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July – September, 2021

Dear Reader,

We take great pleasure in welcoming you to Issue 3, Volume 6 of the Uganda National Institute of Public Health (UNIPH) Quarterly Epidemiological Bulletin (UQEB).

We aim to inform the district, national, and global stakeholders 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; COVID-19 cluster in Omoro, an outbreak of Rift Valley Fever in Kiruhura, incidence and spatial distribution of bacterial meningitis, and trends and distribution of malaria deaths in Uganda.

Should you have any questions or require additional information related to articles in this bulletin please contact us on: akomakech@musph.ac.ug, sahirirwe@musph.ac.ug, selayeete@musph.ac.ug, ssenyange@musph.ac.ug, OR lbulage@musph.ac.ug

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

Thank you

Inside this issue:

UPCOMING EVENTS

Upcoming Public Health Events, Nationally and Globally, October-December, 2021

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Summary

The numerous international days, weeks and months are observed globally in the field of health to raise awareness of specific health matters of public health concern. The following national and global health awareness days will be celebrated in the next quarter October-December, 2021.

World Breast Cancer Awareness Month October, 1-30

In 2020, there were 2.3 million women diagnosed with breast cancer and 685 000 deaths globally. As of the end of 2020, there were 7.8 million women alive who were diagnosed with breast cancer in the past 5 years, making it the world's most prevalent cancer. October is Breast Cancer Awareness Month (BCAM), an annual campaign to raise awareness about the impact of breast cancer. This year's BCAM theme focuses on "**Teaming up**" with one another because no one should fight cancer alone.

World Mental Health Day October, 10

Many people with mental illness do not receive the treatment that they deserve and together with their families and care givers continue to experience stigma and discrimination. World Mental Health Day 2021 will be commemorated on 10, October with the theme: **'Mental Health in an Unequal World'** and focuses on the issues that perpetuate mental health inequality locally and globally. The overall objective of the day is to raise awareness of mental health issues around the world and to mobilize efforts in support of mental health. The Day provides an opportunity for all stakeholders working on mental health issues to talk about their work, and what needs to be done to make mental health care a reality for people worldwide.

Uganda National Field Epidemiology Conference October, 29

Scheduled to take place on the 29 October, 2021, the conference is organised by Ministry of Health Uganda in collaboration with Makerere University School of Public Health and US CDC. During the conference, the advanced field epidemiology fellows will showcase their experiences and projects on investigation and response to public health emergencies, evaluation of surveillance systems, analysis of surveillance data, cost analysis of outbreaks and quality improvement approaches to health service delivery in the country. The 2021, 7th Uganda National Field Epidemiology Conference whose theme is **'Fighting at the frontlines – Field Epidemiology Fellows at the helm of the COVID-19 response'** will be virtually held.

World AIDS Day December, 1st

World AIDS Day is marked on 1 December each year and has been an annual event since 1988. People around the world raise awareness about HIV/ AIDS and come together to show support for people living with HIV, commemorate those who have died from AIDS-related illnesses and celebrate victories of increased access to treatment and prevention services. The day is an opportunity for private and public stake holders to spread awareness about the status of the pandemic and encourage progress in HIV/ AIDS prevention, treatment and care globally. This year's World AIDS Day will be celebrated with the theme: "Global Solidarity, Shared Responsibility"

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Universal Health Coverage Day, December 12

Universal Health Coverage Day is observed annually on December 12 with the aim of ensuring that people around the world get the quality health services they need without financial hardship. To end the crisis and build a safer and healthier future, we must invest in health systems that protect every one. The event will be commemorated with the theme: "**Leave No One's Health Behind: Invest in health systems for all**"

UPDATES

Uganda Public Health Fellowship Program Continues to Excel in its Grand Mission of Producing a Skilled Workforce

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Since its inception in 2015, the field epidemiology training program has contributed immensely to the strengthening of Global Health Security through Africa's first absolute post-master's program. The program which is based in Ministry of Health, is funded by the US Centres for Disease Control and Prevention with Makerere University School of Public Health providing fiscal support. The program has stood out in its performance to contribute to building a resilient and sustainable public health system in Uganda. Under the program, fellows are trained to be leaders in outbreak investigations, epidemiological studies, scientific communication, and innovative solutions to solving public health problems.

TEPHINET Training Programs in Epidemiology and Public Health Interventions Network

CDC Centers for Disease Control and Prevention

2021 CDC Director's Award for Excellence in Outbreak Investigation and Response

TEPHINET and CDC-FETP hereby present this award to

Uganda Public Health Fellowship Program - Field Epidemiology Track

during the **2021 FETP International Nights** *on* **July 14-15, 2021.**

International Night is co-sponsored by Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET), a program of the Task Force for Global Health, Inc., and the Field Epidemiology Training Program (FETP), Centers for Disease Control and Prevention (CDC).

We recognize your contribution to improving public health with your commitment to evidence-based research.

Carl Reddy, MBBCh, FCPHM, MSc
Program Director, TEPHINET
The Task Force for Global Health, Inc.

Kip Baggett, MD, MPH
Chief, Workforce and Institute Development Branch
Field Epidemiology Training Program, CDC

The award won by Uganda Public Health Fellowship Program at 2021 FETP International Nights.

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Table 1: Awards won by Uganda Public Health Fellowship Program, 2015-2021

No.	Award Title	Awarding Institution-Conference	Awarded Presentation	Awarded Individual	Cohort	Year Awarded
1	Jeffrey P. Koplan Award for Excellence in Scientific Poster Presentation	EIS Conference – International Night 2016	Risk Factors for Podoconiosis: Kamwenge District, Uganda September 2015	Christine Kihembo	2015	2016
2	2nd runner best oral presentation	AFENET Conference in Abuja, Nigeria, 2016	Exposure at Crowded Health Centers, Vaccine Failure and Failure to Vaccinate Facilitated Measles Transmission during an Outbreak in Kamwenge District, Western Uganda, April to August 2015	Fred Nsubuga	2015	2016
3	Best Oral presenter	East African Health and Scientific Conference, Burundi, 2017	Cholera outbreak caused by drinking lakeshore water contaminated by feces washed down from a hill-side residential area: Kaiso Village, Uganda	David Oguttu	2015	2017
4	2nd runner best oral presentation	AFENET Conference in Maputo, Mozambique, 2018	Burden of road traffic injuries in Kampala District, Uganda (2012 - 2016)	Claire Biribawa	2017	2018
5	2017 CDC Director's Award for Excellence in Outbreak Investigation and Response	EIS Conference - 2017 FETP International Nights	Uganda Public Health Fellowship Program's Effective Contribution to Outbreaks Investigation and Response in Uganda	PHFP	Not applicable	2017
6	Best Oral presenter	Uganda Society for Social Scientists Conference, 2019	Cholera outbreak associated with drinking contaminated water from a Well – Kampala City, Uganda, January 2019	Daniel Eurien	2018	2019
7	Best presenter	East Africa COVID19 Conference 2020	Contact tracing and Community-Based Surveillance for Covid-19 Using Environmental Health Workers in Masindi District, Uganda	Bob Omoda Amodan	2020	2020
8	2021 CDC Director's Award for Excellence in Outbreak Investigation and Response	EIS Conference - 2021 FETP International Nights	Uganda Public Health Fellowship Program's Effective Contribution to COVID-19 Response in Uganda	PHFP	Not applicable	2021

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At the recent Epidemic Intelligence Service (EIS) Conference in July 2021, an annual flagship event for all field epidemiology training programs (FETPs) around the world, the program scooped the CDC Director's Award for Excellence in Outbreak Investigation and Response. This award recognizes the significant contributions towards public health responses to public health threats (natural or man-made disasters, disease outbreaks, and other public health emergencies). Many more awards have been won previously; below is a full list of all individual and program awards since 2015 (Table 1).

Uganda Launches the Intermediate Field Epidemiology Training Program

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Uganda continues to face public health emergencies and training more field epidemiologists to manage these emergencies is vital. On 31st August 2019, Uganda officially launched the intermediate-level field epidemiology training (FETP-Intermediate). This completes the CDC-funded FETP pyramid model in the country, which already had the FETP-Advanced and FETP-Frontline in place. FETP-Intermediate is a supervised, on-the-job, competency-based training and service (workforce development) program to improve field epidemiologic capacity at the regional level. It aims to build competencies in surveillance, data analysis and interpretation, outbreak investigation, communication, and mentorship. The 9-month training involves residential trainings interspersed with on-job field projects during which participants return to workstations and conduct job relevant projects to concretize what they have learned.

The first cohort of FETP-Intermediate trainees comprises 17 health workers from four regional hospitals (Kabale, Fort Portal, Entebbe, and Naguru) and Ministry of Health (MoH) headquarters. Participants include M&E specialists, community health specialists, medical officers, nursing officers, and hospital planners, among others. Trainees will be mentored by FETP-Advanced fellows and program staff and will in turn be expected to mentor their colleagues at their workplaces. Graduation is expected to be in April 2022.

The launch event which was hosted by the FETP-I Technical Advisor, Miss Doreen Gonahasa, took place at the Mansion Hotel in Jinja and was officiated by Hon. Natalie Brown, the United States Ambassador to Uganda. Also in attendance was the Country Director for CDC Uganda, Dr. Lisa Nelson, Uganda FETP Resident Advisor Dr. Julie Harris, the Director, Uganda National Institute of Public Health, Dr. Alex Riolexus Ario, and the Ag. Asst. Commissioner of Health Services, Division of Health Information, Ministry of Health, Mr. Paul Mbaka.

U.S Ambassador to Uganda, HE. Natalie E. Brown flanked by Dr. Lisa J. Nelson, Dr. Alex R. Ario, Dr. Julie R. Harris and participants launches the program

Epidemiological assessment of COVID-19 cluster among attendees of a church activity, Omoro District, Northern Uganda, September 2020

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words

Summary

On 2 October 2020, a cluster of COVID-19 infections was reported in Omoro District in northern Uganda. Despite government directives banning public gatherings, many infected persons had reportedly attended a farewell party at Church X on 5 September. We conducted a retrospective cohort study to determine the source of infections, understand the outbreak magnitude, and identify risk factors for transmission.

We developed a line list by reviewing records and interviewed the index case-patient, church farewell party attendees, and several community members to ascertain possible exposures. We conducted a retrospective cohort study among attendees of the farewell event held on 6 September 2020 at Church X in Omoro District.

Twenty-three confirmed case-patients were identified, including 12 in the Church X cluster. Illness onsets ranged from 23 August to 29 September. The index case, Mr. A was a businessman, Church X choir member, and Church X treasurer with onset on 23 August. Mr. A interacted with the second case Mr. B multiple times before the farewell party Close contact with Mr. A and Mr. B at the farewell party was associated with infection (RR 2.6; 95%CI 1.1-6.7).

Improved adherence to national guidelines and government directives for COVID-19 were recommended.

Background

Since the inception of the SARS-CoV-2 pandemic in late 2019, clusters of infections have been widely reported associated with family gatherings, workplaces, choirs, shopping centres, and night clubs (1, 2). These clusters have often represented super-spreader incidents, in which transmission is facilitated largely by one highly infectious person with many contacts (3, 4). For reasons that aren't fully clear, super-spreaders contribute disproportionately to the pandemic by infecting larger number of cases than most infected persons (5). Identification of transmission and risk factors within such clusters is key to providing evidence-based recommendations that can avert such incidents (6).

To reduce the risk of such incidents, Uganda, along with many other countries, implemented recommendations to ban public gatherings including places of worship, weddings, music shows, rallies, bars and other entertainment centers; these directives were given by the president of Uganda on 18 March 2020 (7). In addition, persons with symptoms of COVID-19 were urged to stay home and isolate themselves from others.

On 21 March 2020, Uganda registered its first case of COVID-19 (8)(9). By mid-June 2020, the epidemic had begun to shift in Uganda from sporadic cases to clusters of community cases (10). On 17 August 2020, the District Health Officer of Omoro District, in Northern Uganda, was notified of the first confirmed COVID-19 case in the district. By 2 October 2020, the district had 29 confirmed cases. Of these, several were reportedly linked by residence, social events, or both.

We investigated this cluster of case-patients in Omoro District to understand its source, risk factors, and recommend prevention measures.

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Methods

Outbreak setting

We conducted the investigation in Omoro Town Council, Omoro District. Omoro District is located in Northern Uganda and has a population of approximately 200,000 persons. Opit Mission, the site of the church associated with the outbreak (Church X), is a complex housing a church, priests' residence, convent, health facility, and schools. Wiyagweng community is in the neighborhood, also located within Omoro Town Council, about two kilometers from Opit Mission. The second cluster of infections was in Wiyagweng where the index case-patient resided.

Case definition and finding

We defined a confirmed case as a positive PCR test for SARS-CoV-2 infection in a resident of Omoro District, 4th September-5th October 2020.

We abstracted information for all confirmed cases from the district COVID-19 case management line list. Information collected included socio-demographic characteristics of the respondents (age, sex, occupation, village of residence); date of sample collection and date of confirmation; whether or not the case-patient had symptoms at sample collection; symptoms developed, if any; underlying medical condition. We visited both Opit Mission and the community to interview case-patients who had been discharged from the treatment units and visited Gulu Regional Referral Hospital to interview case-patients who were still under admission. Seven case-patients, who were admitted in a non-traditional isolation facility (Namboole Stadium) in Kampala, were interviewed over telephone.

Descriptive epidemiology

We described the case-patients by person, place, and time. We constructed an epidemic curve to describe the distribution of cases in the district over the outbreak period. We also computed attack rates by sex, age, and events attended. Maps were drawn in QGIS version 3.2.1 to show residences of cases.

Hypothesis generation

Twenty-three case-patients were interviewed about exposures before their illnesses using a modified standard COVID-19 case investigation form. The variables captured included basic socio-demographic information including age, sex, and residence at the time of illness, attending church or social events during August and September, including attending mass or choir practice at Church X, attending any burials, and attending the farewell party. We also asked about contact with the primary and secondary case-patients and use of personal protective equipment either at Church X or in the community.

Retrospective cohort study

Based on the hypothesis generation findings, we conducted a retrospective cohort study among attendees of the farewell event held on 6 September 2020 at Church X in Omoro District. A list of all the 69 attendees of the farewell event was obtained from the church authorities and 62 attendees interviewed using a questionnaire.

We used Epi Info 7.2 for entering, cleaning, and analyzing data. We calculated frequencies and proportions to describe the demographic characteristics. We used 2x2 tables to cross tabulate the outcome variable with exposures and stratified the outcome variable with other exposures to obtain risk ratios, and their 95% Confidence Intervals.

Ethical considerations

This was a public health emergency, and the Ministry of Health (MoH) gave the directive to have it epidemiologically investigated. Additionally, the Office of the Associate Director for Science, U.S. Centers for Disease Control and Prevention, determined that this activity was in response to a public health emergency with the primary intent of pub-

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lic health practice (epidemic disease control activity). We sought verbal consent from the case-patients so as they understand the nature of the study, risks and benefits. During data collection respondents' data was kept confidential. Information was stored in password protected computers and was not shared with anyone outside the investigation team.

Results

Descriptive epidemiology

Church X and the primary case-patient, Omoro District, September 2020

Church X had approximately 850 members. Its choir had approximately 30 choir members who practiced every Wednesday, Friday, and Saturday. Despite a presidential directive in Uganda banning church gatherings (implemented on 18 March 2020)(7), Church X continued conducting mass (every Sunday) and choir practice every Wednesday, Friday, and Saturday throughout this time.

The primary case, Mr. A, was a 45-year-old businessman and a resident of Wiyagweng village, residing in a parish (village) near the parish where Church X is located. He was a Church X choir member and also the treasurer at the church, and interacted closely with church leadership. He first developed cough and general weakness on 23 August 2020. He later developed chest pain and shortness of breath. On 9 September, he remained unwell and went to Opit Health Centre III where he was advised to proceed to the Gulu Regional Referral Hospital for a COVID-19 test. On 12 September, he was informed by the district surveillance person that he was positive and was isolated at Gulu Regional Referral Hospital. Due to Mr. A's underlying Hepatitis B and worsening condition, he was later referred to the larger Mulago National Referral Hospital. During late August and early September, Mr. A interacted multiple times with the second case, Mr. B. Mr. B was a 64-year-old leader (parish priest) at Church X. Mr. B had symptom onset on 31 August but was not tested for COVID-19 until 10 September.

During much of 2020, Church X had been under renovation. On September 5, the church organized a farewell party for the builders who had come to renovate the church. The event was attended by approximately 62 persons belonging to the church leadership and/or choir, including Mr. A, and was held in the church garden. At the time of the farewell event, both Mr. A and Mr. B had already developed symptoms. On September 6, a mass was held at the church, attended by both Mr. A and Mr. B.

Clinical and demographic characteristics of case-patients in a church and community COVID19 cluster, Opit Town Council, Omoro District Uganda, September 2020

A total of 23 confirmed COVID-19 case-patients (median age 36 years; range 2-81 years) were identified as being in 2 linked clusters; a community and church cluster. No deaths were recorded. Most (17; 74%) were male. About half (11; 48%) of the case-patients belonged to Church X, including four (17%) choir members (Tables 1 and 2). The most common sign and symptoms were cough (13; 57%) and headache (11, 48%) (Table 1).

Attack rates among a church and community COVID19 cluster case-patients, Opit Town Council, Omoro District Uganda, September 2020

Attack rates were highest among those who attended the farewell party at 24.2/100 followed by choir members at 13.3/100, Wiyagweng neighbouring community at 6.9, and lowest among the general church members at 1.4/100.

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Table 1: Clinical and demographic characteristics of case-patients in a church and community

Characteristic	Frequency (N=23)	Percent
Age		
≤17	2	9
18-60	19	83
≥61	2	9
Sex		
Female	6	26
Male	17	74
Belong to Church X		
Yes	12	52
No	11	48
Choir member		
Yes	4	17
No	19	83
Church X Event attendance		
Farewell party		
Yes	15	65
No	8	35
Attended September 6 Mass		
Yes	10	43
No	13	57
Signs and symptoms		
Cough	13	57
Headache	11	48
Chest pain	8	35
General weakness	6	26
Running nose	5	22
Chills	3	13
Shortness of breath	4	17
Sore throat	3	13.

Distribution of case-patients over time in two clusters of COVID 19 cases, Omoro District, September 2020

The epidemiological curve showed point-source outbreak, with most cases having onset 3-21 days after the farewell party (Figure 1).

Distribution of case-patients by place of residence

All the case-patients (100%) resided in Omoro Town Council, with 45.5% residing in Lagude parish and 36.4% in Parwech parish (Figure 2). The rest were from nearby Opit North, Tegot, and Lukwi parishes.

Transmission tree of case-patients in a church and community COVID19 cluster, Omoro District, September 2020

There were two clusters that were linked by the primary case-patient (Figure 3), including one associated with the Church (15 cases, including the primary case) and one associated with the community (9 cases, including the primary case). In the Church X cluster, the second case had a direct link with the primary case. Ten of the fourteen (non-primary case) case-patients in the Church X cluster had a possible transmission from either the primary or secondary case. Six of

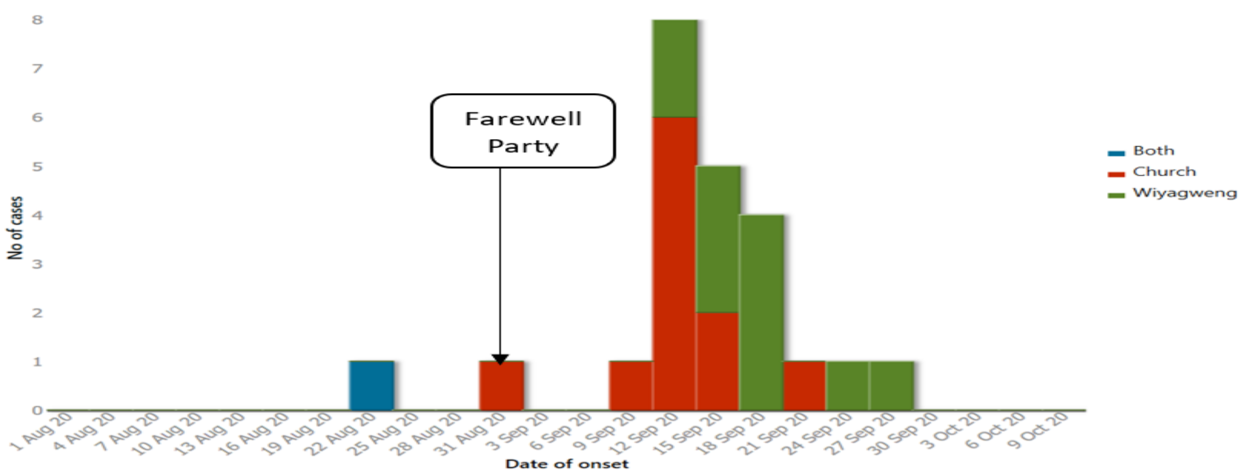

Figure 1: Epidemiological curve of confirmed COVID 19 cases, Omoro Town Council, Omoro District, September 2020

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the eight (non-primary case) case-patients in the community cluster were either family or neighbours of the primary case while the other two were infected by persons infected by the primary case.

Hypothesis generation findings

For hypothesis generation, we assessed exposures including participation in choir practice, attendance of church service, attendance of burial and farewell event. Given the frequent attendance of Mr. A and the secondary case at social and church events during their illnesses, we hypothesized that the outbreak could have been linked to contact with Mr. A and/or the secondary case at the farewell event.

Retrospective cohort

We obtained a list of all choir members and those who attended the farewell event for builders on 5 September. We interviewed a total of 62 people including the case-patients in a retrospective cohort study.

We asked about party attendees' exposure to Mr. A or Mr. B during the party. In total, nine (14.3%) partygoers were exposed to the primary case and 10 (16.1%) were exposed to the second case. Three (4.8%) reported that they were neither exposed to the primary nor the second case.

Table 2: Risk factors for COVID-19 infections among party attendees, Omoro District, September 2020

Exposure	**Exposed**		**Not Exposed**		**Risk Ratios**	**95% CI**
	Ill	Well	Ill	Well		
Exposure to only Mr. A	9	15	6	32	2.4	1.1-5.8
Exposure to only Mr. B	10	17	5	30	2.6	1.2-6.7
Exposure to both Mr. A and Mr. B	9	13	6	34	2.7	1.1-6.7
Exposure to neither Mr. A nor Mr. B	6	32	9	15	0.4	0.1-0.9

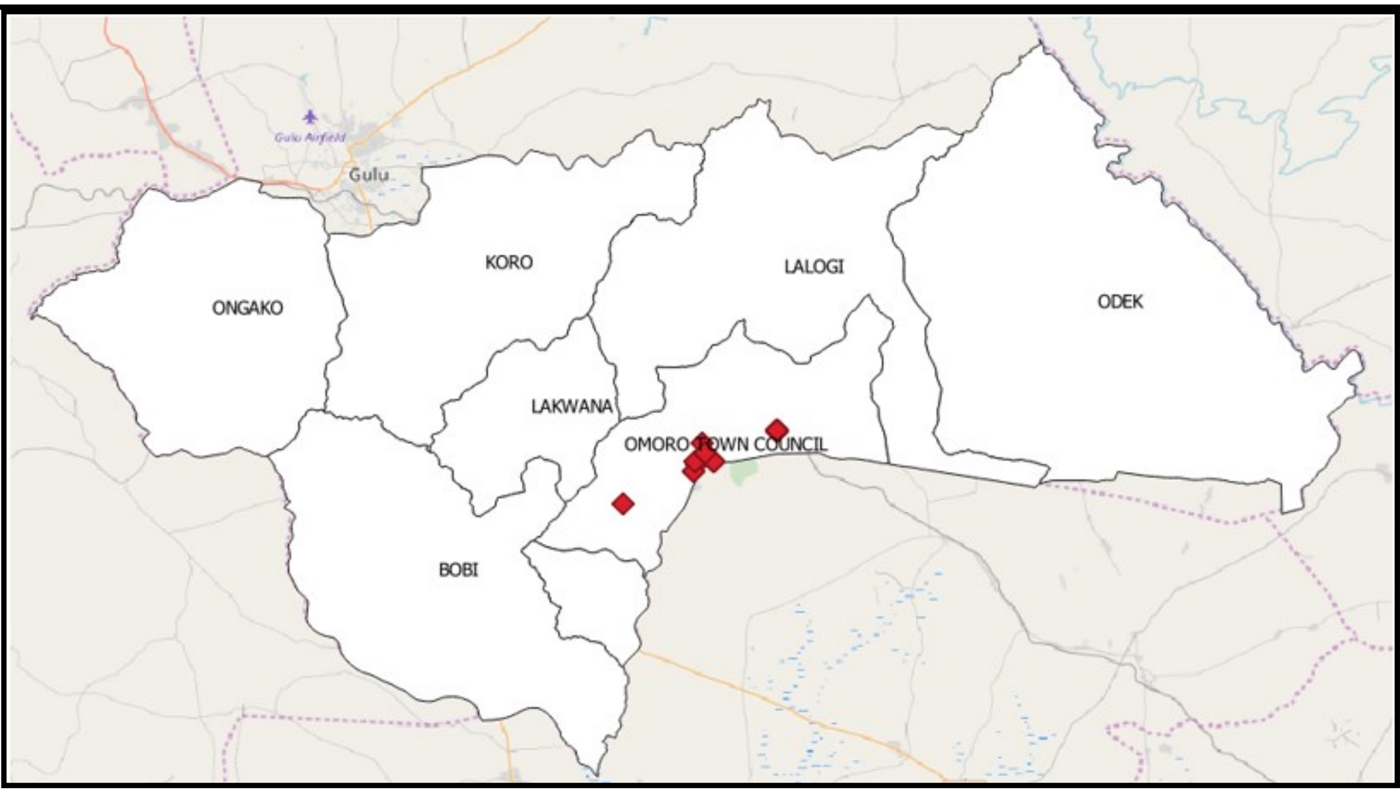

Figure 2: Distribution of COVID-19 case-patients by place of residence, Omoro District, September 2020

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Forty percent (9/22) of party attendees who were in close contact with both Mr. A and Mr. B became ill (RR 2.6; CI 1.1-6.7) while 15% (6/40) of attendees who reported no contact with both Mr. A and Mr. B became ill (RR 0.4; CI 01-0.9) (Table 2).

Discussion

This investigation identified 23 confirmed COVID-19 case-patients from two clusters: one among attendees of a farewell event in the church and one in the community. The index case-patient, Mr. A, was a businessman, choir member, and treasurer at Church X, and resident of Wiyagweng village. He attended the farewell event and multiple Church X services in August. The second case-patient, Mr. B, was a leader in Church X, frequently interacted with Mr. A, and attended the farewell party. Mr. A's late diagnosis provided an opportunity for spread to Mr. B, the community, and other church members. In addition, although Mr. A developed symptoms on 23 August, he continued interacting with church members and the community until he received his test result on 12 September. Diagnosing and treating people early in the course of infection speeds recovery, reduces the likelihood that they develop severe outcomes, prevents spread to others, and reduces demand on the healthcare system(11). Mr. A and Mr. B both attended the farewell event despite their symptoms and this provided an opportunity to spread.

Despite the presidential directive banning all social gatherings, Church X continued to have choir practice, church mass, and party. The emergence of SARS-CoV-2 in China in late 2019 refocused global attention on national, regional, and pandemic spread through mass gathering events. Since early March 2020, there was a step increase in cancellation of international and national religious, sporting, musical, and other mass gathering events as countries worldwide took measures to contain the spread of SARS-CoV-2 (12). While the outbreak is widespread, such measures should be continued to avert large COVID-19 clusters.

Clusters of COVID-19 and high transmission have been reported elsewhere in health facilities, families, church events, and other gatherings (6, 12-15).With the on and off reopening of in-persons

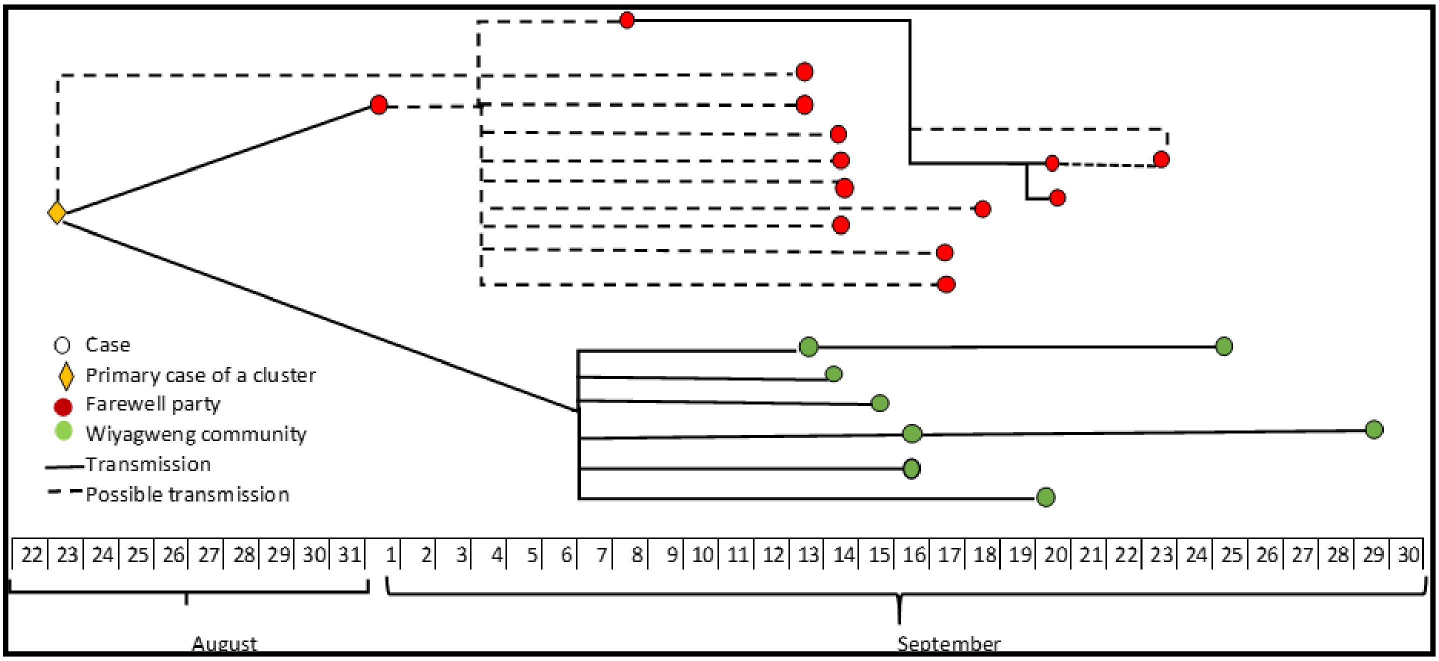

Figure 3: Transmission tree of case-patients in a church and community COVID19 cluster Omoro District, September 2020 1

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church services and other events, this serves as a signal to the risk of high transmission. This outbreak of COVID-19 underscores the importance of physical distancing, including maintaining at least 6 feet between persons, avoiding group gatherings and crowded places, and wearing cloth face cover-ings in public settings where other social distancing measures are difficult to maintain during this pandemic.

Limitations

Our findings should be interpreted with the following limitation. Despite an intensive epidemiologic investigation, we were not able to reach six case-patients who were still at isolation centers and did not have phone contacts. We could have possibly missed other exposures related to this cluster. However, the number not reached out of the total case-count for the cluster was too small to have an impact on the study's overall results and the interpretation.

Conclusion

The social gathering at church X provided an opportunity for a COVID-19 superspreading event. We recommended adherence to SOPs for COVID by church and community members and halt of church activities by church X.

Acknowledgement

We acknowledge Omoro District Local Government for supporting and permitting us to undertake this investigation. We thank the respondents for agreeing to take part in the investigation, the Ministry of Health, and the Uganda Public Health Fellowship Program for jointly supporting this investigation.

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Rift Valley Fever Outbreak, Kiruhura District, Uganda, June 2021

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Summary

Rift valley fever (RVF) is an endemic viral zoonosis in Uganda, where there are sporadic outbreaks. On May 14, 2021, a 19-year-old female from Kasaana village, Kiruhura District died; reverse-transcriptase polymerase chain reaction (RT-PCR) was positive for RVF. We investigated to determine the magnitude of the outbreak, source of infection, and recommend evidence-based control measures.

A confirmed case was defined as detection of RVF virus nucleic acid by RT-PCR or serum IgM/IgG antibodies by enzyme-linked immunosorbent assay (ELISA) in a resident of/visitor to Kasaana village from April 24-June 24, 2021. We tested blood samples from 25 persons (3 with RVF symptoms, 2 neighbors of the index case, and 20 randomly-selected villagers) using RT-PCR or ELISA, and 57 livestock (33 randomly-selected cows and 24 goats) from 4 village farms reporting any animals with RVF symptoms) by ELISA. We collected data on demographics, history of RVF symptoms, and animal-related activities. We characterized cases epidemiologically.

We identified 9 confirmed human cases in Kasaana village (2 RT-PCR-positive, 2 IgM/IgG-positive, 2 IgM -positive; 3 IgG-positive). One died (case fatality rate=11%). Five (56%) were female; median age was 20 years (range, 15–60 years). All cases kept cows and goats. Two case-patients reported headache, fever, and hemorrhage. The index case-patient, who milked cows on her family farm, had hemorrhagic symptoms consistent with RVF starting 1 week before death. She presented to five health facilities during that week but was only diagnosed after death. Three (9%) cows and five (21%) goats were IgM-seropositive for RVF.

This RVF outbreak likely resulted from contact with infected animal products. Earlier diagnosis might have prevented the index case-patient's death. We conducted health education among Kasaana villagers, and recommended training of health workers at facilities within the region to emphasize the importance of early diagnosis of haemorrhagic fevers.

Background

Rift Valley Fever (RVF) is a zoonotic disease that primarily affects animals but can also affect humans. Human infections result from contact with the blood organs, products of infected animals, and mosquito bites [1]. To date, no human-to-human transmission of RVF virus has been documented. The incubation period for RVF varies from 2 to 6 days [2]. Interepidemic virus maintenance is thought to occur either transovarially in Aedes species mosquitoes or through cycling of low-level transmission between domestic livestock or wild ungulates [3]. After periods of heavy rainfall, Aedes mosquitoes rapidly emerge, resulting in extensive amplification of the virus through infection of livestock [2, 4].

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Presentation of RVF in animals can vary among species with a range of clinical severity. Livestock particularly cattle, sheep, and goats are highly susceptible to RVF and present with symptoms of fever, loss of appetite, weakness, low milk production, nasal discharge, vomiting, and diarrhea [5, 6]. During large epizootics, "abortion storms", particularly in goats and cattle, have been reported. High newborn mortality (80–100%) and adult mortality (5–20%) may also be observed in animals [7].

Humans infected with RVF usually have non-specific symptoms. Majority of cases typically have mild, self-limited febrile illness (4). Severe disease occurs in about 2% of the cases and manifests as ocular, meningoencephalitis or hemorrhagic fever with severe jaundice, rhinitis and encephalitis [2]. Among those infected, case fatality rate is about 50% mainly among case-patients who develop hemorrhagic symptoms [5].

Outbreaks of RVF have been reported frequently in East Africa, especially Kenya and Tanzania [2]. The emergence of RVF virus in East Africa resulted in widespread livestock morbidity and mortality, with hundreds of laboratory-confirmed human cases, and likely thousands of asymptomatic human infections going undetected [8]. In Uganda, Rift Valley fever virus was first detected in mosquitos collected in Semliki forest, Western Uganda, in 1944, and has since been detected several times by the Uganda Virus Research Institute (UVRI) [8, 9].

On May 14 2021, UVRI notified the Uganda Ministry of Health (MoH) of a rift valley fever case confirmed by reverse transcriptase polymerase chain reaction (RT-PCR). The case person was a 19-year-old female who had been involved in milking her father's cows. She presented to six health facilities with bleeding, high grade fever and acute kidney injury for one week. At the sixth facility, a viral hemorrhagic fever was suspected, a blood sample was taken and sent to the UVRI viral hemorrhagic fever (VHF) laboratory for testing. The patient died and later, the blood sample tested positive for RVF virus. We investigated to determine the magnitude of the outbreak, source of infection, and recommend evidence-based control measures.

Methods

Outbreak area

The outbreak was reported in Kiruhura District, located in South western Uganda and part of the Ankole sub region (Figure 1). Animal keeping is the main economic activity in Kiruhura District; every household owns at least a cow or goat. Milk and meat are important food and trade products in this area. However, by the time of the RVF outbreak, there was an ongoing foot and mouth disease outbreak that caused a ban on animal movements and trade of animal products in Kiruhura District from late January 2021.

The outbreak occurred in Kasaana Village, Kinoni Sub-county, Kiruhura District. Kinoni Sub-county had a total of 26 villages and a population of 26,097. Kasaana village, where the study was conducted has a population of 1,157 persons.

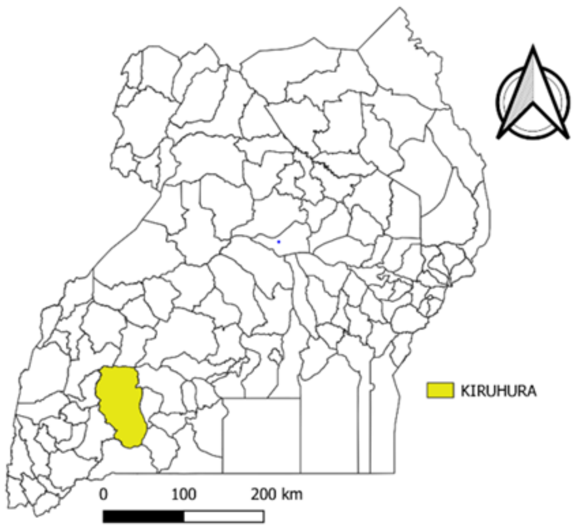

Figure 1: Map of Uganda showing Kiruhura District

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Case definition, finding, and environmental assessment

We defined a suspected case as onset of fever with a negative malaria test and at least 2 of any of the following symptoms: headache, muscle pain, dizziness, blurred vision, nausea, vomiting, abdominal pain, diarrhea, unexplained bleeding symptoms in a resident or visitor of Kasaana village from April 24, 2021 to June 24, 2021. A confirmed case was a suspected case plus laboratory confirmation of RFV by either detection of RVF virus nucleic acid by reverse-transcriptase polymerase reaction (RT-PCR), or serum IgM or IgG antibodies by enzyme linked immunosorbent assay (ELISA)

Upon notification regarding the death of a confirmed RVF case from Kiruhura District, we collected additional information on the first case patient from attending clinicians and close family members. We identified more cases through active case finding in Kasaana village. We interviewed cases on their demographics, history of RVF symptoms, and history of interaction with animals.

Laboratory testing

We conducted laboratory testing on both humans and animals using RT-PCR, or enzyme linked immunosorbent assay (ELISA).

We collected blood samples from twenty-five case patients; three were symptomatic, two were neighbours to the index case patient and the other 20 were randomly selected Kasaana villagers. Three case patients were tested using RT-PCR while the other 22 were tested for serum IgM and IgG antibodies for RVF virus by ELISA.

We collected blood samples from 57 animals; 33 cows and 24 goats randomly selected from four village farms reporting animals with RVF symptoms. The animals were tested for IgM antibodies by ELISA.

Environmental assessment

We observed the animals at the village farms and nearby water ponds at the farms. We assessed for the presence of dead animals in Kasaana village, animal/meat transport mechanisms, selling of grilled meat and how meat was prepared before it was sold. We also assessed selling points for milk and meat, asked about animal movement, and trading in the area.

Data analysis

We conducted descriptive analysis. We generated an epidemic curve to describe the outbreak over time, described the characteristics of the affected persons by age, sex and RVF symptoms, and their geographical location.

Ethical considerations

This investigation was in response to a public health emergency and was therefore determined to be non-research. The MoH Uganda through the office of the Director General of Health Services gave the directive and approval to investigate this outbreak. The Office of the Associate Director for Science, CDC/ 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). We obtained verbal informed consent from case-persons during this investigation and other interviewed community members that were above 18 years, as well as the owners of the animals that were tested. For participants below 18 years of age, we sought verbal assent from their parents or guardians. We ensured confidentiality by conducting interviews in privacy ensuring that no one could follow proceedings of the interview. The questionnaires were kept under lock and key to avoid disclosure of personal information of the respondents to members who were not part of the investigation.

Results

We identified nine case-patients from Kasaana village, Kinoni Subcounty, Kiruhura District; 2 RT-PCR -positive, 2 IgM/IgG-positive, 2 IgM-positive; 3 IgG-positive. Five (56%) were female. Participants' medi-

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an age was 20 years (range: 15 – 60 years). Of the nine case patients, one died (CFR= 11%).

Two of the confirmed case persons had symptoms consistent with those of RVF; fever, headache, and vomiting while the others were asymptomatic. Apart from the reported death, the other symptomatic case patients were followed up to recovery.

The rift valley fever outbreak began in early May and went on till June 2021. The outbreak began following heavy rainfall in April 2021 (Figure 2). There was evidence of heavy rains due to the many water-filled ponds at the village farms.

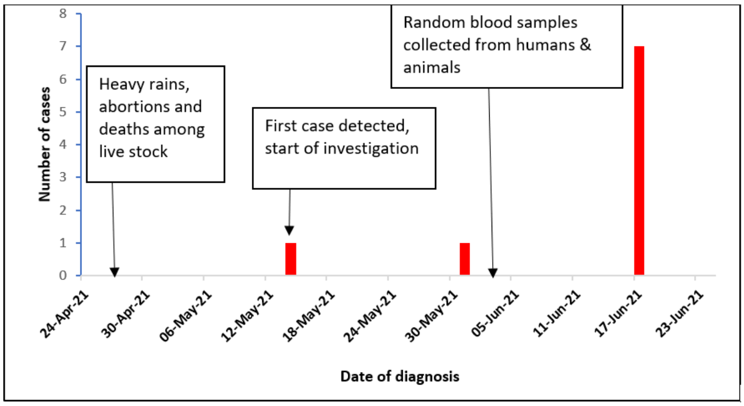

Figure 2: Epidemic curve of the rift valley fever outbreak, Kasaana village, Kiruhura District, May – June, 2021

Of the 57 animals tested from Kiruhura District, eight (14%) were IgM sero-positive for RVF virus; three (9%) cows and five (21%) goats.

All case persons kept cows and goats; they milked and grazed them. None of the case patients ate meat of any dead animal. Farmers reported that their animals had been having abortions, and young animals on their farms died. Carcasses were disposed in the bushes for dogs to eat. Animal movements and sale of animal products were prohibited in Kiruhura District. There was already an ongoing outbreak of Foot and Mouth Disease in Kiruhura District so there was a ban on animal movement and trade of animal products. The ban had been on since late January 2021.

Case-patients were living near each other and the farms with infected animals (Figure 3).

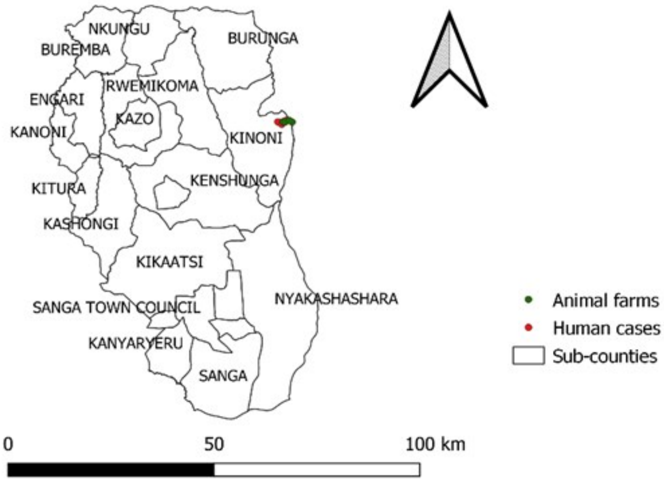

Figure 3: Map of Kiruhura District showing residences of case persons and animal farms during an outbreak of Rift Valley Fever in Kinoni Subcounty, Uganda, 2021

Discussion

The investigation found that nine persons and eight animals were infected with RVF virus in Kasaana village, Kinoni sub-county in Kiruhura District. While most of the human cases were asymptomatic, two had symptoms consistent with RVF including, fever, headache and haemorrhage. In addition, the animal cases at the village farms had typical signs and symptoms of RVF such as abortions and deaths among young ones. Given that all cases kept animals, person, and place descriptive data showed that caring for livestock and living near infected animals are potential risk factors for RVF.

Although symptoms of RVF are usually mild and non-specific, two case persons in this outbreak had typical haemorrhagic symptoms with vomiting blood and bleeding from body orifices, consistent with RVF virus infection as in previous similar studies [2, 7, 10]. These hemorrhagic symptoms should have raised suspicion of a haemorrhagic fever. However, despite

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these symptoms, the index case patient presented to five health facilities without any health care worker suspecting a hemorrhagic fever until she got to the sixth facility where a blood sample was collected for viral haemorrhagic fever testing before her death. Had the patient had a more virulent and transmissible hemorrhagic fever virus like Ebola, the implication of delayed diagnosis would probably have been worse.

Death among RVF cases is said to occur in about 50% of cases mainly among those who get hemorrhagic symptoms[5]. The index case patient, who died during this outbreak had bleeding from all body openings as it is reported in similar studies [2, 11, 12]. Had the case patient been diagnosed early and provided with supportive care, organ damage and death could have been prevented.

The study reported that all cases were farmers keeping at least a cow or goat which indicates the occupational nature of the disease. Several previous studies have reported high-risk occupations for RVF infection including: abattoir workers, veterinary personnel, and farmers [10, 12, 13]. It was found that farm workers/farmers, animal health workers and abattoir workers or butchers were most affected during an outbreak in South Africa [14]. In Northern Africa, the RVF outbreak affected shepherds, animal breeders, farmers, and veterinarians which shows the occupational nature of the infection [15].

The environmental assessment revealed that the RVF outbreak occurred shortly after a rainy season. There were many water-filled ponds lying close to homes and farms but without *Aedes* mosquito larvae. Elsewhere, other countries have reported that majority of RVF outbreaks occur during or immediately after a rainy season because *Aedes* mosquitoes breed during the rainy seasons [3, 6]. After multiplication in bigger numbers, the mosquitoes transmit RVF virus infection in livestock and sometimes in humans [3, 4].

Findings suggest that RVF infections among animals preceded human infections as noted in previous studies. Establishment of an active animal health surveillance system to detect new cases is essential in providing early warning for veterinary and human public health authorities [5, 6, 11, 12].

Study Limitations

We may have underestimated of the magnitude of the outbreak. Many of the RVF cases never exhibited any signs or symptoms and were less likely to even realize that they were sick. This implies that many cases could have been missed by the healthcare system. In addition, some cases were identified through random testing; we could have missed out on many more.

Conclusion

There was active infection of RVF among residents of Kasaana village although most of them were asymptomatic. Contact with products of infected animals could have been the source of human infection. Early diagnosis and supportive therapy could have prevented the index case patient's death. This investigation highlights the need for continuous clinician education on the importance of early diagnosis and continuous awareness about viral haemorrhagic fevers in areas where they are endemic.

Public Health Actions

Mass testing of both animals and humans was conducted in Kasaana and other villages to determine the magnitude of infection. Health education and community sensitization was done extensively in Kasaana village with emphasis on the prevention and control of rift valley fever. Use of insecticide treated mosquito bed nets was encouraged among community members. Animal quarantine was strengthened as the district was already facing foot and mouth disease outbreak.

Recommendations

We recommend training of health workers to improve their alertness about viral haemorrhagic fevers. Ani-

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mal vaccination against RVF virus should also be conducted.

Acknowledgements
We thank the family of the deceased, the Kiruhura District health team and the residents of Kasaana village for their willingness to support this investigation. We appreciate the Uganda Virus Research Institute and Ministry of Agriculture, Animal Industry and Fisheries for testing all samples and the timely release of results. We acknowledge the Uganda Public Health Fellowship Program for the technical guidance towards making the investigation a success.

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Incidence and Spatial Distribution of Bacterial Meningitis, Uganda, 2014-2018

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Summary

Uganda is one of the countries with highest rates of meningitis and the risk of incidence is attributable to the fact that it lies within the extended meningitis belt of Sub-Saharan Africa. The most susceptible regions include West Nile, Bunyoro, Acholi, Lango, Teso, and Karamoja regions because they lie within the meningitis belt. Although there have been efforts to vaccinate against meningitis sporadic cases still occur. We characterised bacterial meningitis incidence in Uganda to inform programming.

We analysed routinely collected meningitis data from the District Health Information System (DHIS2),2014- 2018. We included all bacterial meningitis patients reported in DHIS2.

Overall, there was an increase in the incidence of meningitis from 0.005/100,000 in 2014 to 5.31/100,000 population in 2017; and a slight decline in 2018. The incidence of bacterial meningitis was higher among under-five population ranging between 6.5-10.6/ 100,000 compared to those aged five and above (2.5-4.2/ 100,000). Karamoja region was most affected compared to the other 14 regions in the country.

Sporadic cases of meningitis still occur across the country increasing from 2014 to 2017 with a slight decline in 2018. Children under five and Karamoja region were most affected. Regardless of efforts to vaccinate meningitis remains a disease of public health concern. We recommend that MoH introduces the meningitis vaccine in routine immunisation.

Introduction

Meningitis is an illness caused by inflammation of the meninges (1), the membranes that surround the brain and spinal cord and protect the central nervous system (CNS), together with the cerebrospinal fluid. It is a serious condition that can be life threatening (2). It can be caused by a variety of organisms that include bacteria, fungi, or viruses. As such, different forms exist: viral, non-pyogenic, bacterial, meningococcal, hemophilus, pneumococcal and neonatal meningitis. Of these, the bacterial form is the most severe and most common (3,4) Bacterial meningitis is very serious and can be fatal, with death occurring in a few hours. Most people recover from meningitis; However, permanent disabilities (such as brain damage, hearing loss, and learning disabilities) can result from the infection (5). Meningitis cases typically present with stiff neck, high fever, and sensitivity to light, confusion, headaches, and vomiting (4,5). Other symptoms include weakness, irritability and poor feeding. Even when the disease is diagnosed early, and adequate treatment is started, 5 to 10% of patients die, typically within 24 to 48 hours after the onset of symptoms. If left untreated, up to 50% of cases may die. Bacterial meningitis may also result in brain damage, hearing loss or a learning disability in 10 to 20% of survivors(6).

While bacterial meningitis can happen at any age, infants are susceptible (5). The age groups most at risk of infection are; infants 6 to 18 months of age, children under the age of 5 years, adolescents and young adults, elderly people (due to their declining immune function), and people with illnesses which affect the immune system (1,7,8). It occurs sporadically and in small outbreaks worldwide (10), except in the African Meningitis Belt where large outbreaks are common. Uganda is one of the countries with highest rates of the meningitis A disease and also one of the 26 countries that lie within the extended meningitis belt of Sub-Saharan Africa, which stretches from Senegal in the West Africa to Ethiopia in the East Africa.

We determined the incidence and described the spatial distribution of bacterial meningitis using surveillance data, Uganda, 2014-2018 to inform targeted interven-

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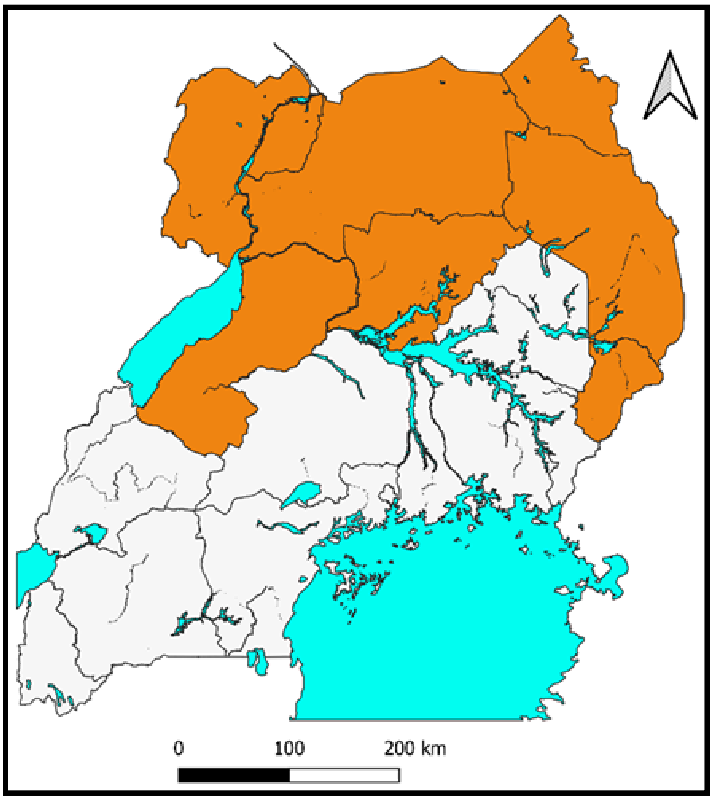
tions.

Methods

Study area

Data utilized in this study was collected nationwide. Uganda has an estimated population of 44m people and is divided into 15 sub regions; Kampala, North Central, South Central, Busoga, Bukedi, Bugisu, Teso, Karamoja, Lango, Acholi, West Nile, Bunyoro, Toro. Some regions of the country lie within the meningitis belt of Sub Saharan Africa, which has experienced frequent outbreaks of meningitis(12). These regions include West Nile, Bunyoro, Acholi, Lango, Teso, and Karamoja regions (shown in orange in Figure 1).

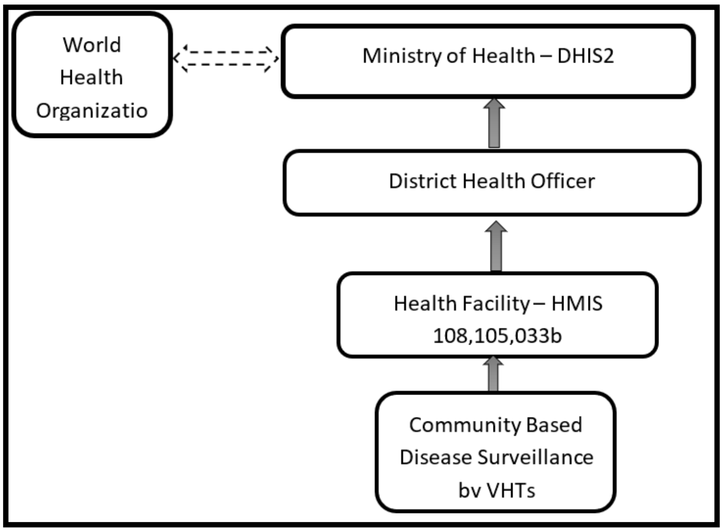
Figure 1: Regions lying in the meningitis belt, Uganda



Study design and data source

We abstracted meningitis surveillance data collected by healthcare facilities in all the districts in Uganda from the District Health Information System v2 (DHIS2). The DHIS2 is an open source software used for reporting, analysing, and disseminating health data as part of the Health Management Information System (HMIS). We considered all records of bacterial meningitis patients that reported to the outpatient department (OPD) of health facilities. According to IDSR guidelines, a suspected bacterial meningitis case is any person with sudden onset of fever (> 38.5 °C rectal or 38.0 °C axillary) and one of the following signs: neck stiffness, altered consciousness or other meningeal sign while a confirmed case is a suspected case confirmed by isolation of *Neisseria meningitidis* from cerebrospinal fluid or blood (11). At the facility, individual patient records are captured using an appropriate medical form and then entered into the OPD register. There are three reporting forms for bacterial meningitis; weekly report (HMIS 033b), monthly summary reports for outpatients (HMIS 105), and inpatients (HMIS 108) (Figure 2). It is from the summaries that data are entered in to the DHIS2. For this analysis we used data submitted through HMIS 105 monthly report.

Figure 2: Surveillance system using DHIS2 to report bacterial meningitis



Data abstraction and analysis

We abstracted data on bacterial meningitis for the period, 2014-2018 from the DHIS2. For each case, we abstracted data on age, sex, and district. We used population data from the Uganda National Census 2014, extrapolating populations for consequent years using an annual population growth estimated of 3% (1).

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We used Epi Info 7.2.0 for data analysis. Descriptive data were analyzed using frequencies, means, and dispersion. We calculated disease incidence per 1,000 with the number of bacterial meningitis cases as numerator and the population per affected area as the denominator. We calculated the incidence of bacterial meningitis during the study period and disaggregated it by, age-group, sex, and district. We used quantum geographic information system (QGIS) version 3.2.2 to generate choropleth maps of incidence per year.

Ethical considerations

This analysis used routine surveillance data reported by health facilities for the Uganda Ministry of Health. This data is also aggregated with no individual patient identifiers. However, we sought and obtained permission from MoH to use the data. The US Centers for Disease Control and Prevention (CDC) also provided the non-research determination for non-human subjects. Data were only accessed by the study team.

Results

There was an increase in the incidence of meningitis from 0.005/100,000 in 2014 to 5.31/100,000 popula-

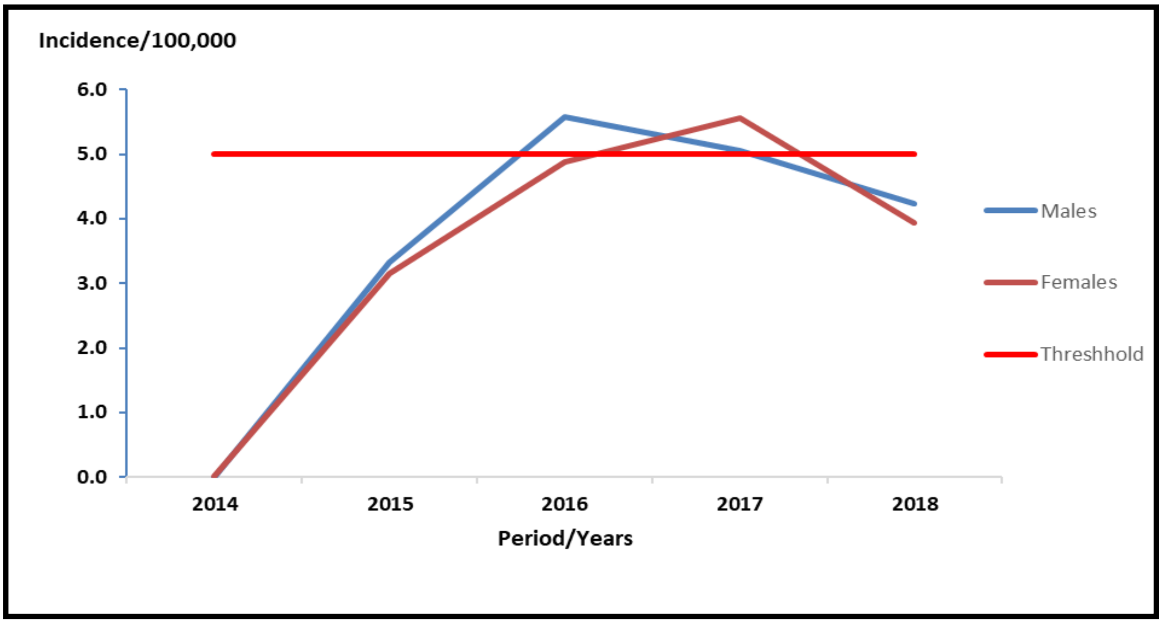

Figure 3: Incidence of bacterial meningitis disaggregated by sex, Uganda,2014-2018

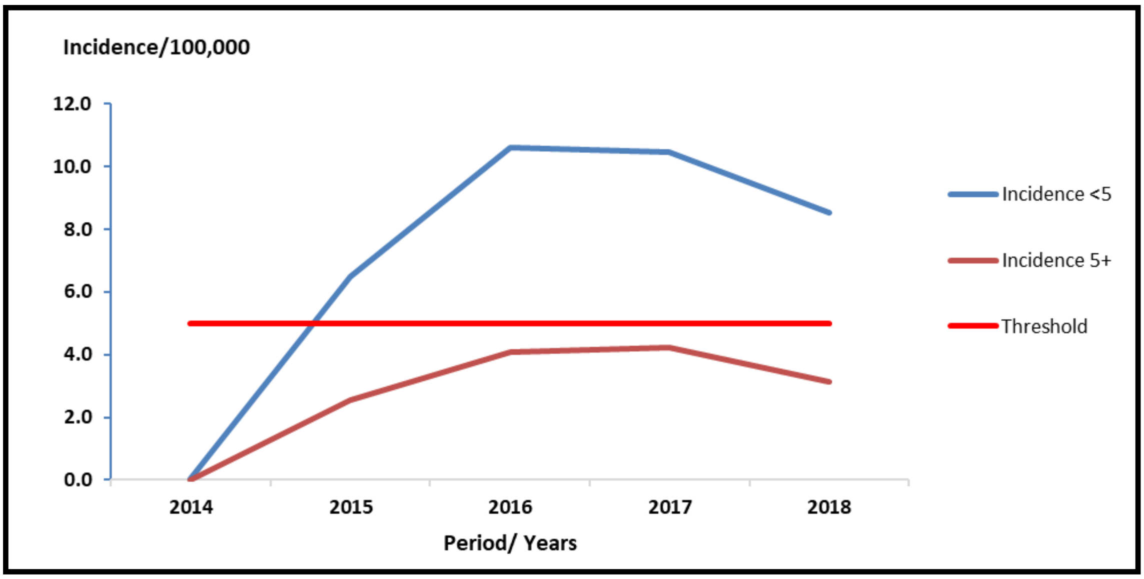

Figure 4: Incidence of bacterial meningitis disaggregated age group, Uganda, 2014- 2018

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tion in 2017; and a slight decline in 2018. On average, males (3.6/100,000) and females (3.5/100,000) were similarly affected across the period of consideration (Figure 3). The incidence in 2016 and 2017 was slightly higher than the threshold of 5/100,000.

Across the period of review, a general increase in the incidence of meningitis from 2014 to 2016 in both age groups (under 5 and 5+) (Figure 4) was observed. There was a slight decline between 2016 and 2017 and a more remarkable decline between 2017 and 2018. Generally, the incidence was higher in the population under five years of age (6.5-10.6/ 100,00) compared to that aged five and above (2.5-4.2/ 100,000).

The highest incidence of meningitis cases (shown in deep red) was reported in Kampala over the five-year period, Napak and Nakapiripirit, districts in Karamoja region, and Gulu in the Northern region while central and western regions reported the lowest incidences (Figure 5).

Discussion

For the period between 2014 and 2017, incidence of bacterial meningitis increased. Kampala, Karamoja, and northern regions were the most affected. The illnesses affected mainly children under five years of age.

The incidence of meningitis increased from 2014 to 2017 and there was a slight decline in 2018 following a mass meningitis immunization campaign in 39 high-risk districts across the country in January 2017 (13). This drive was conducted by the Ministry of Health in collaboration with WHO and the United Nations International Children's Fund (UNICEF). The campaign was targeted to immunize the population in the age group 1 -29 years,

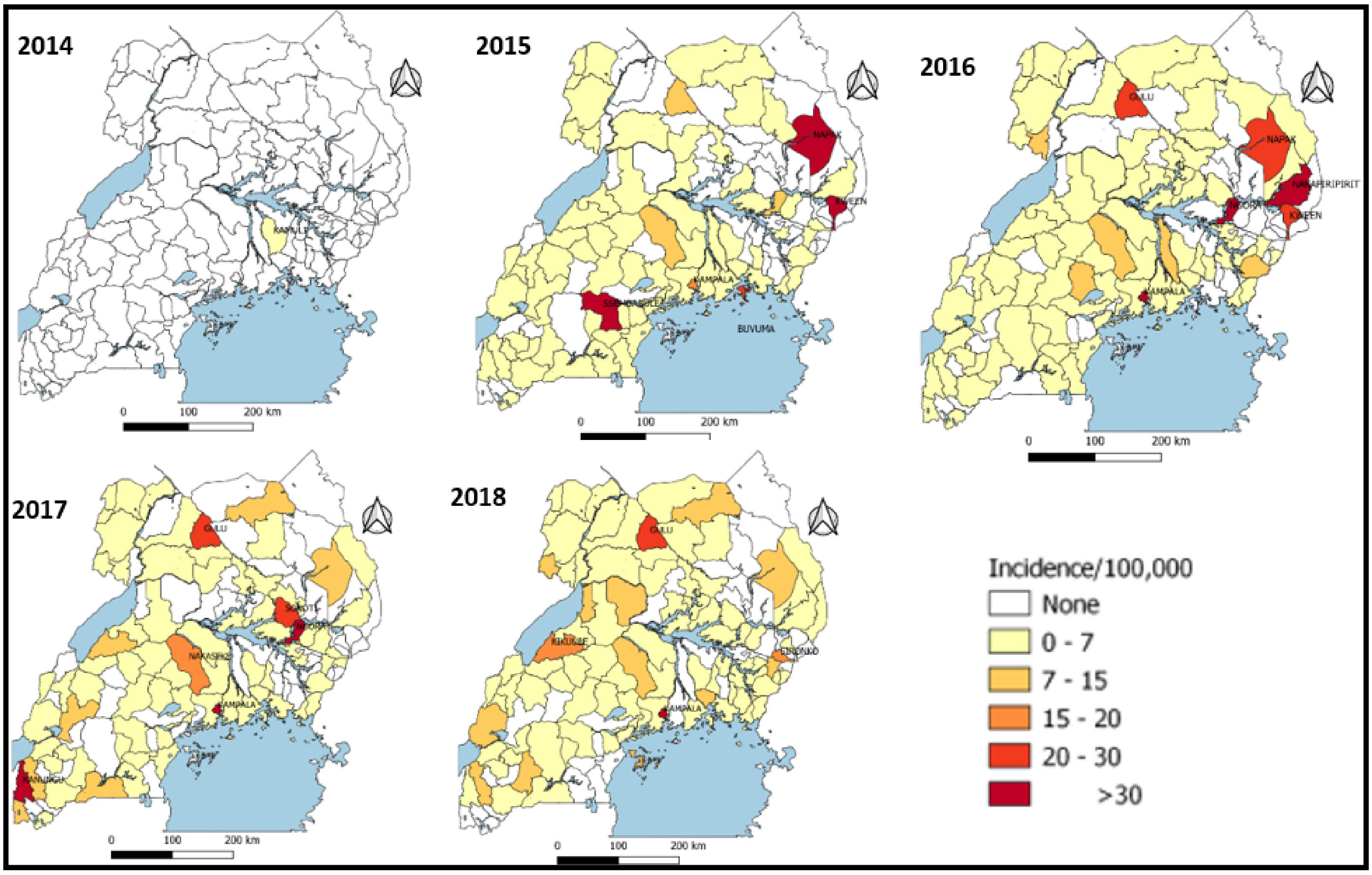

Figure 5: Geographical distribution of bacterial meningitis incidence/100,00 population, Uganda, 2014-2018

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strengthen surveillance, and routine immunization service delivery in the districts, and achieve at least 80% coverage for vaccination in the 39 high risk districts. The area targeted, as reflected in the results of this analysis has been prone to meningitis. The preventive immunization campaign focused on the greater Northern Uganda and parts of Western Uganda, because they lie in the meningitis belt of Sub Saharan Africa, which has experienced frequent outbreaks of meningococcal meningitis This is because the dusty winds and cold nights which characterize the period between December and June in the meningitis belt increase the risk of meningitis (14). Transmission of meningitis is further facilitated by overcrowded housing(15) and large population displacements (16).

This analysis showed that children under five were most affected. It is reported that bacterial meningitis is life-threatening and mostly affects children and adolescents, and may be the cause of severe neurological sequelae (1). Documentation has highlighted similar findings (18). These findings could be attributed to poor prognosis(17) and the fact that children have an under developed immune system especially in the central nervous system (CNS) to prevent infection from crossing to the brain. Also, children are prone to numerous bacterial infections resulting into septicaemias that later affect the CNS(19). Therefore, there is need to vaccinate children which is an effort that has proven to work in reducing the incidence of meningitis (20,21)

Study limitations

Data analysed for this study was collected from a passive surveillance system hence the results are subject to reporting biases like under reporting caused by delays and failure to submit monthly reports by the health facilities. Some patients do not seek care at the health facilities leading to lower reported numbers and eventual underestimation in the burden of disease.

Conclusions

Between 2014 and 2018, data abstracted from the DHIS2 showed that incidence of bacterial meningitis was higher among the under-five population compared to that aged five and above. Males were slightly more affected and spatial incidence was higher in the north eastern region of the country. While there have been efforts by the government to carry out vaccination against meningitis there are still sporadic cases that may need to be intentionally targeted particularly in the northern region where although a mass vaccination was carried out in 2017 and a decline noted, cases continue to occur. The country remains at risk owing to proximity to the DRC where there has been a recent outbreak. We recommend that the MoH includes meningitis in the routine immunization schedule.

Acknowledgement

We would like to acknowledge the responsible departments: Integrated Epidemiology, Surveillance and Public Health (IES&PH) and Division of Health Information (DHI) of the MoH for allowing us to use the routinely generated surveillance data.

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Trends and Distribution of Malaria Deaths Among the General Population, Uganda, 2015-2019

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Summary

In Uganda, malaria is endemic in approximately 95% of the country, affecting over 90% of the population with up to 20% of all hospital deaths. We conducted a descriptive cross-sectional analysis of surveillance data (2015-2019) for confirmed malaria deaths from health facilities into the DHIS2 to understand the magnitude of malaria deaths and hence inform targeted interventions in Uganda.

Between 2015 and 2019, a total of 23,022 malaria deaths were reported, leading to an overall incidence of 62 deaths/100,000. Incidence of malaria deaths significantly increased from 15/100,000 in 2015 to 17/100,000 in 2016. The incidence then declined from 17/100,000 in 2016 to 13/100,000 in 2017 and to 7/100,000 in 2018. Malaria deaths generally significantly declined over the 5 years. The overall incidence among those aged >5 years was 43.2/100,000 and for those 5+years was 5.8/100,000, while incidence among both sexes was equal at 13/100,000. Malaria deaths were highest in May (2,121) through June (2,212) and then July (2,161) and November (2,016) of each year.

Malaria deaths were highest in May through June and then July and November of each year with children under five years being the most affected. The National Malaria Control Division (NMCD) should sustain the programs it is implementing such as the national net distribution campaigns, Integrated Vector Management (IVM), Indoor Residual Spraying, chemoprevention, provision of ACTs and RDTs for VHTs, passive and active malaria surveillance through improved weekly reporting and sustained field supervision. More efforts should be focused on the children under five years and months of May, June, July, and November when most deaths occur.

Background

Malaria is a leading cause of morbidity and mortality in many developing countries, where young children and pregnant women are the groups most affected[1]. In 2019, there were an estimated 229 million cases of malaria worldwide[2]. The estimated number of malaria deaths stood at 409,000 with children aged under five years being the most affected group; accounting for 67% (274,000) of all malaria deaths worldwide. The Global Technical Strategy for Malaria 2016–2030 (GTS) calls for reducing malaria cases and deaths by at least 75% by 2025 and at least 90% by 2030. Without a major turnaround, these targets are unlikely to be met – a challenge further compounded by insufficient levels of funding for malaria control[3].

With a prevalence of 19% in Uganda, malaria has remained endemic in approximately 95% of the country, affecting over 90% of the population[4]. It is the leading cause of morbidity and accounts for 30-50% of outpatient visits at health facilities, 15-20% of all hospital admissions, and up to 20% of all hospital deaths. More than one-quarter of inpatient deaths among children under five years of age are due to malaria[1].

The National Malaria Control Division Uganda has put in place several interventions to fight malaria and reduce malaria deaths. Some of the interventions put in place include: Long Lasting Insecticide Nets (LLINs) distribution through mass campaigns and 10% in antenatal care facilities, Rapid diagnostic testing kits distribution, distribution of Artemisinin-based Combination Therapy (ACT), Integrated Community Case Manage-

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ment (iCCM), Indoor Residual Spraying (IRS), protecting women using IPTp with the antimalarial drugs Sulfadoxine-Pyrimethamine (SP)[2]. Despite the highlighted interventions, Uganda has continued to register malaria deaths.

We analyzed surveillance data on malaria deaths in Uganda from 2015-2019, in order to guide the allocation of the limited available resources and inform the design of interventions to reduce malaria deaths.

Methods

Study setting

This analysis covered all the 136 districts of Uganda which were reporting through the District Health Information System 2 (DHIS2) at the time. Uganda is subdivided into 15 sub geographical regions of which three namely west Nile region, Busoga, and Teso regions are marked as high malaria death burden areas.

Study design and data source

We conducted a descriptive cross-sectional analysis of surveillance data for confirmed malaria deaths from health facilities into the District Health Information Software2 (DHIS2). DHIS2 is an open-access system for aggregating and collection and validation of case-based routine data with associated data elements of key epidemiological and data quality indicators. According to the malaria surveillance system, a malaria death is defined as death occurring from malaria and confirmed by malaria Rapid Diagnostic Test (*m*RDT) or microscopy in a reporting health facility. Malaria death data is reported in such a way that when the malaria patients from the community seek health care from the Village Health Team (VHT) or health facility, the date of visit, their demographics, clinical presentation, diagnosis and treatment given is captured through the HMIS forms which is entered into the electronic system on a weekly basis. VHTs submit their quarterly data to respective health facilities, which then submit their reports to the health sub district on a quarterly basis which further submit their data to the district health office where it is then submitted to the DHIS2.

Data abstraction, study variables, and analysis

We downloaded monthly malaria deaths reported in the inpatient departments by each district from DHIS2 on 14th January 2020. The data captures the malaria death's demographics (age and sex), and health facility where they died, district, and region.

We abstracted data into Excel and analyzed using Excel and EPI info version 7.2. We computed incidence of malaria deaths per 100,000 population overall during 2015-2019 by sex, age (under 5 years and 5 years and above), district, and region. We computed incidences using population figures projected from 2014 census figures as denominators. The projected population for each year were: 35,502,100 in 2015, 36,652,700 in 2016, 37,838,900 in 2017, 9,059,000 in 2018 and 40,308,000 in 2019 with a growth rate of 3.3% (UBOS, 2015, 2018).

We also plotted the malaria deaths by month to establish seasonality in the reported number of deaths and by year to identify the variations in different years. We drew line graphs to identify trends of malaria deaths and tested the significance of the trends using logistic regression. We also used choropleth maps to show distribution of malaria deaths by place in the 135 districts in Uganda.

Ethical considerations

We utilized routinely collected malaria surveillance data from DHIS2. Ministry of Health gave us the permission to utilize the data. Data utilized did not have personal identifiers.

Results

Description of confirmed malaria deaths, Uganda, 2015-2019

Between 2015 and 2019, a total of 23,022 deaths were reported. Children < 5 years contributed the

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highest count of malaria deaths 14,314 (62%) compared to persons aged ≥5 years. Overall, males and females contributed equally to the total count of malaria deaths reported within the study period (50%).

Incidence of malaria deaths, Uganda, 2015-2019

The overall incidence of deaths in the 5 years was 62 deaths/100,000 population. The lowest incidence in deaths was recorded in 2018 (7/100,000) and the highest in 2016 (17/100,000) **(Table 1).**

Table 1: Incidence of malaria deaths, Uganda, 2015-2019

Years	Deaths	Population	Incidence/100,000
2015	5,153	35,502,100	15
2016	5,991	36,652,700	17
2017	4,722	37,838,900	13
2018	2,611	39,059,000	7
2019	4,545	40,308,000	12
Total	**23,022**		**62**

Trend of the overall incidence of malaria deaths, Uganda, 2015-2019

Incidence of malaria deaths significantly increased from 15/100,000 in 2015 to 17/100,000 in 2016. The incidence then declined from 17/100,000 in 2016 to 13/100,000 in 2017 and to 7/100,000 in 2018 **(Figure 1)**.

Significance of trends of malaria deaths, Uganda, 2015-2019

Considering 2015 as the reference year. There was an observed significant increase of incidence of malaria deaths in 2016 by 28%; (OR=1.28; 95% CI =1.20-1.36) **(Table 2)**. There was a reduction in malaria-related deaths by 16% (OR=0.84; 95% CI=0.78-0.90) in 2017, 52% reduction (OR=0.48; 95% CI=0.44-0.52) in 2018. There was a further significant reduction of malaria deaths by 16% in 2019 with (OR=0.84; 95% CI=0.79-0.90) **(Table 2).**

Table 2: Significance of trends of malaria deaths, Uganda, 2015-2019

Year	OR	95% CI	p-value
2015	1		
2016	1.28	1.20-1.36	0.000
2017	0.84	0.78-0.90	0.000
2018	0.48	0.44-0.52	0.000
2019	0.84	0.79-0.90	0.000

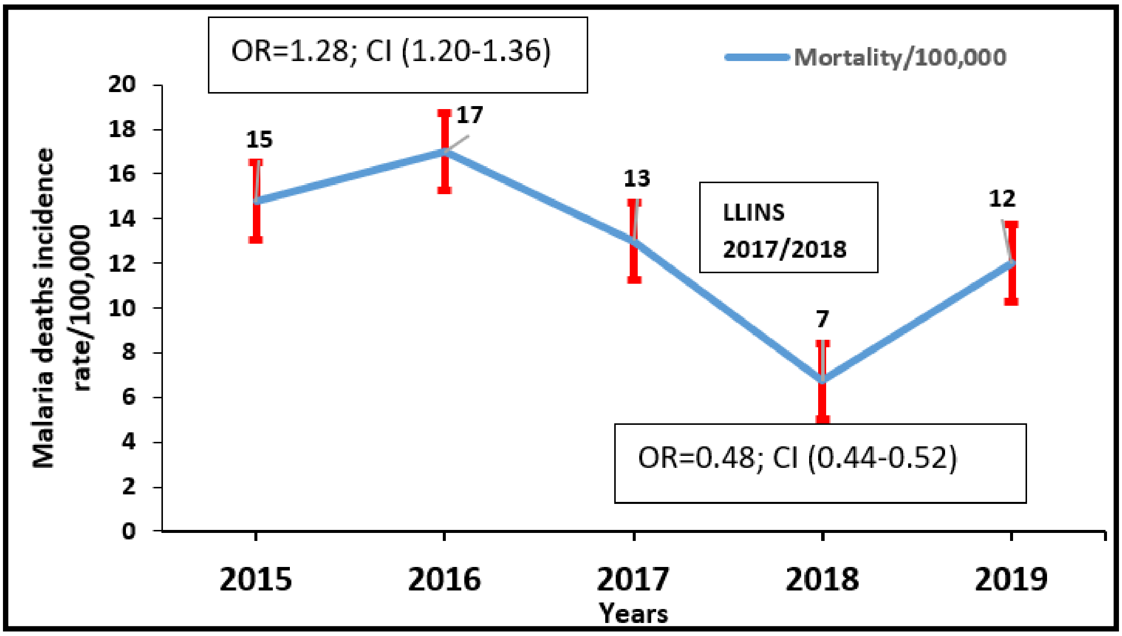

Figure 1: Trend of overall incidence of malaria deaths after distribution of Long-Lasting Insecticide Nets in the year 2017/2018, Uganda, 2015-2019

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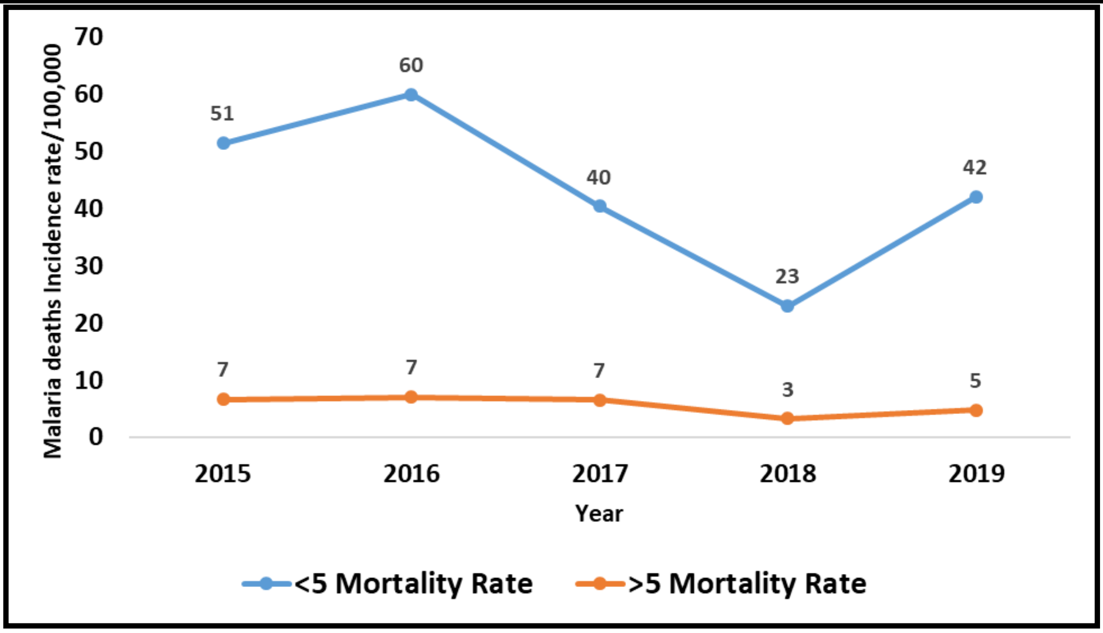

Figure 2: Incidence of malaria deaths by age group, Uganda, 2015-2019

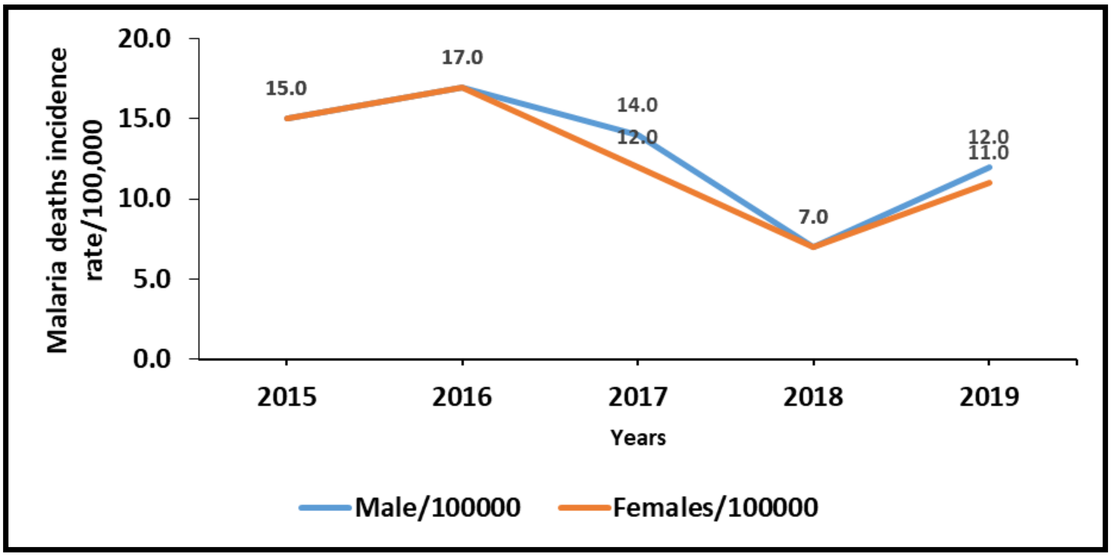

Figure 3: Incidence of malaria deaths by sex, Uganda, 2015-2019

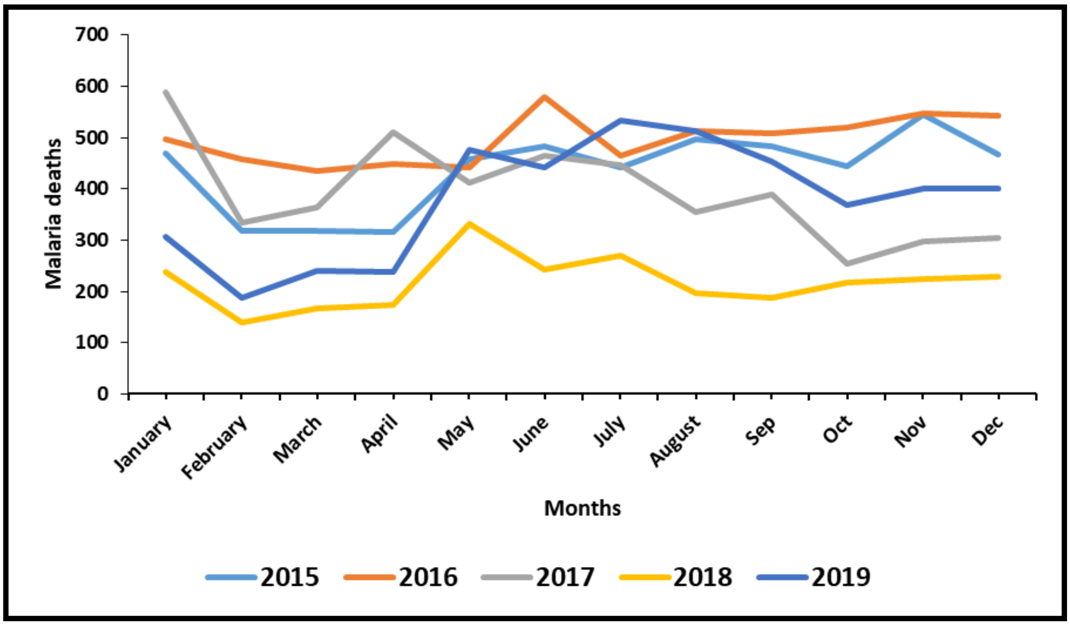

Figure 4: Seasonal variation of total malaria deaths, Uganda, 2015 - 2019

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Incidence of malaria deaths, by age, Uganda, 2015-2019

Consistent with the national trend, we observed that the total deaths of both the <5 and 5+ years aged persons significantly recorded **(Table 2)** their highest incidence of malaria deaths in 2016 with children < 5 years having an incidence of 60/100,000 and ≥ 5 years having 7/100,000. The deaths then reduced by half in both age groups falling to 23/100,000 for children < 5 years in 2018 (**Figure 2).**

Incidence of malaria deaths by sex, Uganda, 2015-2019

Consistent with the national trend of the total deaths **(Table 2)**, we observed a similar statistically significant increase in incidence rates of malaria mortality of 13 deaths/100,000 population in females vs. 13 deaths/100,000 population in males. In 2016, the incidence of deaths in both sexes significantly increased to (IR=17/100,000) population OR=1.28; 95% CI (1.20-1.36) (**Figure 3).** Both sexes reported a decline in malaria related death incidence in 2018 with the overall average incidence of 7/100,000; OR=0.48; 95% CI (0.44-.52). In 2019, the incidence in both sexes shot up registering (IR=12/100,000) in males and (IR=11/100,000) in females OR=0.84; 95% CI (0.79-0.90) **(Figure 3).**

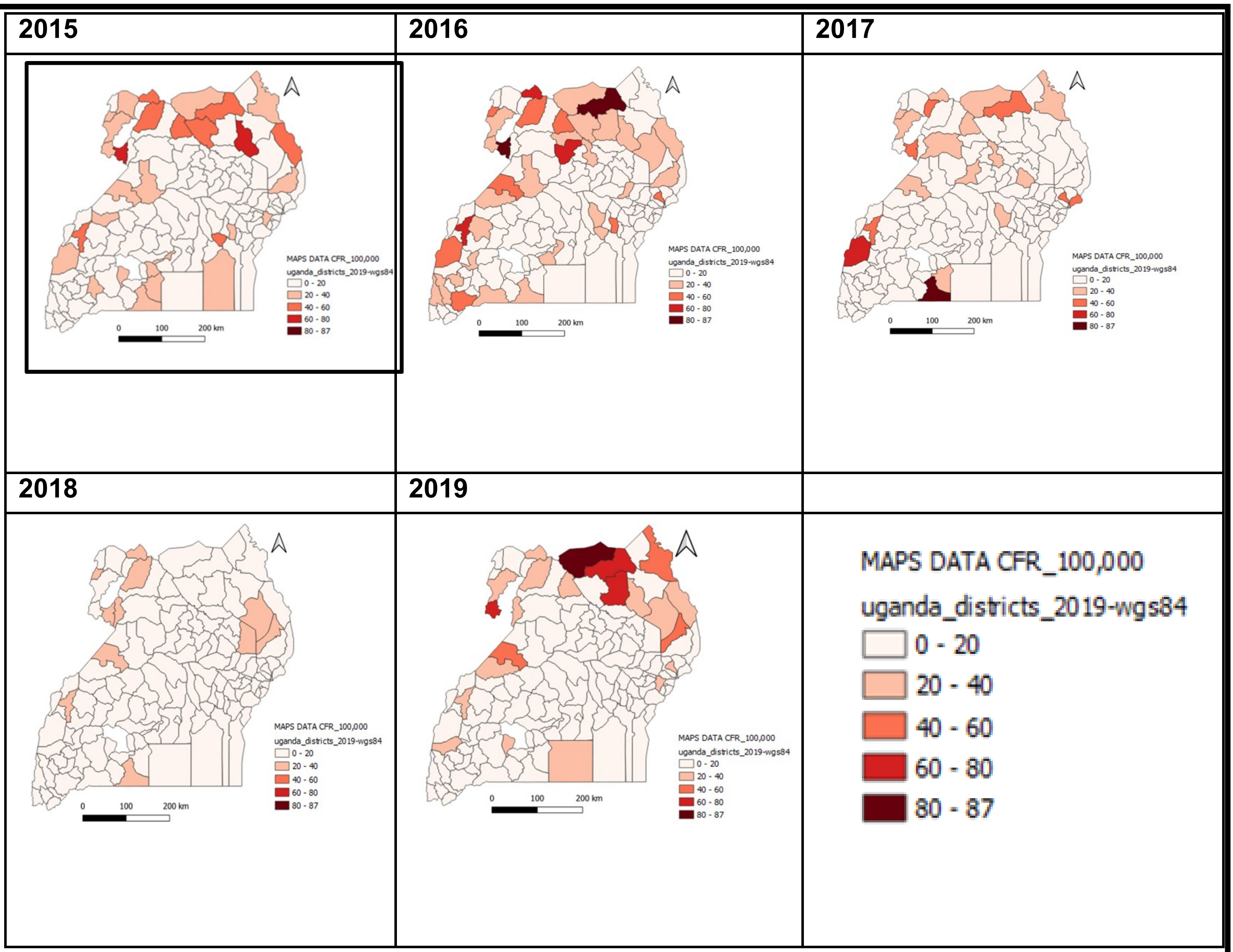

Figure 5: Distribution of malaria deaths by district, Uganda, 2015-2019

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Seasonal variation of total malaria deaths, Uganda, 2015-2019

Consistent with the national trend of malaria deaths, the lowest deaths in malaria was reported in 2018 with the month of February (1438) having the lowest deaths. The highest deaths were reported in 2016. The months that experienced the highest deaths were: May (2,121), June (2,212), July (2,161) and November (2,016) There were notable spikes in the months of November 2015 and June 2016 **(Figure 4).**

Distribution of malaria deaths by district, Uganda, 2015-2019

The geographic distribution of malaria mortality/100,000 in Uganda indicates a general decline in malaria deaths over the 5 years. The years with the highest incidence in deaths are 2016 and 2019. While those with the lowest incidence in deaths were 2017 and 2018. The northern part of the country especially West Nile, Karamoja, and Acholi regions had higher incidences of malaria deaths in 2015-2019. In 2015, 24 districts recorded IR above 20 deaths/100,000 population. The deaths went up by 11 districts with a total of 31 districts reporting above 20 deaths/100,000 population. In 2018 the incidence of death declined with districts that had 20/100,000 deaths reducing to only 7 **(Figure 5).**

Discussion

There was a general reduction in malaria deaths incidence with the only significant increase being in 2016. The incidence of malaria deaths was higher among children < 5 years. Similar results from in a study in Zambia found that children aged < 5 years usually had a 4-fold risk of contracting and dying from malaria compared to their older counterparts above 5 years old [5]. This is also similar to studies done in Zimbabwe and Ethiopia where children were among the most affected people with many deaths occurring amongst them[6] [2] [7].

The northern part of the country especially West Nile, Karamoja, and Acholi areas had higher incidences of malaria deaths, 2015-2019. The transmission of malaria is dependent on the presence of the vector mosquitoes whose breeding habits depend on rainfall patterns and ambient temperatures[7]. The semi-arid climate with warm temperatures, humid conditions, coupled with rainfall favors mosquito breeding in these areas hence more cases of severe malaria which result into deaths. Poor health seeking behaviour including delay in seeking treatment and the long distances to heath facilities have also led to the delay of managing severe malaria hence resulting into deaths[8]. Similar to the districts identified to have the highest incidence in this study, the annual report of 2017 and a study on the 2016 malaria upsurge identified districts in the north including Yumbe, Moyo, Adjumani, Lamwo, and Namayingo from the East to have the highest incidence of deaths [9][10].

The rise in deaths in April and June is due to the rainy season which leads to increased breeding sites for mosquitoes increasing vector density and in turn exposure to mosquito bites[11].

In 2018, the rise in total malaria deaths in the months of April to June was not as high as the previous years. Such flattening of the incidence curves is indicative of interrupted transmission possibly due to the effect of interventions such as: Long Lasting Insecticide Nets which are rendered effective for 3 years while Indoor Residual Spraying effectively reduces mosquito density in the households for 6 months after the last spray[11] [9]. Furthermore, at the start of 2017 to early 2018, LLINs were distributed through a universal campaign achieving an operational coverage of over 95% from 51% in 2016 [10].

Incidence of malaria deaths increased exponentially in 2015, 2016, and 2017 in November and May respectively[3]. In 2019, malaria deaths were on the rise compared to 2018 and the transmission peak was untypical-

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ly long with causes pointing to increased rains and aging of mosquito nets. This emphasizes the need to increase efforts towards maintaining gains obtained so far[11][12].

Limitations

We utilized surveillance data characterized by missing values hence a possible under or over estimation of the magnitude of the incidence of malaria deaths in the country.

Conclusion and recommendation

Whereas there was an increase in Incidence of malaria death in 2016, there was a general decline in malaria deaths incidence between 2017 and 2019. Malaria deaths were highest in May through June and then July and November of each year with children < 5 years being the most affected. The National Malaria Control Division (NMCD) should sustain the programs it is implementing such as the national net distribution campaigns, Integrated Vector Management (IVM), Indoor Residual Spraying, chemoprevention, provision of ACTs and RDTs for VHTs, passive and active malaria surveillance through improved weekly reporting and sustained field supervision. More efforts should be focused on the children < 5 years and months of May, June, July, and November when most deaths occur.

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