives and husbands were closer to fellow survivors than their spouses.

"…. survivors interact more, they have maintained the friendship to help console each other in case of any form of abuse… However, this close interaction among survivors has resulted in marital conflicts as wives and husbands are closer to

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fellow survivors than their spouses…." A Key informant in Kassanda District

***Proposed measures to control stigma among* Ebola disease survivors and their household members in Mubende and Kassanda Districts, 2022**

Respondents proposed a number of measures needed to control stigma. Among them was to intensify efforts to reintegrate survivors back to the community. A key informant from Kassanda District noted that:

"…intensify the integration of survivors in the community. We need to show that they are as normal as us and reduce on the extra attention..."

"…. allow survivors use public means to the survivors clinic and have their transport refunded, this will reduce on the attention during pickups and drops from the clinic which causes extra attention…" a key informant from Mubende District.

Use of visual messages for health education and sensitization in the communities. A key informant in Mubende District revealed that:

"……I can remember the education I received as a youth about prevention of HIV because they were showed in video form in the community squares but I cannot remember all that was said a few months back when the ETU was opened….".

Additional measures suggested to control stigma included supporting survivors in management of their long Ebola signs and symptoms and integrated management of interventions to avoid frequent visits to survivors and their households in the community by different teams. It was suggested that all teams should move to the field together to avoid frequent visits and the so many cars that park in survivors' compounds.

Additional support required to improve the well-being of survivors and their household members

Respondents revealed the need for additional support for improved wellbeing of survivors and their household members. These included: help to achieve a sustained livelihood through startup capital, school fees support for at least 6 months to allow them regain financial stability since majority lost their jobs or cannot work due to long Ebola symptoms and replacement of destroyed phones in the Ebola treatment unit.

Discussion

Our study revealed that survivors and their household members faced enacted, institutional, and felt stigma that persisted despite control measures. It was aggravated by the prolonged EVD symptoms, extra attention given to the survivors and some health workers activities intended to control the disease and to support the survivors like risk communication. Despite the fact that stigma control measures were in place, survivors were still considered a threat hence the need to strengthen stigma control measures.

Our findings noted enacted, institutional, and felt stigma as the forms of stigma faced by EVD survivors and their household members; the enacted stigma being the most greatly experienced. This finding is similar to other studies conducted in Liberia and Sierra Leone where EVD survivors encountered primarily enacted and perceived external stigma rather than internalized stigma[11, 13-15]. Contrary to this finding, a study conducted in Sierra Leone among EVD survivors reported higher levels of felt stigma (0.92 ± 0.77) compared to total enacted stigma (0.71 ± 0.61) and social isolation was the highest reported enacted stigma subscale [7]. Strengthening community engagement and psychosocial support would help reduce stigma among EVD survivors and their household members.

Among the reasons for aggravated stigma was prolonged EVD symptoms that persisted after discharge. This finding is similar to other scholars where survivors reported health problems; the most common symptoms being blurred or partial loss of vision, dizziness, headache, sleeplessness, and myalgia[11, 16, 17]. These were per-

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ceived as active disease and a confirmation to the community that EVD does not heal. Other causes included activities and messages passed by health workers to contain the disease like health education, home visits, transportation from the community to the survivor's clinic and offering of support items like food among others in public. In a research conducted on unpack causes and consequences of EVD stigma on the children, children drew images and wrote vividly about health campaigns initiated to contain the epidemic, such as the 'no touch' policy as the main cause of stigma [18]. Repackaging health education messages to the community for appropriateness, integrated response interventions by partners and private distribution of support items would help control stigma in addition to community engagement.

The stigma has affected survivors economically, socially and has also affected the education of the school going household members. This is similar to other studies where EVD survivors have suffered from after-effects, social and economic consequences and have emphasized the critical need for the provision of a packet of materials, including clothing and cash [11, 19]. Various partners came in to support with material items like food stuffs and household items including monetary support. However, they expressed a need for startup capital to enable sustained self-reliance and support with children's school fees for a few months as they get financially stable.

Support was provided to EVD survivors to improve stigma among EVD survivors which included psychosocial support and community engagements to improve acceptance. Despite these efforts, stigma persisted requiring strengthening of these control measures. Similar findings have been noted in other studies where survivors emphasized the critical need for comprehensive discharge counseling as well as facilitation of reentry into the community by professional psychosocial support counselors[11]. Contrary to this, other researchers have reported better coping for EVD survivors following similar support by family, friends, and prayer groups [15, 20]. Strengthening community re-entry engagements and increasing awareness and sensitization through video messages could reduce stigma among the SUDV survivors.

Study limitations

We might not have sampled the most severely affected survivors, some families had survivors who had endured enormous stigma but did not wish to tell their story. However, the recruitment of participants until saturation may have minimised this limitation.

Conclusion

Survivors experienced felt stigma, enacted stigma, and structural stigma that persisted even after implementation of control measures. Strengthening community engagement to counteract stigma, rethinking response activities that aggravate stigma, management of long-term SUDV symptoms for survivors, integrated response interventions by partners, private distribution of support items, and increasing awareness and sensitization through video messages could reduce stigma among the SUDV survivors.

Conflict of Interest

The authors declare no conflict of interest.

Author contribution

GMZ, BS, ZK, JFZ, PCK, MWW, PK, SNK, HNN, BA and RZ collected data under technical guidance and supervision of JH, ARA, DK, RM, BK, JG, SP, ERG, EJN, AA and JK. GMZ analyzed and interpreted the data. GMZ drafted the bulletin. GMZ, LB, and ARA critically reviewed the bulletin for intellectual content.

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The Role of Community Beliefs and Practices on the Spread of Ebola in Uganda, September 2022

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Summary

Background: Traditional community beliefs and cultural practices can facilitate the spread of ebolaviruses during outbreaks. On September 20, 2022, Uganda declared a Sudan Virus Disease (SVD) outbreak after a case was confirmed in Mubende District. During September–November 2022, the outbreak spread to eight additional districts. We investigated the role of community beliefs and practices in the spread of SUDV in Uganda in 2022.
Methods: A qualitative study was conducted in Mubende, Kassanda, and Kyegegwa Districts in February 2023. We conducted nine focus group discussions (FGDs) and six key informant interviews (KIIs). FGDs included SVD survivors, household members of SVD patients, traditional healers, religious leaders, and community leaders. Key informants included community, political, and religious leaders, traditional healers, and health workers. We asked about community beliefs and practices to understand if and how they contributed to the spread of SUDV. Interviews were recorded, translated, transcribed, and analyzed thematically.
Results: Frequently-reported themes included beliefs that the community deaths, later found to be due to SVD, were the result of witchcraft or poisoning. Key informants reported that SVD patients frequently first consulted traditional healers or spiritual leaders before seeking formal healthcare, and noted that traditional healers treated patients with signs and symptoms of SVD without protective measures. Additional themes included religious leaders conducting laying-on-of-hands prayers for SVD patients and symptomatic contacts, SVD patients and their symptomatic contacts hiding in friends' homes, and exhumation of SVD patients originally buried in safe and dignified burials, to enable traditional burials.
Conclusion: Multiple community beliefs and cultural practices likely promoted SVD outbreak spread during the 2022 outbreak in Uganda. Engaging traditional and spiritual healers early during similar outbreaks through risk communication and community engagement efforts could facilitate outbreak control. Targeted community messaging, including clear biological explanations for clusters of deaths and information on the dangers of exhuming bodies of SVD patients, could similarly facilitate improved control in future outbreaks in Uganda.

Introduction

Ebola disease (EBOD) is a viral hemorrhagic fever transmitted from primates or bats to humans, generally through human contact with the body fluids of such an animal [1,2]. Infection in humans usually causes acute fever and, in many people, a hemorrhagic syndrome later in the course of disease that is fatal in 50-90% of cases [3, 4]. Contact with the body fluids of infected patients can lead to infections in their household members, close contacts, and caregivers [5-8]. Even after the death of a patient, the body remains highly infectious, and contact with the bodies of persons who have died of EBOD without appropriate personal protective equipment is considered extremely high-risk [9].
In African settings, community members often seek advice from traditional healers or religious leaders before accessing formal medical care [10]. Practices among these persons can involve very close contact without appropriate protective equipment. An example is the treatment of "false teeth" (locally called *ebinyo*), which involves the gouging-out of unerupted teeth, believed by many communities to be a source of illness in children [10, 11]. Other practices include crude tonsillectomies to treat *gapfura*, a childhood illness usually characterized by respiratory disease, in which a child's tonsils and throat are manually scraped by a traditional healer until blood and pus drain from the mouth [12]. Beyond traditional treatments, some cultural practices, such washing and touching of the body of dead persons by mourners at a funeral, can also spread infection [13].

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On September 20, 2022, for the first time in over a decade, Uganda declared an outbreak of Sudan Virus Disease (SVD) caused by the Sudan virus (formerly called *Sudan ebolavirus*). By the end of the outbreak, there were 142 confirmed cases and 22 probable cases from nine districts [14,15]. Anecdotal reports from the epidemiologic investigations revealed that many patients had undergone treatment by traditional healers or religious leaders for their illnesses before they were diagnosed with SVD.

To effectively provide interventions to stop an outbreak, it is necessary to understand specific cultural practices and beliefs that may facilitate disease spread, and to work with the community to design interventions that can maintain safety while respecting important cultural aspects [1,16]. However, the role of such beliefs and practices and how they may have contributed to the outbreak were poorly understood. We evaluated the role of community beliefs and cultural practices in the spread of Ebola across Uganda, in 2022.

Methods

Study design and site

We conducted a qualitative study in Mubende, Kassanda, and Kyegegwa Districts. We conducted key informant interviews (KII) and focus group discussions (FGDs) with healthcare workers (HCW), village health team members (community health workers, also called VHTs), traditional healers, religious leaders, and district surveillance staff.

We also reviewed the case investigation reports collected by the field teams during the outbreak to summarize self-reported visits to traditional healers and religious leaders occurring after the onset of illness for patients.

Data collection

The study participants were identified, recruited, and organized with the assistance of VHTs in their communities. All interviews were conducted in the local language (Luganda) and used interview guides.

We conducted nine FGDs, each with a maximum of 10 participants. Four FGDs in Mubende District, four FGDs in Kassanda District, and one FGD in Kyegegwa District. Only one FGD was conducted in Kyegegwa because there were very few cases, compared to Mubende and Kassanda Districts. In the FGDs, we asked about the different community practices and beliefs that could have contributed to the spread of SVD in these districts. Each FGD included five males and five females. The participants were selected by convenience sampling by the village health team leaders (VHTs) from the affected villages.

Six KIIs were conducted. These included two health workers from the clinics where most early cases were treated, two traditional healers, and two religious leaders. Three KIIs were conducted in Mubende District and three KIIs in Kassanda District. We purposively selected the key informant participants from the most affected subcounties in the two districts.

Data analysis

FGDs and KIIs were audio recorded, translated into English, and transcribed verbatim for analysis at the end of each data collection day. Data were stored by the principal investigator on a password-protected computer. Participants were identified based on the type of interview and district of residence (e.g., FGDM1 represents FGD Mubende 1; FGDK1 represents FGD Kassanda 1). This code was applied to transcripts. Transcripts were reviewed by the study investigators, coded, and analyzed thematically using the CDC Excel thematic analysis tool, ver. 10.18.22 [17].

Ethics approval and consent to participate

The Ministry of Health of Uganda gave the directive and approval to carry out this investigation. Further approval to conduct this study was obtained from Mubende and Kassanda District offices, Mubende Regional Referral Hospital case management team, the National Institute of Public Health and Uganda Ministry of Health. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy. See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

Results

Five major themes emerged potentially contributing to the spread of SVD among the different districts: engaging traditional healers, communalism, touching ill persons during prayers, attribution of illness to supernatural forces, and cultural practices around burials. Reviews of case investigation reports identified at least 11 patients who went to one or more traditional healers during their illnesses and received unspecified treatment, and four who went to a traditional healer and had *ebinyo*, *gapfura*, or removal of the epiglottis performed. At least seven patients underwent traditional prayers for healing during which religious leaders laid hands on them to heal them. Two SVD patients were traditional healers and two were religious leaders.

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Use of traditional healers

FGD and KII participants reported that when someone falls sick suddenly, it is usually assumed to be due to witchcraft. At the beginning of the outbreak, many FGD participants in Mubende District felt that Ebola was a curse upon their community and that traditional medicine was a necessary intervention to counteract the curse. They believed that traditional medicine would reverse the witchcraft and thus reduce the community deaths. However, participants reported that "the traditional practices only spread Ebola to other areas".

"…When the child started passing out blood from the mouth suddenly, we thought we needed to consult with the traditional healers because we all thought it was a traditional illness. We needed to consult our ancestors because her illness was strange. She was vomiting blood so we needed to know where the blood was coming from. We took her back to our home district. The traditional healer, her grandmother, and others got infected with Ebola."

-FGD participant, female, Mubende

"…In the beginning, many community members died, but we thought it was witchcraft and because many were passing out blood, rumors had it that it was poisoning. So the community members went to traditional healers to help them suck that poison out of their bodies using traditional herbs instead of seeking care in the health facilities. This contributed to the spread of Ebola in our community and the neighboring districts."

-KII participant, female, Mubende

"…when our brother fell sick, we thought our enemies had cast a spell on him, so we took him to a traditional healer in Luweero and another one in Kampala. After his death, we lost six other family members to Ebola and two survivors."

-FGD participant, male, Mubende

"… when my brother started coughing and vomiting blood, my mother suggested that we take him to Kampala to a renowned traditional healer. Taking my brother to (a traditional healer in) Kampala led to the first cluster of Ebola cases in Kampala."

-FGD participant, male, Kassanda

Participants reported that some traditional healers ended up contracting the disease themselves and passing it to their other patients or family members.

"... My mother was a traditional healer, (and) she treated a young girl who was vomiting and coughing blood from Mubende District. The girl's mother thought she had false teeth but my mother had to check if her tonsils had burst. So, mother used her bare hands to check where the blood from this girl's mouth was coming from. Days after she treated this girl, Mother fell sick. She was infected with Ebola and died a week after she was taken to the Ebola treatment unit in Mubende. My young brother and father also got Ebola but survived."

FGD participant, female, Kyegegwa

"...My wife treated one of the first patients in Kassanda with different herbs as the entire community initially thought he was passing out blood because of witchcraft. This young man was a thief of goats…so the community members thought he had been bewitched this time. My wife got infected with Ebola and died. My maid (who took care of my wife while she was sick) and I also got infected with Ebola but luckily survived."

FGD participant, male, Kassanda

Communalism

The FGD participants reported that if a community member is sick or has a patient, the entire community is obliged to support that member. The participants noted that the practice of shared responsibility also contributed to the spread of Ebola in this community and other areas.

"…In this community, people are always willing to help. I invited my neighbors to help me carry the child when she was vomiting blood. I didn't know this was Ebola. This is how my neighbors got infected with Ebola".

FGD participant, female, Mubende

"… one of the first Ebola cases in Kassanda was a young man who had a butchery and roasted goat's meat in the evenings. When he fell sick… his many friends came to visit him in the clinic. At the time of his evacuation, he was vomiting blood but many of his friends were there to support him. This communalism led to so many other Ebola cases and deaths in our community".

FGD participant, male, Kassanda

"…when our elder sister fell sick, we all participated in taking care of her until she passed on. After her death, we lost four other members of our family to Ebola and two Ebola survivors".

FGD participant, female, Mubende

"….[when] my brother started vomiting blood, we moved to Kampala, to live with my mother's sister for better management. This led to all these family members, the neighbors and I catching Ebola in Kampala. We lost so many people to Ebola".

FGD participant, male, Kassanda

"…In our culture, it is an abomination for someone to fall sick, and fail or refuse to visit them while in the health facility. Many of these young men got infected during those moments because (an Ebola case) was heavily bleeding. Many took it upon themselves, to participate in bathing and washing

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clothes for the patient. This exposed many of them to Ebola. It is very unfortunate that we lost most of these youth who would make our community a better place in the future".
KI, female, Kassanda

Touching ill persons during prayers

FGD participants reported that religious healers who prayed for Ebola victims by laying hands on the sick not only ended up contracting the disease themselves but passing the disease to other people. It was reported that different church members contracted Ebola virus after they participated in a healing prayer session in which they laid hands on the body of a sick person.

''…As a pastor, when praying for someone seeking spiritual healing, you can't avoid getting in contact with them. We lay hands on them for a special healing and anointing. This exposed us as spiritual healers to Ebola but also our family and church members. We lost some church elders in the church (prayer warriors and intercessors) to Ebola. My family and I are also survivors of Ebola."
FGD participant, male, Mubende
''…during that period, many people were seeking for spiritual healing as (they) believed their community had been put under a spell. So my son being a pastor in this community, prayed for so many sick people. This exposed him, his wife, and son to Ebola. My grandson died but his parents are Ebola survivors."
FGD participant, female, Mubende
''…Many sought spiritual healing in our church. My wife and I prayed for some neighbors who had malaria-like symptoms but later started having bleeding symptoms. My wife shortly fell ill, she was six months pregnant when she was taken at the Ebola treatment unit. I am glad she survived Ebola but sadly a few days after her discharge, we lost our baby."
FGD participant, male, Mubende

Attribution of illness to supernatural forces

FGD and KII participants reported that there was general lack of understanding of the Ebola disease, and this had a negative influence on adherence to preventive measures. Many community members initially believed that the illnesses were caused by witchcraft or were punishment from God.

''…We didn't know what this disease was and how it came in our community. I thought it was a disease found on the borders of Congo. I had heard of that disease but in DRC and at its borders. That is why many people fell sick and others died when Ebola was in our district. Many of us thought this was witchcraft or a punishment from God."
FGD participant, male, Kassanda.
''... During the Ebola lockdown in our district, we didn't practice the control measures because most of us as young men, we thought it was witchcraft (and) not Ebola. When our friends fell sick, we would visit them. This led to more Ebola cases in Kikandwa (Village). We only believed when our friends started dying. This scared us and we eventually started practicing the preventive measures."
FGD participant, male, Kassanda.
''...The community didn't believe the cause of death among the many community deaths in early August was a medical disease. They believed it was a traditional spell, so many more people died as all the burials were never supervised".
KI, male, Mubende
''…Our communities also believed that the community members who died in the earlier days… were poisoned by some new community members to steal their land as rumor had it that our land had gold."
FGD participant, male, Mubende
''...A very old man (over 100 years) died, and his people started dying, the family lost six people in a duration of one month. The rumors had it that the old man wouldn't die alone, he had to take some relatives with him as it was believed that he was a witch doctor."
FGD participant, male, Mubende

Religious and cultural practices around burials

In this region of Uganda, funeral and burial practices hold extreme significance, as they are perceived as crucial steps in transitioning from the world of the living to the spiritual world. Common funeral rituals include washing and cleaning of the deceased person's body before burial. If a person being buried fails to obtain the appropriate ancestral spiritual rituals - which should be given by the surviving close relatives – it is believed that the deceased's spirit may return and punish the living relatives. As a result, some community members exhumed bodies of persons who had been buried in safe and dignified burials to achieve the appropriate rituals before re-burial.

''…one of the Ebola cases in Kassanda was from a very strong Moslem background. When he passed on, the health burial team buried him at night. However, his relatives decided to exhume his body to bury him in the right Islam (way) (wash his body), perform all the Islam funeral practices and confirm that all his body parts were intact".
KI, male, Kassanda
''…after one family exhuming an Ebola body, many of his family relatives got infected with Ebola. Three died and four family members are survivors of Ebola".

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FGD participant, male, Kassanda
"...the two men who exhumed [an Ebola patient]'s body, bathed and wrapped this body, all got infected with Ebola and died. These two men were known for exhuming bodies and transferring the graves in case someone has sold their burial grounds. These two men were in their late 50s so they were not friends with [the patient]".
FGD participant, female, Mubende
"…In our culture, when someone dies, we have so many rituals that we practice. Some of which include bathing, shaving and rolling the dead body in different clothes. In the earlier days of August, as a community, we didn't know that this disease was so contagious. That is how Ebola spread to other areas and killed many of our people".
FGD participant, male, Mubende
"...During burials of some community members who had been bleeding in their late stages of their illnesses, some people would come from other districts like Kampala. These people would be close relatives of the deceased. They actively participated in the burial rituals, this led to some Ebola cases in Kampala".
KI, male, Mubende

Discussion

We identified multiple traditional and cultural practices that contributed to the spread of Sudan virus in Uganda during 2022. These included engaging traditional healers for treatment, communalism, touching ill persons during prayers, attribution of illness to supernatural forces, and conduct during traditional burials. Such practices should be recognized for their potential contribution to spread of infection during ebolavirus outbreaks in Uganda and similar settings. A follow up study to identify the acceptable alternatives to these approaches together with the community could help reduce spread of infection in future outbreaks.
Traditional healers are regarded as custodians of daily traditional and cultural values in many communities in Africa, and using them as the first line of care during an illness is common [18, 19]. Media reports from 2021 suggested that traditional healers outnumbered medical doctors by a ratio of 35:1 in Uganda [20]. Traditional healers are often more highly regarded than persons who promote unfamiliar (i.e., modern) forms of health care [18]. Many practices of traditional healers in Uganda put them – and subsequently their future patients – at risk of ebolavirus infections during an outbreak. A study from Northern Uganda reported traditional healers making incisions into people's bodies and rubbing in herbal medicine, which led to the spread of ebolavirus [21]. Reports for at least 15 patients in our study documented their visits to traditional healers while they were ill; participants in our qualitative study suggested that such visits led to at least some subsequent SUDV infections. Indeed, at least two patients in the outbreak were themselves traditional healers. Because of the preference in some communities for traditional healers as the first line of treatment, some have advocated for the engagement of traditional healers in controlling the spread of ebolaviruses [4, 16, 18]. In a study in West Africa, traditional healers were trained about ebolaviruses, how to recognize symptoms early, where suspected patients should be referred, and how to protect themselves; they were subsequently involved in risk communication for their communities. The communities trusted their communication, ultimately supporting disease control in the outbreak [18].

Some people believed that the illness caused by SUDV infection was caused by supernatural beings, witchcraft from neighbors or vengeance from an offended god as a result of transgressions committed in the past by an individual or parents. A study in Nigeria also found that community members, especially those living in rural areas, believed that most health problems were spiritually related and could be resolved without modern medicine, resulting in their seeking treatment from a traditional healer to remove the witchcraft rather than a hospital [22]. In Sierra Leone, both traditional healers and community members initially attributed outbreak-related deaths to witchcraft or poisoning [23].

Religious and spiritual healing practices (touching ill persons during prayers) may also have contributed to the spread of the 2022 SUDV outbreak in Uganda. Multiple patients had documented experiences during their illness of visiting religious leaders and those healers themselves also represented some of the outbreak patients. Community members reported that they sought spiritual healing to dispel the 'witchcraft'. Similar findings were reported in a study in West Africa, in which religious leaders both contracted the illness from sick persons and passed it to others in prayer sessions [18, 24]. A subsequent intervention engaging religious leaders enabled them to educate their institutional members about the importance of seeking healthcare first in health facilities, isolating if ill, and using protective equipment in case of unexplained bleeding [25].
The normal cultural practices around funerals in many African settings, which involve washing and touching the body by family and mourners, can contribute to EBOD spread during an outbreak

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[26]. Such practices, according to community members, are highly valued because they are regarded as critical steps in the transition from the world of the living to the spiritual world, which must be facilitated by surviving relatives through specific rituals [2, 4, 13, 18]. Similar to other studies, we heard from participants that funeral practices contributed to the spread of SUDV in Uganda [14, 21, 27]. Other practices reported by study participants, such as exhumation, are related to the lack of acceptance of safe and dignified burials, and contributed to the spread of SUDV. The rapid burial of the deceased without allowing relatives to view the dead bodies gave rise to the suspicion that medical professionals were keeping the corpses in order to sell their relatives' body parts [14]. During a SUDV outbreak in Northern Uganda in 2003, such mistrust was exacerbated by rumors that some Westerners were purchasing human body parts [8, 28]. Without mutual trust between community members and health workers, adherence to preventive measures during an EBOD outbreak is likely to be compromised. In some communities, health officials attempting to conduct safe and dignified burials were attacked and prevented from executing their duties [28]. Initiating community engagement studies to identify appropriate and acceptable ways to allow them to participate in safe and dignified burials could reduce illness spread in a future SVD outbreak.

Conclusion

The recent Sudan virus outbreak response in Uganda has demonstrated the importance of involving community, traditional, and religious leaders to facilitate disease control during outbreaks. Collaboration between health workers and these leaders at all stages of outbreak response campaigns, especially when the interventions include activities incompatible with affected communities' cultural and religious practices or beliefs, may help effectively contain disease spread. Engagement of formal public health systems with traditional healers as well as spiritual and religious leaders in Uganda may help facilitate ebolavirus outbreak control. Consideration of engagement activities with communities during inter-epidemic periods – before an outbreak happens - to identify alternative acceptable and scientifically-backed actions to control infection is likely to support disease control in future outbreaks. It may also be useful to engage formal healthcare professionals with traditional and religious leaders' regional and national associations to discuss these approaches and how to implement them in the event of an outbreak. Such approaches could also help bring these leaders on board when an outbreak does occur.

Conflict of interest

The authors declare that they have no conflict of interest.

Authors' contributions

HNN took the lead in conceptualizing the study idea, data collection, data analysis, writing, and editing of the bulletin. JFZ, SNK, BA, GMZ, BNS, RA, ZK, PCK, RZ, MN, PK, MWW, and KT were involved in data collection, data analysis, and writing of the manuscript. RM, DG, IK, BK DK, LB, ARA were involved in conceptualizing the study idea and writing, editing, and reviewing the bulletin. All authors read and approved the final manuscript.

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Knowledge, attitude, and practices of traditional healers towards Ebola Virus Disease in affected communities, Uganda, September 2022

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Summary

Background: Traditional healers (TH) often serve as initial healthcare providers in Uganda. During September to November 2022, 164 Sudan virus disease cases were registered in Uganda. We assessed knowledge, attitudes, and practices (KAP) of TH regarding Ebola Virus Disease (EBOD) among affected communities in Mubende and Kassanda Districts.
Methods: We surveyed TH in Mubende and Kassanda Districts during April–May 2023. We randomly sampled 62 TH registered with an official association and used snowballing to identify 103 additional unregistered TH. We assessed socio demographics; knowledge of EBOD symptoms and transmission; attitudes towards using recommended IPC measures and referral of suspected EBOD patients; and IPC practices during management of suspected EBOD patients. We scored participants' responses as "1" (correct) or "0" (incorrect); adequate knowledge was ≥8/16, positive attitude was ≥4/8, and good practices was ≥11/21. Logistic regression was used to identify factors associated with KAP.
Results: Among 165 respondents, 57% were male; mean age was 53 years. In total, 62% had adequate knowledge, 40% had a positive attitude, and 4% had good practices. Having formal education (aOR=7.6, 95%CI: 3.6–11.8) and being registered with a TH association (aOR=3.4, 95%CI: 1.5–9.5) were associated with adequate knowledge. Being aged <40 years (aOR=3.8, 95%CI: 1.2–16.3) and female (aOR=4.3, 95%CI: 1.3–12.7) were associated with good practices. Having formal education (aOR=3.0, 95%CI:2.7-8.8) and being aged <40 years (aOR=4.5, 95%CI: 1.3–15.6) were associated with a positive attitude.
Conclusion: Practices of TH interviewed in Kassanda and Mubende put them at risk for EBOD during an outbreak. Younger, female THes were more likely to have good practices and those with formal education were more likely to have good knowledge and a positive attitude. Structured training programs by Ministry of Health to address specific knowledge and practice gaps among TH could facilitate EBOD control.

Introduction

Despite their lack of official affiliation with certified medical services, traditional healers are often the first and last place where people in many epidemic-prone countries, including Uganda, seek care [1,2]. During Ebola virus disease (EVD) outbreaks, seeking care from traditional healers is highly risky for both the patient and the healer; however, it has been observed in previous Ebola virus outbreaks and was widely reported during the 2022 Uganda Sudan ebolavirus outbreak [3]. Patients who consult traditional healers may not only delay their own proper medical management [4], but also put healers at risk as the healers lack proper protective equipment. In previous outbreaks, traditional healers have both frequently contracted the disease themselves as well as passing it to other patients [5].
However, rather than demonizing traditional healers as agents of propagation of communicable diseases and ignoring their role in the health seeking process, there may be value in harnessing their popularity and turning them into potential collaborators and providers of health education, early detection, and notification of health authorities in the context of epidemic outbreaks [6,7]. In Uganda, the critical role of traditional healers has been incorporated in surveillance for diseases like HIV and Kaposi's sarcoma [8]. Despite the common assumptions regarding the engagement of traditional healers in patient care for EVD in Uganda, there are limited data on their knowledge, attitudes, and practices (KAP) around EVD.
To improve the prevention of Ebola, patient management and mitigation of further risk of transmission, there is need to understand the role of traditional healers, their knowledge, attitudes and beliefs about the disease, their practices regarding patient care, and their relationships with the for-

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mal health care system. This would provide critical information about their practices and influencing factors, identify the communication and referral processes for traditional healers regarding Ebola virus disease, identify their needs as part of the lay health care system, and how to involve them better in the prevention and control of Ebola virus disease. The goal of this study was therefore, to describe Knowledge, attitude and practices of traditional healers in relation to Ebola Virus Disease in an epidemic-prone country. We described the knowledge, attitude and practices among traditional healers on Ebola Virus Disease and associated factors in affected communities in Uganda, September 2022

Methods

We conducted a cross-sectional study in April 2023 employing quantitative methods of data collection. We sampled traditional healers from 2 districts (Mubende and Kassanda). The two districts were the most affected by the latest SVD outbreak in September 2022 [9]. We interviewed traditional healers aged ≥18 years that were residing in Mubende and Kassanda six months before the SVD outbreak.

We estimated the sample size for the study using the Kish leslie formula[10] for cross sectional studies. We estimated that 49% of respondents would answer 'Yes' [11] to the question "do you believe that Ebola exists in Uganda?" and calculated a sample size of 150 participants from the 2 districts. To cover for non-response, we added 10% of the calculated sample and got a total sample size of 165 traditional healers. We used the probability proportionate to size method to estimate the total number of traditional healers to be contributed by each district. Out of the 400 traditional healers Mubende District had, we sampled a proportion of 21% and got 85 participants while Kassanda with a population of 350 traditional healers, a proportion of 32% was got yielding 80 participants.

We collected data regarding overall KAP of traditional healers towards EBOD using an adapted standardized questionnaire developed in Liberia by World Health Organization (WHO), Johns Hopkins Center for Communication Programs (CCP), and US Centers for Disease Control and Prevention (CDC) during the 2015 West Africa EVD outbreak [12]. We designed the questionnaire in Kobo collect software version 2022.3.6., and imported it to STATA version 14 software for analysis. Variables considered for knowledge included: causes of EBOD, source of information, symptoms, risk awareness, infection prevention and control (IPC), and treatment / management. Variables considered for practices included: IPC practices, symptoms of Ebola patients, data and records, and referral processes. For attitudes, we considered Ebola treatment, IPC, and treatment of other health conditions. Each question was scored "1" for a correct response and "0" for an incorrect response, adequate knowledge score was ≥8, positive attitude was ≥4, and good practices score was ≥11. These scores were later summed up in each of the categories and percentages were calculated.

To get a general description of the characteristic of the traditional healers, we carried out descriptive analysis using means, standard deviation, and percentages. Categorical variables (sex, religion, marital status, occupation, education level, traditional healer type, registration status) were summarized into frequencies and proportions and displayed using bar graphs. To identify the factors associated with knowledge, attitudes, and practices among traditional healers, we summarized the outcome of each component of KAP in a binary scale that is to say knowledge as knowledgeable / not knowledgeable, attitudes as positive / negative, and practices as adequate / inadequate. We used logistic regression analysis to determine the association between the dependent variables (that is knowledge, attitude, and practices) and the independent variables.

We conducted this KAP survey in response to a public health emergency and as such was determined to be non-research. The MoH authorized this survey and the office of the Center for Global Health, US Center for Diseases Control and Prevention determined that this activity was not human subject research and with its primary intent being for public health practice or disease control. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy. [§]

[§]See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

We obtained permission to conduct the survey from the district health authorities of Mubende and Kassanda. Permission was also obtained from the office of the Resident District Commissioner. We obtained written informed consent from all the respondents. Participants were assured that their participation was voluntary and

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that there would be no negative consequences for declining or withdrawing from the study (none declined or withdrew). Data collected did not contain any individual personal identifiers and information was stored in password-protected computers, which were inaccessible by anyone outside the investigation team.

Results

Socio-demographic characteristics of traditional healers during a study to assess the knowledge, attitudes and practices regarding Ebola Virus disease, Uganda, May – April 2023

A total of 180 traditional herbalists were identified in the Kassanda and Mubende districts between 1st April to 31st May 2023. Of these, 15 were not staying in the study area six months before the SVD outbreak and hence not eligible for the study. A total of 165 traditional healers whether registered (37.6) or not with an association consented to participate in the study and these were analyzed for knowledge, attitude and practices regarding Ebola Virus Disease. Men represented (57%) traditional healers from the two districts where the study was carried out. The average age of traditional healers was 53 (SD = 15.7) ranging from 27 -100 years and 70% of them were of Christians; 74% of the traditional healers were married or living with a spouse. Most traditional healers had a primary education level in (53.1%) and had as primary activity the practice of farming (75%) (Table 1).

Table 1: Socio-demographic characteristics of traditional healers during a study to assess the knowledge, attitudes and practices regarding Ebola Virus disease, Uganda, May – April 2023

Variable	Frequency	Percentage
Age (years)		
20 -30	9	5.4
31 – 40	34	20.6
41 – 50	39	23.6
>51	83	50.3
Sex		
Male	94	57.0
Female	71	43.0
Religion		
Christian	115	70.1
Moslem	35	21.3
Traditional believer	9	4.9
Other	6	3.6
Marital status		
Divorced / Separated	13	7.9
Married / Living together	122	73.8
Single / Never been married	10	6.1
Widow / widower	20	12.2
Education Level		
Never gone to school	35	21.3
Primary	88	53.1
Secondary	39	23.8
Tertiary	3	1.8
Where TH skill was acquired		
Called by the spirit	67	40.6
Learnt from a senior	74	44.8
Trained in an institute	18	10.9
Other	6	3.7
Primary Occupation		
Farming	124	75
Traditional healer	22	13.4
Business	9	5.5
Casual Laborer	10	4.3
TH -type		
Bone-setter	22	13.4
Herbalist	54	32.9
Traditional birth attendant	30	18.3
Spiritualist	59	35.7
Registered		
No	88	53.3
Yes	62	37.6
I don't know	15	9.1
Reason for no registration		
Ignorant about registration	29	46.8
Lack of funds	21	33.9
Not interested	6	9.7
New	6	9.7
Mentor other THs		
No	100	60.6
Yes	65	39.4

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Knowledge of traditional healers regarding Ebola Virus disease, Uganda, May – April 2023

In response to theme 1 (knowledge of the cause of Ebola), 98% (162) of traditional healers were knowledgeable, while 83% (137) correctly answered theme 2 (symptoms of Ebola). In response to theme 3 (knowledge of sources of health information as needed), 90% (n=148) of traditional healers were knowledgeable. Theme 4 (Knowledge of the recent Ebola outbreak in the country) revealed that 80% (132) were knowledgeable. In response to theme 5 "Perceived to be at risk of getting Ebola during the outbreak), only 30% (n=50) answered correctly, and theme 6 (Ebola Virus disease infection methods), 71% (117) traditional healers were knowledgeable.

Practices of traditional healers regarding Ebola Virus disease, Uganda, May – April 2023

We found 96% (158) had inadequate practice regarding proper infection control and prevention practices including handwashing, use of personal protective gears and use of disinfectants, 76% (110) were not able to recognize symptoms of concern with a patient that could suggest Ebola. A total of 25% (41) of the traditional healers were keeping treatment records for their patients. We found 70% (115) of the traditional healers were referring patients to health facilities.

Attitudes of traditional healers regarding Ebola Virus Disease, Uganda, May – April 2023

The attitudinal responses of traditional healers about EVD such as in response to a question regarding seeking medical attention if they developed EVD symptoms, 96% (158) of the traditional healers agreed to this whereas 44% (73) disagreed that they adapted new practices to avoid being infected with EVD. In response to another question “traditional healers can treat VHFs like Ebola, 71% (117) of traditional healers disagreed, similarly 84% (137) of the traditional healers disagreed with being able to treat other infectious diseases like TB (Figure 1)

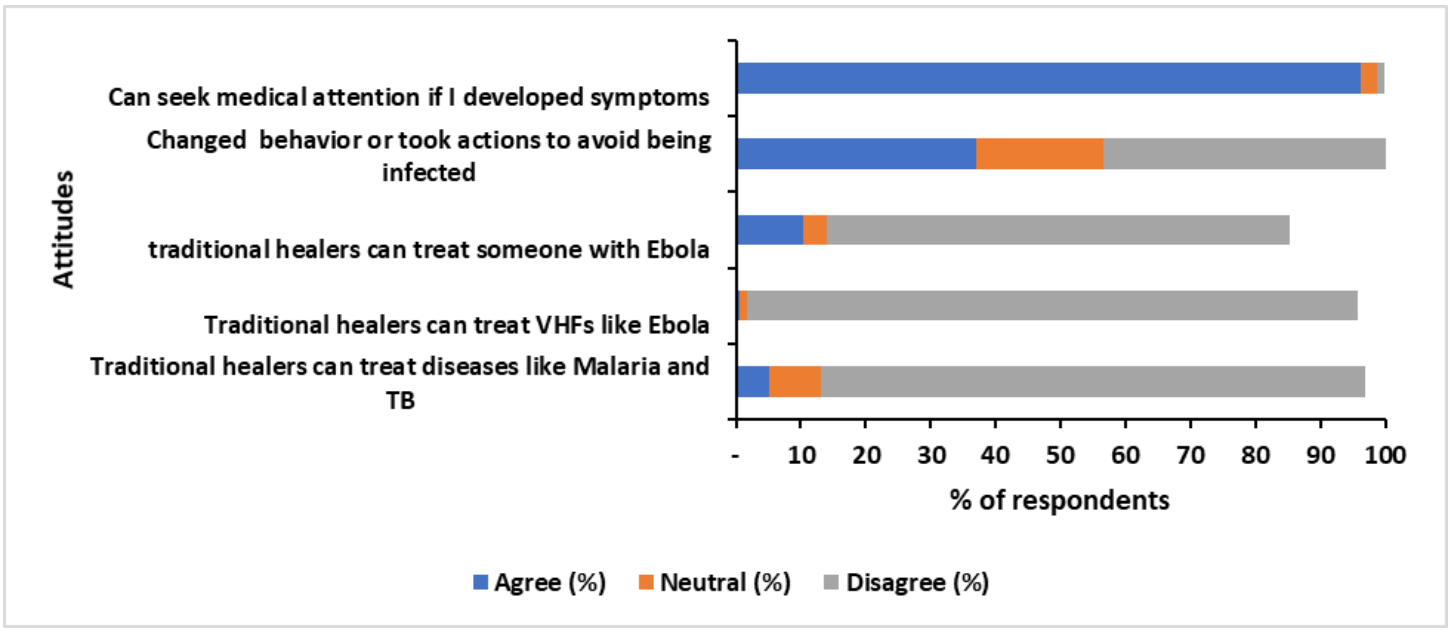

Figure 1: Attitude of traditional healers regarding Ebola Virus Disease, Uganda, May – April 2023

Factors associated with knowledge, attitude and practices of traditional healers regarding Ebola Virus Disease, Uganda, May – April 2023

Factors associated with knowledge of traditional healers regarding Ebola Virus Disease

In the unadjusted analysis, sex, registration status with an association and education level were associated with being knowledgeable of EVD. Following adjusting, two factors were identified as significantly associated to being knowledgeable of EVD. Having primary level of education increased the odds of being knowledgeable by 2.5 times (aOR=2.50, 95% CI: 2.0 – 8.6 among the traditional healers com-

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pared to those who had never gone to school. Similarly having secondary level of education had 8 times the odds (aOR=7.61, 95% CI: 3.6 – 11.8 of being knowledgeable compared to those who had never gone to school. Indicating that the higher the education level the higher the odds of being knowledgeable of EVD. with any associations (Table 2).

Table 2: Factors associated with Knowledge of traditional healers regarding Ebola Virus disease, Uganda, May – April 2023

Variable	OR	95% CI	aOR	95% CI
Age	1.23	0.2 – 5.2	1.15	0.5 – 3.6
Sex				
Female	Ref		Ref	
Male	0.29	0.2 – 0.8	0.16	0.1 – 3.5
Marital status				
Single	Ref		Ref	
Married	1.90	0.02 - 4.7	2.4	0.6 – 3.5
Religion				
Christian	Ref		Ref	
Moslem	0.99	0.48 - 2.5	0.26	0.23 - 2.1
Traditional believer	0.78	0.12 - 3.7	0.47	0.20 -1.5
Other	1.01	0.93 - 2.1	1.23	0.45 - 5.0
Education level				
Never gone to school	Ref		Ref	
Primary	1.36	1.2 – 6.2	2.50	2.0 – 8.6
Secondary and higher	10.5	4.8 – 15.6	7.61	3.6 – 11.8
Registered with an association				
No	Ref		Ref	
Yes	1.28	1.1 – 4.6	3.4	1.5-9.5

Factors associated with attitudes of traditional healers regarding Ebola Virus Disease

In the unadjusted analysis, age, sex, and education level were associated with being a positive attitude. Following adjusting, two factors were identified as significantly associated to having positive attitude towards management of EVD. Having primary level of education had 4 times the odds (aOR=3.60, 95% CI: 1.3 –9 .6), of having a positive attitude among the traditional healers compared to those who had never gone to school. Similarly having secondary level of education had 3 times higher odds (aOR=3, 95% CI: 2.7 – 8.8), of a positive attitude compared to those who had never gone to school. Being 20 – 30 years of age had 4.5 times the odds (aOR=4.5, 95% CI:1.3 – 15.6 of having a positive attitude on EVD compared to those who are 40 years and older (Table 3).

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Table 3: Factors associated with attitudes of traditional healers regarding Ebola Virus disease, Uganda, May – April 2023

Variable	OR	95%CI	aOR	95%CI
Age				
20-30	3.23	2.7 – 6.0	4.5	1.3 - 15.6
31-40	1.15	0.8 - 8.9	1.8	0.4 – 6.7
>40	Ref		Ref	
Sex				
Male	Ref		Ref	
Female	2.56	1.1 – 5.5	1.23	0.2 – 4.2
Marital status				
Single	Ref		Ref	
Married	1.90	0.8 - 4.4	6.4	0.3 - 9.2
Religion				
Christian	Ref		Ref	
Moslem	1.01	0.5 - 1.1	0.26	0.2 - 2.1
Traditional believer	1.34	0.6 - 1.4	0.47	0.2 -1.5
Other	1.39	0.6 – 1.4	1.23	0.4 - 5.0
Education level				
Never gone to school	Ref		Ref	
Primary	2.54	1.4 - 3.1	3.60	1.3-9.7
Secondary and higher	1.45	0.8 – 2.7	3.00	2.7-8.8
Registered with an association				
No	Ref		Ref	
Yes	2.9	0.1 - 1	1.3	0.2 – 4.3

Factors associated with good practices of traditional healers regarding Ebola virus disease

In the unadjusted analysis, age, sex, marital status, being registered with an association and education level were associated with adequate practices. Following adjusting, two factors were identified as significantly associated to having good practices of EVD management. Being 20 – 30 years of age was twice the odds (aOR=2.4, 95% CI:2.0 – 8.1) of having good practices among traditional healers compared to those who were >40 years of age. Similarly, traditional healers aged 31 – 40 years had 4 times odds (aOR=3.8, 95%CI:1.2 – 16.3) of having good practices among traditional healers compared to those who were >40 years of age. Being a female traditional healer was 4 times (aOR=4.3, 95% CI:1.3 – 12.7) the odds of having good practices compared to being a male traditional healer (Table 4).

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Table 4: Factors associated with good practices of traditional healers regarding Ebola Virus disease, Uganda, May – April 2023

Variable	OR	95%CI	aOR	95%CI
Age				
20-30	2.33	0.7 - 5.4	2.43	2.0-8.1
31-40	1.32	0.4 - 2.9	3.81	1.2-16.3
>40	1		1	
Sex				
Male	1		1	
Female	3.2	2.4 – 8.5	4.3	1.3-12.7
Marital status				
Single	1		1	
Married	0.91	0.1 – 2.3	0.64	0.4 – 3.1
Religion				
Christian	1		1	
Moslem	0.99	0.7 - 5.3	2.34	0.2 – 4.2
Traditional believer	0.78	0.4 - 2.9	0.75	0.5 – 5.1
Other	1.09	0.3 - 2.3	1.01	0.8 – 2.3
Education level				
Never gone to school	1		1	
Primary	2.31	1.2 – 4.3	1.38	0.6 – 5.2
Secondary and higher	3.13	2.7 – 8.3	1.34	0.4 – 3.2
Registered with an association				
No	1		1	
Yes	1.28	1.1 – 4.3	3.4	0.3 – 4.6

Discussion

Several studies suggest that there is still high utilization of traditional healers' services in most communities[13] [14, 15]. In this study, we described the knowledge, attitudes and practices of traditional healers on Ebola Virus Disease in affected communities in Uganda and the factors associated. It aimed to provide critical information about their practices and influencing factors regarding KAP on Ebola virus disease, and how to involve them better in the prevention and control of Ebola virus disease.

We found that the traditional healers were knowledgeable on Ebola virus disease, the signs and symptoms of EVD and how the infection is spread from person to person, the sources of health information. This might be accredited to the intensive awareness campaigns and risk communication both during and after the outbreaks [13]. These findings are similar to those reported from other settings like west Africa [12] that indicated that traditional healers usually had knowledge about EVD in previous EVD outbreaks [16]. In addition, the communities were reported to have a high level of knowledge regarding EVD [17]. However, a study in north Africa reported poor knowledge regarding Ebola among the population that included traditional healers in 2017 [18].

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The findings reveal a noteworthy level of awareness and understanding among traditional healers regarding various aspects of EVD. In terms of knowledge, an impressive 98% (162) of traditional healers demonstrated knowledge about the cause of Ebola and a good understanding of the clinical presentation of the disease where 83% (137) of the traditional healers were able to correctly identify the symptoms of Ebola. This suggests a high level of awareness among traditional healers regarding the etiology and the clinical presentation of the disease, however traditional healers did not consider themselves to be at high risk of contracting the disease. This might be due to the beliefs in the communities that Ebola is caused by witchcraft or curses which are not infectious [19] and the trust the traditional healers have traditional medicine to cure all ailments [20]. These findings align with similar studies conducted in Sierra Leone. For instance, Kamara et al. (2015) conducted a study in Sierra Leone that reported a high level of knowledge among traditional healers regarding the cause, symptoms, and transmission of Ebola [16]. However, it's notable that a discrepancy emerges when considering the perception of personal risk. In our study, 30% of the traditional healers correctly identified their own vulnerability to contracting Ebola during an outbreak. Misconceptions were also identified, such as the mistaken belief in airborne transmission. In contrast, Conteh et al. (2016) conducted a study in Sierra Leone that revealed inadequate knowledge and practices regarding EVD among traditional healers. And another by Aminu and Jegede (2017) found that traditional healers in Nigeria had a strong grasp of EVD symptoms but lacked comprehensive understanding of its cause, transmission, and prevention. Notably, traditional healers in our study reported using traditional remedies for EVD treatment, potentially putting themselves at risk.

Our study reported that approximately 90% (148) of the traditional healers were knowledgeable about the sources of health information available to them and this suggests that they are aware of where to access reliable information about health-related matters, these findings echo those of a study conducted in Liberia by Soka et al. (2016), which identified the role of traditional healers in educating communities about EVD and providing care to patients. Moreover, approximately 80% (132) of the traditional healers demonstrated awareness of the recent EVD outbreak in Uganda, indicating a reasonable level of consciousness. This parallels the observations of Aminu and Jegede (2017), who noted a similar awareness of recent EVD outbreaks among traditional healers in Nigeria.

Education emerged as a significant factor influencing traditional healers' knowledge of EVD, mirroring findings from Conteh et al. (2016) in Sierra Leone. That is, 60% of traditional healers with secondary education knew that EVD is a deadly disease, compared to only 30% of traditional healers with no education. The study showed that traditional healers with higher levels of education exhibited better understanding and practices concerning EVD. Several studies emphasize the potential role of traditional medicine in EVD prevention and control. Gbary et al. (2016) emphasized the complementary nature of traditional medicine alongside modern approaches in combating EVD. Camara et al. (2016) stressed the value of training and educating traditional healers about EVD, while Okello et al. (2015) emphasized their role in community education and patient care.

In our study, we found traditional healers who were affiliated with a registered association were knowledgeable about EVD compared to their non-affiliated counterparts. These findings closely align with outcomes from a qualitative investigation conducted by Sesay et al. (2022), which indicated that registered traditional healers exhibited higher levels of familiarity with EVD symptoms, transmission modes, and the importance of early medical intervention. Moreover, a separate study conducted in Nigeria by Gbagba et al. (2022) corroborated our findings, demonstrating that traditional healers affiliated with associations displayed enhanced EVD knowledge, greater adoption of preventive measures, and an increased tendency to refer patients to formal healthcare facilities for treatment. The observed association between traditional healers' affiliation with associations and their heightened EVD awareness is likely attributable to the valuable opportunities these associations provide. These include access to expert insights, knowledge-sharing among peers, and availability of specialized training and

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resources.

Our study highlights that traditional healers who have received formal education are more likely to exhibit a positive attitude towards EVD management. This inclination is likely rooted in education's capacity to provide traditional healers with the knowledge and skills necessary to grasp the intricacies of EVD and devise effective treatment approaches. Furthermore, education enables them to critically evaluate information from various sources, including traditional beliefs and practices, contributing to a more optimistic perspective on EVD. Our study further described attitudinal responses of traditional healers, 96% (158) of traditional healers expressed willingness to seek medical attention if they exhibited EVD symptoms. Conversely, 44% (73) disagreed with the notion of adopting new practices to prevent EVD infection. These responses are comparable to the mixed attitudes observed among traditional healers in Liberia, as highlighted by Soka et al. (2016) where 80% of the traditional healers agreed that they would seek medical attention if they developed EVD symptoms, but only 32% agreed that they had adapted new practices to avoid being infected with EVD. Our study revealed a notable finding regarding age groups. Specifically, individuals aged less that 40 years had a positive attitude towards EVD when compared to their older counterparts among traditional healers. This outcome mirrors a parallel investigation conducted in Nigeria by Aina et al. (2022), which similarly identified that younger traditional healers displayed a greater propensity for a positive attitude towards EVD, along with an increased likelihood of adopting preventive measures and referring patients to healthcare facilities for treatment. This might be due to the rigidity of the older traditional healers based on their years of experience in traditional medicine.

Education level significantly impacts EVD management practices among traditional healers. Those with primary education had 3.6 times higher odds, and those with secondary education had 3 times higher odds of practicing good EVD management compared to uneducated counterparts, as per the Logistic Regression model. A study by Sesay et al. in Sierra. (2022) found similar results that traditional healers who had good practices of EVD management were more likely to have received education. They were also more likely to be willing to collaborate with health workers in the prevention and control of EVD. Age is a pivotal determinant of proficient EVD management practices among traditional healers, particularly within the 20 – 30-year bracket. This suggests that female traditional healers within this age range are four times more likely to exhibit adept EVD management practices compared to their male counterparts. Beyond age, gender emerges as a noteworthy influencer in shaping positive EVD management approaches among traditional healers. Our study underlines that female healers tend to manifest superior practices than males. This discrepancy is underpinned by multifaceted dynamics: female traditional healers actively engage with EVD-related information through community involvement and interactions with healthcare professionals. and their proclivity for enhanced communication with health workers, driven by heightened trust, fosters collaborative efforts in EVD prevention and control.

Study limitations

We acknowledge some limitations in our study. First, the exclusive reliance on self -reported measures for the KAP may have had a risk of response bias including recall and social desirability bias. Secondly, the cross-sectional nature of the study made it difficult to draw the association between the study variables in terms of cause and effect. Despite these limitations, our study conducted a census of all traditional healers who were in the 2 affected districts during the EVD outbreak and this gave the study high power. Additionally, findings from this study provides evidence to MoH about the key drivers of KAP amongst traditional healers who treat people in the communities. These can be used to design policies that support the establishment of avenues for collaborations to control future outbreaks.

Conclusion

The study reveals a commendable level of knowledge about Ebola Virus Disease (EVD), while also highlighting persistent misconceptions, while also highlighting persistent misconceptions, emphasizing the need for targeted education. Pa-

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tient care practices exhibited a mix of willingness to seek medical attention but reluctance to adopt preventive measures, warranting behavior change strategies. Attitudes towards EVD management varied, necessitating comprehensive persuasion efforts. Factors associated with traditional healers' knowledge, attitudes, and practices included education, association affiliation, age, and gender, emphasizing their roles in shaping EVD awareness and engagement. Ultimately, the study emphasizes the importance of tailored interventions and collaborative approaches to optimize traditional healers' contributions to EVD prevention and control within the broader public health context.

We recommend development and implementation of structured training programs that focus on EVD prevention, transmission modes, symptoms, and evidence-based treatment approaches. These programs should be tailored to address the specific knowledge gaps and misconceptions identified among traditional healers. Also establishment of platforms for regular interaction and collaboration between traditional healers and formal healthcare providers, such as health workers and medical professionals can facilitate knowledge exchange, mutual understanding, and joint efforts in EVD prevention and control. In addition, emphasizing the importance of evidence-based traditional remedies that have been scientifically proven to be effective against EVD and providing traditional healers with access to credible sources of information and research on traditional remedies that have demonstrated efficacy may breed trust and recognition of traditional practitioners among different stakeholders.

Conflict of interest

The authors declare that there is no conflict of interest.

Author contributions

BNS and GES participated in the conception, design, analysis, interpretation of the study and wrote the draft bulletin; BNS, HNN, RM, SKN, TK, JFZ, MVN, RZ, PCK, MWW, PK, BA, ZK reviewed the report, reviewed the drafts of the manuscript for intellectual content and made multiple edits to the draft bulletin; BNS, MGZ, RA, EBK, JN, DK, LB, DNG and ARA reviewed the bulletin to ensure intellectual content and scientific integrity.

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The first ever reported anthrax outbreak in Bududa District, Eastern Uganda, February – May 2022

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Summary

Background: In Uganda, anthrax is one of the highest-ranking priority zoonotic diseases, based on a systematic assessment of epidemic potential and socioeconomic impact. Since 2018, anthrax outbreaks have been reported in new districts in Eastern Uganda and for the first time ever, human anthrax was confirmed in Bududa District on May 20, 2022 by

anthrax was confirmed in Bududa District on May 20, 2022 by the Uganda Virus Research Institute. We investigated to determine the outbreak scope, identify risk factors, and inform control and prevention measures.
Methods: We defined suspected cutaneous anthrax as onset of eschars/skin vesicles; suspected gastrointestinal anthrax was onset of abdominal pain and ≥1 of: diarrhea, vomiting, lymphadenopathy, pharyngitis, or oropharyngeal lesions among Bududa residents in January-May 2022; confirmed anthrax was PCR-positivity for *Bacillus anthracis* from a swab from skin lesions or blood. We identified cases through active community search and medical records review at health facilities serving the affected villages. We conducted a retrospective cohort study among all household members in affected villages to identify risk factors.
Results: Among 216 study participants, we identified 21 case-patients (15 suspected, 6 confirmed) and 1 death (Case Fatality Rate: 5%) with onsets ranging February-May 2022. Sixteen

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(76%) were male; mean age was 29 years (range: 5-72).

Twelve (57%) had cutaneous anthrax, four (19%) had gastrointestinal anthrax, and five (24%) had both. Bunatsami sub-county was the most affected (Attack Rate: 6/1,000). Cooking (aRR: 122.5, 95% CI: 34.3-439) and eating meat from an animal that died suddenly (aRR: 84, 95% CI: 18-388) increased risk of anthrax.
Conclusion: This outbreak was characterized by both cutaneous and gastrointestinal forms and was associated with cooking and eating meat from cattle that died suddenly. The spread to new regions underscores a need for widespread risk communication about anthrax, and consideration of broad vaccination of animals in this region.

Introduction

Anthrax is a zoonotic disease caused by a gram-positive, endospore-forming bacterium named *Bacillus anthracis* and is transmitted to humans through contact with or handling infected animals or their products [1]. In humans, it manifests itself in four forms; cutaneous, gastrointestinal, inhalational, and injection anthrax depending on the route of exposure. The cutaneous form affects the skin, the gastrointestinal form affects the digestive system, the inhalational form affects the lungs, and the injection form affects the skin or other body parts [2]. The cutaneous form, with an average incubation period of up to 7 days, accounts for 95% of anthrax cases reported globally and mostly occurs in Africa [2, 3].

Worldwide, approximately 20,000-100,000 cases of human anthrax are reported annually [4] and while the global burden in animals is poorly documented, it has been estimated that a total of 1 billion livestock live in high-risk areas [5]. In Uganda and the neighboring East African countries, anthrax is recognized as one of the highest-ranking priority zoonotic diseases, based on a systematic assessment of socioeconomic impact, epidemic potential, and severity of disease [6-10]. Despite this, sporadic outbreaks continue to occur and are generally poorly documented leading to underestimation of the actual morbidity and mortality of the disease [11].

The first documented occurrence of anthrax in Uganda is at least 1918 [12]. According to the outbreak inventory housed at the National Public Health Emergency Operations Center (NPHEOC), a total of 13 outbreaks were reported in humans and 16 in animals between 2013 and 2022 (Figure 1). In 2018, anthrax appeared for the first time in Eastern Uganda, particularly Kween District [13], and since then, there have been recurrent outbreaks reported in that region. Worse still, there is no policy in place regarding routine vaccination against anthrax in animals, meaning costs of vaccination are privately met [11].

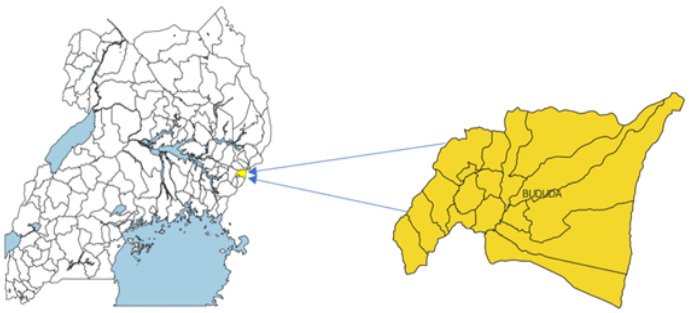
On May 16, 2022, the District Health Officer (DHO) of Bududa District informed the Uganda Ministry of Health (MoH) of cows that died suddenly and suspected cases of human anthrax in neighboring villages. Samples were collected and shipped to the Uganda Virus Research Institute (UVRI), which confirmed the outbreak on May 20, 2022. Bududa District had previously never reported anthrax but is adjacent to districts in Eastern Uganda which have been reporting outbreaks since 2018. We investigated to determine the scope and magnitude of the outbreak in humans and to identify exposures leading to infection in humans.

Methods

Outbreak area

Bududa District is located in Eastern Uganda on the slopes of Mt. Elgon, approximately 257 kilometres from the capital city, Kampala. The district is bordered by the republic of Kenya in the east; the district of Sironko in the north; Mbale in the west; Kween in the northeast and Manafwa in the south. It has an estimated population of 210,173 with an annual growth rate of 4.5% [14]. The district is agriculture-based where the majority of the farmers area small holders who grow both perennial and annual crops [15].

Figure 1: Location of Bududa District in Uganda



Case definitions and case finding

We defined a suspected cutaneous anthrax case as onset of skin lesions (papule, vesicle or eschar) in a person residing in Bududa District from January – May 2022. A suspected gastrointestinal anthrax case was onset of abdominal pain and at least one of the following: diarrhea, vomiting, lymphadenopathy, pharyngitis, and oropharyngeal lesions in a person residing in Bududa District from January – May 2022. A confirmed human anthrax case was defined as a suspected case that is laboratory-confirmed by isolation of *Bacillus anthracis* from an affected tissue or site;

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or any other laboratory evidence of *Bacillus anthracis* infection based on at least two supportive laboratory tests.

We defined a suspected animal anthrax case as sudden death of an animal in Bududa district from January – May 2022. A probable animal anthrax case was defined as a suspected case with unclotted blood emerging from body orifices in Bududa district from January – May 2022. A confirmed animal anthrax case was defined as demonstration of gram-positive rod-shaped *Bacillus anthracis* from blood or tissue.

We reviewed medical records at two health facilities serving the affected villages: Bunamono Heath centre III and Namaitsu Heath centre II in order to identify human cases. Additionally, with the help of Bududa District Health Team, District Veterinary Officers, and village health teams (community health workers), we conducted active community search in the villages to identify human and animal cases. We modified the Uganda Ministry of Health human anthrax case investigation form [16] to include relevant demographic characteristics and exposures, and accommodate our case definition. Following this, we generated a line list of case-patients.

Descriptive epidemiology
We described case-patients by person, place, time, and clinical characteristics. Using population data obtained from the Uganda Bureau of Statistics (UBOS) and community health workersof the affected villages, we computed attack rates by sex, village, and sub county. We used QGIS version 3.2.2 to draw maps to present the distribution of cases by place.

Hypothesis generation
We interviewed all 21 case-patients and asked about various exposures to animals from January to May 2022 in Bududa District. These included eating meat from an animal that died suddenly, cooking it and participation in butchering (touched meat/body fluids, carried sick/dead animal, removed animal organs, touched skin/hides, slaughtered animal, had wound, found dead animal remains in garden and did soil related work)

Retrospective cohort study
We conducted a retrospective cohort study in villages located in the more affected sub-county, Bunatsami, where 90% of the cases occurred. We chose to do a cohort study because the affected villages had small populations and all households were easily accessible. We used a structured questionnaire to gather data on demographic characteristics and potential exposures (touching meat/body fluids, carrying sick animal, removing animal organs, touching skin/hides, slaughtering, skinning, presence of a wound at time of contact, doing soil related work, cooking meat from a sick animal and, eating meat). We collected data using KoboToolbox, an open source electronic platform [17]. For respondents below 7 years, we spoke to the parent on their behalf. To measure the associations between exposure variables and illness status, we estimated risk ratios (RR) and their 95% confidence intervals. We conducted additional common reference group analysis for the factors that were statistically significant.

Environmental assessment
We observed the affected areas for any factors that could be associated with introduction of anthrax in the area and its further transmission.

Laboratory investigations
We collected 30 human samples, four animal samples, and two soil samples for laboratory analysis by the Uganda Virus Research Institute and the National Animal Disease Diagnostics and Epidemiology Centre (NADDEC), respectively.

Ethical considerations
This investigation was in response to a public health emergency and was, therefore, determined to be non-research. The MoH through the office of the Director General of Health Services gave the directive and approval to investigate this outbreak. Additionally, the US Centers for Disease Control and Prevention (CDC) determined that this activity was not human subjects' research, and its primary intent was public health practice or a disease control activity. We obtained informed consent and assent from respondents accordingly. They were informed that their participation was voluntary and refusal to participate would not result in any negative consequences. Unique identifiers were used to ensure confidentiality.

Results

Descriptive epidemiology
We identified a total of 21 case- patients, 15 (71%) of whom were suspected and six (29%) confirmed (Overall AR:10/100,000) including one death in a 55year-old-male (CFR: 5%). The case-patients presented with signs and symptoms suggestive of either cutaneous only (12, 57%), GIT only (4, 19%), and a combination of both forms of anthrax infection (5, 24%). Fourteen (67%) case-patients' occupation was related to livestock.

The median age was 26 years (range: 5-72), 16 (76%) were male and were more affected (3 per

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1,000) than females. Bunatsami sub county was more affected (6 per 1,000) than Nangako town council (0.3 per 1,000) (Table 1). All case-patients had history of either contact or eating meat from an animal that died suddenly.

Table 1: Attack rates by sex, village, and subcounty during an anthrax outbreak in Bududa District, Uganda, February – May 2022

Characteristic	Frequency (N=21)	Percentage (%)	Population	Attack Rate/1,000
Sex				
Male	16	76	5,115	3
Female	5	24	5,102	1
Bunatsami subcounty	19	90	3,263	6
Bumabala lower	6	29	77	5
Bunalakala	4	19	108	4
Bumalakala	4	19	87	3
Bumabala upper	4	19	71	3
Muririnyi	1	5	98	1
Nangako Town Council	2	10	6,954	0.3
Bunamasongo	1	5	79	1
Bunabunyu	1	5	145	1

Clinical manifestations of human case-patients

Overall, an eschar (21, 100%), skin swelling (15, 71%), itching of skin, abdominal pain, fever (each at 10, 47%) were the most common symptoms. Upon stratification, an eschar (12, 100%) and skin swelling (10, 83%) were the most common symptom among the 12 cutaneous-only case-patients. All the four GIT-only case-patients presented with abdominal pain and non-bloody diarrhoea (4, 100%), and malaise (3, 75%). All case-patients that had both forms of anthrax presented with fever, malaise, and skin swelling (5, 100%); followed by abdominal pain and non-bloody diarrhoea (each at 4, 80%) (Figure 3)

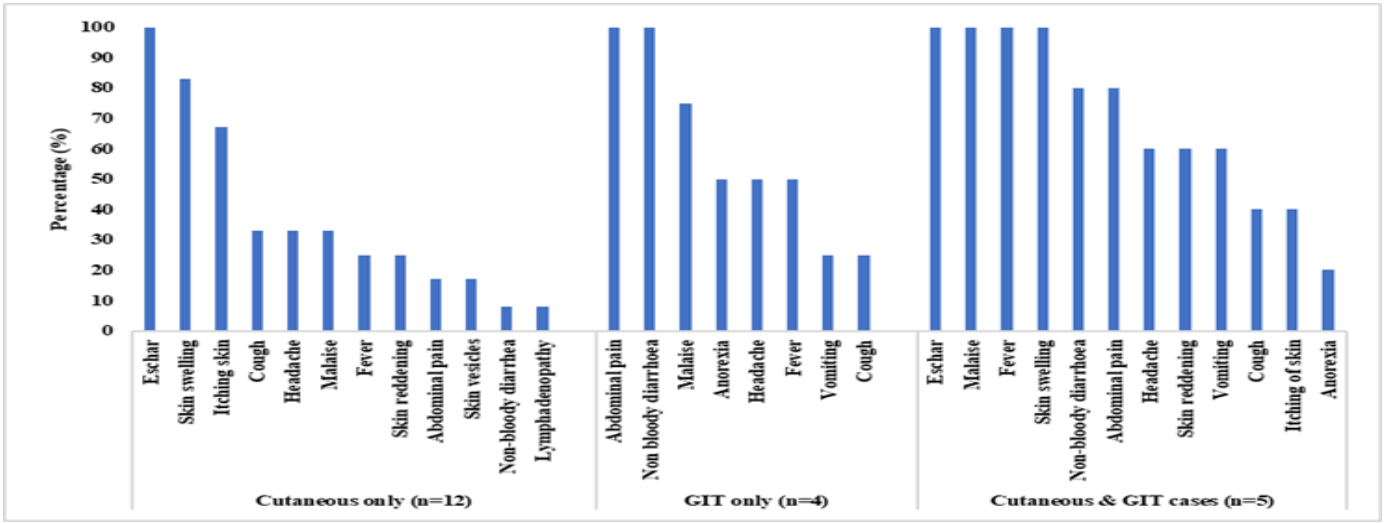

Figure 2: Clinical manifestations of anthrax case-patients during an anthrax outbreak, Bududa District, Uganda, January – May, 2022

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Clinical manifestations of animal cases

We identified a total of 17 suspected animal anthrax cases from seven villages in the two sub counties reporting human cases; Bunatsami (16, 94%) and Nangako town council (1, 6%). Two out of the 17 were subsequently confirmed positive by NADDEC; All 17 (100%) animal died within a day of onset of illness while 8 (47%) had blood oozing from orifices; 7 (41%) had difficulty in breathing and rapid bloating.

Deaths among animals occurred from February 14 – May 22, 2022 while onset among case-patients occurred from March 10 – May 27, 2022 (Figure 4). Death among animals precedes onset of disease among humans; all 21 case-patients reported exposure to animals that died suddenly. The first two case-patients with onsets on March 10 and 13 respectively, are a skinner and butcher who both worked at an abattoir in Bushika market and routinely handle meat.

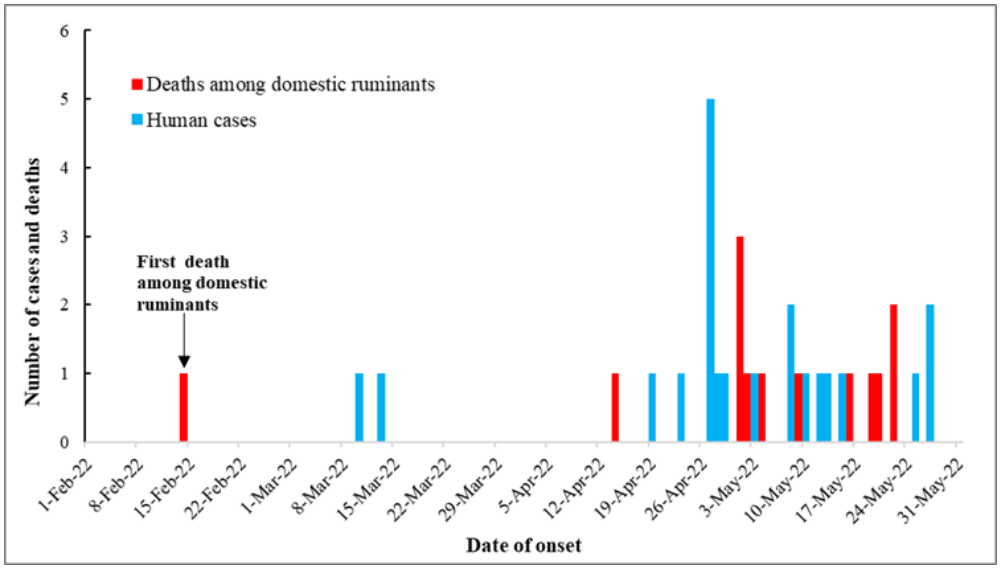

Figure 3: Distribution of case-patients and animal deaths by date of onset during an anthrax outbreak, Bududa District

The outbreak in both humans and animals occurred in Bunatsami subcounty and Nangako Town Council (Figure 5).

Figure 4: Distribution of anthrax cases among humans and animals during an outbreak in Bududa District, Uganda, February – May 2022

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Hypothesis generation findings

Of the 21 case-patients interviewed, 18 (86%) ate meat from an animal that died suddenly, 12 (57%) had participated in butchering (which included touching meat/body fluids, carrying sick animal, removing animal organs, touching skin/hides, slaughtering, skinning, presence of a wound at time of contact and doing soil related work); 10 (48%) cooked the meat.

Based on the descriptive epidemiology and the hypothesis generation interview findings, we hypothesized that handling and eating meat from an animal that died suddenly was associated with an increased risk of anthrax infection (Table 2).

Table 2: Exposures for anthrax, Bududa District, Uganda, February – May 2022

Exposures	N	%
Participation in butchering		
Touched meat/body fluids of animal that died suddenly	12	(57)
Carried sick animal/one that died suddenly	6	(29)
Removed animal organs	6	(29)
Touched skin or hides	6	(29)
Slaughtered animal that died suddenly	5	(24)
Skinned animal that died suddenly	4	(19)
Did you have a wound/ cut at time of contact	3	(14)
Found dead animal remains in garden	1	(5)
Did soil related work	0	(0)
Ate meat from animal that died suddenly	18	(86)
Cooked meat of animal that died suddenly	10	(48)

Retrospective study findings

The villages where we conducted the cohort study had a total population of 441. However, we reached 216 persons who were present in the area at the time of the outbreak.

Participating in butchering, preparing and eating meat of an animal that died suddenly was associated with an increased risk of developing anthrax infection (Table 3).

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Table 3: Risk factors of anthrax, Bududa District, Uganda, February – May 2022

Exposure	RR	95% CI
Age category		
10 – 19 (reference)		
<10	0.3	0.0 – 2.2
20 – 30	1.7	0.3 – 8.4
31 – 40	1.6	0.4 – 6.4
Sex (Female)	0.3	0.1 – 0.7
Participation in butchering, preparation/eating meat		
Touched meat/body fluids of animal that died suddenly	15.3	7.7 – 30.4
Carried sick animal/one that died suddenly	9.3	4.4 – 19.4
Slaughtered animal that died suddenly	13.3	8.3 – 21.3
Skinned animal that died suddenly	12.6	8.0 – 19.9
Removed animal organs	14.1	8.7 – 23.0
Touched skin or hides	14.1	8.7 – 23.0
Did you have a wound/ cut at time of contact	13.3	8.3 – 21.3
Found dead animal remains in garden	12.0	7.7 – 18.6
Cooked meat of animal that died suddenly	16.0	7.8 – 33.0
Ate meat from animal that died suddenly	116.1	16.1 – 835.8

At multivariate level (common group reference analysis), females were less likely to develop anthrax in comparison to men. People that did not cook but ate meat were 84 times more likely to develop anthrax in comparison to those that did not cook or eat; while people that cooked and ate meat were 122 times more likely to develop anthrax than those that did not cook or eat (Table 4).

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Table 4: Factors associated with human anthrax outbreak based on common group analysis, Bududa District, Uganda, February – May 2022

Exposure	RR	95% CI
Age category		
10 – 19 (ref)		
<10	0.3	0.0– 2.3
20 – 30	1.7	0.3– 8.4
31 – 40	1.6	0.4– 6.4
≥ 41	0.8	0.2 – 2.6
Sex		
Male (ref)	0.4	0.2 – 0.9
Female		
Education level		
Primary (ref)		
None	1.5	0.9 – 2.7
≥ Secondary	0.5	0.1 – 1.7
Cooking/eating meat		
Did not cook or eat (ref)		
Ate but did not cook	84.4	18.4 – 388
Cooked and ate	122	34.3 – 438
Participated in butchering	1.4	0.9 – 2.6
Did not butcher (ref)		
Butchered		

Discussion

This outbreak investigation documented the occurrence of cutaneous and gastrointestinal forms among people who either consumed beef or handled the meat of a cow suspected to have died of anthrax in Bunatsami and Nangako sub-counties. The clinical manifestations including eschar and skin swelling are evidence of the cutaneous form of anthrax while abdominal pain and vomiting are suggestive of the GIT form. Males were more affected than females. The index case was a skinner and butcher who routinely participates in butchering and skinning of carcasses from several sources.

In Uganda, anthrax has been occurring among animals with occasional leakage to humans. For humans, the major sources of exposure to *B. anthracis* are direct or indirect contact with infected animals or contaminated animal product [18]. This particular outbreak among humans occurred after reports of sudden animal deaths; subsequent laboratory testing confirmed anthrax among animals. Butchering anthrax-infected animals, combined with limited vaccination enables further environmental contamination with *B. anthracis* spores and propagation of the outbreak in both animals and humans [18]. Findings from this investigation are consistent with what has been found in other outbreaks [19].

Anthrax is typically associated with four forms of presentations: cutaneous, gastrointestinal, inhalation, and injection. Our findings suggested that the cutaneous form of anthrax was the most common form in this outbreak. This finding is consistent with other studies where anthrax has been reported both locally and within the African region [20].

The major cause of anthrax in humans is direct or indirect exposure to infected animal products, whereas the risk factors of anthrax among the animal population are host susceptibility, droughts followed by heavy rains, and low levels of pastures hence animals graze close to the ground [5]. These factors were present most likely influencing the anthrax outbreak in both animals and humans. Previous investigations of outbreaks in Uganda that have been done recently also found the association of anthrax to handling of meat from animals that died suddenly [20]. All cases reported in this outbreak were known to have had contact with animals or their products before symptom onset. Contact with animals included any form of participation in butchering. Butchering is a largely male-dominated role which explains why males were usually the most affected sub-population during anthrax outbreaks [21] and why adults were more affected than children.

Study limitations

Surveillance of anthrax in humans and animals is challenging due to a lack of awareness and identification of cases. Some individuals may have experienced mild, non-specific signs and symptoms of anthrax hence they were likely missed during case-finding. This may have contributed to an underestimation of the scope of the outbreak.

Conclusion

This outbreak was characterized by both cutaneous and gastrointestinal forms and was associated with handling and eating meat from cattle that died suddenly. The spread to new regions underscores a need for widespread risk communication about anthrax, and consideration of broad vaccination of animals in this region.

Conflict of interest

The authors declare that they had no conflict of interest.

Author contribution

Zainah Kabami: led the conception, design, analysis, interpretation of the study and wrote the

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draft bulletin; Zainah Kabami, Brian Agaba, Helen Nelly Naiga, and Robert Zavuga, participated in the investigation and data collection; Brenda Simbwa, Joshua Kayiwa and Sauda Namubiru supported data analysis; Lilian Bulage and Fred Monje reviewed the report and bulletin.

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Anthrax outbreak associated with handling and consuming meat from animals that died suddenly, Ibanda District, Uganda, May 2023

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Summary

Background: On March 24, 2023, Ibanda District reported seven suspected anthrax cases, after reportedly slaughtering, and eating meat from animals that died suddenly before slaughter at Kakijerere II village, Kagongo Division Ibanda District, Western Uganda. They all presented with blisters, oedema, and skin lesions typical of anthrax infection. Four days later, 6 cases were confirmed to be positive using PCR at the Uganda Virus Research Institute (UVRI), Arua. We investigated the outbreak to determine its magnitude, identify possible exposures associated with it, and recommend evidence-based control interventions.

Methods: We defined a suspected cutaneous case as an acute onset of skin lesions (papule or vesicle) plus ≥2 of; skin itching, reddening, swelling, or regional lymphadenopathy that occurred between February 1, 2023, and April 21, 2023, in a person living in Ibanda District. A suspected gastrointestinal case was an acute onset of ≥2 of the following symptoms (abdominal pain, vomiting, diarrhoea, sore throat, mouth lesions, neck swelling), that occurred between February 1, 2023, to April 21, 2023 in a person living in Ibanda District. A confirmed case was a suspected case patient with a PCR-positive result for *Bacillus anthracis*. We identified cases by active case search in the affected community from house to house, reviewing health facility records, and snowballing from identified cases. We collected human, animal, and soil samples to test for the presence of *Bacillus Anthracis*. We conducted a case-control study with 24 cases and 108 controls (1:4 ratio). A control was defined as a resident of Kagongo division, Ibanda District from February 1, 2023, to April 21, 2023, with no symptoms at all and picked from the villages where the cases originated.

Results: We identified 24 cases (18 suspected and 6 confirmed), with one death (case fatality rate =4.2%), 18 (75%) were male. Of the 24 cases, 13 were cutaneous and 11 gastrointestinal, with a mean age of 37 years. The overall attack rate (AR) was 15.2/1000 and males were the most affected (AR=22.0/1000). The outbreak lasted for 32 days, from 3rd March 2023 to 3rd April, peaking on 16th March 2023. In the case-control investigation, 79% (19/24) of case patients compared to 16% (17/108) of control persons ate meat from an animal that had died suddenly (aOR = 22.3; 95% CI: 3.5–139.3). In addition, 46% (11/24) of case patients compared to 1% (1/108) had participated in slaughtering an animal that had died suddenly (aOR = 51; 95% CI: 4.2–608.5). Compared to persons that did not eat or have contact with an animal that died suddenly, the odds of acquiring anthrax were highest among persons who ate and had contact with an animal that died suddenly (OR=178.2, 95% CI: 6.2-470), followed by persons that did not eat meat but had contact (OR=81, 95% CI:2.7-2431), with the lowest being among persons that ate the meat but had no contact with the animals that died suddenly (OR=54, 95% CI:6.2-470). We found evidence of *Bacillus anthracis* in the soil samples picked from the suspected grazing area from farm D where animals had recently died suddenly.

Conclusions: Our investigation revealed that the anthrax outbreak in Kagongo Division in Ibanda District was caused by handling and consuming meat from animals that died suddenly. We recommended increased surveillance and reporting of sudden livestock deaths and enforcement of livestock movement and quarantine, especially in known affected parts of the district.

Background

Anthrax is an acute zoonotic bacterial disease that is irregularly distributed worldwide in places where outbreaks occur regularly and is caused by *Bacillus anthracis*; a gram-positive, rod-shaped, spore-forming bacteria that are thought to survive for long in the carcasses and burial sites of infected animals. There are no reports of person-to-person transmission of anthrax, and the main transmission pattern to humans is mainly through handling or eating meat from infected animal carcasses, contact with their products (e.g. hair, wool, hides, bones), or by breathing in

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spores(1),(2),(3).

Historically human anthrax infection has been classified into four forms, depending on the route of exposure, with each having a differing degree of severity and incubation period; cutaneous (1–12 days), inhalational (1–60 days), gastrointestinal (1 –6 days), injectional (1–10 days). Cutaneous anthrax is the most frequently reported form of human anthrax infection, accounting for up to 95% of cases, and is characterized by itching and skin lesions starting 1–7 days after infection, followed by depressed eschars(4).

Approximately 2,000 to 20,000 cases of human anthrax are reported globally annually, with most occurring in rural areas with low livestock vaccination rates. Uganda has reported anthrax outbreaks in the past among humans and livestock, and these outbreaks have mainly occurred in areas where people commonly keep livestock primarily within western, eastern, and northern Uganda(5),(6),(7).

On March 24, 2023, seven suspected anthrax case patients were reported to the District Health Team after reportedly skinning, carrying, and eating meat from an animal that died suddenly at Kakijerere II village, Kagongo division Ibanda District, Western Uganda. They all presented with blisters, oedema, and skin lesions typical of anthrax infection.

A total of seven human samples (7 whole blood and 7 swabs) were collected from suspected case patients and shipped via the hub system to Uganda Virus Research Institute (UVRI) Arua for analysis using PCR, of which 6 returned positive for *Bacillus anthracis*. Additionally, three cows were reported to have died suddenly within the same kraal in Kakijerere II village. We investigated to determine the scope and magnitude of the outbreak as well as identify possible exposures and recommend evidence-based control and prevention measures.

Methods

Outbreak area

This outbreak occurred in Kagongo division Ibanda District which is located in southwestern Uganda (Figure 1). The District has a population of approximately 277,300 living in over 600 villages in 17 sub-counties with an average population density of approximately 287.2/km. Agriculture forms the backbone of the economy of the District, although most of it is at subsistence level.

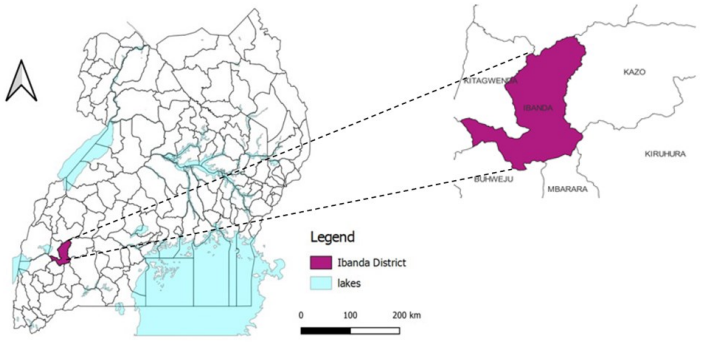

Figure 1: Location of Ibanda District in Uganda

Case definition and case finding

We defined a suspected cutaneous anthrax case as acute onset of skin lesions (papule or vesicle) plus ≥2 of; skin itching, reddening, swelling or regional lymphadenopathy that occurred between February 1, 2023 to April 21, 2023 in a person living in Ibanda District. We defined a suspected gastrointestinal anthrax case as acute onset of ≥2 of the following symptoms (abdominal pain, vomiting, diarrhea, sore throat, mouth lesions, neck swelling), that occurred between February 1, 2023 to April 21, 2023 in a person living Ibanda District. A Confirmed anthrax case was defined as a suspected case patient with PCR-positive results for *Bacillus anthracis*.
We conducted house to house and health facility active case search using a standard case definition to identify case patients in the affected areas since February 1, 2023. We also used snowballing by asking already identified case patients to lead us to people with similar signs and symptoms in the community. We interviewed identified case patients to identify possible exposures for contracting anthrax.

Descriptive epidemiology

We calculated proportions to describe the distribution of cases by age, sex, and symptoms. We further described case patients by time of onset of symptoms using an epidemiological curve and calculated attack rates to describe the distribution of cases by place (village).

Laboratory investigations

In humans, seven whole blood and swabs were collected from anthrax-suspected cases and available fluids from lesions. In animals, seven swabs and body tissue (ear lobe) were collected from carcasses and animals already butchered. In addition, four soil samples from the suspected grazing area and the three slaughter areas were

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sampled. Rumen extracts from one of the slaughter areas were sampled. All samples were packaged using a triple package technique (tertiary leak-proof plastic container with ice packs for all except for soil samples) and transported using the hub system to the Uganda Virus Research Institute (UVRI) in Arua and the National Animal Disease Diagnostics and Epidemiology Centre (NADDEC) laboratory in Entebbe Uganda for human, animal, and soil sample testing. Anthrax confirmation was based on the identification of *Bacillus anthracis* by real-time PCR assay and GIEMSA blood smear for animal samples. Soil sample DNA extraction was done using the UltraClean® Soil DNA Isolation Kit MO BIO laboratories.

Environmental investigations

We interviewed case patients and community center health workers to identify possible sources of contaminated meat and treatment options sought by those affected.
We inspected animal farms in the affected villages to identify those that had reported sudden death of cattle, goats or sheep between February 1, 2023 and April 21, 2023. We additionally gathered information on the farm management practices and how the meat and other animal products were distributed. We interviewed the identified dealers of meat for animals that had died suddenly to obtain information on the dates when the animals died and where the meat had been distributed/sold after slaughter.

Hypothesis generation interviews

We conducted 15 hypothesis generation interviews with the suspected cases to identify possible sources and factors associated with contracting anthrax. The interviews focused on consuming and handling meat from animals that had died suddenly, keeping of hides of animals that died since March 2023 and animal ownership by the respondent.

Case-control study

We conducted an unmatched case control study in the affected villages in Kagongo Division to test the generated hypotheses. We recruited and interviewed case patients who met the case definition in the case-control study. For each case-person, we selected 4 control persons. A control-person was an individual who never had any signs of cutaneous or gastrointestinal anthrax from February 1, 2023 to the time of the investigation, resident in the same village as the case-person. To randomly select control-persons, we obtained the locations of case patients' household and spun a bottle while at these households to obtain the first control -person household. The bottle was spun after every interview until the four different households were got. All members in the households were then listed and one was chosen randomly as a control-person.
For each case and control, we obtained information on their meat consumption history, contact with dead livestock (slaughtering, dressing, carrying), eating meat of an animal that had died suddenly, the clinical characteristics, as well as demographic variables.
We used logistic regression to identify factors associated with anthrax infection. Variables that had a p-value <0.2 at bivariate level were included in the final model for multivariable analysis and corresponding adjusted odds ratios (aOR's) and 95% confidence intervals were reported. Common reference group analysis was conducted to assess the differences in the odds of infection based on combinations of the risk factors of anthrax in this study.

Ethical considerations

This outbreak investigation was in response to a public health emergency and was therefore, determined to be non-research. The Ministry of Health (MoH) gave permission to investigate this outbreak. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy. §§See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.
The authors sought administrative clearance to conduct the investigation from Ibanda District health authorities. The authors also sought verbal informed consent and assent from the respondents accordingly. They were all informed that their participation was voluntary and their refusal would not attract any negative consequences. Unique identifiers were used to ensure confidentiality.

Results

Descriptive epidemiology

We line listed 24 anthrax case patients, of which 6 were confirmed and one died (Case fatality rate=4%). Males were more affected (Attack rate [AR]: 22.0/1000) than females (AR: 8.6/1000). The village of Kakijerere I was the most affected (AR: 36.9/1000), followed by Kakijerere II (AR: 20.6/1000), and the least affected villages were Rwampanga (AR: 6.3/1000) and Kashambya (AR: 1.8/1000) (Table 1). Of the 24 cases, 13 were cutaneous and 11 gastrointestinal, with a median age of 32 and a mean of 34; (range: 4-

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84). The commonest symptoms amongst the case patients with gastrointestinal anthrax were abdominal pain (63%), general body weakness and fever (54%), diarrhea (50%). Cutaneous anthrax case patients presented with itching of skin (46%), eschars (38%), skin swelling and reddening (33%) (Figure 2).

Figure 2: Distribution of anthrax cases by symptoms by form: Ibanda District, Uganda, February - April, 2023

After sudden death and slaughtering of the cow on March 3, 2023, cases started to appear from March 4, 2023 (Figure 3). The cases rapidly increased and peaked on March 16, 2023, after the second and the third cow died and were slaughtered. This epidemic curve suggests a multiple-source outbreak. The last case onset occurred on April 3, 2023.

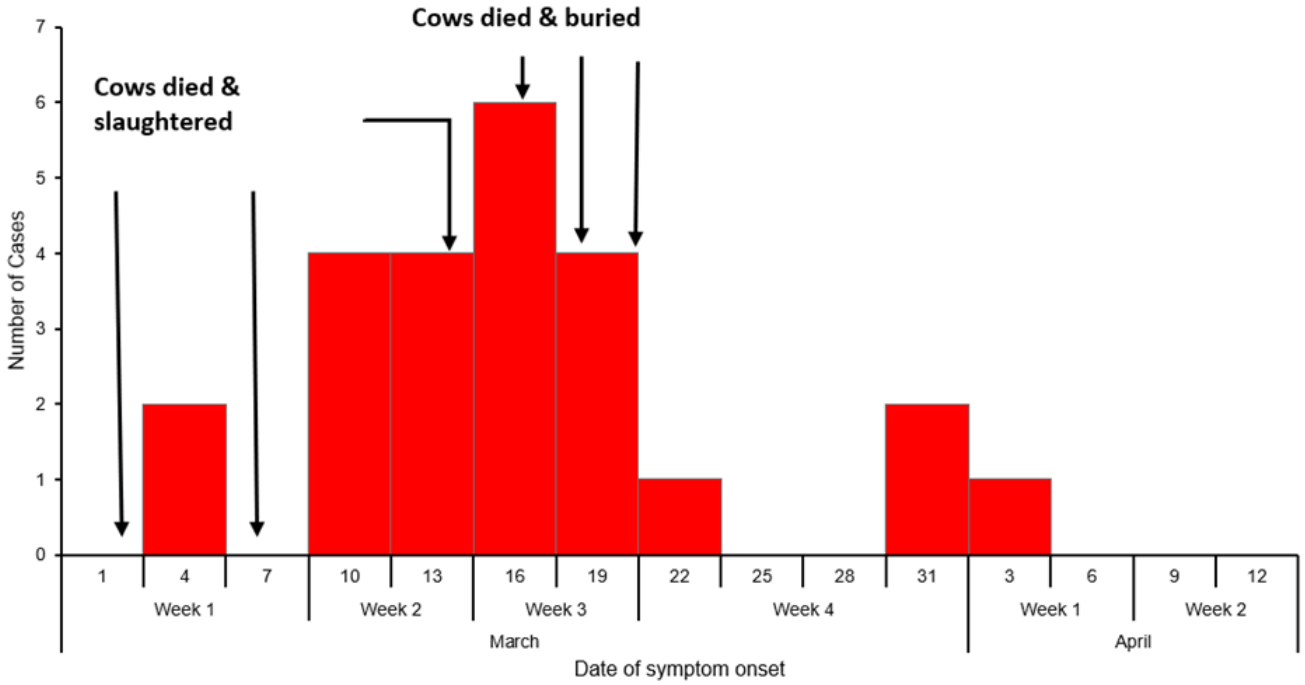

Figure 3: Distribution of anthrax cases by date of symptom onset: Ibanda District, Uganda, February - April, 2023

As of April 3, 2023, the outbreak had affected 4 villages in Kagongo Division, with Kakijerere I village being the most affected AR: 36.9/1000), followed by Kakijerere II (AR: 20.6/1000). Most of the case persons lived next to the farm with reported animal deaths in Kakijerere II (Figure 4).

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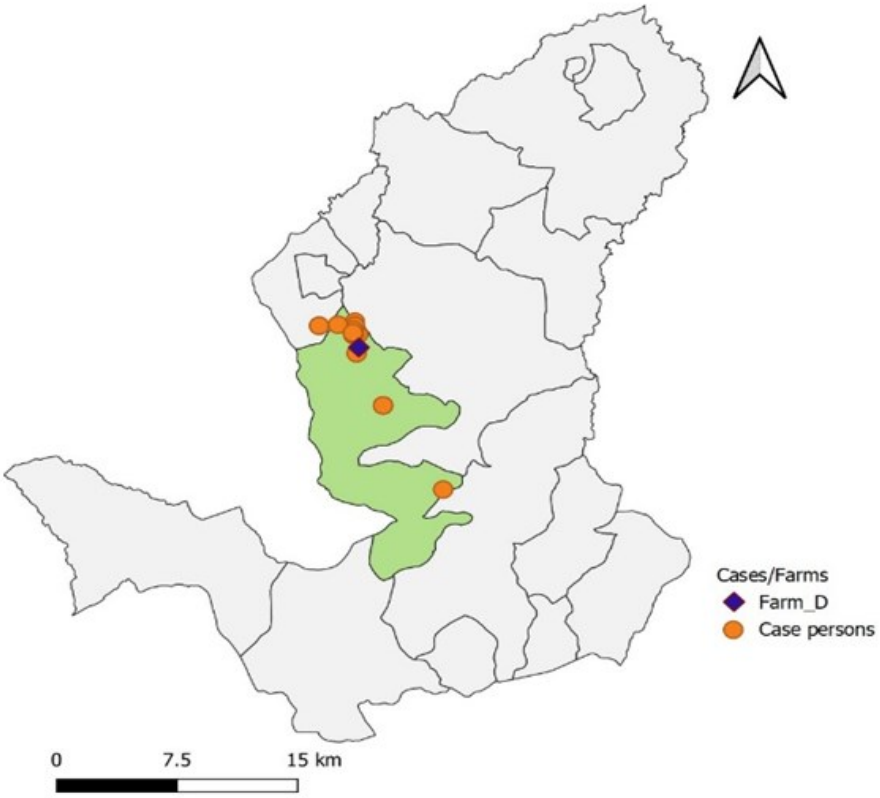

Figure 4: Location of case patients and the implicated farm in the villages during an anthrax outbreak, Kagongo Division, Ibanda District, February - April, 2023.

Laboratory investigation findings

A total of 19 (seven human, seven animals, four soil, and one rumen content) samples were collected and tested for *Bacillus anthracis*. Six of the human samples returned PCR positive, while none of the seven animal samples turned positive by microscopic examination. The soil samples from the suspected grazing area, slaughter position 1 & 3 returned positive while slaughter area 2 and the rumen extract returned negative results.

Environmental assessment findings

There was a total of 6 suspected cases of animal anthrax in one farm (Farm D) which had two grazing areas, one in Kakijerere I and another one in Kakijerere II, separated by a marram road. Part of the grazing area in Kakijerere II was tilled for crops from 2021 to December 2022, the grazing in this part resumed in January 2023.

The first three animals to die on farm D were sold to the "dead animal meat dealer X'' who slaughtered them with the help of others who also got infected and the meat sold in Kagongo Division. The last three animals were buried in 7ft deep pits on the pastureland. However, the burials were not supervised. An organized market dealing in cheap meat from animals that died suddenly was discovered in Ibanda District. The nurse in the community health center indicated that the case patients bought antibiotics from her drug shop, but the deceased case patient only sought medical attention towards his death.

Hypothesis generation

Based on the 15 hypothesis generation interviews, 84% of respondents indicated they had consumed meat from an animal that had died suddenly, while 58% had handled animal products or participated in slaughtering animals that died suddenly. 32% had animal hides in their homes, while 21% owned animals in their homesteads.

We hypothesized that handling and consuming meat from animals that died suddenly were associated with the March 2023 anthrax outbreak in Ibanda District.

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Case-control study findings

In the case-control investigation, 79% (19/24) of case persons compared to 16% (17/108) of control-persons ate meat from an animal that had died suddenly (aOR = 22.3; 95% CI: 3.5–139.3). In addition, 46% (11/24) of case persons compared to 1% (1/108) had participated in slaughtering an animal that had died suddenly (aOR = 51; 95% CI: 4.2–608.5) (Table 2).

Table 2: Distribution of exposure status among cases and controls during an anthrax outbreak: Ibanda District, Uganda, February - April, 2023

Variables	N (%)		Crude ORs, CIs	Adjusted ORs, CIs
	Case (n=24)	Control (n=108)	OR (95% CI)	aOR (95% CI)
Slaughtered a dead animal	11 (46)	1 (1)	91.7 (6.0,1389)	51 (4.2, 608.5)
Ate meat	19 (79)	17 (16)	46.4 (6.5, 328.9)	22.3 (3.5, 139.3)

Compared to persons that did not eat or have contact with an animal that died suddenly, the odds of acquiring anthrax were highest among persons who ate and had contact with an animal that died suddenly (OR=178.2, 95% CI: 6.2-470), followed by persons that did not eat meat but had contact (OR=81, 95% CI:2.7-2431), with the lowest being among persons that ate the meat but had no contact with the animals that died suddenly (OR=54, 95% CI:6.2-470) (Table 3).

Table 3: Distribution of exposure status among cases and controls during an anthrax outbreak: Ibanda District, Uganda, February - April, 2023

Ate meat	Touched meat	Cases n (%)	Controls n (%)	OR	95% CI
Didn't eat	No contact	1 (4.8)	81 (81.8)	Ref	
Ate meat	No contact	8 (38.1)	12 (12.1)	54	6.2-470
Didn't eat	Contact with meat	1 (4.8)	1(1.0)	81	2.7-2431
Ate meat	Contact with meat	11 (52.3)	5 (5.1)	178.2	19.0-1669

Discussion

Based on the epidemiologic, laboratory, and environmental assessments, we determined that this was a multiple point source cutaneous and gastrointestinal human anthrax outbreak associated with handling and eating meat from cows that had died prior to slaughter. Our results were consistent with other anthrax outbreak investigations conducted which indicated that the infection was as a result of consumption and contact with animals that had died suddenly(8),(9).

Ibanda District is situated adjacent to the cattle corridor of Uganda which is documented to have sporadic anthrax outbreaks over the years (5),(7),(10). Prior to the outbreak, animals dying suddenly in the community were reported, an indication of a possible anthrax as seen in previous outbreaks(5), (11), (12), (13). The outbreak was observed in four neighboring villages that were located near farm D, where the implicated animals had recently died suddenly and the meat sold to the communities by meat traders. Interviews with dealers in meat of animals that die suddenly also indicated that the Kagongo Division is one of their main areas of operation. Meat dealers of a similar kind have been documented to have distributed meat that lead to an anthrax outbreak in Kagongo in the past(14), which affirms the presence of the illegal trade in meat from animals that die suddenly.

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The positive soil samples picked from the suspected grazing area and slaughter positions 1 and 3, further indicated that the animals that were slaughtered and sold to the Kagongo community had died of anthrax. This finding is consistent with studies that indicated survival of *Bacillus anthracis* in soil(2),(15),(16).

Adult males were the most affected. This group is most likely to be engaged in exposures to animal carcasses such as slaughter, skinning, transportation, and selling of such meat as evidenced in other studies relating to anthrax. (17),(18).
There was one human death reported in this outbreak, and according to a community health center nurse, it was due to delayed access to healthcare by the deceased case-patient, yet cutaneous anthrax has been shown to be fatal if not treated(4). The low case fatality rate could be explained by the prompt treatment that was given to the infected persons as soon as they reported any signs and symptoms consistent with anthrax. This was confirmed by the community health center nurse who saw a number of the case patients purchasing antibiotics from her drug shop as soon as they experienced signs and symptoms related to anthrax.

The main sources of exposures were handling and consuming meat from animals that had died suddenly. Combination of the two main exposures by an individual posed the highest potential for cutaneous and gastrointestinal anthrax. Previous investigations of outbreaks in Uganda also found the association of anthrax to handling and eating of meat from animals that died suddenly before slaughter(5), (6), (10).

Study imitations
The investigation had the following limitations: Some cases may not have been picked up during case-finding, given that they may have experienced mild, non-specific symptoms of anthrax. We were also unable to obtain samples of the meat from the implicated carcasses for testing, although the team was able to obtain soil samples from the grazing areas where the animals that died had grazed.

Conclusion
Our investigation revealed that the anthrax outbreak in Kagongo Division in Ibanda District was caused by handling and consuming meat from animals that died suddenly. We recommended increased surveillance and reporting of sudden livestock deaths by veterinary teams to the other sections of the One-Health team in the District so as to mount preparedness and response in case an outbreak occurs. We also recommended health education sessions to be conducted by the District Health Teams in the communities, regarding anthrax. We further recommended efforts to increase the laboratory capacity to handle outbreaks such as anthrax in the district.

Public health actions
Following the dissemination of our findings to the Ibanda district Health Team, continued surveillance in the district and recommendations to the district leadership to stop the markets dealing in meat from animals that died suddenly was done.

Conflict of interest
The authors declare no conflict of interest

Author contribution
BK, EN, SM, GB, SG, RM, DK, ARA, conceived and designed the study. KB, EN, DA, YN, JR, DK, AK, BN, IS, SW, MK, DO, LT, SM, LNB, PA, AK, MAN, contributed to data collection, cleaning and analysis. SM, LNB, PA, AK, MAN, EA, GB, SG, participated in coordination of laboratory work. BK, EN, SM, GB, SG, RM, DK, DNG took lead in developing the original manuscript. All authors contributed to the final draft of the paper. All authors read and approved the final manuscript.

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Measles outbreak propagated by visiting a health facility, in a refugee hosting community, Kiryandongo District, Western Uganda, August 2022 – May 2023

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Summary

Introduction: Measles outbreaks in refugee settlements are a public health concern due to the potential for rapid spread. Kiryandongo District, Uganda, has a large population of refugees and has experienced measles outbreaks previously due to low vaccination coverage. In December 2022, Kiryandongo District reported an outbreak of measles in the refugee hosting community. We investigated the outbreak to determine its scope, identify risk factors for transmission, evaluate vaccination coverage and effectiveness, identify the barriers and facilitators of vaccination coverage, and recommend evidence-based control measures to prevent future outbreaks.
Methods: We defined a probable case as onset of fever (≥3 days) and generalized rash, plus ≥1 of the following: conjunctivitis, cough, and/or runny nose in a Kiryandongo District resident August-May, 2023. A confirmed case was a probable case with measles-specific IgM (+) not explained by vaccination. We reviewed medical records and conducted active community case-finding. In a case-control investigation involving probable case-patients and controls matched by age and village, we evaluated risk factors for transmission for both cases and controls during the case-patients's likely exposure period (i.e., 7–21 days prior to rash onset). We estimated vaccine effectiveness (VE) using the formula: VE≈(1-ORprotective) × 100. We calculated vaccination coverage using the percentage of controls vaccinated. We further assessed the factors leading to the low vaccine coverage.
Results: We identified 280 probable cases during the outbreak period (attack rate [AR] =8.2/10,000), including 11 confirmed. Refugees were 73% (205/280) of the total case persons identified in the outbreak. Children aged <1 year were the most affected (AR=70/10,000). Thirty-eight percent of case-patients and 16% of control persons visited a health facility (by themselves or with parents) during the case-patient's likely exposure period (OR_{M-H}=6.6; 95% CI =2.1-21). Among children aged 3–240 months, the effectiveness of the measles vaccine was 91% (95% CI = 64–98); vaccination coverage was 68% (95% CI = 61–76). Low coverage was due to refugees' ongoing mobility and the language barrier.
Conclusion: Early case detection and proper health facility isolation of case-patients in addition to strengthening immunization services in refugee settlements is critical to improving vaccine coverage and preventing future outbreaks.

Background

Measles is a highly contagious viral respiratory infection caused by a morbillivirus of the Paramyxoviridae family [1]. It remains a major public health concern globally, despite the availability of an effective vaccine [2]. Refugees and internally displaced individuals are at a heightened risk of experiencing outbreaks of vaccine preventable diseases like measles [3]. Measles outbreaks have been observed in various refugee communities across the globe, driven by factors including poor living conditions, limited healthcare access, insufficient vaccination rates[4, 5]. For example, in Rohingya refugee camps in Bangladesh, the combination of overcrowding and healthcare constraints amplified the measles outbreaks[6, 7]. Additionally, multiple Sub-Saharan African countries have grappled with measles outbreaks, frequently tied to poverty, conflict, and displacement, leading to low vaccination coverage and inadequate healthcare availability [8]. To address these challenges effectively, comprehensive vaccination strategies, enhanced surveillance systems, and strengthened healthcare infrastructure are essential for mitigating the impact of measles outbreaks among displaced populations [9].
Uganda has made significant progress in reducing the burden of measles through the national immunization program [10]. However, measles outbreaks continue to occur in pockets of low vaccination coverage, particularly in refugee camps. In 2019, Uganda reported 9,774 cases of measles, with 7,119 cases occurring in refugee settlements. Kiryandongo District has a high population of refugees, with over 100,000 refugees from South Sudan and the Democratic Republic of Congo [11]. Vaccination coverage in refugee camps is often below the threshold due to factors such as inadequate healthcare infrastructure, vaccine hesitancy, and mistrust of healthcare providers [12]
At the end of December 2022, a measles outbreak was confirmed in Kiryandongo and Palabek refugee settlements. A cumulative total of 11 confirmed cases by measles IgM were re-

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ported from January to February 2023. On 8th February 2023, the Uganda Ministry of Health was notified about the measles outbreak in Kiryandongo District through the Public Health Emergency Operations Centre (PHEOC). We investigated the outbreak to determine its scope, identify risk factors for transmission, evaluate vaccination coverage and effectiveness, identify the barriers and facilitators of vaccination coverage, and recommend evidence-based control and prevention measures.

Methods

Outbreak setting

Kiryandongo is a peri urban district located in western Uganda along the Kampala-Gulu highway. It comprises of 8 sub-counties and 2 town councils[13] with an estimated population of 287,200 people by 2021.[14] [9]. It was among the first districts to receive and resettle refugees since the onset of the civil conflict in South Sudan. A total of 52,545 individuals were resettled in this refugee and Internally Displaced Persons camp during December 2013-March 2017. Of the total camp population, approximately 99% are from South Sudan, with <0.5% each from Democratic Republic of Congo, Kenya, Sudan, and Uganda. According to UNHCR statistics, 2018 42% of the refugees and internally displaced persons (IDPs) are <18 years of age[15]. The refugee settlement is served by three Health Centre IIs, two Health Centre IIIs, and one General Hospital[14]. The camp exceeded its population and therefore no longer admits new refugees. However, given the free entry and exit nature of the camp, refugees continue to move out and/or receive visitors from the neighboring far and near settlements or move to South Sudan. Like the rest of the country, Kiryandongo participated in the 2022 mass measles campaign. The campaign was conducted in April and October, 2022. While the rest of the district vaccination coverage was 76%, the refuge settlement coverage was 58% in the October campaign.

Case definition and finding

We defined a probable case as onset of fever and generalized rash with at least one of the following symptoms: coryza, conjunctivitis, or cough, in a resident of Kiryandongo District between August 2022 and May 2023. A confirmed case was a probable case with measles IgM (+) in the absence of vaccination in the preceding 2 weeks. We actively searched for case-persons in the community with the help of community leaders, community health workers and EPI (Expanded Program for Immunization) focal persons in the district (i.e., a cadre of public health workers involved in monitoring immunization activities ref). We reviewed surveillance data from the District Health Information System 2 (DHIS2) to identify areas or sub counties affected by the outbreak. We further reviewed health facility records at all health centres that had reported measles cases in the district to update the line list. We conducted community active case search and updated the linelist. Using a standardized case investigation form, we collected data on case-patient's demographics, clinical information, and exposure history.

Descriptive epidemiology

We assessed the time distribution of measles cases by constructing epidemic curves. We calculated attack rates by age, sex, nationality, subcounty using Kiryandongo District population by extrapolating from the 2014 Uganda National Population Census using the district-specific population growth rates [10]. We presented attack rates by sub-county using a chloropleth map.

Laboratory investigations

Laboratory confirmation was conducted at the Expanded Program for Immunization Laboratory (EPI Lab) at Uganda Virus Research Institute, using the recommended World Health Organization (WHO) procedures[16].

Hypothesis generation

We conducted 20 hypothesis generating interviews amongst case-patients or caretakers of case-patients in the sub-county with the highest attack rate. We asked about potential risk factors for measles transmission 7 and 21 days prior to symptom onset including: visits to health facilities, community playgrounds, and water-collection points, attendance at schools, and either history of travel to Lamwo District or South Sudan-Palabek county or receipt of visitors from the two places with ongoing measles outbreaks within the outbreak period.

Case-control investigation

To test the generated hypothesis, we conducted a matched case-control study in the most affected sub-county. We matched in by village and age in a ratio of 1:1. The case-control study was conducted among children aged 3–300 months because all of the case-patients were in this age group. We administered the questionnaire to case-patients, caregivers/guardians if the case-patient was a minor. For households with more than one case-patient, the first case to develop a rash was selected for interview. We collected data on the following variables: demographic characteristics, travel to an area with ongoing measles outbreak,

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congregating at health facilities, water collection points, food collection points, and schools, and measles vaccination status and the doses received.We performed logistic regression to assess the risk factors associated with the outbreak.

Vaccination coverage and vaccine effectiveness

We estimated vaccination coverage (VC) using the percent of control-persons vaccinated.
VE ¼ 1−RR Protective ≈ 1−OR Protective
Vaccination status was obtained from child health card or any medical records obtained from the care takers or through interviews (verbal reports with or without immunization cards).
We also obtained the administrative data on the number of doses of measles vaccines administered reported in the DHIS2 for Kiryandongo District August2022-February2023. In estimating the administrative VC, we used the population estimates for Kiryandongo District provided by the Uganda National Population Census report 2016 [10].

Qualitative interviews to assess the reasons for the low vaccination coverage, Kiryandongo refugee settlement, August 2022-December 2023

Through key informant interview, we collected data on the reasons for the low vaccination coverage despite the high measles vaccination effectiveness. The key informants included the village health team members/mobilisers for vaccination, camp commandant, EPI focal persons for the district and camp/settlement and the district immunization focal person.

Ethical consideration

We conducted this study in response to a public health emergency and as such was determined to be non-research. The MoH authorized this study and the office of the Center for Global Health, US Center for Diseases Control and Prevention determined that this activity was not human subject research and with its primary intent being for public health practice or disease control. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy. We obtained permission to conduct the investigation from the district health authorities of Kiryandongo. We obtained written informed consent from all the respondents. Participants were assured that their participation was voluntary and that there would be no negative consequences for declining or withdrawing from the study (none declined or withdrew). Data collected did not contain any individual personal identifiers and information was stored in password-protected computers, which were inaccessible by anyone outside the investigation team.

Results

Descriptive epidemiology

We identified 280 case-patients (overall attack rate [AR] =8.3/10,000), including 11 confirmed by measles-specific IgM. The median age of the case-patients was 35 months (range: 6 months to 45 years). Refugees were 73% (205/280) of the total case-patients identified in the outbreak. The most affected age groups were 0–11 months (AR = 69.5/10,000). Males and females were equally affected. The outbreak affected 5 sub-counties, the most affected being Bweyale Town council (AR = 25.3/10,000) (Figure 1). In Bweyale Town council, the most affected parish was Southern Ward (AR = 33/10,000) followed by Northern Ward (AR = 28/100,000) (Table 1). None of the case-patients exhibited any complications or died.

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Table 1: Measles attack rate by age, sex, and sub-county during a measles outbreak: Kiryandongo District, Uganda, August 2022 – May 2023

Characteristic		Population	Cases	AR/10,000
Age in years				
	Under I year	13230	92	69.5
	1-4	42943	133	31
	5-9	49855	30	6
	≥10	116953	21	1.8
Sex				
	Male	172,300	144	8.4
	Female	166,900	134	8
District				
	Kiryandongo	339200	280	8.3
Parishes in Bweyale TC				
	Southern Ward	63730	179	28.1
	Northern Ward	10858	36	33.2
	Central Ward	16729	15	9.0

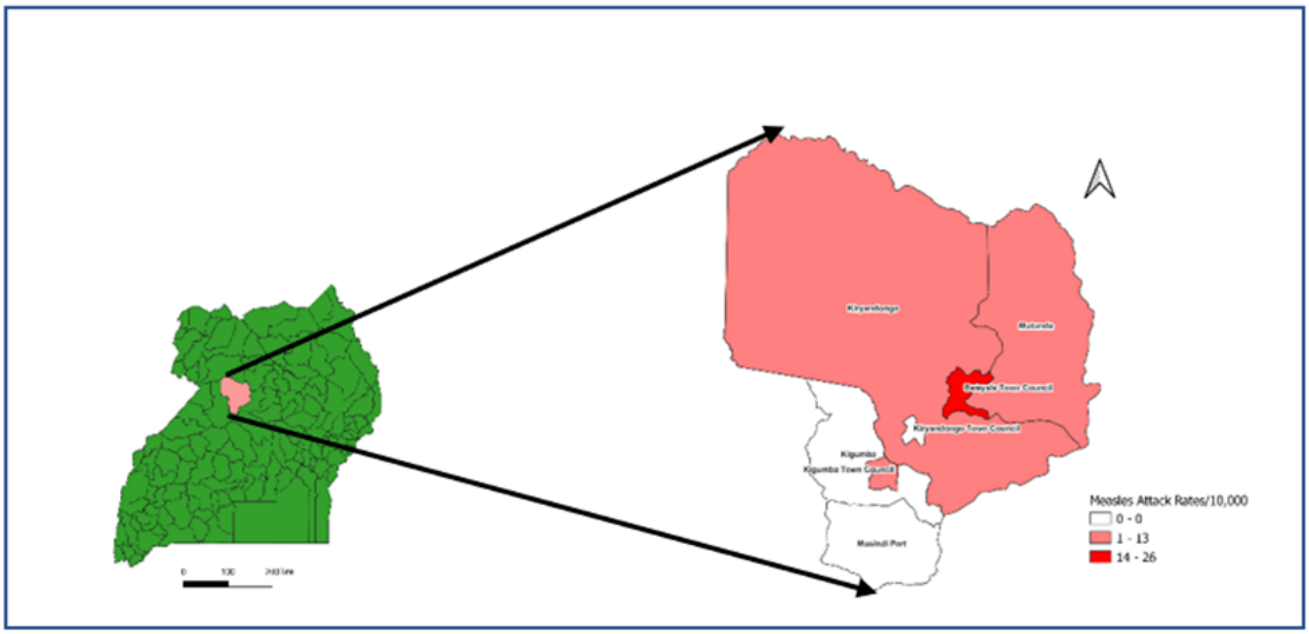

Figure 1: Attack rates by sub-county during a measles outbreak, Kiryandongo District, August 2022- May 2023

The epidemic curves indicated person-to-person transmission (Figure. 2a). From the symptom onset date of the index case-person (12th August 2022) to that of the last case-person (5th May 2023), the outbreak lasted about 8 months. On 20th August, 2 refugees, reportedly moved from Lamwo district which had been experiencing an outbreak of Measles around that time to visit a relative and a friend in Kiryandongo refugee camp. The district was notified about this travel from Lamwo refugee camp although they couldn't not trace these refugees. Around the same time, a mother with a 2year old male baby also travelled back from Palabek in South Sudan which also had been experiencing a measles outbreak

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(where she had gone to check on her husband). A week later, the older siblings and the neighbors also developed similar measles like symptoms. These children were taken to Nyakadoti health centre on September 11th, and samples were taken off. The district was notified about the positive results in November and on 22nd December, the number of cases had increased to include 11 confirmed and hence declared an outbreak. The health facilities continued to receive patients with measles like rash from different parishes and sub-counties.

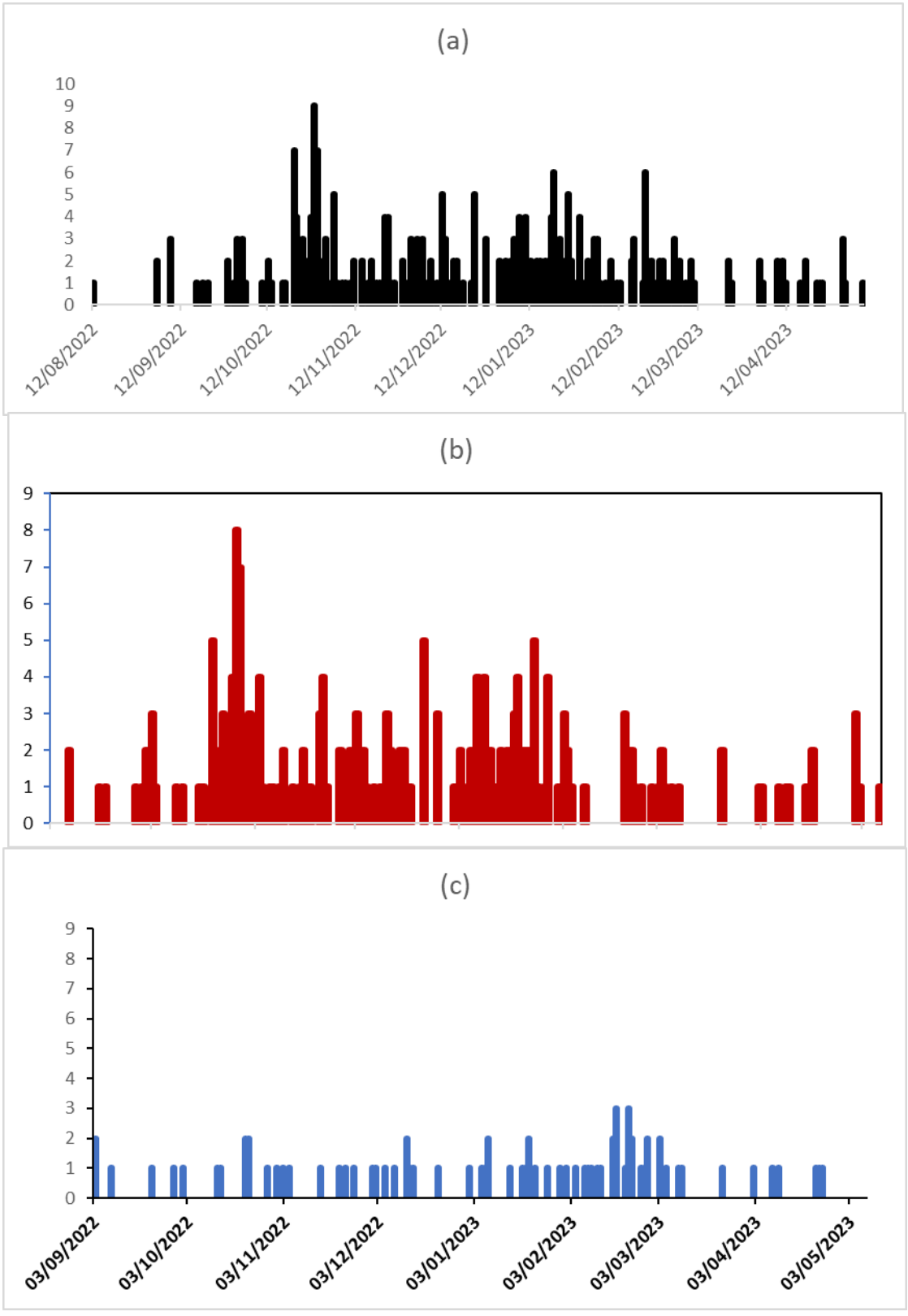

Figure 2: Date of rash onset among measles case-patients August, 2022 – November, 2023. a) district epidemic curve, b) epidemic curve for Refugees, and c) epidemic curve for Nationals

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Hypothesis generation findings
Of the 20 case-patients'/care takers interviewed, 55% attended food collection gatherings for refugees and school, 80% congregated at a health facility, 90% had either travelled to or received visitors from Lamwo or South Sudan while 75% visited a communal water-collection point. We hypothesized that Increased attendance at food collection gatherings, school attendance, congregating at health facilities, and going to communal water-collection points among refugees were associated with a higher risk of measles infection.

Case-control investigation findings
Among persons aged 6–300 months, 56% (56/100) of the case-patients, compared with 26% (26/100) of control-persons, had never been vaccinated against measles during the exposure period OR_{MH} = 0.09 95% CI: 0.02–0.36). Thirty-nine percent (39/100) of the case-patients compared with 14% (14/100) of control-persons, visited a health facility during the exposure period (OR_{MH} = 6.64 95% CI: 2.07–21.23) (Table 2). No other risk factors examined in the case-control investigation was significantly associated with measles onset.

Table 2: Risk factors for measles infection among children aged 3-300months during a measles outbreak, Kiryandongo District, Uganda, August 2022 – February 2023

Risk factor	% Cases exposed	% Controls exposed	OR $_{MH}$ (95% CI)
Vaccinated against measles			
Yes	44	74	Ref
No	56	26	0.09 (0.02-0.36)
Visit a health facility during exposure period			
No	61	86	Ref
Yes	39	14	6.64 (2.07 - 21.23)

Measles vaccine effectiveness
From the case-control investigation, 44% (42/100) of case-persons compared to 74% (74/100) of controls had a history of measles vaccination (OR_{MH} =0.09; 95% CI: 0.02-0.36). Using this information, we estimated that VE = 91% (95% CI: 64–98%) in persons aged 6-300months.

Measles vaccine coverage
Of controls aged 6–300 months, 74% (95% CI: 61–76%) had a history of vaccination; this percentage was the estimated VC.

Reasons for the low vaccine coverage for measles vaccine in Kiryandongo Refugee Settlement, February-May 2023

Mobility affects vaccination uptake and coverage
The mobility of families creates barriers to accessing and utilizing vaccination services. Children who are not present in the settlement during vaccination campaigns or scheduled immunization sessions are at risk of missing out on essential vaccinations.
"You know this settlement is a free exit and entry. Some families are registered here but live in Bweyale or even Kampala. Some women go (for months) with their small children back to South Sudan to see their husbands. It is hard to get all the children who are due for vaccination .." (KII interviewee)

Language and Vaccination Participation Challenges
Language barriers between vaccination providers and refugee communities hinder effective communication and engagement, causing reluctance to participate. Limited participation may be due to barriers beyond language.
"…. every year we carry out vaccination campaigns but some people in the refugee communities are

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still missed because they do not turn up. Even the community sensitization is not helpful because some speak a language that even the VHTs can't speak,….we cannot ascertain clearly the exact reason for not turning up" (Provider# 9)

Co-ordinating efforts and partnerships

In some instances, providers reported that there were challenges in identifying responder roles and responsibilities and promptly co-ordinating efforts. *'Perhaps we need to think about [an integrated] model of working with our local authority partners…. Rather than, "That's your job. That's your job," Where there's overlap no one's really doing it, no one's coordinating it, and then it becomes very much, "You didn't do this. Why didn't you do that?" rather than, "How can we make this happen?"' (Provider#16)*

Discussion

The measles outbreak in Kiryandongo refugee settlement from August 2022 to March 2023 was the first measles outbreak following a mass MR vaccination campaign in this area. We investigated the outbreak to determine its scope, identify risk factors for transmission, evaluate vaccination coverage and effectiveness and associated factors. The outbreak was propagated by visiting a health facility whereas low VC and suboptimal VE increased the susceptibility of the population. Two children who travelled from Lamwo refugee settlement which had an ongoing measles outbreak exposed the people.

Congregating at a health facility was associated with increased odds of infection. Other studies have also identified congregation as factors that facilitate the transmission of measles [17, 18].Healthcare facilities are areas where interaction between patients and healthcare workers occurs. If a person at a health facility is sick, there is a high risk that other patients or even healthcare workers, can be put at risk of contracting infection. A similar investigation highlighted that mixing of measles and non-measles patients when they were hospitalized in the pediatric department propagated a measles outbreak in Uganda [17]. In this setting, it is important to educate healthcare workers and patients to recognize possible signs and symptoms of measles, and to appropriately and promptly isolate patients who are experiencing consistent symptoms in order to reduce the risk of propagating measles outbreaks.

The measles coverage in Kiryandongo was estimated at 54% in the settlement while in the host communities it was 62%. Both coverages are lower than the recommended vaccination coverage of > 90% required for herd immunity and for achieving the measles elimination goal set by the WHO for the African Region and adopted by the Uganda Ministry of Health to achieve population immunity [20]. The main reasons for this low vaccination coverage were increased mobility of the refugee population, language barrier, and poorly coordinated immunization efforts and partnerships. A study by Ekezie etal described factors such as poor immunisation rates in refugees' countries of origin, cultural, religious and personal beliefs and healthcare system barriers as contributory to low vaccination coverage in disadvantaged, isolated, and difficult to reach communities like refugee communities [5].

Study limitations

The study used controls that could be have had asymptomatic infections or in their incubation period of disease likely leading to an under estimation of the true burden of disease among controls.

Conclusion

Early case detection and proper health facility isolation of case-patients in addition to strengthening immunization services in refugee settlements is critical to improving vaccine coverage and preventing future outbreaks.

Conflict of Interest

The authors declare that they had no conflict of interest.

Authors contribution

SKN: participated in the conception, design, analysis, interpretation of the study and wrote the draft bulletin; BS, AR, TK, RM, DK, EN, IS reviewed the report, reviewed the drafts of the bulletin for intellectual content and made multiple edits to the draft bulletin; RM, DK, and ARA reviewed the bulletin to ensure intellectual content and scientific integrity.

Acknowledgments

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Investigation of a Bacterial Meningitis Cluster in a Refugee Settlement, Obongi District, Uganda, March, 2023

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Summary

Background: On 6 March 2023, the Uganda Central Public Health Laboratory isolated Neisseria Meningitidis serogroup C from a cerebral spinal fluid sample from Obongi District. This sample was one of many from patients that were presenting with fever, convulsions, and altered consciousness. We investigated to determine the scope and magnitude of the meningitis cluster/ outbreak, identify risk factors of contracting meningitis, and inform control/prevention measures.
Methods: We defined a suspected case as a resident of Palorinya Refugee Settlement with sudden onset of fever (>37.5 °C), and any one of neck stiffness, convulsions, altered consciousness, coma or bulging fontanelle in infants from 1 December 2022 to 1 May 2023. A probable case was any suspected case with macroscopic aspect of cerebrospinal fluid (CSF): turbid, cloudy or purulent; or with a CSF leukocyte count >10 cells/mm3 or with bacteria identified by Gram stain in CSF; or positive antigen detection (for example, by latex agglutination testing) in CSF. In infants, a probable case was CSF leucocyte count >100 cells/mm3; or CSF leucocyte count 10–100 cells/mm3 and either an elevated protein (>100 mg/dl) or decreased glucose (<40 mg/dl) level. A Confirmed case was any suspected/probable case that was laboratory confirmed by culturing or identifying (polymerase chain reaction) a bacterial pathogen (Neisseria meningitidis, Streptococcus pneumoniae, Haemophilus influenzae type b) in the CSF or blood. We reviewed medical records, conducted active case finding, and conducted key informant interviews in the affected communities to identify cases and factors associated with contracting meningitis. We analysed case data by person, place, and time.
Results: Between 22 December 2022 and 1 May 2023, 25 cases with 2 deaths of bacterial meningitis occurred in Palorinya Refugee Settlement, Obongi District. Of these, 4 were laboratory confirmed with Neisseria meningitidis serogroup C, 6 were probable cases, and 15 were suspected cases. Most (76%) of case-patients were <18 years with a median age of 12 years (range 1-66 years). None of the case-patients was vaccinated against Neisseria meningitidis serogroup C. Each case-patient was from a different household and there was no epidemiological link between any of the cases.
Conclusion: This meningococcal meningitis cluster caused by Neisseria meningitidis serogroup C occurred among non-vaccinated persons mostly aged <18 years in Palorinya Refugee Settlement. We recommended vaccination of at-risk persons. As a result of this investigation, at the national level, a technical working group was setup to monitor the cluster of cases. At district level, surveillance activities were continued until 2 weeks after the last case.

Background

Bacterial meningitis is a clinical syndrome characterized by inflammation of the meninges that cover the brain and spinal cord. Up to 95% of patients have at least 2 of the 4 following symptoms: fever, headache, stiff neck, or altered mental status/convulsions [1]. Bacterial meningitis is commonly caused by Streptococcus pneumoniae, Haemophilus influenza, and Neisseria meningitidis. Most outbreaks are now caused by Neisseria meningitidis [2, 3]. With humans being the reservoir, bacterial meningitis is transmitted through direct contact from person to person through droplets of respiratory or throat secretions from infected people. The incubation period ranges from 2-10 days with an average of 3-4 days [4]. Case fatality rate ranges from 5-15% with up to 20% of survivors suffering long term complications such as hearing loss, seizures, limb weakness, difficulties with vision, speech, language, and memory [4].

Uganda lies in the meningitis belt of Sub-Saharan Africa and experiences frequent outbreaks of bacterial meningitis. An analysis of surveillance data between 2015 and 2018 showed that the

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incidence of bacterial meningitis in Uganda was on the increase [5]. In Uganda, the most susceptible regions include West Nile, Bunyoro, Acholi, Lango, Teso, and Karamoja regions [5].

Meningitis outbreak response in the meningitis belt of sub-Saharan Africa encompasses strengthening surveillance for early outbreak investigation, strengthening case management, reactive vaccination of susceptible persons early on in the outbreak and routine mass vaccination campaigns in areas at greatest risk [6]. As per the Uganda national technical guidelines for Integrated Disease Surveillance and Response (IDSR), bacterial meningitis is one of those diseases that must be reported immediately [7]. These guidelines stipulate two thresholds for public health action with regards to

bacterial meningitis. The alert threshold is reached when there are 2 cases per week in an area with less than 30,000 inhabitants or an attack rate of 5 cases per 100,000 inhabitants per week in an area with a population of 30,000 to 100,000 inhabitants. The epidemic threshold is reached when there are 10 suspected cases per 30,000 - 100,000 inhabitants per week or 5 suspected cases in one week in an area with less than 30,000 inhabitants [7]. Despite repeated outbreaks, availability of national and international guidelines, efforts to control bacterial meningitis remain suboptimal for many of the countries in the meningitis belt leading to frequent outbreaks [8].

On 6 March 2023, the Uganda Central Public Health Laboratory isolated Neisseria meningitidis from a cerebral spinal fluid sample from Obongi District, Uganda. This sample was one of many from patients that were presenting with fever, convulsions, and altered consciousness. We investigated to determine the occurrence, scope and magnitude of a meningitis outbreak, identify risk factors of contracting meningitis, and inform control/prevention measures.

Methods

Study setting

Obongi District is located in West Nile, one of the regions of Uganda located within the extended meningitis belt of Sub-Saharan Africa. It is bordered by Moyo District to the north, Adjumani District to the east, Yumbe District to the west, and Madi Okollo District to the south (Figure 1). The district has a population of 173,325 with 122,000 (70%) being refugees from South Sudan. These refugees have occupied Palorinya Refugee Settlement since 2016. This settlement spans an area of 37.58 Km^2 and is comprised of 31 villages across two Sub-counties of Obongi District. Palorinya Refugee Settlement is located about 30 kilometres from the South Sudan boarder. There is frequent movement of people between the settlement and South Sudan. At the time of the outbreak, there are no ongoing vaccination efforts of refugees against meningitis at entry or while in the settlement. Obongi District last carried out a vaccination campaign in 2017 against Neisseria Meningitidis serogroup A. The District has never vaccinated people against Neisseria Meningitidis serogroup C.

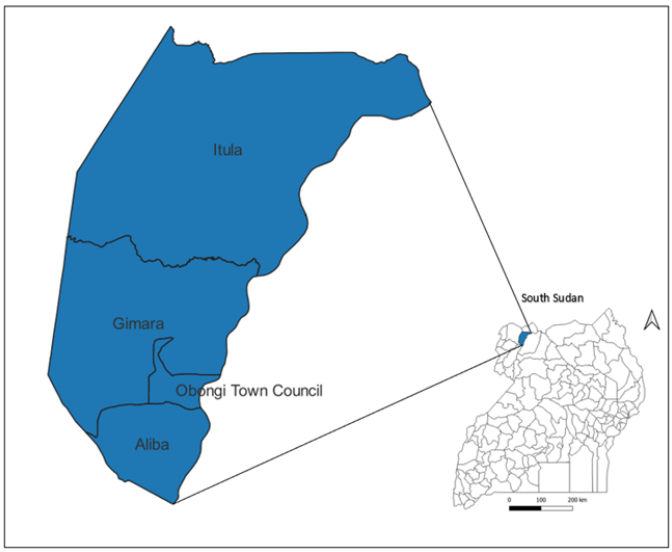

Figure 1: Location of Obongi District in Uganda

Case definition and case finding

We defined a suspected case as a resident of Palorinya Refugee Settlement with sudden onset of fever (>37.5 °C), and any one of neck stiffness, convulsions, altered consciousness, coma or bulging fontanelle in infants from 1 December 2022 to 1 May 2023 [7]. A probable case was any suspected case with macroscopic aspect of cerebrospinal fluid (CSF) turbid, cloudy or purulent; or with a CSF leukocyte count >10 cells/mm3 or with bacteria identified by Gram stain in CSF; or positive antigen detection (for example, by latex ag-

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glutination testing) in CSF. In infants, a probable case was CSF leucocyte count >100 cells/mm3; or CSF leucocyte count 10–100 cells/mm3 and either an elevated protein (>100 mg/dl) or decreased glucose (<40 mg/dl) level. A Confirmed case was any suspected/probable case that is laboratory confirmed by culturing or identifying (polymerase chain reaction) a bacterial pathogen (Neisseria meningitidis, Streptococcus pneumoniae, Haemophilus influenzae type b) in the CSF or blood [7].

We conducted active case search in the community in Palorinya Refugee Settlement and neighboring villages with assistance from community health workers and the district surveillance focal person. We further reviewed the medical records of the health facilities serving the affected villages to identify more cases.

We interviewed the suspected case-patients to identify factors likely associated with contracting the infection. We explored these factors: travel to South Sudan, vaccination against meningitis, and household size.

Information on symptoms and signs, date of onset, date of presentation/admission to hospital, duration of illness, drugs, laboratory results, and medical complications was obtained by interviewing the case-patients and reviewing their medical records.

Descriptive epidemiology

We calculated proportions to describe the distribution of cases by age, sex, and symptoms. We also described case-patients by time of onset of symptoms using an epidemiological curve and calculated attack rates to describe the distribution of cases by place (village). We calculated time from symptom onset to presentation at health facility. A graph of attack rates per week was plotted to determine whether this increase in meningitis cases had reached the epidemic thresh hold.

Factors likely associated with contracting meningitis infection

We conducted key informant interviews with the District health officer, Palorinya Refugee Settlement leadership, District surveillance focal person, health facility leaders, and the community health workers of the affected villages to identify possible sources and factors associated with contracting bacterial meningitis.

Ethical considerations

This investigation was in response to a public health emergency and was therefore determined to be non-research. The Ministry of Health gave a directive to investigate this possible outbreak. The authors sought permission to conduct the investigation from District health authorities of Obongi District, administrators of Palorinya Refugee Settlement, and the health facilities. The authors sought verbal informed consent from the respondents who were at least 18 years old as well as those that were below 18 years of age and emancipated. The authors also sought assent from children below 18 years of age who were not emancipated and informed verbal consent from their parents or guardians.

This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.§§See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

Results

Descriptive epidemiology

We line listed a total of 25 cases of bacterial meningitis. Of these, 4 were confirmed cases, 6 were probable cases, and 15 were suspected cases. The case fatality rate was 8% (2/25). The median age of the case-patients was 12 years (range 1 to 66). Most (76%) of the case-patients were <18 years. Case-patients presented with fever (100%), lethargy (94%), convulsions (83%), headache (72%), neck stiffness (72%), altered consciousness (72%), vomiting (50%), confusion (44%), diarrhea (39%), cough (39%) and runny nose (33%) (Figure 2). In this cluster, 2/25 case-patients reported complications related to meningitis (hearing loss (1/25) and limb weakness (1/25)).

The overall attack rate (AR) for bacterial meningitis in Palorinya Refugee Settlement was 21/100,000 population. Persons aged 12-17 years were the most affected (AR 43/100,000) followed by 1-4 years (AR 33/100,000), >59 years (AR 20/100,000), 5-11years (AR 15/100,000), 18-59 years (AR 10/100,000). Males (AR 30/100,000) were more affected than females (AR 12/100,000). All weeks in which meningitis cases were reported had attack rates below the epidemic threshold of 10 cases per

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100,000.

The median household size was 7 (range 1 to 10) people with 3 (range 1 to 6) people sharing a bed-room. None of the case-patients had travelled out of the refugee settlement in the six months prior to illness. All case-patients received health care from government health facilities. The majority (83%) of case-patients sought medical care within 24 hours of symptom onset. All case-patients were treated with Ceftriaxone antibiotic.

This cluster of bacterial meningitis started on 22 December 2022 and ended on 1 May 2023.The first case of meningitis occurred on 22 December 2022 and laboratory confirmation of meningitis was on 6 March 2023 (Figure 2)

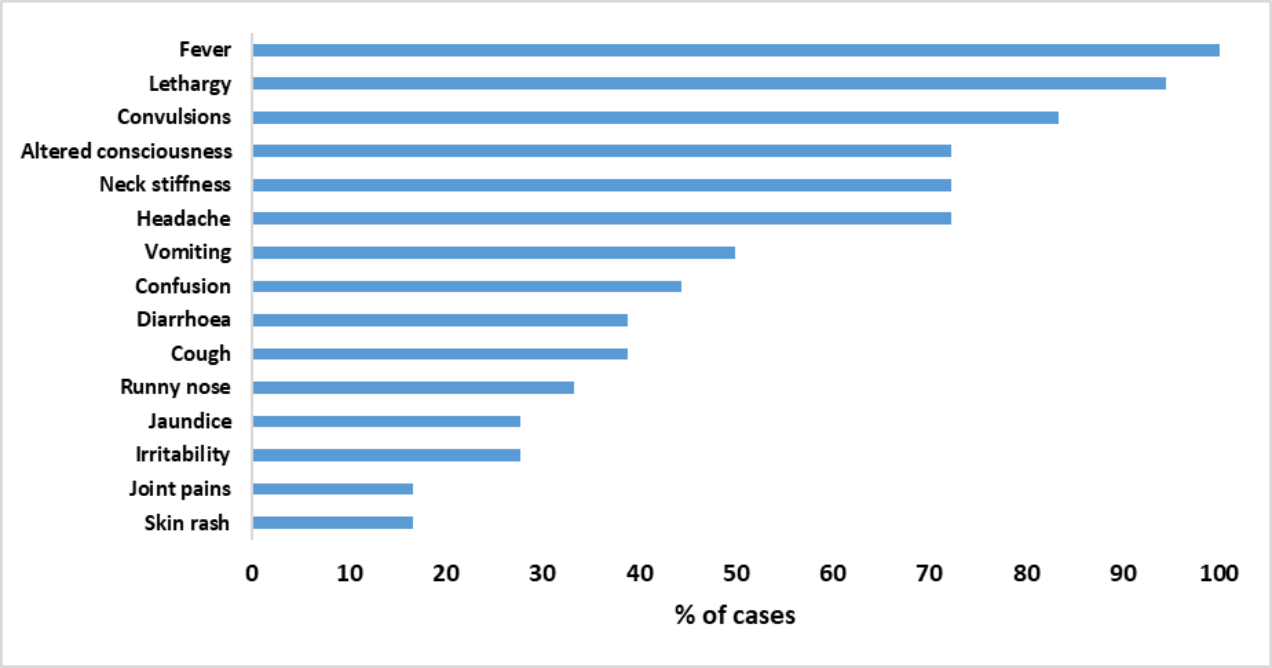

Figure 2: Distribution of bacterial meningitis cases by symptoms during an outbreak, Obongi District, Uganda, December 2022 – May 2023

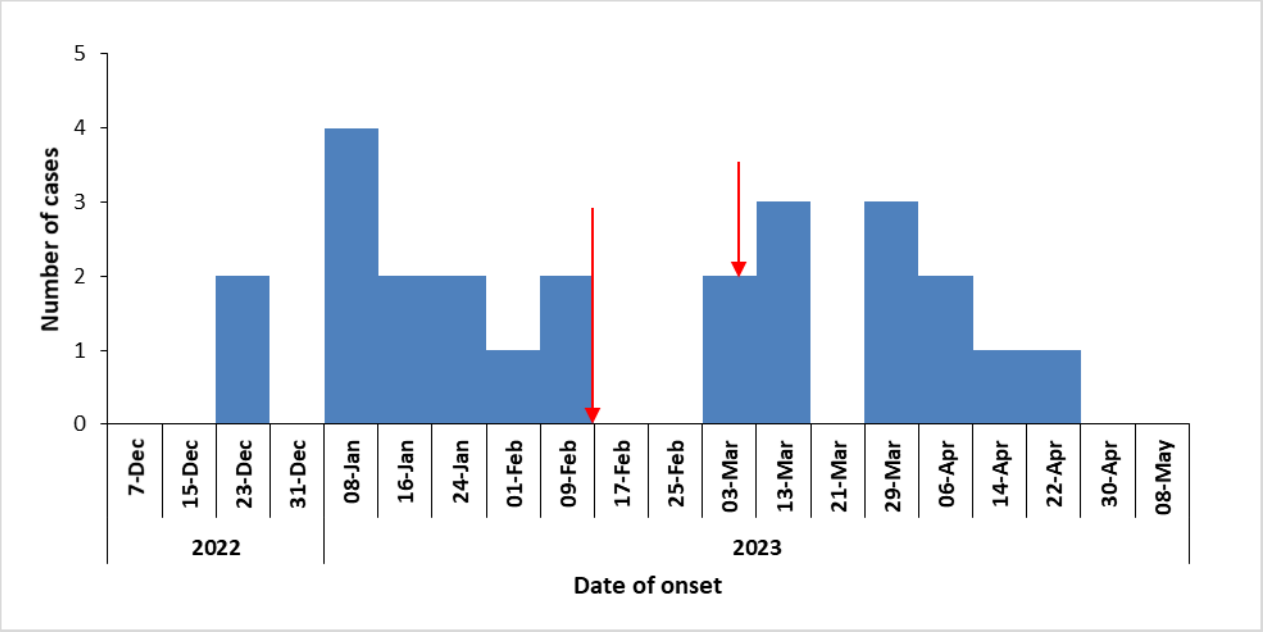

Figure 3: Distribution of bacterial meningitis cases by date of symptom onset, Obongi District, Uganda, December 2022 – May 2023

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As of May 1, 2023, nine villages had reported cases of Bacterial meningitis. Seven of the villages were in Palorinya Refugee Settlement while two of the villages were neighboring the settlement. The affected villages were scattered all over the refugee settlement. Some affected villages were more than 20 Kilometers apart. Luakoke (AR=79/100,000) and Keguru (AR=64/100,000) were the most affected villages (Table 1).

Table 1: Attack rate by village during the Bacterial meningitis cluster, Obongi District, Uganda, December 2022 – May 2023

Village	Cases	Population	Attack rate/100,000
Luakoke	2	2,539	79
Belameling	5	7,737	65
Keguru	6	9,378	64
Luru	3	7,649	39
Idiwa	4	12,354	32
Dongo	1	4,720	21
Pasu	1	9,337	11
Kali	2	NP	
Umbechi	1	NP	

NP: Population data not available, AR: Attack rate

Factors likely associated with contracting meningitis infection

Authorities reported frequent to and from movement of persons from South Sudan and suspected that the cases could be associated to the movement. Although authorities suspected that this cluster could have been imported from South Sudan, there was no evidence to point to that, they had not contacted their counterparts in South Sudan to find out whether there was an ongoing meningitis outbreak.

None of the case-patients was vaccinated against Neisseria Meningitidis serogroup C. Only 2/25 case-patients reported history of vaccination. This was in 2017 with a vaccine against Neisseria Meningitidis serogroup A.

Discussion

This cluster of meningitis caused by Neisseria meningitidis serogroup C was confined to Palorinya Refugee Settlement and neighbouring villages. Although the cluster started on 22 December 2022, the ministry of health was alerted ten weeks later on 6 March 2023. We line listed 25 cases with a case fatality rate of 8% and a complication rate of 8%. The cases were sporadically distributed across an area of 20 Km^2 with no epidemiological link between them. No household reported more than one case. Case-patients had good health seeking behaviour and were all appropriately treated with effective antibiotics. There was frequent in and out movement of persons between South Sudan and the Palorinya Refugee Settlement. There was no vaccination campaign against bacterial meningitis in the district in the last 5 years.

Although the first case of meningitis presented to the health facility on 22 December 2022, the Ministry of Health was only alerted 10 weeks later. According to the Uganda National Technical guidelines on Integrated Disease Surveillance and Response [7], bacterial meningitis is one of the diseases requiring immediate reporting. Surveillance forms the back bone of bacterial meningitis control. Official dec-

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laration of a bacterial meningitis outbreak, resource mobilisation, effective case management and reactive mass vaccination campaigns all depend on an efficient surveillance system [9, 10]. Our investigation revealed a gap in surveillance that needs to be addressed to better protect the at-risk communities against bacterial meningitis.

This cluster of meningitis was caused by Neisseria meningitidis serogroup C. Studies have shown that serogroup C is becoming a major cause of meningococcal meningitis in the meningitis belt of Sub-Saharan Africa[11, 12]. This is because there have been minimal vaccination campaigns against Serogroup C leaving at risk populations susceptible to this serogroup. As of 1 May 2023, there was no documented vaccination campaign against serogroup C in Uganda. In contrast, other causes of bacterial meningitis have been targeted through routine immunisation of children with Haemophilus influenzae and pneumococcal vaccines. In 2017, there was vaccination against Neisseria meningitidis serogroup A in Obongi and 38 other districts in Uganda. This could explain why the other causative organisms for bacterial meningitis are declining while serogroup C is increasing. Mass vaccination campaigns have shown efficacy in the meningitis belt of Africa [4, 13].

The case fatality rate (8%) and the complication rate (8%) of bacterial meningitis in this outbreak was low. Studies show that 5-15% of bacterial meningitis cases die while 20% of survivors suffer long term complications such as hearing loss, seizures, limb weakness, difficulties with vision, speech, language and memory [4, 14]. In this outbreak, 83% of case patients received medical care within 24 hours of symptom onset and were all treated appropriately with an effective antibiotic. This could explain the low case fatality and complication rates seen in this outbreak. Without treatment, case fatality rates for bacterial meningitis increase up to 50% [15].

Our investigation failed to establish an epidemiological link between any of the case-patients. None of the affected households had more than one case. Studies show that most cases of bacterial meningitis are spread from asymptomatic carriers [16]. Literature on the epidemiology of bacterial meningitis shows that 10% to 20% of the population carries Neisseria meningitidis in their throat at any given time [15]. However, less than 1% of persons colonised with Neisseria meningitidis progress to invasive disease [17-19]. It is likely that these case-patients acquired the infection from asymptomatic carriers.

Study limitations

This investigation was started 10 weeks after the first case of Bacterial meningitis presented to hospital. As a result, our findings could be affected by recall bias. Case-patients were reluctant to discuss travel in and outside the refugee settlement and felt this could jeopardize their refugee status. This could have led to social desirability bias.

Conclusion

This cluster of meningococcal meningitis caused by Neisseria meningitidis serogroup C did not reach the epidemic thresh hold stipulated in the IDSR guidelines. None of the affected persons was vaccinated against Neisseria meningitidis serogroup C.

We recommend strengthening meningitis surveillance through cross border collaboration between Uganda and South Sudan, training of health workers in case detection and reporting. Mass vaccination of at-risk persons with vaccines targeting common Neisseria meningitidis serogroups (A, B, C, W, Y) could reduce the magnitude, case fatality, and complication rates of outbreaks.

Public health actions

The results from this investigation were shared with the Ministry of Health National Task Force, Palorinya Refuge Settlement leadership, and Obongi District health authorities. As a result, at the national level, a technical working group was setup to monitor the cluster/outbreak and establish a working relationship with South Sudan health authorities to share information. At district level, surveillance activities were continued until 2 weeks after the last case. We supported the district to make daily situation reports of the outbreak.

Conflict of interest

The authors declare that they had no conflict of interest.

Authors contribution

BA, RA, LN, PO conducted the investigation and

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contributed to report writing. DK, RM, ARA critically reviewed the report for intellectual content.

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Effect of ambient air pollution during pregnancy on preterm births: time-to-event analysis in Kampala City, Uganda, October 2021–September 2022

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Summary

Introduction: Gestational exposure to fine particulate matter ($PM_{2.5}$) has been associated with adverse birth outcomes. We investigated the effect of gestational $PM_{2.5}$ exposure on preterm birth (PTB) in Kampala City, October 2021–September 2022.

Methods: We conducted a retrospective cohort study among mothers with singleton pregnancies ≥28 weeks of gestation who resided in Kampala City throughout their pregnancy, and delivered at Kawempe National Referral Hospital. PTB was defined as delivery before 37 weeks from first day of the last menstruation period. We estimated gestational $PM_{2.5}$ exposure based on average $PM_{2.5}$ concentration obtained from the nearest Clarity© Node Solar–Powered monitor to the primary residence during pregnancy. We applied Mann Whitney U test to compare gestational $PM_{2.5}$ exposure between pregnant mothers who had PTB and term birth. Gestational exposure to $PM_{2.5}$ concentration was considered as the principal predictor of PTB, and we subsequently adjusted for potential covariates using multivariate regression with the Cox proportional hazards model. We assessed statistical significance of the multiplicative interaction by antepartum complications using Wald's Chi-squared test.

Results: Among 1,540 births, 229 (15%) were preterm. Overall, average gestational $PM_{2.5}$ exposure was 66µg/m^3 (range: 45–75µg/m^3). Significant difference in gestational $PM_{2.5}$ exposure was observed between pregnant mothers who had preterm birth and those who delivered at term (p=0.002). For every unit increase in average gestational $PM_{2.5}$ exposure, risk of incidence of preterm birth increased by 3% (HR=1.03, 95%CI: 1.01–1.05). Pregnant mothers who developed hypertensive disorders had 61% (HR=1.61, 95%CI: 1.05–2.48) higher risk of experiencing PTB compared to their counterparts. There was no statistically significant difference in stratum specific hazard ratios between gestational $PM_{2.5}$ exposure and incidence of preterm birth by antepartum complications.

Conclusion: We observed significant impact of $PM_{2.5}$ concentration on incidence of PTB in Kampala City. Efforts aimed at reducing preterm births should also prioritize mitigation of air pollution to improve maternal and child health.

Background

Fine particulate matter ($PM_{2.5}$) is among the health-damaging air pollutants that pose adverse risks to humans due to its small size and diameter: which easily permit penetration into invasive systems [1]. $PM_{2.5}$ has been recommended as the best measure of air quality due to its prevalence in the environment and broad range of health effects with levels >15 µg/m^3 being associated with adverse consequences. Gestational exposure to $PM_{2.5}$ increases the risks for preterm birth, defined as delivery before 37 weeks or 259 days from the first day of a pregnant woman's last menstruation to delivery. Preterm birth is categorized into extremely preterm birth (<28 weeks), very preterm birth (28 to <32 weeks), and moderate preterm birth (32 to <37 weeks). Preterm births have been substantially linked to an increase in neonatal and infant mortality and development of chronic physical and neurological morbidity among the survivors compared to term births. The prevalence of preterm birth attributed to gestational $PM_{2.5}$ exposure ranges from 12% to 24% worldwide [2]. A study conducted in Africa found a significant association between gestational exposure to $PM_{2.5}$ and the incidence of preterm birth with an odds ratio of 1.08 (95% CI: 1.01, 1.16) [3]. Despite the fact that the direct causative mechanism is unknown, it is hypothesized that $PM_{2.5}$ affects transplacental oxygen and nutrient transport thus placental inflammation, oxidative stress, and blood coagulation which may limit intrauterine fetal growth.

Cities are more prone to poor air quality compared to non-urban areas. This is attributed to high population density, exhaust emissions from

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vehicles and industries, infrastructure construction, open fuel and solid waste burning. As of 2021, Kampala City was among the cities with the highest levels of $PM_{2.5}$, exceeding the annual WHO recommended air quality $PM_{2.5}$ levels by 5 to 7 times. [4]. However, limited evidence has been presented about the association between $PM_{2.5}$ exposure and preterm births in this city. Understanding the impact of air quality on the incidence of preterm births would be a great initiative towards influencing the implementation of evidence-based air quality control strategies that address adverse birth outcomes. We investigated the impact of $PM_{2.5}$ exposure during pregnancy on preterm birth (PTB) in Kampala City, Uganda, October 2021–September 2022.

Methods

Study setting

This assessment was conducted in Kampala, the capital city of Uganda. It is divided into 5 administrative divisions: Central, Kawempe, Makindye, Rubaga, and Nakawa. The city has a surface area of 189 km^2, including 176 km^2 of land and 13 km^2 of water [5]. The 2023 population was estimated at 1.76 million; however, the city has a dynamic and transient day population estimated at 5 million people [6]. Kampala Capital City Authority (KCCA) has been mandated to govern and administer Kampala Capital City on behalf of the Central Government of Uganda.

Kawempe National Referral Hospital (KNRH), located about 12km away from the city centre of Kampala, is a government-funded hospital largely providing free maternal and newborn healthcare services to patients referred from public and private health facilities within and outside Kampala City, as well as walk-ins from Kampala Metropolitan Area and surrounding districts. KNRH is serving a population of approximately 4.5 million [7]. The catchment area of the hospital has a heterogeneous population, consisting of the urban poor and those with average income. In 2019, 2,784 (11%) out of 24,526 deliveries were preterm based on KNRH records [8].

Study design, population, exclusion criteria, and sample size considerations

We conducted a retrospective cohort study among mothers who delivered at KNRH. Mothers with viable pregnancies of at least 28 weeks of gestation who delivered from the labour suite or theatre between October 1, 2021, and September 30, 2022, were identified to define our population-based birth cohort (n=22,192). Mothers whose weeks of gestation at birth or the first day of the last normal menstrual period were not documented in the file were excluded. Furthermore, all mothers whose first day of the last normal menstrual period occurred before October 1, 2021, were excluded to ensure that the exposure period accommodates all the weeks of gestation. Every mother with a valid telephone contact was reached out to confirm whether she resided in Kampala City, and then specify the division, parish, and duration of residence during pregnancy. Only 1,540 mothers who resided in Kampala City throughout their pregnancy time were enrolled in this assessment.

Study variables and data abstraction

Covariates

We abstracted data regarding the covariates from the mother's files using a data abstraction tool deployed in Kobo Collet. We considered the following potential individual covariates: demographic characteristics (maternal age, highest education level, marital status, occupation, HIV status), antenatal attendance, number of antenatal visits, history of smoking and alcohol use, and antepartum obstetric complications (eclampsia, pre-eclampsia, placenta abruptio, placenta previa, intra uterine fetal death (IUFD), preterm premature rupture of membranes, chorioamnionitis, and oligohydramnios). Only primary antepartum complications were considered for mothers who had multiple complications. Eclampsia and pre-eclampsia were categorized under hypertensive disorders. Placenta abruption and placenta previa were categorized under antepartum hemorrhage. Information on any covariates with missing data were obtained through telephone interviews with the mothers.

Gestational $PM_{2.5}$ exposure

In December 2019, KCCA installed twenty–four Clarity© Node Solar–Powered monitors for outdoor air quality monitoring in all five divisions of Kampala City (Figure 1). Clarity© Node Solar–Powered monitors were permanently set up at least 1.5 meters above ground level in secure areas away from obstruction or emission sources that could interfere with air quality measurements. Calibration of Clarity© Node Solar–Powered monitors was based on co–location data with the reference air quality monitoring station at the US Embassy in Kampala City. Clarity© Node Solar–Powered monitors use inbuilt cellular connectivity to transmit raw data for $PM_{2.5}$, PM_{10}, nitrogen dioxide (NO_2), temperature, and relative humidity. Calibrated data generated by these monitors are accessed in real–time on the Clari-

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ty© Dashboard by authorized KCCA staff and Clarity© operating team.

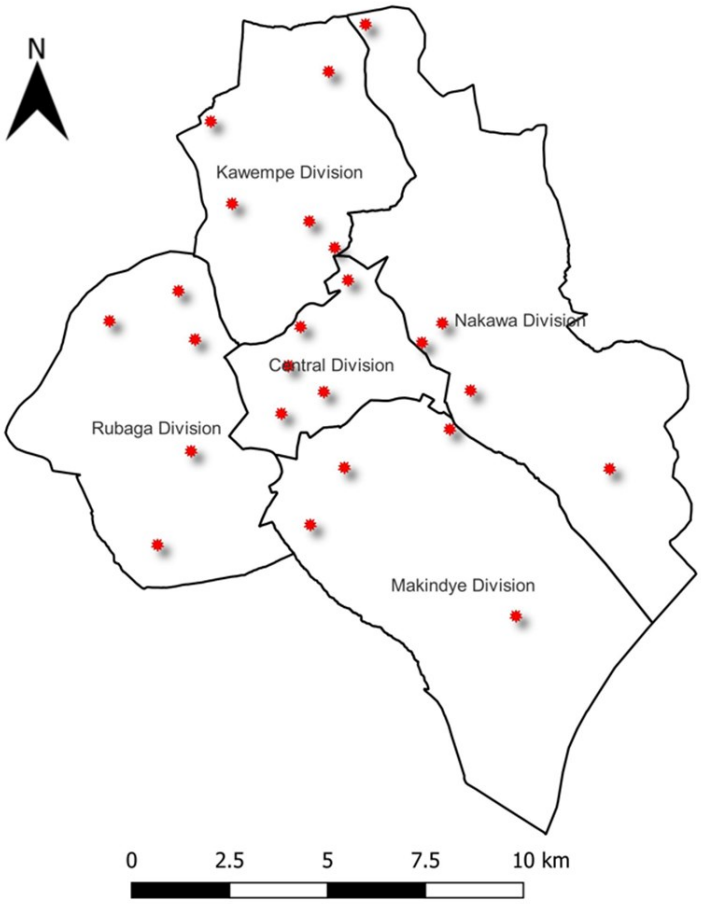

Figure 1: Location of Clarity© Node Solar–Powered monitors in Kampala City, Uganda

We abstracted 24–hour average $PM_{2.5}$ concentrations generated by calibrated Clarity© Node Solar–Powered monitors from the Clarity© Dashboard from October 1, 2021, to September 30, 2022. For each mother, the centroid coordinates for the respective parish of residence in Kampala City was obtained from the geo-spatial database for Kampala City. The distance between parish coordinates and coordinates for all the Clarity Node Solar-Powered monitors installed in the city was calculated. The nearest Clarity Node Solar-Powered monitor to the parish of the mother was determined based on the least distance obtained. We estimated $PM_{2.5}$ exposure during pregnancy based on average $PM_{2.5}$ concentration obtained from the nearest Clarity© Node Solar–Powered monitor throughout the gestation period.

Outcome variable

Our outcome variable was preterm birth, defined as delivery before 37 weeks or 259 days from the first day of a pregnant woman's last menstruation to delivery. Preterm birth was categorized into extremely very preterm birth (28 to <32 weeks) and moderate preterm birth (32 to <37 weeks) [9, 10]. Weeks of gestation were determined following standard obstetric practice based on first day of the last normal menstrual period or obtained from the ultrasound scan done during the first trimester for mothers who did not recall their first day of the last normal menstrual period.

Data analysis

Descriptive statistics were performed for demographic characteristics, antenatal attendance, and antepartum complications. We computed the incidence of preterm births (28<37 weeks) and further stratified into extremely very preterm birth (28 to <32 weeks) and moderate preterm birth (32 to <37 weeks). We calculated gestational $PM_{2.5}$ exposure among pregnant mothers who experienced preterm birth (28<37 weeks) and term birth (≥37 weeks). We applied Mann Whitney U test to compare gestational $PM_{2.5}$ exposure between pregnant mothers who experienced preterm birth and term birth. Gestational exposure to $PM_{2.5}$ concentration was considered as the principal predictor of PTB. Due to variability in the exposure length (weeks of gestation) for each birth, we utilized the Cox proportional hazards models based on weeks of gestation to determine the association between gestational $PM_{2.5}$ exposure over the entire pregnancy and the risk of preterm birth. We subsequently adjusted for potential covariates using multivariate regression with the Cox proportional hazards model to obtain adjusted hazard ratios (HR), corresponding 95% confidence intervals and p-values. We stratified data by each covariate to generate stratum-specific hazard ratios between gestational $PM_{2.5}$ exposure and preterm birth. To assess whether antepartum complications modified the relationship between gestational $PM_{2.5}$ concentration and preterm birth, we generated interaction terms between gestational $PM_{2.5}$ concentration and antepartum complications. Interpretation of the interaction term's hazard ratios and respective statistical significance explained whether the effect of gestational $PM_{2.5}$ concentration on preterm birth varied by the presence or absence of the antepartum complications. We used the Wald's Chi-squared test to assess the statistical significance of the multiplicative interaction between gestational $PM_{2.5}$ exposure and antepartum complications. Statistical significance was set at a p-value <0.05. All statistical analyses were performed using STATA 16.0.

Ethical considerations

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The Office of the Associate Director for Science, US Centres of Disease Control and Prevention/ Uganda, also determined that this activity was not human subject research, and its primary intent was public health practice or a disease control activity (specifically, epidemic or endemic disease control activity). Administrative clearance to extract data from patient files and $PM_{2.5}$ exposure data from the Clarity© Dashboard was obtained from Kawempe National Referral Hospital and Kampala Capital City Authority respectively. All methods were performed in accordance with the approval and administrative clearance. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy. [§]

[§]See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d); 5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

Results

Characteristics of study participants during an evaluation of gestational $PM_{2.5}$ exposure on preterm births in Kampala City, Uganda, October 2021–September 2022

Out of 1,540 pregnant mothers, 1,030 (66.9%) were aged 18–29 and 892 (57.9%) were housewives. Of note, only 819 (53.2%) attended antenatal care. Only 382 (24.8%) had antenatal obstetric complications (Table 1).

Table 1: Characteristics of study participants during an evaluation of gestational $PM_{2.5}$ exposure on preterm births in Kampala City, Uganda, October 2021–September 2022

Study variables	Frequencies (n=1,540)	Percentages (%)
Completed age		
Below 18	53	3.4
18–29	1,030	66.9
30–39	419	27.2
40–49	38	2.5
Division of residence		
Kawempe	466	30.3
Makindye	336	21.8
Nakawa	105	6.8
Rubaga	428	27.8
Central	205	13.3
Highest education level		
None	412	26.8
Primary	346	22.5
Secondary	515	33.4
Tertiary or above	267	17.3
Marital Status		
Not Married	236	15.3
Married	1,304	84.7
Occupation		
House wife	892	57.9
Formal employment	156	10.1
Business	492	32.0

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Study variables	Frequencies (n=1,540)	Percentages (%)
Number of children		
1 – 2	931	60.5
3 – 4	447	29.0
5 and above	162	10.5
HIV status		
Negative	1,412	91.7
Positive	107	6.9
Unknown	21	1.4
Antenatal attendance		
No	721	46.8
Yes	819	53.2
Number of antenatal visits (n=819)		
1 – 2	111	13.6
3 – 4	401	48.9
5 and above	307	37.5
History of smoking		
No	1,523	98.9
Yes	17	1.1
History of alcohol use		
No	1,512	98.2
Yes	28	1.8
Antenatal obstetric complication		
No	1,158	75.2
Yes	382	24.8
Preterm premature rupture of membranes		
No	1,436	93.2
Yes	104	6.8
Hypertensive disorder		
No	1,431	92.9
Yes	109	7.1
Antepartum hemorrhage		
No	1,484	96.4
Yes	56	3.6
Oligohydramnios		
No	1,495	97.1
Yes	45	2.9
Chorioamnionitis		
No	1,493	97.0
Yes	47	3.0
Intra uterine fetal death (IUFD)		
No	1,519	98.6
Yes	21	1.4

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Incidence of preterm births in Kampala City, Uganda, October 2021–September 2022
Among pregnant mothers who resided in Kampala City throughout pregnancy and delivered from KNRH, 229 (14.9%) had preterm births (Table 2). Of these, the majority, 198 (86.5%) had moderate to late preterm births whereas only 31 (13.5%) had very preterm births.

Gestational $PM_{2.5}$ exposure
Overall, the average gestational $PM_{2.5}$ exposure was 66µg/m^3 (range: 45–75µg/m^3). Gestational $PM_{2.5}$ exposure was slightly higher among pregnant mothers who experienced preterm birth compared to those who delivered at term (Table 2). Significant difference in gestational $PM_{2.5}$ exposure was observed between pregnant mothers who experienced preterm birth and those who delivered at term (p=0.002).

Factors associated with incidence of preterm births in Kampala City, Uganda, October 2021–September 2022
At multivariate analysis, gestational $PM_{2.5}$ exposure and development of hypertensive disorders were statistically significantly associated with incidence of preterm births among pregnant mothers in Kampala City. For every unit increase in average $PM_{2.5}$ exposure during pregnancy, the risk of incidence of a preterm birth increases by 3% (HR=1.03 [1.01 – 1.05]). Pregnant mothers who developed hypertensive disorders were 61% more likely to have preterm births compared to those who did not develop hypertensive disorders during pregnancy (HR=1.61 [1.05 – 2.48]) (Table 2).

Table 2: Factors associated with incidence of preterm births in Kampala City, Uganda, October 2021–September 2022

Study variables	Term birth n (%)	Preterm birth n (%)	Adjusted hazard ratios	95% confidence intervals
Socio-demographic characteristics				
Completed age				
Below 18	43 (3.3)	10 (4.4)	Ref.	
18–29	879 (67.0)	151 (65.9)	0.63	[0.33 – 1.21]
30–39	358 (27.3)	61 (26.6)	0.59	[0.29 – 1.17]
40–49	31 (2.4)	7 (3.1)	0.79	[0.30 – 2.09]
Highest education level				
None	348 (26.5)	64 (27.9)	Ref.	
Primary	297 (22.7)	49 (21.4)	0.86	[0.58 – 1.25]
Secondary	440 (33.6)	75 (32.8)	0.91	[0.64 – 1.28]
Tertiary or above	226 (17.2)	41 (17.9)	0.92	[0.61 – 1.40]
Marital Status				
Married	1,118 (85.3)	186 (81.2)	Ref.	
Not married	193 (14.7)	43 (18.8)	1.31	[0.92 – 1.86]
Occupation				
House wife	761 (58.0)	131 (57.2)	Ref.	
Business	423 (32.3)	69 (30.1)	0.93	[0.69 – 1.26]
Formal employment	127 (9.7)	29 (12.7)	1.21	[0.79 – 1.86]
HIV status				
Negative	1,210 (92.3)	202 (88.2)	Ref.	
Positive	86 (6.6)	21 (9.2)	1.31	[0.83 – 2.08]
Unknown	15 (1.1)	6 (2.6)	1.82	[0.77 – 4.26]

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Study variables	Term birth n (%)	Preterm birth n (%)	Adjusted hazard ratios	95% confidence intervals
Antenatal attendance				
No	624 (47.6)	97 (42.4)	Ref.	
Yes	687 (52.4)	132 (57.6)	1.13	[0.85 – 1.49]
History of smoking				
No	1,297 (98.9)	226 (98.7)	Ref.	
Yes	14 (1.1)	3 (1.3)	0.93	[0.29 – 2.98]
History of alcohol use				
No	1,289 (98.3)	223 (97.4)	Ref.	
Yes	22 (1.7)	6 (2.6)	1.20	[0.52 – 2.79]
Gestational $PM_{2.5}$ exposure [Mean (range)]				
$PM_{2.5}$ concentration	66 (45 – 75)	67 (53 – 75)	1.03	[1.01 – 1.05] **
Antepartum complications				
Preterm premature rupture of membranes				
No	1,223 (93.3)	213 (93.0)	Ref.	
Yes	88 (6.7)	16 (7.0)	1.24	[0.73 – 2.08]
Hypertensive disorder				
No	1,221 (93.6)	204 (89.1)	Ref.	
Yes	84 (6.4)	25 (10.9)	1.61	[1.05 – 2.48] *
Antepartum hemorrhage				
No	1,264 (96.4)	220 (96.1)	Ref.	
Yes	47 (3.6)	9 (3.9)	1.23	[0.62 – 2.43]
Oligohydramnios				
No	1,274 (97.2)	221 (96.5)	Ref.	
Yes	37 (2.8)	8 (3.5)	1.37	[0.68 – 2.82]
Chorioamnionitis				
No	1,271 (96.9)	222 (96.9)	Ref.	
Yes	40 (3.1)	7 (3.1)	1.06	[0.49 – 2.27]
Intrauterine fetal death				
No	1,296 (98.9)	223 (97.4)	Ref.	
Yes	15 (1.1)	6 (2.6)	1.87	[0.81 – 4.29]

* p<0.05 ** p<0.01 *** p<0.001

Association between gestational $PM_{2.5}$ exposure and preterm birth stratified by antepartum complications

There was a significant risk of preterm birth attributed to gestational $PM_{2.5}$ exposure among mothers without preterm premature rupture of membranes, hypertensive disorders, antepartum hemorrhage, oligohydramnios, chorioamnionitis, and intra uterine fetal deaths compared to those with these antepartum complications. Based on p-values, there was no statistically significant difference in stratum specific hazard ratios between gestational $PM_{2.5}$ exposure and incidence of preterm birth by antepartum complications (Table 3).

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Table 3: Association between gestational $PM_{2.5}$ exposure and preterm birth stratified by antepartum complications, in Kampala City, Uganda, October 2021–September 2022

Antepartum complication	Frequency (%)	Stratum specific hazard ratios[1]	95% Confidence Intervals	p-value
Preterm premature rupture of membranes				0.696
No	1,436 (93.2)	1.04	[1.01 – 1.06] **	
Yes	104 (6.8)	1.00	[0.93 – 1.09]	
Hypertensive disorder				0.564
No	1,431 (92.9)	1.03	[1.01 – 1.06] **	
Yes	109 (7.1)	1.00	[0.93 – 1.09]	
Antepartum hemorrhage				0.511
No	1,484 (96.4)	1.03	[1.00 – 1.05] **	
Yes	56 (3.6)	1.10	[0.93 – 1.31]	
Oligohydramnios				0.897
No	1,495 (97.1)	1.03	[1.01 – 1.06] **	
Yes	45 (2.9)	1.09	[0.92 – 1.30]	
Chorioamnionitis				0.518
No	1,493 (97.0)	1.03	[1.01 – 1.06] **	
Yes	47 (3.0)	1.33	[0.92 – 1.93]	
Intra uterine fetal death				0.098
No	1,519 (98.6)	1.03	[1.01 – 1.06] **	
Yes	21 (1.4)	0.97	[0.87 – 1.09]	

* p<0.05 ** p<0.01 *** p<0.001
[1]Adjusted for age, educational level, marital status, occupation, HIV status, antenatal attendance, history of smoking and alcohol use
[@]p-values for Wald's Chi-squared test for interaction (p-values for effect modification)

Discussion

In our assessment, gestational exposure to $PM_{2.5}$ concentration was considered the primary predictor of preterm birth (PTB) in Kampala City, and we subsequently adjusted for potential covariates using multivariate regression with the Cox proportional hazards model. We observed a 3% rise in the risk of PTB for each incremental unit increase in average gestational $PM_{2.5}$ exposure (HR=1.03, 95% CI: 1.01–1.05), after adjusting for potential covariates in our multivariate regression analysis. Notably, pregnant mothers who developed hypertensive disorders exhibited a higher likelihood of experiencing preterm births compared to their counterparts. Despite the well-established elevated risk of preterm births associated with gestational PM2.5 exposure among mothers without preterm premature rupture of membranes, hypertensive disorders, antepartum hemorrhage, oligohydramnios, chorioamnionitis, and intrauterine fetal deaths, we found that the effect modification by these antepartum complications did not achieve statistical significance.

Our findings align with previous studies which have demonstrated the increased risk of preterm births attributed to gestational $PM_{2.5}$ exposure. A study in Italy observed a 3% risk of preterm births per unit increase in gestational $PM_{2.5}$ exposure [11]. A multi country study in Africa reported a significant association between gestational $PM_{2.5}$ exposure and increased risk of preterm births [1.08 (95% CI: 1.01–1.16)] [3]. A significant risk of preterm birth estimated at 1.2% per unit increase in gestational $PM_{2.5}$ exposure was reported based meta regression analysis across 204 countries [12]. However, inconsistent findings were reported in a retrospective cohort study among 2,966,705 million singleton live

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births in Canada, where gestational $PM_{2.5}$ exposure provided a protective effect by reducing the risk of preterm births by 20% [0.80 (95% CI: 0.75 –0.86)] [13]. Another retrospective cohort study among 7,961 births occurring from June 2008 to May 2010 in Detroit, Michigan, United States revealed that maternal exposure to $PM_{2.5}$ was not statistically significantly associated with incidence of preterm birth (p value = 0.376) [14]. Differences in air quality, population characteristics, sample size, time periods, and $PM_{2.5}$ exposure measurement among studies conducted in different regions, such as Kampala, Canada and Detroit, may explain variations in the observed effects of gestational $PM_{2.5}$ exposure on preterm birth, with one study suggesting a protective effect while another found no significant association. Nevertheless, the significant association between gestational $PM_{2.5}$ exposure and preterm birth indicates the effect of air pollution on health outcomes. Such findings should implore relevant stakeholders to prioritize implementation of appropriate interventions to avert anticipated health consequences in Kampala City, where the 24–hour average $PM_{2.5}$ concentration from January, 2020–June, 2022, was 59 $\mu g/m^3$; exceeding targeted WHO targeted safe levels [15].

The increased risk of preterm birth among pregnant mothers who developed hypertensive disorders has been previously evidenced. A recent scoping review highlighted hypertensive disorders among the most frequently reported risk factors for preterm births in Sub Saharan Africa [16]. A meta-analysis conducted in East African countries reported that mothers who had pregnancy induced hypertension were three times likely to experience preterm births compared to their counterparts [17]. What is quite challenging is that the risk of developing hypertensive disorders during pregnancy has also been attributed to gestational $PM_{2.5}$ exposure. Gestational $PM_{2.5}$ exposure increases the risk of pregnancy induced hypertensive disorders following endothelial dysfunction, autonomic nervous system imbalance, oxidative stress, and systemic inflammatory response [18-20]. A 5 $\mu g/m^3$ increment in gestational $PM_{2.5}$ exposure significantly increased the risk of developing pregnancy-induced hypertensive disorders by 57% [21]. Due to the complex relationship of gestational $PM_{2.5}$ exposure, hypertensive disorders, and preterm birth, the observed risk of preterm births among pregnant mothers who developed hypertensive disorders may as well be indirectly confounded by gestational $PM_{2.5}$ exposure.

Despite the growing evidence on the association between air pollution and preterm births, very few studies have investigated whether the association between gestational $PM_{2.5}$ exposure and birth outcomes vary by antepartum complications. We hypothesized that the effect of gestational $PM_{2.5}$ exposure on incidence of preterm births might be modified by antepartum complications such as preterm premature rupture of membranes, hypertensive disorders, antepartum hemorrhage, oligohydramnios, chorioamnionitis and intra uterine fetal deaths. However, this was not evidenced in this study with reference to the observed non-significant effect modification. The observed non-significant effect modification by hypertensive disorders was synonymous with findings from a population based cohort study in California which concluded that pre-existing and pregnancy-induced hypertension did not modify the relationship between air pollution and preterm birth [22]. This implies that the effect of gestational $PM_{2.5}$ exposure on incidence of preterm births does not differ depending on the presence or absence of the antepartum complication.

Study strengths and limitations

Our findings should be interpreted in line with the following limitation. We were unable to reach out to 1,354 mothers who met the eligibility criteria because they did not have valid documented telephone contacts. We were not able to confirm their primary address and thus excluded them from the analysis. This could have led to underestimation or over estimation of the risk of preterm births attributed to gestational $PM_{2.5}$ exposure in Kampala City. Despite the limitation, this assessment presents the first comprehensive investigation examining the association between gestational $PM_{2.5}$ exposure and preterm birth in Kampala City using ground-level air quality data sourced from Clarity© Node Solar-Powered low-cost monitors.

Conclusion

We observed a significant impact of air pollution on the incidence of preterm births in Kampala City. Kampala Capital City Authority and other relevant partners are implored to prioritize interventions aimed at reducing air pollution to improve maternal and child health. Furthermore, efforts aimed at reducing preterm births should not underscore the urgent need to mitigate air pollution.

Conflict of interest

The authors declare no conflict of interest.

Authors' contributions

MN designed the protocol under the technical guidance of AN, AO, SZ, DA, TK, PW, LA, DK, LB, RM, ARA, LA, JRH, and DAO. MN, AN, DA,

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TK and SZ supervised data collection, analyzed, and interpreted the data. MN drafted the bulletin. MN, AN, AO, PW, LA, DK, LB, RM, ARA, LA, JRH, and DAO, critically reviewed the bulletin for intellectual content. All co–authors read and approved the final bulletin.

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Factors associated with severe pneumonia among children <5 years, Kasese District, Uganda, 2023

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Summary

Background: An analysis of trends and spatial distribution of pneumonia hospital admissions among children <5 years in Uganda,2013–2021 indicated a high incidence of severe pneumonia in Kasese District. However, data on the factors associated with developing severe pneumonia in this area was limited. We, assessed factors associated with severe pneumonia among children <5 years in the Kasese District, January to April 2023 to inform effective evidence-based control and prevention strategies.

Methods: We conducted an unmatched hospital-based case-control study with a 1:1 ratio among children aged 2-59 months presenting with pneumonia at the outpatient department at 5 high-volume health facilities in Kasese District. Cases were selected based on presenting with severe pneumonia defined as pneumonia with any danger signs including oxygen saturation <90%, central cyanosis, severe respiratory distress, inability to drink or breastfeed or vomiting everything, altered consciousness, and convulsions. Controls were selected based on presenting with pneumonia as defined as lower chest wall indrawing or fast breathing (respiratory rate ≥50 breaths per min if aged 2–11 months; ≥40 breaths per min if aged 12–59 months) and without signs of severe pneumonia. Risk factors assessed included: caregiver's, child's health, health-seeking behaviour, and environmental exposure characteristics. Logistic regression analysis was used to identify risk factors associated with severe pneumonia.

Results: A total of 336 children <5 years presenting at 5 high-volume facilities in Kasese District with pneumonia between January to April 2023 were included in the study. Of these 199 were cases while 174 were controls. The median age of children was 12 months, interquartile range; of 6-24 months. After adjusting for covariates, having diarrhoea only (aOR=2.88,95% CI:1.69-4.89), malaria and diarrhoea (OR: 3.41,95% CI:1.98-5.86), not being exclusively breastfed at least 6 months (aOR=1.97,95% CI:1.1-3.34), and exposure to indoor air pollution through proximity to cooking combustion sources during home cooking with the child in the kitchen (aOR=2.89,95% CI:1.77-4.72) were associated with severe pneumonia.

Conclusion: Having diarrhoea only, malaria and diarrhoea, not being exclusively breastfed for at least 6 months and exposure to indoor air pollution through proximity to cooking combustion sources during home cooking with the child in the kitchen were associated with developing severe pneumonia. These results can be used to develop tailored interventions for reducing morbidity and mortality due to severe pneumonia.

Background

Pneumonia, a largely preventable disease persists as a major public health problem among children <5 years. By 2019, pneumonia was the lead-

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ing infectious cause of death among children <5 years accounting for 14% of all deaths in this age group. (1) Half of pneumonia cases and deaths are reported in Sub-Saharan Africa(2) .

Pneumonia is classified based on clinical severity and risk of poor outcomes into non-severe and severe pneumonia. Severe pneumonia often requires hospitalisation and has a higher case fatality rate than non-severe pneumonia. Severe pneumonia is also linked to long-term morbidity and life-long disability(3,4). Between 2015-2019, McAllister et al documented a worrying trend of severe pneumonia among children <5 years in Sub-Saharan Africa with a seven-fold increase in severe pneumonia cases(2). This suggested a growing burden of severe pneumonia in this region. In Uganda, the incidence of severe pneumonia was 108 per 100,000 children under five years in 2022 based on the routinely-collected weekly national surveillance data. Furthermore, a 2013-2021analysis of trends and spatial distribution of pneumonia hospital admissions and mortality among children under five years in Uganda, indicated a particularly high incidence of pneumonia admissions (> 3000 per 100,000 children<5 years in all years with the highest of 7,421 cases per 100,000 in 2019) in the Kasese District indicating a high burden of severe pneumonia in this area.

This growing burden of severe pneumonia creates a need to understand the factors associated with severe pneumonia among children <5 years in order to implement effective evidence-based control and prevention strategies. Previous studies by Rudin et al(5) found that about 7-13% of pneumonia cases develop severe pneumonia, but the reasons why they do remains a unclear. Although there is reasonable data on the risk factors for pneumonia, data on risk factors for development of severe pneumonia is limited. In developing countries, documented risk factors for the development of severe pneumonia include bacterial aetiology, immunisation status, low weight for age, low caregiver education, low wealth quintile delayed care seeking, household crowding, co-morbidities, exposure to household crowding, malnutrition, and young age(6–8). However, these were inconsistent and varied with unique contextual differences observed in different settings. Little is documented on the factors associated with severe pneumonia among children <5 years in Uganda especially in high burden areas such as Kasese District. We identified the factors associated with development of severe pneumonia among children < 5 years in Kasese District in to inform control and prevention strategies.

Methods

Study setting

We conducted the study from January to April 2023 in Kasese District located in western Uganda. Kasese is one of the districts where the integrated community case management for childhood illnesses including diarrhoea, malaria, and pneumonia are implemented(9). Kasese District has 139 health facilities, out of which 81 were health centre IIs, 48 health centre IIIs, 6 health centre IVs and 4 general hospitals. As per the revised package of basic health services for Uganda, 2014, severe pneumonia can only be managed at health centre IIIs, health centre IV, and general hospitals(10). We specifically conducted the study in in five health facilities reporting the highest number of severe pneumonia cases. These included Kagando Hospital, Bwera Hospital, Kasanga PHC Health Centre III, St Francis of Assis-Kitabu Health Centre III. These facilities offer both in-patient and outpatient child care services.

Case control study

We conducted an unmatched hospital-based case control study between January to April 2023. We defined severe pneumonia cases as a child aged 2-59 months presenting with pneumonia with any danger signs including: oxygen saturation <90%, central cyanosis, severe respiratory distress, inability to drink or breastfeed or vomiting everything, altered consciousness, and convulsions(11). Controls were defined as a child aged 2-59 months presenting with lower chest wall indrawing or fast breathing (respiratory rate ≥50 breaths per min if aged 2–11 months; ≥40 breaths per min if aged 12–59 months), and without signs of severe pneumonia at the health facility during the same period as cases.

We determined the sample size using the Fleiss

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et al (12) formula using Open Epi software. We assumed a two sided confidence level (CI) =95%, power =80%, 1:1 ratio of cases to controls, taking non-exclusive breastfeeding as a main predictor for severe pneumonia in developing countries with an odds ratio of 2.7(13), and percentage of exposed controls at 9%(14). We obtained a total sample of 153 cases and 153 controls.

Using a structured questionnaire, we collected data regarding socio-demographics, child's health, health seeking behaviour, environmental related factors from both the cases and controls. We further reviewed medical records and child health cards to obtain more details on the clinical characteristic including the immunization status of the children. Socio-demographic factors included 1) age categorised into infants 2–11 months, young children 12–23 months, toddlers 24–59 months, 2) sex categorised as male and female ,3) birth order categorised as1– 2, 3–4 and ≥5 caregiver's 4) education level categorised based on the Uganda Education system to include: none, primary, O' level and A 'level and 5) wealth status, a composite variable constructed using principal component analysis of data on ownership of consumer items and livestock, characteristics of the dwelling unit, water sources and sanitation facilities. Child health factors included 1) nutritional status categorised into normal stunting, wasting, underweight and overweight. This was assessed by the following MUAC (in cm), weight for age Z score (WAZ), weight -for height/length Z score (WHZ), height-for-age Z score (HAZ), 2) breast feeding status defined based on WHO classification of breastfeeding was used to categorize patients as exclusively breastfed for at least 6months and those who were not ,3) underlying illness was defined as having diarrhoea, measles, malaria or HIV during the current illness, 4)immunisation status was defined age-appropriate receipt of vaccines (including Pneumococcal Conjugate Vaccine (PCV), DPT-HebB+Hib2, measles and polio vaccines) as indicated in the Uganda Immunisation schedule 5) previous respiratory illness. Environmental factors included 1) type of cooking fuel used at home 2) exposure to household air pollution from cooking fuel assessed using proximity to cooking combustion sources during home cooking with child in the kitchen and 3) exposure to tobacco smoke defined as staying with a cigarette smoker in the same household. Health seeking behaviour factors included1) duration in days to seeking care following caregiver's recognition of illness 2) healthcare sought for this episode of illness prior to enrolment in the study, yes or no and 3) place where health care was sought for this episode of illness prior to enrolment in the study: home remedies, village health team, clinic, drug shop, health centre II, health centre III, and health centre IV.

Data analysis

We calculated frequencies with percentages for categorical variables (birth order, wealth status, nutrition status, breast feeding status, underlying illness, immunisation status, type of cooking fuel and exposure to indoor air pollution during home cooking exposure to tobacco to smoke and place where health care was sought prior to enrolment in the study) while medians with interquartile ranges (IQR) for continuous skewed variables (duration of seeking care following caregiver's recognition of illness). We used logistic regression to obtain independent variables significantly associated with the outcome variable. The independent variables with p-values ≤0.2 at bi-variate analysis were used to develop a multivariable logistic regression model using a forward stepwise approach. The strength of association between outcome variable and the independent variables of interest were assessed by calculating Odds ratios (ORs) with 95% confidence intervals. Variables with 95% confidence intervals not including 1 and $p<0.05$ were considered statistically significant.

Ethical Considerations

The MoH of Uganda through the office of the Director General Health Services gave the administrative clearance to carry out this investigation and access anonymised patient data. Additionally, the MOH has also granted the program permission to disseminate the information through scientific publications. In addition, the Office of the Associate Director for Science, U.S. Centers for Disease Control and Prevention, determined that this study was not a human subjects research with the pri-

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mary intent of guiding public health planning and practice. This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy.§

§See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d);

Results

Socio-demographic characteristics of children <5 years in a hospital-based case-control study assessing factors associated with severe pneumonia in Kasese District, Uganda

The study comprised of 366 children <5 years, including 174 cases and 192 controls.
The median age of children was 12 months, IQR:6- 24 months with 60% males and 44% in the ≤ 11 months age group. Forty-eight percent (48%) of children were in the 1-2 birth order with 62% with primary caregivers whose highest level of education was primary level education and 21% from households in the highest wealth quintile. Slightly more controls were in 1-2 birth order category (54% Vs 41%) and female (44% Vs 36%) (Table 1)

Table 1: Socio-demographic characteristics of children <5 years in a hospital-based case-control study assessing factors associated with severe pneumonia in Kasese District, Uganda

Characteristic	Cases		Controls		
	n	%	n	%	P-value
Gender					
Male	112	64	107	56	0.092
Female	62	36	85	44	
Age group					
≤11 months	78	45	84	44	0.489
12–23 months	47	27	44	23	
≥24months	49	28	64	33	
Birth order					
1– 2	72	41	103	54	0.063
3–4	60	35	53	28	
≥5	42	24	36	19	
Primary care giver's level of education					
None	22	12	26	14	0.689
Primary level	113	65	115	60	
Second	36	21	45	23	
Tertiary	3	2	6	3	
Wealth Status					
Upper tercile	52	30	73	38	0.248
Middle tercile	59	34	60	31	
Low tercile	63	36	59	31	

Factors associated with severe children <5 years in a hospital-based case-control study assessing factors associated with severe pneumonia in Kasese District, Uganda

At the bivariate analysis level, , birth order, being in the lowest wealth tercile, not being exclusively breast fed to at least 6 months, and exposure to indoor air pollution through proximity to cooking combustion sources during home cooking with child in the kitchen were associated with having severe

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pneumonia. Seeking care from a VHT reduced the odds of having severe pneumonia. Gender, age group, primary care giver's education, nutrition status, immunisation status, type of fuel used for cooking, and staying with a tobacco smoker in the same house did not have a statistically significant relationship with pneumonia development. Following adjusting, children who were not exclusively breast feed had twice the odds (OR=1.97,95% CI:1.13-3.36) of having severe pneumonia compared to children who were exclusively breast fed for at least 6 months. ; Children with diarrhoea only had 3 times the odds (OR:2.88,95% CI:1.69-4.89) of having severe pneumonia compared to children with no underlying disease at the time of their pneumonia-related diagnosis. Children with malaria and diarrhoea had 3 times the odds (OR:3.41,95% CI:1.98-5.86) of having severe pneumonia compared to children with no underlying disease at the time of their pneumonia-related diagnosis. Children who were exposed to indoor air pollution through proximity to cooking combustion sources during home cooking with child in the kitchen had 2 (OR: 2.89,95% CI:1.77-4.73) times higher odds of developing severe pneumonia.

Table 2: Factors associated with severe children <5 years in a hospital-based case-control study assessing factors associated with severe pneumonia in Kasese District, Uganda

Characteristic	Case	Control	Unadjusted Odds Ratio			Adjusted OR		
	n	n	OR	95% CI	P-value	OR	95% CI	P-value
Birth order								
1-2	72	103	Ref					
3-4	60	53	1.62	1.01-2.61	0.047*	1.55	0.82-2.93	0.176
≥5	42	36	1.67	0.98-2.86	0.062	1.40	0.72-2.70	0.331
Wealth Status								
Upper tercile	52	73	Ref					
Middle tercile	59	60	1.37	0.83-2.27	0.212	1.05	0.56-1.96	0.185
Low tercile	63	59	1.74	1.05-.90	0.032*	1.51	0.82-2.78	0.889
Exclusive breast feeding for at least 6 months								
Yes	50	75	Ref					
No	124	117	1.80	1.13-2.87	0.013*	1.97	1.13-3.46	0.017*
Underlying illness								
None	65	108	Ref					
Malaria only	13	4	0.85	0.49-1.48	0.575	0.99	0.88-1.12	0.937
Diarrhoea only	52	37	2.54	1.63-3.93	<0.001*	2.88	1.69-4.89	<0.001*
Malaria and diarrhoea	44	33	2.76	1.69-4.56	<0.001*	3.41	1.98-5.86	<0.001*
Place of first care								
Health Facility	70	55	Ref					
VHTs	65	102	0.50	0.31-0.80	0.004*	0.78	0.44-1.39	0.404
Home remedies	27	22	0.96	0.50-1.87	0.915	1.33	0.63-2.80	0.449
Exposure to indoor air pollution through proximity to cooking combustion sources during home cooking with child in the kitchen								
Yes	98	79	1.89	1.19-2.98	0.007*	2.89	1.77-4.72	<0.0001*
No	54	76	Ref					

Note: Gender, age-group, primary care giver's education, vaccination status appropriate for age, previous respiratory illness, main source of energy used for cooking and staying in a household with a tobacco smoker were not associated with severe pneumonia at bivariate analysis with p>0.2

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Discussion

We assessed factors associated with severe pneumonia among children <5 years in five high volume health facilities in Kasese District. Our findings indicated that children who were not exclusively breast feeding, having diarrhoea only and diarrhoea and malaria at the pneumonia diagnosis and exposure to indoor air pollution through proximity to cooking combustion sources during home cooking with child in the kitchen were associated with severe pneumonia.

Children who were not exclusively breast fed for at least 6months had twice the odds of developing severe pneumonia compared to those that were exclusively breastfed. This is consistent with a systematic review of studies largely outside the African Region done by Lamberti et al that found that children who were not exclusively breast fed had a 5-fold increased risk in developing severe pneumonia which often requires hospitalisations (15). Breast milk contains Immunoglobulin G (Ig) and Immunoglobulin A (IgA) antibodies which enhance the child's immune system and strengthens defence mechanisms against infectious agents protecting the child from developing severe disease (14,15). Our findings highlight the need for exclusive breast feeding in order to prevent severe pneumonia.

Children with diarrhoea only and malaria or diarrhoea, had higher odds of getting severe pneumonia compared to children with no underlying illness. Previous studies have indicated that malaria predisposes children to bacterial infections of common pneumonia causing organisms such as *Streptococcus Pneumoniae* and *Klebsiella Pneumoniae* often with severe forms of disease(16). Similarly diarrhoea may predispose children to pneumonia(17). Due to their immature immune system, children already suffering from an illness are more likely to suffer from severe illness if they get another coinfection(18).

Children who were exposed to indoor air pollution through proximity to cooking combustion sources during home cooking with child in the kitchen had twice the odds of developing severe pneumonia compared to those who were not. In the study setting, like other parts of Africa solid fuels such as firewood and charcoal are the main source of energy(19). Combustion of wood during cooking releases air pollutants such as $PM_{2.5}$ (20). A previous study conducted in Ugandan kitchens where charcoal and firewood was used indicated $PM_{2.5}$ concentrations higher than the World Health Organization 24-h Air Quality Guideline(21). Under these circumstances, children whose caregivers cook with them often get exposure to these air pollutants. Such exposure compromises their immune response against invading pathogens in the respiratory tract which predisposes them to more severe disease(22).

Other previously documented risk factors for severe pneumonia such as younger age, immunisation status, and health seeking behaviour were not associated with severe pneumonia in our study. This could be attributed to the similar baseline characteristics in terms of age, immunisation status, and health seeking behaviour among cases and controls.

Study limitations

Our findings should be interpreted with the following limitations, to ensure case ascertainment, we selected hospital-based controls. Hospital-based pneumonia cases maybe different from community controls(23). Due to the differences in the diagnostic capacities of the selected health facilities, we did not explore clinical features and causative microorganisms associated with severe pneumonia.

Conclusion

In conclusion, having an underlying illness, not being exclusively breast fed for at least 6 months, and exposure to indoor air pollution through proximity to cooking combustion sources during home cooking with child in the kitchen were associated with developing severe pneumonia. These results can be used to develop tailored interventions in reducing morbidity and mortality due to severe pneumonia.

Conflict of interest

The authors declare that they had no conflict of interest.

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Authors' contribution

MW, RM, KA and KP: Participated in the conception, design, analysis, interpretation of the study and wrote the draft bulletin; RM reviewed the report, reviewed the drafts of the bulletin for intellectual content and made multiple edits to the draft bulletin; RM, DK, BK, LB, and ARA reviewed the bulletin to ensure intellectual content and scientific integrity.

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Predictors of exclusive breastfeeding for six months among HIV-exposed infants in Uganda: Insights from a prospective cohort study, 2017–2019

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Summary

Background: Exclusive breastfeeding is recommended for HIV-exposed infants (HEIs) for six months to lower the risk of mother-to-child HIV transmission and enhance HIV-free survival. We estimated the predictors of exclusive breastfeeding (EBF) for 6 months in mothers receiving routine prevention of mother-to-child HIV transmission (PMTCT) care in Uganda.
Methods: We conducted a secondary analysis of data from a prospective cohort study of Uganda's PMTCT impact evaluation, conducted at 152 randomly selected public and private facilities during 2017-2019. HEIs were defined as infants born to HIV-positive mothers who tested HIV-negative at baseline. Mother-HEI pairs were recruited ≤3 months postpartum and followed at 6, 9, 12, 15, and 18 months. Baseline data included the HEIs' and mothers' HIV status, while follow-up data included infant feeding practices. We excluded HEIs with missing feeding data at 6 months. Multivariate modified Poison regression was used to determine predictors of EBF for six months.
Results: Among 1,527 eligible HEIs, 767 (50%, 95%CI 48-53%) were male, 464 (30%, 95%CI 28 -32%) were exclusively breastfed for six months, and 310 (20%, 95%CI 18-22%) of their mothers received PMTCT services at a level IV health centre (HC) or hospital. Among 1,013 mothers with data on viral suppression, 890 (88%, 95%CI

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86-90%) were virally suppressed at baseline. Of 1,278 mothers with data on HIV disclosure, 205 (16%, 95%CI 14-18%) disclosed their HIV status to their spouses. Having a mother who was virally suppressed (aRR=2.1, 95%CI 1.2-3.8), disclosed her HIV status to her spouse (aRR=1.4, 95%CI 1.0-2.0), and received PMTCT at a HC IV or hospital vs a lower-level health facility (aRR=1.4, 95%CI 1.1-1.9) were associated with increased likelihood of receiving EBF for 6 months among HEIs.
Conclusion: HEI six-month EBF rates were low. Factors that have been previously associated with adherence to ART (viral suppression, disclosing status to spouses) were also associated with EBF for 6 months. Further investigation is needed to understand the reasons for these, as well as the reasons for higher EBF rates among women attending PMTCT at higher-level facilities.

Introduction

Globally, there has been a decrease in new HIV infections among children under five years from 320,000 in 2010 to 160,000 in 2021 [1]. However, this progress fell short of achieving the 2020 targets of fewer than 20,000 new infections set under the super-fast track framework to end AIDS by 2030 [2, 3]. Breastfeeding can be a route of mother-to-child HIV transmission (MTCT) accounting for about a quarter of the overall infant HIV infection rate[4, 5]. However, early cessation of breastfeeding can have detrimental effects on both mothers and infants [6, 7]. Premature weaning poses risks such as infant growth failure and increased HIV transmission during this vulnerable period. On the other hand, exclusive breastfeeding (EBF) for up to six months has been shown to reduce the risk of postpartum HIV transmission to HIV-exposed infants (HEIs) and increase HIV-free survival rates [4, 8-10]. Non-adherence to EBF poses a more than doubled risk of postpartum HIV transmission to the HEI [11-13]. For instance, in a study done in Cameroon, infants on mixed feeding had a 7- fold higher rate of HIV vertical transmission at 24 months compared to those on EBF, while infants on exclusive replacement feeding had a 1.5-fold higher transmission rates compared to those who had breastfeeding [14]. Breastfeeding is the optimal method of feeding infants, particularly in low-income countries, supporting their growth, development, and overall survival [15, 16]. Breastfeeding (EBF) provides vital protection against life-threatening conditions such as Pneumonia, Diarrhoea, and Malnutrition as breast milk contains anti-infective whey proteins[8, 16-19]. The World Health Organization (WHO) guidelines from 2016 recommend that mothers living with HIV, who consistently take antiretroviral therapy (ART), exclusively breastfeed their infants for the first 6 months and introduce complementary feeding while continuing to breastfeed until 12 months. These recommendations remain unchanged, even in situations where access to ART drugs may be uncertain, such as during acute emergencies, as it contributes to increased survival [8]. The Uganda 2010 national guidelines for prevention of mother to child transmission of HIV (PMTCT) and Infant Feeding in the Context of HIV recommended Mothers to exclusively breastfeeding until 6 months of age, and continue breastfeeding while introducing complementary feeds until 12 months of age[19-21]. Despite these guidelines, non-adherence to EBF has been reported among HIV-exposed infants (HEIs), particularly in developing countries [22-26]. Few studies have been done in Uganda to assess the predictors for EBF for 6 months among HEIs. We assessed the prevalence and predictors of exclusive breastfeeding up to 6 months among HIV exposed infants at routine PMTCT sites in Uganda: 2017-2019 to inform control and prevention interventions.

Methods

Study design, setting, and data source

We conducted a secondary analysis of data from a prospective cohort study of Uganda's PMTCT impact evaluation, conducted at 152 randomly selected public and private facilities during 2017-2019 [27].

In the baseline study conducted between September 2017 and March 2018, infants aged 4 to 12 weeks and their caregivers at selected healthcare facilities were enrolled. Participants were excluded if critically ill, caregivers were <18, or they declined infant HIV testing. Maternal HIV status was confirmed by documented ART use (e.g., ANC card, mother's medical record, infant's health card) or positive antibody test following the Ministry of Health national testing algorithm. Viral load tests were conducted for HIV-positive mothers. Infants were screened for HIV-1/2 antibodies using finger stick whole blood to determine maternal HIV status as well as infant HIV exposure status if the infant was accompanied by a caregiver. Confirmatory polymerase chain reaction (PCR) using Cobas Ampliprep/Taqman HIV-1 Qualitative Test Version 2.0 was performed for reactive infant results using dry blood. HIV negative infants and

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their HIV positive mothers were enrolled in the follow up study. HIV-positive infants were connected to ART care and excluded from the prospective study.

The prospective study had two cohorts. Cohort I: HIV-positive mothers with HIV-negative infants from the baseline study, and Cohort II: HIV-negative mothers with HIV-negative infants. Follow-up visits for both occurred at 6, 9, 12, 15, and 18 months postpartum, with ±6 weeks flexibility. Cohort I additionally tracked infant HIV prophylaxis and maternal ART. All infants were assessed for HIV, <18 months via PCR and ≥18 months with on-site antibody testing. Cohort I mothers had viral load tests at 6- and 12-month visits. Follow- up visits for Cohort I focused on infant-related questions only including the infants feeding options measured as Exclusive breastfeeding (EBF), exclusive replacement feeding (ERF), and mixed feeding (MF). EBF was defined as breastfeeding with no added supplements except vitamins; ERF was defined as the administration of commercial formula feeding using bottles; and MF was described as a combination of both breastfeeding and formula feeding practices. At each visit, mothers in cohort II were screened for new HIV infection using on-site rapid antibody testing, following the MoH algorithm. If during follow-up visits, a mother in cohort II was identified as having HIV infection, the mother-infant pair became part of cohort I. However, by 6 months of follow up, we did not have any mother cross-over from cohort II to cohort 1.

Tests were performed at the Central Public Health Laboratory in Kampala. Infants of mothers with HIV were tested for presence of HIV RNA by PCR using COBAS Ampli Prep/TaqManHIV-1 Qualitative assay, version 2.0 (Roche Diagnostics, Branchburg, New Jersey) utilizing infant dried blood samples (iDBS) on Guthrie cards. All first positive or indeterminate results were confirmed by a second PCR test (Amplicor HIV-1 DNA, version 1.5, Roche Diagnostics). For maternal viral load measurement, maternal dried blood spots (mDBS) on Guthrie cards were tested using the Abbott real-time 1.0ml HIV RNA DBS version 2.00 protocol. Left over iDBS and mDBS were stored at -80℃ at Central Public Health Laboratory after testing.

Study variables and data abstraction

In this analysis, we abstracted data on Mother Infant pairs from cohort 1 defined as infants who were HIV negative and born to HIV infected mother at baseline. All HEIs in cohort I were eligible for the analysis. HEIs whose feeding information at six months was missing were excluded due to data quality issues.

We abstracted baseline data on predictor variables for EBF for six months. The independent variables at baseline included infant sex, infant age, infant birthweight, nevirapine prophylaxis, mother's age, mother's status, mother's education level, other's viral suppression, mother's HIV disclosure to spouse, mother's use of alcohol during pregnancy, ANC booking, mother's HIV diagnosis in relation to 1st ANC visit, number of ANC visits, delivery place, birth attendant, prophylaxis, initiation of breast feeding, and Level of PMTCT facility, nevirapine.

We also abstracted 6-month follow up data on the outcome variable. The outcome variable was exclusive breastfeeding for six months defined as infants breastfed at baseline and at six months.

Statistical analysis

Using descriptive analysis, we computed the proportion of infants who received exclusive breastfeeding for 6 six months as the proportion of total HEIs (denominator) that were exclusively breastfed for six months (numerator). Multivariate modified poison regression was used to estimate unadjusted and adjusted risk ratios, adjusting for potential confounders that would cause a significant difference in the risk ratios. To generate the model, we performed a backward stepwise elimination at $p>0.05$. All statistical tests were performed at 5% level of significance. The model was a good fit for the data. All statistical analyses were performed using STATA® version 14 (Stata Corp LP, Texas, USA).

Ethical approval

The impact evaluation study obtained clearance from the ethical review boards of the Uganda Virus Research Institute (UVRI), Research Ethics Committee (FWA No.00001354), and the U.S. Centers for Disease Control and Prevention (CDC) Atlanta. It was cleared and registered by the Uganda National Council for Science and Technology (FWA No. 00001293). The secondary analysis was determined to be non-research by the Office of the Associate Director for Science at the CDC because the project did not involve collection of primary data from human subjects' research. The project was aimed at addressing a public health problem. In addition, we obtained permission from the Ministry of Health, Kampala, Uganda to access and utilize the data. Data accessed did not have personal identifiers.

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Results

Demographic and clinical characteristics of HIV exposed infants and their mothers

Out of 17,520 infants enrolled in the impact evaluation study, 799 were excluded due to missing information on HIV exposure status at baseline. 1804 HEIs from cohort I were screened for eligibility and further 277 were excluded due to missing information on feeding at 6 months. 1,527 HIV-exposed infants (HEIs) were included in the analysis.
Out 1,523 HEIs with data on sex, 767 (50.4% 95% CI 47.8%-52.9%) were male. Out of 1,013 mothers with data on viral suppression, 890 (87.9% 95% CI 85.7%-89.7%) achieved viral suppression at baseline. Out of 1,278 mothers with data on HIV disclosure, 205 (16% 95%CI 14.1%-18.2%) disclosed their HIV status to their spouses. Out of 1527 mothers, 310(20.3% 95% CI18.4%-22.4%) received PMTCT services at HC IV or hospital.

Proportion of HIV exposed infants that received exclusive breastfeeding for six months, Uganda, 2017–2019

Out of 1,527 HEIs, 464(30.4%, 95% CI 28.1-32.8%) were exclusively breastfed for 6 months, 1,012 (66.3%, 95% CI 63.8-68.6%) were on mixed feeding, and 51 (3.3%, 95% CI 2.8-4.4%) were on exclusive replacement feeding.

Predictors of exclusive breast feeding for 6 months among HIV-exposed infants in Uganda, 2017–2019

At bivariate analysis, mothers who were virally suppressed at baseline, and mothers who attended PMTCT at HC IV or hospital were more likely to exclusively breast feed their HEIs for six months. Alcohol use during pregnancy, HIV disclosure, skilled birth attendant, mother's age, education level, marital status, ANC booking, number of ANC visits, place of delivery, birth weight, nevirapine prophylaxis, and initiation of breast feeding within 1 hour were not associated with EBF for six months.

In multivariate analysis, HEIs whose mothers had viral suppression at baseline (aRR=1.8, 95% CI 1.1-2.9) were more likely to be exclusively breastfed up to six months compared to those whose mothers were not virally suppressed. HEIs born to mothers who attended PMTCT at HC IV or hospital (aRR=1.4, 95% CI 1.1-1.9), were more likely to be exclusively breastfed for 6 months compared to those whose mothers attended PMTCT at a HC II or private clinic. HEIs born to mothers who disclosed their HIV status to their spouses (aRR=1.4, 95% CI 1.0-2.0) were more likely to be exclusively breastfed for 6-months compared to those whose mothers did not disclose the HIV status to their spouses. Not using alcohol during pregnancy cofounded on the on the association between VL suppression and EBF for 6-months and the HEI's birthweight equal to or more than 2.5 kg cofounded on the on the association between VL suppression and EBF for 6-months (Table 1).

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Table 1: Bivariate and multivariate analysis for predictors of exclusive breastfeeding for 6 months among HIV exposed infants, Uganda, 2017-2019

	EBF for 6-months, N=464		No EBF for 6-months, N=1,063					
Variable	**n**	**(%)**	**n**	**(%)**	**cRR**	**(95%CI)**	**aRR***	**95%CI**
Mother's Viral Load								
Not suppressed	23	(7.6)	100	(14.0)	1.0		1.0	
Suppressed	279	(92.4)	796	(86.9)	1.6	(1.1-2.4)	1.8	(1.1-2.9)
PMTCT facility level								
II or Private clinic	198	(42.7)	451	(42.4)	1.0		1.0	
III	146	(31.5)	422	(39.7)	0.8	(0.7-1.0)		
IV or Hospital	120	(25.8)	190	(17.8)	1.3	(1.0-1.6)	1.4	(1.1-1.9)
Alcohol use								
Yes	36	(8.3)	88	(9.2)	1.0		1.0	
No	398	(91.7)	870	(90.8)	1.1	(0.8-1.5)	1.1	(1.1-1.9)
Disclosure to partner								
No	322	(83.0)	751	(84.4)	1.0		1.0	
Yes	66	(17.0)	139	(15.6)	1.1	(0.8-1.4)	1.4	(1.0-2.0)
Skilled birth attendant								
No	30	(9.0)	101	(7.6)	1.0			
Yes	303	(91.0)	676	(87.0)	1.4	(0.9-2.0)		
Age of mother (years)								
15-24	141	(30.5)	319	(30.3)	1.0			
≥25	321	(69.5)	735	(69.7)	0.99	(0.8-1.2)		
Marital status								
Never married	51	(11.5)	107	(10.7)	1.0			
Cohabiting	46	(10.4)	110	(11.0)	0.91	(0.6-1.4)		
Married	347	(78.2)	779	(78.2)	0.95	(0.7-1.3)		
Education level								
None	48	(10.3)	141	(13.3)	1.0			
Primary	297	(64.0)	696	(65.5)	1.2	(0.9-1.6)		
Secondary	119	(25.7)	226	(21.3)	1.4	(0.97-1.9)		
ANC booking								
Late	286	(67.8)	629	(65.9)	1.0			
Early	136	(32.2)	326	(34.1)	0.9	(0.8-1.2)		
ANC visits								
1-3	171	(40.6)	342	(36.1)	1.0			
≥4	250	(59.4)	606	(63.9)	0.9	(0.7-1.1)		
Place of delivery								
Home	39	(8.6)	131	(12.7)	1.0			
Private clinic	86	(19.0)	220	(21.3)	1.2	(0.8-1.8)		
Public facility	327	(72.4)	680	(66.0)	1.4	(1.0-2.0)		
Child's gender								
Male	223	(48.2)	544	(51.3)	1.0			
Female	240	(51.8)	516	(48.7)	1.1	(0.9-1.3)		
Birth weight (kg)								
<2.5	27	(8.2)	55	(7.2)	1.0			
≥2.5	304	(91.8)	710	(92.8)	0.9	(0.6-1.4)		
Infant number								
>1	2	(0.4)	15	(1.4)	1.0			
1	462	(99.6)	1048	(98.6)	2.6	(0.6-10.4)		
Nevirapine at birth								
No	47	(14.2)	116	(14.9)	1.0			
Yes	285	(85.8)	664	(85.1)	1.0	(0.8-1.4)		
Initiation of BF								
>1 hour	106	(35.8)	116	(14.9)	1.0			
Within 1 hour	190	(64.2)	664	(85.1)	1.0	(0.8-1.4)		

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cRR: crude Risk Ratio, aRR: adjusted Risk Ratio, EBF: Exclusive breastfeeding, BF: breastfeeding, ANC: antenatal care, PMTCT: prevention of mother to child HIV transmission *adjusted for birthweight of infant and use of alcohol during pregnancy

Discussion

This study estimated the prevalence of EBF at 6 months and assessed predictors for exclusive breast feeding for 6 months among HEIs at routine PMTCT sites in Uganda. The EBF rate among HEIs was 30%. Mothers virally suppressed at baseline, disclosed their HIV status to their spouses, and attended PMTCT at higher level health facilities were more likely to exclusively breastfeed for 6 months. The infant's birthweight equal or greater than 2.5 kg confounded on the association between VL suppression and EBF up to 6-months and disclosure and EBF up to 6-months. Not using alcohol during pregnancy confounded on the association between VL suppression and EBF up to 6-months.

The prevalence of EBF at 6 months was 30%. This is comparable to 43% EBF at 14 weeks reported in Northern Uganda [28], and the 32% prevalence of EBF at 6 months among HEIs in south Africa [29]. Another study in Western Uganda reported 29% of HIV positive mothers adhering with the recommended infant feeding practices[30]. However, the prevalence we found is twice lower than the 65% prevalence reported in Western Kenya [31] and three times lower than the 88% prevalence of EBF among HEI reported in Ethiopia[32]. The difference could be due to the differences in the study designs. The study in western Kenya and Northern Ethiopia were cross-sectional studies and mothers were requested to do a self-report for the periods they did exclusive breastfeeding while this was a prospective study design with 3-monthly follow-up. The 30% prevalence is low and the remaining close to three quarters of HEIs on non-exclusive breastfeeding especially MF up to 6 months could be exposed to killer child hood illness of pneumonia, diarrhoea, and malnutrition and could affect the survival of HEIs in Uganda [8, 16-18].

Mothers who were virally suppressed had 80% higher chances of exclusively breastfeeding HEIs for 6 months compared to mothers who were not virally suppressed. This finding agrees with findings reported in northern Uganda where HIV positive mothers who adhered to ART during pregnancy were more likely to exclusively breastfeed up to 14 weeks [28]. Further, the findings agree with another study in rural Tanzania [33]. This finding suggests that effective HIV treatment and viral suppression play a role in EBF for 6 months.

Mothers who disclosed their HIV status to their partners had 40% higher chances of exclusively breastfeed for 6 months compared to mothers who did not disclose. This is similar to findings in Ethiopia where HIV positive mothers who disclosed to their spouses were more likely to exclusively breastfeed their HEIs for 6 months[24, 25]. The mother's HIV disclosure to the partner could support the mother to minimize stigma of EBF reported among mothers[34, 35]. This suggests that open communication and support within the family may contribute to the successful practice of EBF.

Mothers who attended PMTCT at a higher-level health facility had 40% higher chances of exclusively breastfeed for 6 months compared to mothers who attended at level II or private facilities. This could be possibly explained by the comprehensive PMTCT package provided at higher level health facilities. This suggests that the quality of healthcare services and counseling at these facilities may positively influence EBF practices.

The birthweight equal to 2.5kg or more confounded on the association between disclosure and EBF and on the association between VL suppression and EBF. This is possibly due to the infant's health and feeding capabilities of low birthweight babies. This is supported by finding from other studies elsewhere that reported higher birthweight being associated with EBF of HEIs up to 6-months [36-38]. There are no recent studies showing relation between Viral suppression and infant birthweight. However, earlier studies reported low birthweight less than 2.5 kg as a complication of non-adherence with high viral load and poor CD4 response during pregnancy[39].

Not using alcohol during pregnancy confounded on the association between VL suppression and EBF up to 6-months. Studies elsewhere have reported use of alcohol were less likely to breast feed exclusively for 6 months[29, 40-43]. Studies have also reported the use of alcohol being associated with missing antiretroviral drugs which could result in non-viral suppression[44]. This indicates that alcohol consumption during pregnancy may be a factor affecting EBF practices among HIV-positive mothers. Therefore, efforts need to be intensified to support HIV positive mothers to abstain from using alcohol during and after pregnancy to improve their feeding practices.

Study limitations

Out of the 17,520 infants enrolled in the impact evaluation, screened for eligibility, 799 (6.9%)

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were excluded due to missing information on HIV exposure status and further 277/1804 (15%) were excluded due to missing information on feeding option at 6 months. This exclusion may have led to a potential underestimation of the observed effect.

Conclusion

HEI six-month EBF rates were low. Factors that have been previously associated with adherence to ART (viral suppression, disclosing status to spouses) were also associated with EBF for 6 months. In addition, mothers attending PMTCT at higher level health facilities were more likely to do EBF for the HEIs. Further investigation is needed to understand the reasons for these, as well as the reasons for higher EBF rates among women attending PMTCT at higher-level facilities.

Conflict of interests

The authors declare that they have no conflict of interests.

Authors' contributions

PCK developed the study concept, participated in its design, analysis, interpretation of the study and drafting of the bulletin. RA, and LN participated in design, analysis, interpretation, and review of the bulletin. TL, and BSN participated in the analysis, interpretation, and review of the bulletin. RM, BK, DK, LB, PM, and ARA participated in the interpretation and review of the bulletin to ensure intellectual content and scientific rigor. All authors read and approved the final bulletin.

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Increasing stock outs of critical malaria commodities in public health facilities in Uganda, 2017-2022

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Summary

Background: Consistent access to malaria treatment commodities at health facilities is necessary to address malaria morbidity and mortality. In Uganda, there needs to be documentation of the trends of stock outs of these commodities. We described the trends and spatial distribution of stock outs of malaria diagnostic and treatment commodities in Uganda, 2017-2022.

Methods: We analyzed monthly artemisinin combination therapy (ACT) and rapid diagnostic test (RDT) stock data from the District Health Information System (DHIS2) for public facilities at the general hospital level and below during 2017-2022. A facility was considered stocked out in a month if it reported ≥1 day of stock out of a commodity during that month. We calculated the proportion of facilities stocked out of ACT and RDTs per month and evaluated ACT stock outs by health facility type. We used the seasonal Mann-Kendall test and Sen's slope estimator to evaluate trends. Districts were considered stocked out for a commodity in a year if the average monthly health facility stock out proportions were >10% in that year.

Results: Among an average of 2,210 facilities reporting per month (range, 1,341-2,791), most (56%) were Health Centre IIs. There were seasonal peaks in stock outs of ACTs and RDTs, with small peaks in December through February and sharp peaks in June through September. At the national level, we observed a significant increase in the monthly ACT ($S'=474$, $p<0.001$; Sen's slope=+0.59) and RDT ($S'=444$, $p<0.001$; Sen's slope=+0.616) stock outs over the study

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period. Monthly ACT stock outs increased significantly across all facility levels, with Health Centre IIs having the largest increase (S'=472, p<0.001; Sen's slope=+0.697) while general hospitals reported the smallest increase (S'=198, p=0.026; Sen's slope=+0.201). Among 136 districts, the number of districts experiencing ACT stock outs increased steadily, from 5 in 2017 to 85 in 2022.

Conclusion: Malaria diagnosis and treatment commodity stock outs increased from 2017-2022 across Uganda. Reasons for this increasing trend should be explored and addressed to improve access to essential malaria treatment commodities.

Background

Uganda has made tremendous progress in malaria control in recent years, with significant reductions in morbidity and mortality over the last decade, malaria parasite prevalence dropping from 45% in 2009 to 9% in 2019[1, 2]. Despite these reductions, malaria remains one of the leading causes of morbidity and mortality in Uganda[3], accounting for 5% of all global malaria cases in 2021 and 3.2% of all reported deaths in the same year[4].

The Uganda National Malaria Control Program (NMCP) is charged with providing quality assured services for Malaria prevention and treatment to all people in Uganda. The program aims to reduce malaria morbidity by 50% and malaria-related mortality by 75% by 2025 compared to 2019 levels of 11 million reported cases and 12,000 recorded deaths2019 [5]. To accomplish this, a combination of prevention and treatment interventions are intensively implemented. These include prompt and effective case management, nationwide distribution of long-lasting insecticide-treated bed nets (LLINs), indoor residual spraying (IRS), seasonal malaria chemoprevention, and intermittent malaria prevention during pregnancy. The presence of a consistent, reliable, and sufficient supply of malaria commodities when and where they are required is critical to achieve malaria control; NMCP aims to have at least 90% of all facilities reporting no stock outs of antimalarial commodities at any given time[5].

Stock-outs, on the other hand, are frequently reported across the country. According to the weekly national malaria bulletins, >10% of all districts have insufficient artemisinin Combination Therapy (ACTs) and rapid diagnostic tests (RDTs) each week to last them until the next resupply, putting them at risk of stock-out. These stock-outs are caused by a number of factors that include; irregular pattern of supply due to complex bureaucratic processes, illegal commodity diversion, inaccurate quantifications, and insufficient financing[6-8]. The stock-outs limit access to effective malaria treatment contributing to inappropriate care, poor adherence to prescribed regimes since the patients have to incur an out-of-pocket expense to buy stocked out medicines, poor healthcare utilization increasing morbidity and, possibly, mortality[8-10].

While stock status was regularly monitored, providing a snapshot of the stock situation, there had been no documentation on the trends of stock-out of vital malaria commodities. This information, on the other hand, was critical for informing the Ministry of Health about progress in improving access to essential commodities and generating innovative ways to manage antimalarial commodity stock. We described the trends and spatial distribution of stock outs of malaria diagnosis and treatment commodities in Uganda, 2017-2022.

Methods

Study design and setting

We conducted a descriptive analysis of national surveillance data for Health facility level reports on stock outs of malaria commodities. As of 2018, Uganda had approximately 6,900 health facilities of which close to half of them were government owned, a third were private not for profit, and the rest were private or community owned. The health system is divided into levels with health facilities designated as health centre level two (HC 2) to health centre level four (HC 4); general hospital, regional referral hospital, and national referral hospital. The largest proportion of healthy facilities in Uganda are HC 2s[11]. The commodity supply

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chain at these facilities is divided into two levels: (i) push supply chain strategy at HC 2 and 3, in which commodities are calculated once a year based on various quantification methods like disease morbidity and consumption; constant supply kit sizes customized to these facilities and dispatched every 2 months with no room for adjustment and (ii) pull strategy utilized at HC 4 and general hospitals that offers a quarter basis quantification plan[12, 13]. This analysis involved government owned facilities from general hospitals and below that are non-autonomous in regards to medical commodities acquisition; all with capacity to test and treat malaria.

Study variables, data sources, data abstraction, and analysis

We used malaria commodities surveillance data (ACT and RDTs) obtained from the District Health Information System (DHIS2) for the period of 2017 -2022. Artemisinin combination therapy and rapid diagnostic test stock out data are captured on a monthly basis using the Health Management Information System (HMIS) form 105 and entered into DHIS2, a web-based reporting system. These monthly data were extracted and summarized. We specifically abstracted monthly data from HMIS 105 105-SS01b. artemether/lumefantrine-days out of stock and 105-SS11b. malaria rapid diagnostic tests-days out of stock during 2017-2022 for every reporting public health facility from general hospital level and below. We summarized the data in Microsoft excel sheets and exported to Stata V.14 for analysis. The data was aggregated into health facility level, districts, regions, and national levels. A facility was classified as stocked out in a month if it reported ≥1 day of stock out of a commodity during that month. Analysis of stock out data was done primarily on a monthly basis to check for seasonality given that malaria is a seasonal disease. The proportion of facilities classified as stocked out per month was calculated by dividing the total number of health facilities at that level reporting as stocked out of a malaria commodity per month by the total number of health facilities at that level reporting that month. The health facility monthly stock out proportions were then averaged over a particular year to calculate the yearly stock out proportions for both RDTs and ACTs for that year at national level. A seasonal Mann-Kendal test for trends Sen's slope estimator were used to determine the significance of stock out trends. Since ACT and RDT stock out data followed a similar trend, we focused on ACT stock outs for secondary analysis by health facility type and examined it's spatial distribution by district and region as they are critical for case management. **Dist**ricts and regions were classified as stocked out for a commodity in a year if the average monthly health facility stock out proportions were >10% in that year with reference to the Malaria Strategic Plan 2021-2025 target of <10% of all facilities in an organization unit reporting stock outs at any one point in time[5]. We drew choropleth maps using QGIS to show this stock out distribution.

Ethical considerations

Our study utilized routinely generated aggregated surveillance data with no personal identifiers in health facility monthly reports, obtained from the DHIS-2. The Uganda Public Health Fellowship Program is part of the National Rapid Response Team, and has been granted permission to access and analyse surveillance data in the DHIS-2 and other data such as survey and field investigation data to inform decision making in the control and prevention of outbreaks and public health programming. Additionally, the MOH has also granted the program permission to disseminate the information through scientific publications. We stored the abstracted data set in a password-protected computer and only shared it with the investigation team. In addition, the Office of the Associate Director for Science, U.S. Centers for Disease Control and Prevention, determined that this study was not a human subjects research with the primary intent of improving use of surveillance data to guide public health planning and practice.

This activity was reviewed by CDC and was conducted consistent with applicable federal law and CDC policy. §
§See e.g., 45 C.F.R. part 46, 21 C.F.R. part 56; 42 U.S.C. §241(d);5 U.S.C. §552a; 44 U.S.C. §3501 et seq.

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Results

Trends of artemisinin combination therapy and rapid diagnostic tests stock outs, Uganda, 2017 -2022

Between 2017 and 2022, a total of 159,172 reporting public health facilities (from general hospital downwards) were recorded and included in the analysis. Highest number of reporting facilities were observed in 2022 with 2,505 reporting facilities on average every month and the lowest in 2020 with 1,625 reporting facilities each month.

Monthly visualization of the data showed seasonal peaks in the proportion of facilities reporting stock outs of both commodities, with small peaks in December through February and sharp peaks in June through September, with the highest peaks for ACTs and RDTs recorded in August and September 2021, respectively coinciding with the malaria case peaks around mid every year (Figure 1).

On aggregation into annual data, the proportions of facilities reporting stock outs of ACTs increased steadily over the years peaking in 2022 alongside malaria cases while RDT stock outs peaked in 2021 contrary to the reducing patterns in malaria cases that year (Figure 2). Overall, the proportion of health facilities reporting stock out of both commodities increased significantly over the study period after accounting for seasonality.

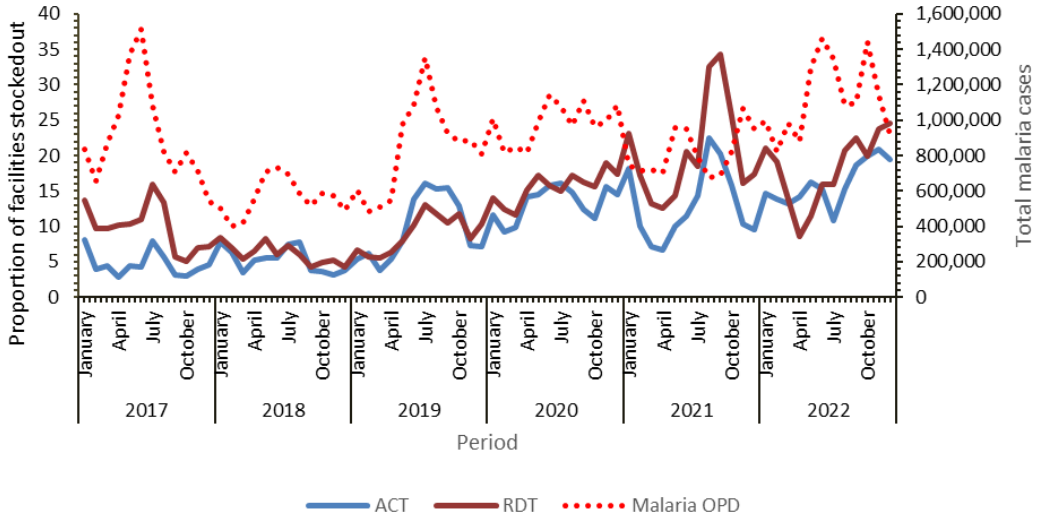

Figure 1: Proportion of public health facilities stocked out for artemisinin combination therapy and rapid diagnostic tests by month, Uganda, 2017-2022

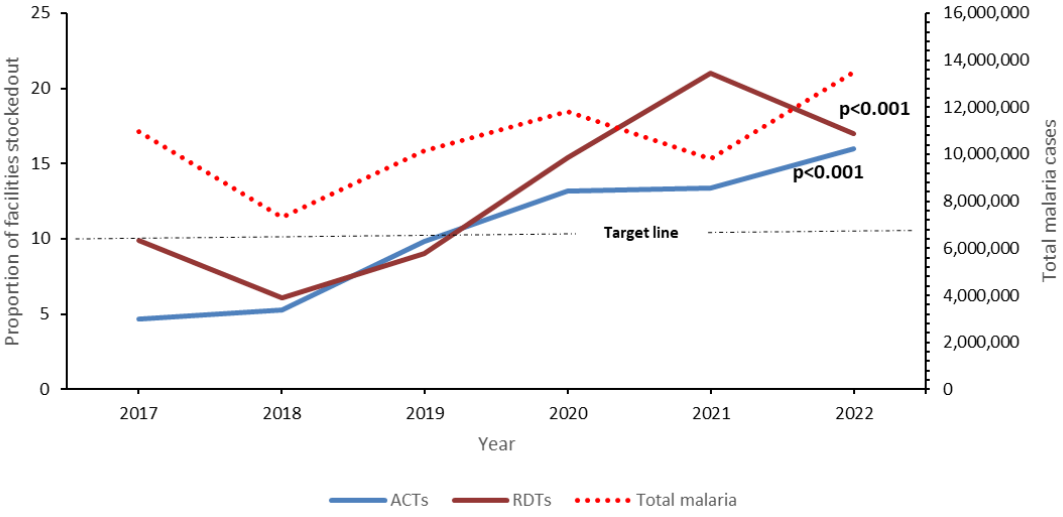

Figure 2: Proportion of public health facilities stocked out for artemisinin combination therapy and rapid diagnostic tests by year, Uganda, 2017-2022

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Trends of artemisinin combination therapy stock outs by health facility level, Uganda, 2017-2022

On stratification by health facility level, the majority (56%) of reporting facilities over the study period were health centre 2s. The total of reporting facilities over the six-year period were: i) 88,384 health centre 2s (10,000-17,000 HC 2s reporting each year), ii) 57,198 health centre 3s (7000-11,000 HC 3s each year), iii) 9,765 health centre 4s (1,100-1,800 HC 4s each year), and iv) 2,976 general hospitals (300-500 reporting each year). Overall, the burden of ACT stock outs increased significantly over the six -year study period across all health facility levels. The highest burden and largest increase in ACT stock outs were recorded among health centre 2s (Figure 3).

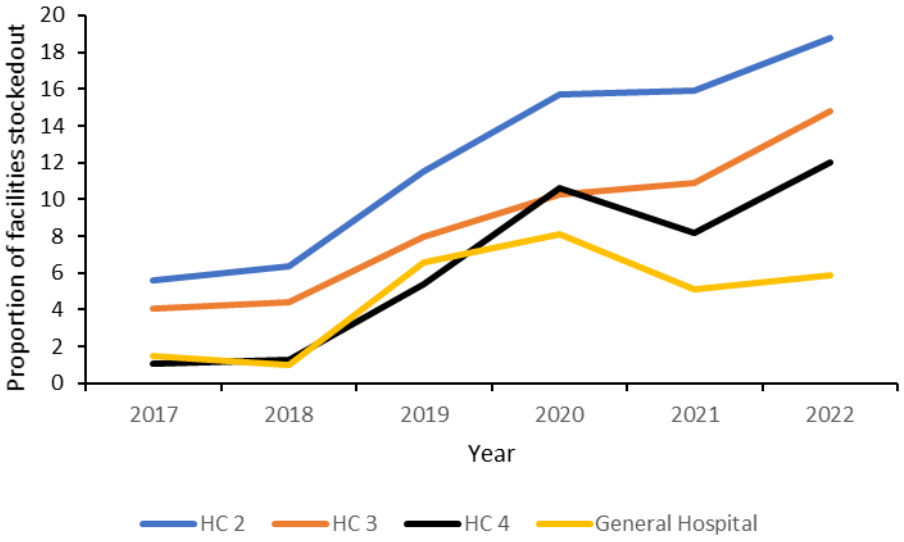

Figure 3: Proportion of public health facilities stocked out for artemisinin combination therapy by health facility level, Uganda, 2017 - 2022

Spatial distribution of artemisinin combination therapy stock outs, Uganda, 2017-2022

Distribution of artemisinin combination therapy stock outs by regional level, Uganda, 2017-2022

At regional level, the ACT stock outs were within the target before 2019 when 4 regions reported a burden >10% after which, Busoga and North Central regions consistently recorded >10% of their facilities with stock outs (Figure 4).

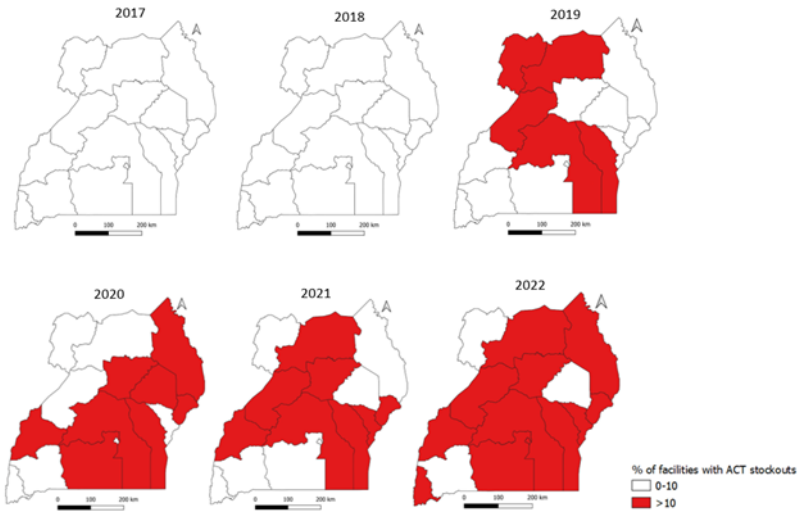

Figure 4: Spatial distribution of artemisinin combination therapy stock outs by region, Uganda, 2017-2022

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Distribution of artemisinin combination therapy stock outs by district level, Uganda, 2017-2022

The burden of ACT stock out at district level increased over the years from 5 districts reporting a burden greater than 10% in 2017 to 85 in 2022. Stock outs were reported in the northern and eastern parts of the country in 2017 and 2018 before spreading to all regions in the country in the subsequent years (Figure 5).

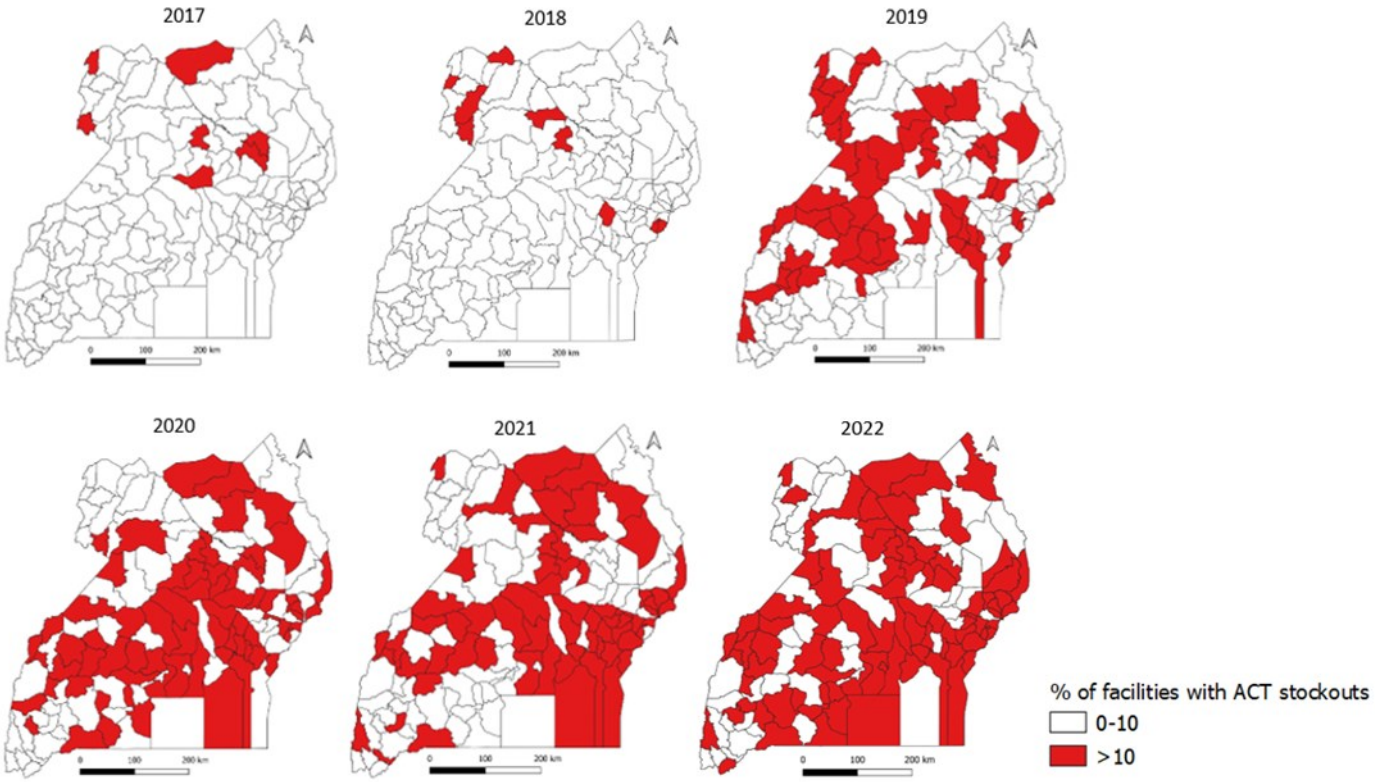

Figure 5: Spatial distribution of artemisinin combination therapy stock outs by district level, Uganda, 2017-2022

Discussion

This descriptive analysis of surveillance data evaluated the stock out of malaria diagnosis and treatment commodities over a period of six years and found that stock outs of malaria commodities was common and increased significantly over the study period. As of 2022, 16 in every 100 facilities reported stock out of ACTs and 18 in 100 facilities experienced stock out of RDTs. This is much higher than the Malaria Strategic Plan 2021-2025 target of <10% of all facilities reporting stock outs of malaria commodities at any one time. ACT stock outs burden was highest among HC 2s translating into a higher burden for facilities under the push supply chain strategy. Among 136 districts, the number of districts experiencing ACT stock outs increased steadily, from 5 in 2017 to 85 in 2022. Given that malaria case management (diagnosis and effective treatment) is a key element in malaria control, these findings highlight the need to improve malaria commodity supply and availability at all facilities if we are to meet the country's targets of reducing malaria morbidity and mortality.

Stock outs of all medicines are common in Uganda due to various systemic factors like poor planning, prioritization and forecasting of required medicines at facilities, ineffective supervision, polypharmacy tendencies, inadequate data management and monitoring systems that are compounded by distribution barriers[14, 15]. Distribution of medicines to public health facilities in Uganda is mandated to the National Medical Stores (NMS) that has a 2-month cycle plan for distribution. However, challenges are faced along this distribution cycle with facilities missing 2-3 cycles of supply due to delays in release of distribution funds as highlighted by the NMS spokesperson during a phone interview in February 2023

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"…the delays in the distribution of medicines ... have largely been as a result of lack of timely payment of funds for distribution" [16]. These distribution barriers are similar as faced in other low and middle-income countries as highlighted as the most cited reason for stock outs in a systematic review evaluating stock outs of essential medicines among community health workers [8]. Aside from distribution delays, the supply chain faces other major issues such as commodity theft within facilities, which could contribute to rampant stock outs as reported in a 2023 study evaluating organized theft of medicines in the EU and beyond[17] Similarly, theft of medicines has severally been recorded in Uganda with most recent occurrence reported in one of the government health facilities in which a health worker was arrested while in possession of government drugs, including malaria test kits (RDTs)[18]. This could explain the noticed discrepancies in peaking of RDT stock outs while malaria cases went down.

From this analysis, stock outs of malaria diagnosis and treatment commodities increased over the years. However, these increases were not uniform with noticeable sharp increases between 2018-2019 and 2019-2021. Between 2018 and 2019, we notice a 4.5 and 2.9 absolute difference in proportion of facilities reporting stock out of ACTs and RDTs respectively. This could be explained by the increased diagnosis and treatment needs following the observed sharp rise in diagnosed malaria cases in 2019 as reported in other Ugandan studies [19, 20]. These studies attributed these increases to changes in the existing malaria control measures at the time: i) waning off of IRS effects in some districts where the intervention had been discontinued in 2017 leading to 5-fold increase in malaria incidence relative to the baseline within 10 months of stopping IRS and ii) ageing of mosquito nets distributed in 2017/2018 [19, 20]. Mosquito net wear and tear is thought to start within one year of net distribution contributing to the increase in malaria cases in 2019; a year after the mass mosquito net campaign. A study conducted in western Uganda reported 33.7% of distributed nets having holes a year after distribution and 77.4% after 36-42 months of use[21]. It is therefore, no surprise that malaria diagnosis and treatment commodities followed a similar trend that year; increased case numbers translates into increased testing and treatment needs which might be higher than the projected needs of the country at the time since retrospective data is utilized in projecting commodity needs[13].

Between 2019 and 2021, another sharp rise in stock outs of ACTs and RDTs was recorded. In 2020, Uganda reported her first COVID-19 patient and declared an epidemic of the disease[22]. Due to the unspecificity of COVID-19 causing symptoms similar to malaria; fever, headache, joint pains[23], and Uganda being endemic for malaria, we would expect malaria suspicion to be high and contribute to the overconsumption of RDTs and ACTs leading to frequent stock outs as observed in this study. However, a study by Namuganga et al reported a reduced consumption of RDTs during the pandemic contrary to our findings[24]. This could be due to their study being conducted in a small part of the country compared to our national analysis. Beyond diagnosis, the instigated COVID-19 control measures disrupted the supply chain system globally that affected delivery schedules with facilities experiencing longer lead times attributed to reduced movement of goods and limited ability to manufacture[25, 26]. In Uganda, these measures were reported to have totally disrupted the supply chain system and health care services delivery with personnel and resources being diverted away from priority diseases like malaria[27]. This could have contributed greatly to the noticed increases in stock outs in both commodities.

For malaria prevention and control to be effective, we need to effectively treat all cases and stop transmission. Without the treatment commodities, there is persistent parasitemia in the communities with opportunities for transmission[4]. For this paper, we looked deeper into the stock outs of ACTs on lower levels to further understand the problem. The regional and district trends of stock out of ACTs followed a similar trend as the national picture. The number of regions and districts reporting proportions of stocked out facilities

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greater than 10% increased over the study period. This increase also started to rise in 2019 following the increase in malaria case numbers with highly stocked out regions corresponding to those reporting upsurges in the same year and are known high risk regions: Acholi, Busoga, Bunyoro, North Central, and West Nile[28]. Regardless of no regions reporting stock out greater than 10% in 2017 and 2018, deeper analysis revealed districts within the regions with proportions of stocked out facilities as high as 16% and 31% in those respective years. This highlights the need of conducting lowest unit level analysis in order to understand the problem at hand and instigate appropriate control measure as the aggregated data at higher levels could potentially mask the true extent of the problem.

At facility level, stock outs of ACTs increased at all levels with the largest increase among HC 2s followed by HC 3s. This is contrary to findings from a Ugandan study that found lower stock outs of essential medicines and health supplies among HC 2s compared to higher level facilities [29]. These differences in findings can be explained by the bigger sample size in our study and analysis being done over a longer period of time. In Uganda, majority of the reporting health facilities are at the HC 2 level with the ability to test and treat uncomplicated malaria beyond which a formal referral system is utilized. Following this cascade, since majority of malaria cases are uncomplicated, they are managed at the HC 2 and 3 levels[11]. These two levels are under the push supply chain strategy in which commodities are calculated once a year based on various quantification methods like disease morbidity and consumption[12, 13]. During this quantification process, constant population projections are factored in that might not cater for unforeseen seasonal population changes like refugee migrations and urbanization that could contribute to increased unanticipated stock utilization[30, 31].

Beyond the strategy utilized, the supply chain system in Uganda faces numerous human resource challenges with 10-55% of supply chain positions remaining vacant at all levels of care [32]. The same study reported that lower level facilities experienced more understaffing with a higher turnover of supply chain staff. With limited staffing and no specialized personnel to manage stocks and conduct stock quantification based on the changing disease dynamics, facilities would not be able to adequately quantify their commodity needs. This could explain why we observed higher levels of stock outs among HC 2s compared to other levels.

Study limitations

This study utilized secondary data from DHIS2 a platform mandating monthly reporting from all facilities. However, the analysis revealed a disparity in monthly reporting compliance, signifying an 880 -facility variance between periods characterized by the most and least prolific reporting. This might have led to an underestimate of the level of stock out of malaria commodities.

Conclusion

Malaria diagnosis and treatment commodities stock outs increased over the study period across Uganda. The noticed changes could be attributed to changes in malaria control interventions in the country in 2019 and interruptions in health care services due to COVID-19 starting 2020. Stock outs of ACTs increased across all facility levels, regions and districts. Reasons for the observed increasing trend should be explored and addressed to improve access to essential malaria treatment commodities. We recommend conducting a follow-up study to understand the consumer response to stock outs; this might help explain late health seeking behaviours, self-medication practices, and malaria related mortality.

Conflict of interest

The authors declare that they had no conflict of interest.

Authors' Contributions

JFZ, MGZ, HNN, and RA: Participated in the conception, design, analysis, interpretation of the study and wrote the draft bulletin; RK, RM, and CB reviewed the report, reviewed the drafts of the bulletin for intellectual content and made multiple edits to the draft bulletin; LB, DK, and ARA reviewed the manuscript to ensure intellectual content and scientific integrity.

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Updates

Outbreaks and Events of Public Health Importance responded to by Uganda Public Health Fellowship Program, July-September 2023

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As part of the National Rapid Response Team, the Uganda Public Health Fellowship Program fellows routinely participate in response to public health emergencies including outbreaks and other events of public health importance. The fellows' response is primarily through conducting investigations that data used for generating evidence-based control and prevention interventions. During July-September 2023, the fellows responded to the following outbreaks and events: Food poisoning at a school in Mukono District; Suspected Rotavirus outbreak in a babies' home in Mpigi; Measles outbreak in Bundibugyo; Rift Valley Fever in Nakaseke; Cholera outbreaks in Namayingo and Kayunga Districts; and Deaths in Kyotera.

Training of Trainers for Scientific Communication Writing, Jinja Nile Resort, 11th – 15th Sept 2023

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The Uganda National Institute of Public Health (UNIPH) held a scientific communication Training of Trainers workshop in which nine Uganda Public Health Fellowship Program (PHFP) / Field Epidemiology Track Alumni were trained by CDC Foundation's Pascale Krumm during 11-15 Sept 2023 in Jinja. The event was organized by UNIPH (PHFP and Data Impact Program) with funding from the CDC Foundation.

The aim of the workshop was to produce a pool of competent trainers in scientific communication to support the UNIPH including PHFP in efficient production of scientific products such as manuscripts, conference abstracts, and bulletins among others. Training approaches included lectures, case studies, and teach back sessions with question and answer sessions.

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2nd left, Seated in Black Dress, Pascale Krum, with participants of the Scientific Communication Training of Trainers Workshop

Upcoming events: World Health Awareness Days and International Health Days, October-December 2023

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Introduction

Global public health awareness days raise awareness, publicity, and profile of particular diseases or disease conditions among the general population. Every year, different organizations and communities actively promote and support World Health Days observed globally.

October 01st to 31st- Breast Cancer Awareness Month

The event began in 1985 as a week-long awareness campaign by the American Cancer Society, in partnership with Imperial Chemical Industries. It eventually extended to a month-long event. In 1992, the pink ribbon also came into play. Since then, each year, individuals, businesses, and communities come together to show their support for the many people affected by breast cancer.

To prevent breast cancer, early detection can lead to effective treatment and a positive prognosis. About 90% of patients survive for many years after diagnosis when breast cancer is detected at the early stages. Regular self-breast examination and regular mammograms are also key to early detection. Presenting yourself early for treatment can result in more effective treatment, leading to a reduction in pain and suffering and a significant decrease in the loss of life. This year's Breast Cancer Awareness Month theme is '**Thrive 365'.**

October 03 - Virus Appreciation Day

Viruses are the simplest of all living, gene-bearing life forms, they infect host cells with their genetic material and then reproduce. They are found in humans, plants, bacteria, and other places where they can infect cells, adapt, and change.

Recently, new infectious diseases are foreseen as a major threat to global public health in this century. Most of these are caused by viruses that are able to cross the host species barriers as zoonoses or further establish human-to-human transmission. Environmental and social changes, frequently the result of human activities, combined with the ongoing evolution of viral and microbial variants, have increased the likelihood that emerging infections will continue to appear and possibly increase, emphasizing the need for effective surveillance.

October 15- Global hand washing day

Globally, 3 in 10 people – or 2.3 billion people– do not have access to basic handwashing facilities with water and soap at home, including 670 million people without access to any facility at all. In the least developed countries, more than 6 in 10 people lack basic hand hygiene facilities at home. Keeping hands clean can prevent 1 in 3 diarrheal illnesses and 1 in 5 respiratory infections, such as the common cold or flu.

Global Handwashing Day is a yearly reminder that handwashing with soap and water is one of the best steps we can take to avoid getting sick and spreading disease to others. Global Handwashing Day 2023 is themed "Clean hands are within reach". The full campaign says "Through strong leadership and collective efforts, we can close gaps in access and practice to achieve hand hygiene for all. Everyone has a role to play

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to ensure clean hands are within reach."

October 16- World Food Day

World Food Day takes place annually, on the 16th of October and promotes awareness of hunger and action for the future of food, people, and the planet. Initiated by the Food and Agriculture Organisation of the United Nations (FAO) in 1979, it is one of the most celebrated days of the UN calendar. It is organised to bring awareness to how our changing planet affects food production and distribution as well as examine how agriculture needs to adapt due to climate change, to how migration affects food security. World Food Day activities also provide education to individuals on ways they can change simple daily habits and decisions to make a difference.

World Food Day 2023 will focus on the theme, 'Water is Life, Water is Food. Leave No One Behind'. The theme aims to highlight the critical role of water for life on earth and water as the foundation of our food. It also seeks to raise global awareness about the importance of managing water wisely as rapid population growth, economic development, urbanization, and climate change threaten water availability.

November 03- One Health Day

November 3, 2023, marks the 8th annual One Health Day which is a global campaign that celebrates and brings attention to the need for a One Health approach to address shared health threats at the human-animal-environment interface. A One Health approach addresses a wide range of public health concerns like antimicrobial resistance, environmental health, food safety, mental health, vector-borne diseases, and zoonotic diseases. One Health is a collaborative, multi-sectoral, and transdisciplinary approach — working at the local, regional, national, and global levels.

One Health Day provides an opportunity for experts and the community to join together in One Health education and awareness. Communication, coordination, and collaboration among partners working in animal, human, and environmental health as well as other relevant areas are an essential part of the One Health approach. Working together allows us to have the biggest impact on improving the health for people, animals, plants and our shared environment.

November 12 - World Pneumonia Day

Pneumonia is a disease which impairs the air sacs of the lungs, called "alveoli", resulting in the accumulation of fluid or pus in the air sacs, making breathing difficult. According to the United Nations Children's Fund (UNICEF), every 39 sec a child dies of pneumonia. Pneumonia is the world's biggest infectious killer of children and adults. Whereas it is a preventable and treatable infectious disease, it kills more children than the combined mortality rate caused by AIDS, measles, and malaria.

The theme for this year is "Championing the fight to stop pneumonia" is a clear clarion call for action through advocacy and promoting early detection of the disease through timely diagnosis.

November 18 to 24 - World Antimicrobial Awareness Week / World Antibiotics Awareness Week

Antimicrobial resistance (AMR) or drug resistance occurs when bacteria, viruses, fungi and parasites change over time and no longer respond to medicines, making infections harder to treat and increasing the risk of disease spread, severe illness, and death. As a result of drug resistance, antibiotics and other antimicrobial medicines become ineffective and infections become increasingly difficult or impossible to treat. World AMR Awareness Week (WAAW) is a global campaign that is celebrated annually to improve awareness and understanding of AMR and encourage best practices among the public, One Health stakeholders, and policymakers, who all play a vital role in reducing the further emergence and spread of AMR. This year's theme "Preventing antimicrobial resistance together" encourages multi-sectoral collaborations to strengthen preventive measures addressing AMR.

November 19- World Remembrance Day for Road Victims

Road traffic injuries are now the leading killer of people aged 5-29 years killing almost 1.35 million people annually. The burden is disproportionately borne by pedestrians, cyclists and motorcyclists,

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especially those living in developing countries. World Remembrance Day for Road Victims was started by a charity in the UK in 1993, and in 2005, it was endorsed by the United Nations (UN) as a global day to be observed every third Sunday in November each year. It is a high-profile global event to remember the many millions who have been killed and seriously injured on the world's roads and to acknowledge the suffering of all affected victims, families, and communities.

The day has become an important tool for governments worldwide, and all those whose work involves crash prevention or response to the aftermath of crashes, since it offers the opportunity to demonstrate the huge scale and impact of road deaths and injuries and advocate for urgent intensive action to stop the high death toll.

December 01 - World AIDS Day

World AIDS Day is marked annually on the 1st of December to call for standing in solidarity with the 38 million people living with HIV worldwide and we remember the millions who lost their lives to AIDS. The day is also a reminder to achieve a key promise of the Sustainable Development Goals: to end AIDS as a public health threat by 2030.

First observed in 1988, World AIDS Day is a day to unite to help end HIV and remember those lost to AIDS-related illnesses. This year's theme is "Let communities lead the way" because communities living with, at risk of, or affected by HIV, connect people with person-centred public health services, build trust, innovate, monitor implementation of policies and services, and hold providers accountable.

December 12 - International Universal Health Coverage Day

On 12 December 2012, the UN General Assembly endorsed a resolution urging countries to accelerate progress toward universal health coverage (UHC) – everyone, everywhere should have access to quality, affordable health care – as a key priority for international development. On 12 December 2017, the United Nations proclaimed it an International Universal Health Coverage Day.

International Universal Health Coverage Day aims to raise awareness of the need for strong and resilient health systems and universal health coverage with multi-stakeholder partners to make commitments to help move the world closer to UHC by 2030. The 2023 UHC Day theme is "Health for all: time for action" which is a rallying point for advocates to raise their voices and share the stories of the millions of people still waiting for health, call on leaders to make smarter investments in health and remind the world about the importance of Universal Health Coverage.

December 27- International Day of Epidemic Preparedness

The first-ever International Day of Epidemic Preparedness, held on 27 December 2020, was called for by the United Nations General Assembly to advocate the importance of the prevention of, preparedness for and partnership against epidemics. The COVID-19 pandemic brought to light the need for communities at local, national, and global levels to have systems in place to effectively deal with epidemics when they occur but to also work towards preventing future epidemics.

The WHO works closely with governments to support efforts to build strong emergency and epidemic preparedness systems. Global health crises threaten to overwhelm already overstretched health systems, disrupt global supply chains and cause disproportionate devastation of the livelihoods of people, including women and children, and the economies of the poorest and most vulnerable countries.

There is need to raise awareness, exchange information, scientific knowledge, best practices, quality education, and advocacy programmes on epidemics at the local, national, regional, and global levels as effective measures to prevent and respond to epidemics.

End