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July - September, 2022

Dear Reader,

We take great pleasure in welcoming you to Issue 3, Volume 7 of the Uganda National Institute of Public Health (UNIPH) Quarterly Epidemiological Bulletin.

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; assessment of adverse events following AstraZeneca COVID-19 vaccination; knowledge, attitudes, and practices regarding anthrax, investigation of human tungiasis, voluntary male medical circumcision service uptake among men, assessment of oral pre-exposure prophylaxis eligibility and use, effectiveness of a group-based education and monitoring program delivered by community health workers to improve control of high blood pressure in Island districts, and patterns of tuberculosis case notification and treatment outcomes in the context of COVID-19 pandemic.

Should you have any questions or require additional information related to articles in this bulletin please contact us on: mzalwango@uniph.go.ug, agababrian@uniph.go.ug, zkabami@uniph.go.ug OR lbulage@uniph.go.ug

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

Thank you

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Updates

11th TEPHINET Global Conference - Panama, 4th-9th September 2022

Author: Gorreti Marie Zalwango, Uganda Public Health Fellowship Program—Adv Field Epidemiology Fellow, Cohort 2022, Email: mzalwango@uniph.go.ug, Tel: +256-752-610-802

Training Programs in Epidemiology and Public Health Interventions Network (TEPHINET) organized the 11th global conference this year to provide participants with cutting-edge information on global disease detection, prevention, and response activities undertaken by the network of 76 field epidemiology training programs (FETPs) across more than 100 countries. The event was hosted in Panama City, Panama; South America on 4th – 9th September 2022. Uganda was represented by PHFP fellows who presented the following abstracts: Assessment of preparedness of border districts to respond to plague-West Nile Region, Uganda- August, 2021 by Immaculate Atuhaire; The effect of seasonal malaria chemoprevention on the incidence of malaria among children under 5years in Uganda: Interrupted time series analysis by Andrew Kwiringira; and Establishing Sentinel surveillance for black water fever in Uganda and Burden and factors associated with black water fever among children, Eastern Uganda, January 2019-July 2021 by Alice Asio.

Uganda Public Health Fellowship Program shines at the Uganda Society for Health Scientists Conference

Author: Zainah Kabami, Uganda Public Health Fellowship Program—Adv Field Epidemiology Fellow, Cohort 2022, Email: zkabami@uniph.go.ug, Tel: +256-758-630580

Every year under the auspices of Makerere University College of Health Sciences, the Uganda Society for Health Scientists organizes a conference for scientists all over the country to share findings of research projects they are working on. This year, it was held on 11-12 August at Hotel Africana under the theme “Redefining Collaborations on Health Research” with sub-themes revolving around Antimicrobial resistance, data science, health systems, mental health and ethics in research. The Uganda Public Health Fellowship Program was represented by two fellows from Cohort 2021, Dr. Allan Komakech and Petranilla Nakamya who each won awards for best oral presentation and abstract respectively. Allan presented work on “Adverse events following AstraZeneca COVID-19 vaccine among adults in Greater Kampala, March – April 2021” while Petranilla presented work on “Trends and distribution of stillbirths in Uganda, 2014 - 2020”

Best Oral presentation for “Adverse events following AstraZeneca COVID-19 vaccine among adults in Greater Kampala, March – April 2021”

Best abstract for on “Trends and distribution of stillbirths in Uganda, 2014 - 2020”

11th International Conference on Emerging Infectious Diseases (ICEID)

Author: Gorreti Marie Zalwango, Uganda Public Health Fellowship Program-Adv Field Epidemiology Fellow, Cohort 2022, Email: mzalwango@uniph.go.ug, Tel: +256-752-610-802

On August 7 – 10, 2022, the US-CDC hosted the 11th International Conference on Emerging Infectious Diseases (ICEID) at the Hyatt Regency Hotel in Atlanta, Georgia. This is an event held every 2–3 years and it brings together more than 1,500 public health professionals from around the world to encourage the exchange of the latest information on issues affecting the emergence, spread, and control of

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infectious diseases. The PHFP was represented by Edirisa Juniour Nsubuga with an abstract titled: District leaders' community dialogue meetings improved willingness to receive COVID-19 vaccines in Western Uganda, May 2021, on 7 August 2022.

16th Joint Annual Scientific Health (JASH) Conference held at Munyonyo Hotel on 21st—23rd September 2022

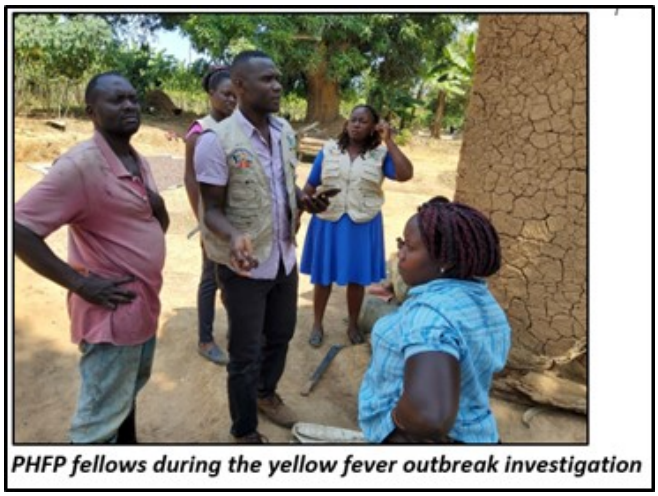
Author: Gorreti Marie Zalwango, Uganda Public Health Fellowship Program—Adv Field Epidemiology Fellow, Cohort 2022, Email: mzalwango@uniph.go.ug, Tel: +256-752-610-802

Annually, Makerere University College of Health Sciences organizes a Joint Annual Scientific Health (JASH) Conference. This year, the 16th JASH conference was organized under the theme: Makerere @100: The role of health professions' education in strengthening health systems, research, global, and community health for economic development. Several sub-themes were focused on with each highlighting the important areas that are linked to the strengths, weaknesses, opportunities, and threats that we need to critically understand as we work towards achieving national and global health care for all. The Uganda Public Health Fellowship Program participated in this knowledge sharing event where a number oral and poster presentations were made. Among the oral presentations were: Sexual and gender-based violence among adolescent girls and young women during the main COVID-19 period in Bukedi subregion, Eastern Uganda by Patience Mwine; Assessment of preparedness of border districts to respond to plague-West Nile Region, Uganda- August, 2021 by Immaculate Atuhaire; Comparative epidemiologic analysis of COVID-19 patients in the first and second waves – Uganda, 2020-2021 by Sarah Elayeete; Trends and spatial distribution of neonatal sepsis in Uganda, 2016-2020 by Stella Migamba; Human and livestock rift valley fever outbreak, Kiruhura District, Uganda, May - June 2021 by Hilda Nansikombi; Patterns of tuberculosis case notification and treatment outcomes in the context of COVID-19 pandemic: analysis of the national surveillance data for January 2019-June 2021 by Veronicah Masanja; and Measles outbreak in Semuto Subcounty, Nakaseke District, Uganda, June–August 2021 by Edirisa Nsubuga. Alice Asio made a poster presentation titled: Black water fever among children in districts of Bugisu, Bukedi, and Busoga Regions in Eastern Uganda, January 2019 – July 2021.

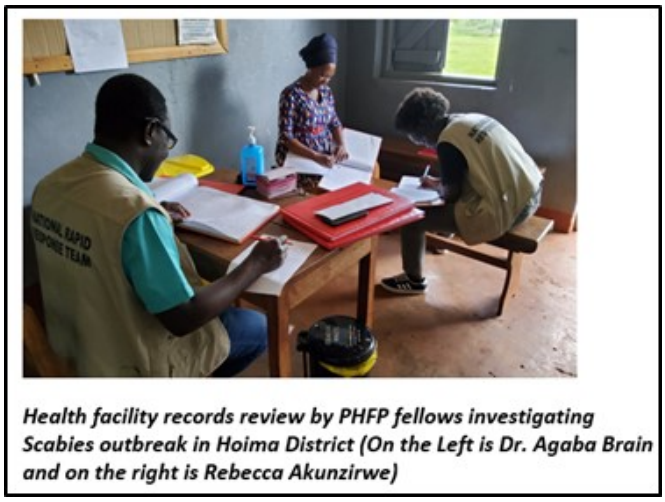
Outbreak investigations responded to:

Author: Brian Agaba, Uganda Public Health Fellowship Program—Adv Field Epidemiology Fellow, Cohort 2022, Email: agababrian@uniph.go.ug, Tel: +256-774-125-554

PHFP fellows have been involved in investigations of disease outbreaks and other events of public health importance. Among those investigated were:
Yellow fever outbreak in Bundibugyo, Masaka and Wakiso Districts, July 2022; Food borne outbreak in Pakwach District, September 2022; Scabies outbreak in Hoima District, February to June 2022; Anthrax outbreak in Ibanda District, Black water fever outbreak in Kakumiro District, Suspected nodding disease in Kitgum and Agago Districts, Crimean Congo Hemorrhagic Fever outbreak in Rakai District, and Methanol poisoning outbreak in Arua and Madi-Okollo Districts.



PHFP fellows during the yellow fever outbreak investigation



Health facility records review by PHFP fellows investigating Scabies outbreak in Hoima District (On the Left is Dr. Agaba Brain and on the right is Rebecca Akunzirwe)

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The launch of indoor residual spraying in West Nile Region, Uganda, September 2022

Author: Gorreti Marie Zalwango, Uganda Public Health Fellowship Program-Field Epidemiology Fellow Cohort 2022, Email: mzalwango@uniph.go.ug, Tel: +256-752-610-802

The government of Uganda in collaboration with the U.S. government's President's Malaria Initiative (PMI), Foreign, Commonwealth and Development Office (FCDO), and the Global Fund, have been implementing indoor residual spraying (IRS) in selected high burden districts since 2009. IRS has contributed to a significant decrease in malaria prevalence in children under the age of five and reduced malaria prevalence during pregnancy and at delivery hence improved maternal and fetal outcomes. On September 8, 2022; the National Malaria Control Division launched IRS in the West Nile region during an advocacy meeting in Moyo District where key local government leaders where engaged. This scale up brings on board nine West Nile Districts namely: Adjumani, Arua, Koboko, Madi-Okollo, Maracha, Moyo, Obongi, Terego, and Yumbe. The PHFP was represented by Gorreti Marie Zalwango to highlight the malaria burden in the region.

Gorreti Marie Zalwango a PHFP Fellow presenting West Nile malaria burden during the Launch of IRS in West Nile Region

US Centers for Disease Control and Prevention Director's visit to Uganda National Institute of Public Health

Author: Zainah Kabami, Uganda Public Health Fellowship Program—Adv Field Epidemiology Fellow, Cohort 2022, Email: zkabami@uniph.go.ug, Tel: +256-758-630580

During July 27th- 30th, the Director of the US Centers for Disease Control and Prevention (CDC), Dr. Rochelle Walensky, visited Uganda to examine US and Uganda collaborations to protect both countries' populations from epidemics. This visit demonstrated the continued importance of US - Uganda partnership in advancing global health security. Dr. Walensky visited peers from the government of Uganda and partners working on HIV service delivery, public health workforce development, public health emergency response, and global health security, among other things. She further interacted with some of the accomplished women who are advancing the fields of medicine and public health and serving as role models for young girls and women on the value of STEM education. She also went to the Mpondwe border, where the World Health Organization (WHO), US-CDC, District, and National public health officials worked together technically to identify spillover cases of the Ebola virus that occurred in 2019 and successfully stopped community spread in Uganda.

Dr. Rochelle Walensky US-CDC Director Atlanta & H.E Natalie Brown U.S Ambassador to Uganda pose with senior officials from US-CDC Uganda, WHO, the Ministry of Health, and the Uganda National Institute of Public

Launch of the 2022 operational plan on the implementation of the National Action Plan for Health Security, 22nd-23rd September 2022

Author: Zainah Kabami, Uganda Public Health Fellowship Program, Adv Field Epidemiology Fellow, Cohort 2022, Email: zkabami@uniph.go.ug, Tel: +256-758-630580

On 22-23 September 2022, the Ministry of Health with support from partners held a multi-sectoral consensus meeting to launch the 2022 operational plan for the implementation of the National Action Plan for Health Security (NAPHS). The NAPHS defines the strategies, actions, and priorities the Government of Uganda will adopt to improve the country's ability to prevent, detect, and respond to public health emergencies. This plan was the first, full-fledged strategy of its kind in Uganda and adopts a whole-of-government approach to health security by leveraging the strengths of many different ministries, departments, agencies, partners, and funding streams.

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Third Deputy Prime Minister and Minister without Portfolio, Ms Rukia Nakadama and senior officials from different MDAs pose with the newly launched National Action Plan for Health, Security, Monitoring and

Regional Population Connectivity Across Borders (PopCAB) Training of Trainers Uganda, Kenya, and Rwanda, 19th- 23rd September 2022

Author: Gorreti Marie Zalwango, Uganda Public Health Fellowship Program—Adv Field Epidemiology Fellow, Cohort 2022, Email: mzalwango@uniph.go.ug, Tel: +256-752-610-802

This year the Ministry of Health Uganda (MoH) organised a regional training of trainers (TOT) for population connectivity across borders (PopCAB). Understanding population movement patterns across borders is important to inform preparedness and response activities for public health emergency and prevention of disease spread across borders. The MoH Uganda organized the event based on their vast experience gained from conducting a number of POPCABs which informed their recommendation for a regional scale up of POPCAB methodology to the health ministries of Kenya and Rwanda. The training engaged 14 participants from Uganda, 14 participants from Kenya, and 4 participants from Rwanda from institutions like: National Public Health Institutes, Ministries of Health and, field epidemiology training programs (FETP) fellows/residents. This training was facilitated by trainers from US-CDC, Baylor Uganda and Infectious Diseases Institute. This activity marked the beginning of a series of trainings aimed to inform and improve outbreak preparedness, prevention and response activities in the region.

Uganda PopCAB participants conducting a roleplay on PopCAB investigation and map annotation

Upcoming Events

National Field Epidemiology Conference, 18 November 2022

Author: Brian Agaba, Uganda Public Health Fellowship Program-Adv Field Epidemiology Fellow, Cohort 2022, Email: agababrian@uniph.go.ug, Tel: +256-774-125-554

The 8th Edition of the National Field Epidemiology Conference will be held on 18 November 2022 at Hotel Africana. This annual event is organized by the Uganda Public Health Fellowship Program, Uganda National Institute of Public Health. This year's conference will feature presentations on projects ranging from Quality Improvement approaches, disease outbreak investigations, evaluations of surveillance systems, response to public health emergencies, and applied epidemiological studies.

World AIDS Day, 1st December 2022

Author: Gorreti Marie Zalwango, Uganda Public Health Fellowship Program-Field Epidemiology Fellow Cohort 2022, Email: mzalwango@uniph.go.ug, Tel: +256-752-610-802

Each year, on 1 December, the world commemorates World AIDS Day. People around the world unite to show support for people living with HIV and to remember those who have died from AIDS-related illnesses. This year's theme will be: Equalize. The "Equalize" slogan is a call to action, a prompt for all of us to work for the proven practical actions needed to address inequalities in access, quality and suitability of services to end HIV. Uganda will join the rest of the world to commemorate this day.

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Assessment of adverse events following AstraZeneca COVID-19 vaccination in Greater Kampala, Uganda, March-April, 2021

Authors: Allan Komakech[1]*, John Kamulegeya[2], Freda Aceng[3], Jonathan Izudi[4], James Acaye[5], Edirisa Junior Nsubuga[1], Petranilla Nakamya[1], Benon Kwesiga[1], Daniel Kadobera[1], Lilian Bulage[1], Alex Riolexus Ario[1]

Institutional Affiliations

[1]Uganda Public Health Fellowship Program Uganda National Institute of Public Health Kampala, Uganda, [2]World Health Organization, Kampala, Uganda, [3]Department of Integrated Epidemiology, Surveillance and Public Health Emergencies, Ministry of Health, Kampala, Uganda, [4]Clarke International University, Kampala, Uganda, [5]Mulago Hospital, Kampala, Uganda.

***Correspondence:** Tel: +256789185617, Email: akomackech@musph.ac.ug

Summary

Background: Tracking of adverse events following vaccination is important for evaluating vaccine safety. During March 2021, Uganda began COVID-19 vaccination using the Astra-Zeneca vaccine targeting teachers, health workers, security personnel and the elderly. We assessed adverse events following AstraZeneca vaccination in Greater Kampala, Uganda to evaluate the safety of the vaccine.

Methods: We used vaccination registers to identify persons who received ≥1 dose of the AstraZeneca COVID-19 vaccine during March 10–April 30, 2021. Adverse events following vaccination were defined as an untoward medical occurrence after vaccination (not necessarily causally related to the vaccine). Serious adverse events were defined as any event considered life-threatening, resulting in in-patient hospitalization, persistent disability >28 days, death or congenital anomaly. We extracted telephone contacts for a systematic random sample of vaccinated individuals and their next of kin where necessary. We then conducted phone interviews with those who consented to collect data on demographics and details of adverse events where they occurred.

Results: Among 374 participants interviewed, mean age was 41 years SD 13 years; range 20 - 85 years; 176 (47%) were female. Of these, 235 (63%) received only one dose and 139 (37%) received two doses. Among the participants, 286 (77%) reported at least one adverse event. Of these, 255 (68%) reported the occurrence of adverse events after receiving the first dose whereas 45 (32%) encountered adverse events after receiving the second dose. The most common adverse events were redness/pain/itching at injection site (34%) and headache (32%). None of the events were classified as serious. Persons aged 20–29 years (AOR 4.7; 95% CI: 2.0–10.2), 30-39 years (AOR 3.7; 95% CI: 1.8–7.4) and 40-49 years (AOR 2.8; 95% CI 1.3–5.0) were more likely to develop adverse events compared to those aged ≥50 years.

Conclusion: Most individuals experienced ≥1 adverse event. No serious adverse events were reported. We recommend administration of the AstraZeneca COVID-19 vaccine in Uganda based on its safety.

Introduction

On March 11, 2020, the World Health Organization (WHO) declared the Coronavirus Disease 2019 (COVID-19) pandemic (1). COVID-19 is an illness caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) (1,2). COVID-19 can manifest as an asymptomatic, mild, moderate or severe illness and can result in death (1,3). The most common symptoms of COVID-19 include fever, cough, fatigue, and dyspnea (4). To slow the spread of SARS-CoV-2, nations around the world implemented different control measures. These measures included social distancing, partial and comprehensive lockdowns, closing of schools and businesses, and wearing face masks in public (5). Although such measures helped in flattening the epidemic curve, the resurgence of COVID-19 was reported as societies and economies reopened (6). Hence, there was an urgent need for vaccination as a long-term preventive measure to address COVID-19 (7).

In November 2020, the first vaccines to protect against the severity of COVID-19 were approved (8). Since then, several vaccines have been rolled out in countries, and more than 200 additional vaccine candidates are still in development (9). The most commonly used vaccines include the AstraZeneca, Moderna, BioNTech, Pfizer, Johnson & Johnson, Sinopharm, and Gamaleya vaccines (10). Following vaccination, adverse events can occur within seconds to weeks (11). Adverse events are events that occur after vaccination but may not necessarily have a causal relationship with usage of the vaccine (11,12). Adverse events can be categorized as serious and non-serious. Serious ad-

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verse events are events that result in death, hospitalization, a permanent/persistent disability or congenital anomalies/defects. Non-serious adverse events are events that do not meet the criteria for serious events (13,14).

In March 2021, the Uganda Ministry of Health (MoH) started the vaccination exercise using the AstraZeneca COVID-19 vaccine, and distribution to all districts was done (15). The target group for vaccination included: teachers, health workers, security personnel, humanitarian front-line workers, the elderly (≥50 years) and those aged 18–49 years with comorbidities (16). In order to track adverse events, the MoH instituted active surveillance for adverse events as recommended by the World Health Organization (WHO) in the post-authorization/Emergency Use Listing period (17). Tracking of adverse events following vaccination is important for evaluating the safety of vaccines. Expected adverse events for the AstraZeneca COVID -19 vaccine included injection site events, headaches, fever and malaise among others (18). With the AstraZeneca vaccine in particular, concern were raised by scientists in Europe about serious adverse events such as deaths, clots, and severe allergic reactions (19). Although the Uganda MoH and WHO assured the public that the AstraZeneca vaccine is safe and effective against COVID-19 (20), no study had been done to fully evaluate adverse events experienced with the vaccine in Uganda. We described the adverse events experienced following AstraZeneca COVID-19 vaccination and determined the factors associated with the occurrence of adverse events in Greater Kampala, Uganda.

Methods and materials

Case definition

We defined a serious adverse event as any medical occurrence that resulted in hospitalization or was considered life-threatening in an individual who received at least one dose of the AstraZeneca COVID-19 vaccine from a vaccination site in Greater Kampala, Uganda during March 10–April 30, 2021. A non-serious adverse event was defined as one that did not meet the criteria for serious adverse events.

Study design

We conducted a cross-sectional study on the experiences of people who received at least one dose of the COVID-19 vaccine. Quantitative methods were employed.

Study area

We conducted the study in Kampala, Wakiso, and Mukono districts, districts that make up Greater Kampala. These districts were chosen because they had the highest proportion of individuals who had received the COVID-19 vaccine at the time, with Kampala (15%), Mukono (2%) and Wakiso (1.7%). Early during the vaccination exercise, the Uganda MoH gazetted COVID-19 vaccination sites in each district. In Kampala Capital City, five vaccination sites were designated for COVID–19 vaccination in each of the five divisions. During the same period, only five vaccination sites per district had been gazetted in Wakiso and Mukono districts.

Sample size

All the 35 vaccination sites located within the Greater Kampala were considered for the study. The sample size for the participants was determined using the Kish Leslie (1964) formula, assuming a 95% confidence Interval, 50% estimated incidence of adverse events, and a margin of error (precision) of 0.05. Based on these assumptions, we estimated that we would need to include 384 individuals for which we inflated this number by 30% to account for non-response.

Sampling procedure

For each of the vaccination sites, we established the proportions of participants who would qualify for the study using probability proportionate to size of vaccinated individuals. At the time of data collection, approximately 36,000 individuals had received the AstraZeneca vaccine in Kampala, Wakiso and Mukono. We apportioned our sample size among the 35 vaccination sites based on the number who had received the vaccine at each of the vaccination sites. We selected 355 participants from 25 vaccination sites in Kampala District, 47 participants from five vaccination sites in Mukono district and 40 participants from five vaccination sites in Wakiso District. We then applied systematic sampling with a random start to identify the individuals who qualified for the study. At each vaccination site, a list of vaccinated individuals was generated from the vaccination registers. We established a sampling interval (i) by dividing the total number of vaccinated individuals at the vaccination site by the required sample size per vaccination site. We then selected a random number (r) between 1 and the i value as our starting point. Individuals (r, r+i, r+2i etc) were selected to participate in our study. We extracted phone

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numbers of the selected participants from the vaccination registers.

Study variables and data collection

We used a standardized questionnaire adapted from the WHO core variables for adverse events (12). The primary outcome variable for this study was experiencing an adverse event following vaccination that could occur within seconds to weeks after vaccination. We collected data on demographic characteristics (age, sex, nationality, profession), individual clinical characteristics (having a chronic illness, ever had previous reactions to a vaccine, usually have reactions to medicine and illness at the time they received the vaccine) and details of where the adverse events occurred. Data collected on adverse events included: adverse events experienced, the dose after which they occurred, time of onset, duration, and outcome of the adverse events. Information from eligible participants was collected through phone interviews. For participants and their next of kin whose phone numbers were not reachable at the first attempt to have an interview, we scheduled up to three other attempts to contact them at later dates.

Data analysis

For quantitative data analysis, we entered data on demographics, individual clinical characteristics, and details of where adverse events occurred into an excel abstraction spreadsheet and analyzed this data using SPSS. Frequencies and percentages were presented for all the categorical variables. Binary logistic regression model was fitted to establish the association between the categorical independent variables and the outcome of interest (experiencing an adverse event following vaccination). First, crude odds ratios, 95% confidence interval (CI) and their respective p-values were obtained. All variables with p-values <0.10 were considered for multivariable analysis. Multivariable logistic regression was conducted to obtain adjusted odds ratios with their respective 95% confidence interval (CI) and p-values. Variables with p-values <0.05 at multivariable analysis were considered to be significant and associated with the outcome.

Results

Demographic and clinical characteristics of study participants during a study assessing adverse events following AstraZeneca COVID - 19 vaccination in Greater Kampala, Uganda, March–April 2021

A total of 374 participants were interviewed. The mean age of the participants was 41 years (range 20 - 85), SD 13 years. Of the participants, 352 (94%) reported that they didn't have any illness at the time of receiving the COVID – 19 vaccine (Table 1).

Table 1: Demographic and clinical characteristics of study participants

Variables	Frequency	Percentage (%)
Health facility/ vaccination site		
Kampala	280	75
Mukono	56	15
Wakiso	38	10
Age group (years)		
20–29	73	20
30–39	113	30
40–49	90	24
Sex	98	26
Male	198	53
Female	176	47
Nationality		
Ugandan	365	98
Non–Ugandan	9	2.4
Profession		
Health workers	67	18
Teacher	83	22
Security officers	11	3
Others	213	57
Have chronic illness		
Yes	104	28
No	270	72
Currently on any long -term medication		
Yes	70	19
No	304	81
Ever had previous reactions to vaccinations		
Yes	19	5
No	330	88
Not sure	25	7
Usually have reactions to any medicine such as antibiotics, anti-inflammatories		
Yes	47	13
No	327	87
Illness at the time you received the COVID-19 vaccine		
Yes	22	6
No	352	94

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Proportion of individuals that experienced adverse events following AstraZeneca COVID-19 vaccination

Among the participants, 255 (68%) experienced at least one event after the first dose and 45 (32%) experienced at least one event after the second dose; 268 (77%) had some form of adverse event after either dose. The most commonly reported adverse events following the first dose were: redness/pain/itching at injection site, 92 (36%); headache, 88 (35%); and fever, 56 (22%) (Figure 1). The most commonly reported adverse events following the second dose were: fever, 11 (24%); redness/pain/itching at injection site, 9 (20%); and headache, 8 (18%) (Figure 2). Overall, injection site events 101 (34%) and headache 96 (32%) were the most experienced adverse events. In the "Others" category, events such as skin rash, insomnia, limb paresis (mild/partial paralysis) and limb paraesthesia (burning or tingling sensation) were reported.

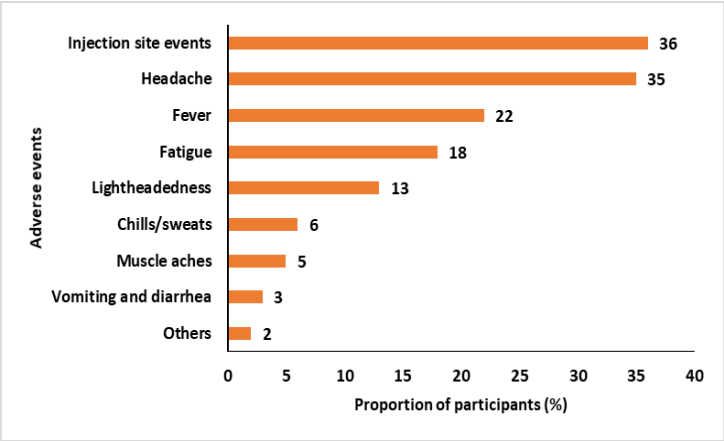

Figure 1: Adverse events after receiving the first dose of AstraZeneca COVID – 19 vaccine in Greater Kampala, Uganda, March–April 2021

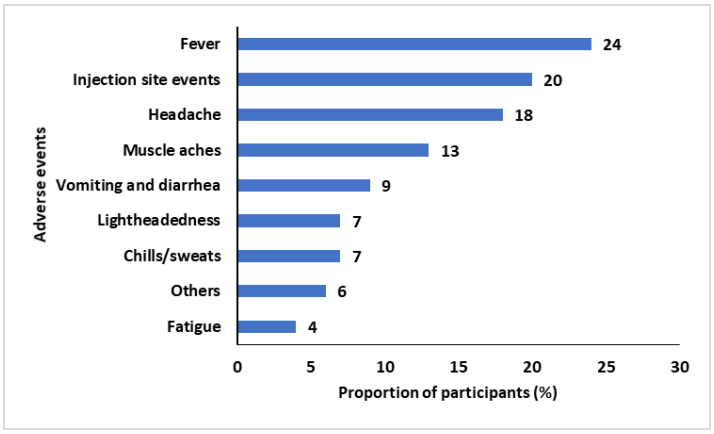

Figure 2: Adverse events after receiving the second dose of AstraZeneca COVID – 19 vaccine in Greater Kampala, Uganda, March–April 2021

Time of onset of adverse events following AstraZeneca COVID-19 vaccination

Most adverse events 146 (32%) after the first dose and most adverse events after the second dose 17 (28%) commenced within 1-6 hours (Figure 3). Generally, most adverse events after the first and second dose commenced within the first 72 hours, 434 (95%) and 56 (93%) respectively (Figure 4). Furthermore, 23 (5%) and 4 (7%) of the adverse events commenced after 72 hours of receiving the first and second dose respectively as indicated in Figure 3.

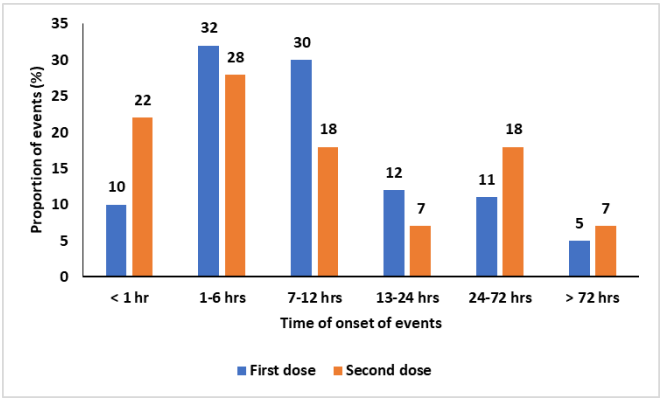

Figure 3: Time of onset of adverse events following AstraZeneca COVID - 19 vaccination

Duration of adverse events following AstraZeneca COVID - 19 vaccination

Two hundred fifty-two (55%) of the events after the first dose and 33 (55%) of the events after the second dose lasted for 1-3 days. Thirty-six (8%) of the events after the first dose and 6 (10%) of the events after the second dose lasted >7 days (Figure 4).

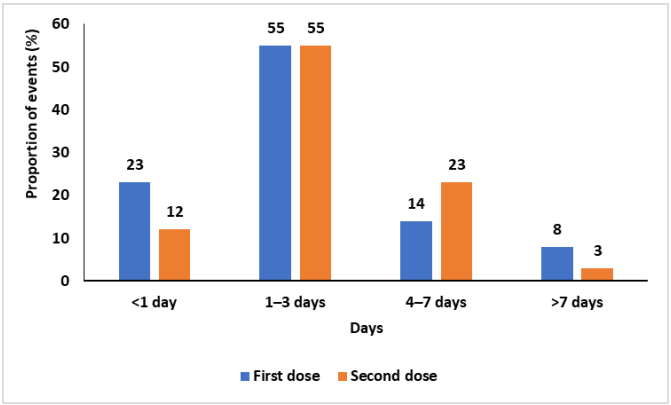

Figure 4: Duration of adverse events following AstraZeneca COVID - 19 vaccination

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Two hundred eighty-two (62%) events after the first dose and 36 (60%) events after the second dose were self-resolved. Twenty-four (5%) of the events after the first dose and 4 (7%) of the events after the second dose resulted in outpatient assessment (Figure 5).

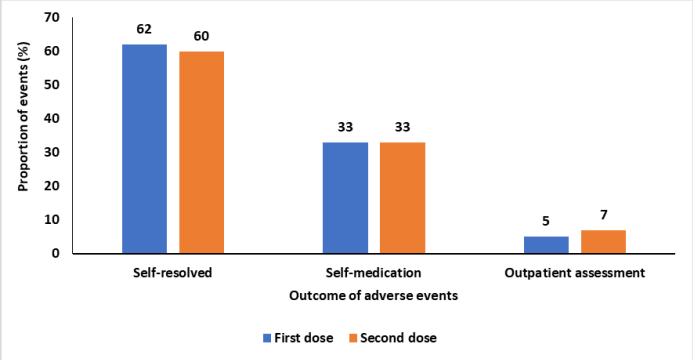

Figure 5: Outcome of adverse events following AstraZeneca COVID - 19 vaccination (AEFIs) in Greater Kampala, Uganda, March–April 2021

Factors associated with experiencing adverse events following AstraZeneca COVID - 19 vaccination, Greater Kampala, Uganda, March–April 2021

Table 2 shows unadjusted and adjusted prevalence ratios with their respective corresponding confidence intervals. At bivariate analysis, age, sex, and currently being on long-term medication were associated with an adverse event at bivariate analysis. Respondents who were aged 20-29 years (COR 5.3, 95% CI, 2.4-12), 30-39 years (COR 3.9, 95% CI 2.1-7.5) and 40-49 years (COR 2.8, 95% CI, 1.5-5.3) were more likely to develop an adverse event than respondents aged 50 years and above. Females were more likely to develop an adverse event compared to males (COR 1.7, 95% CI, 1.02-2.7); and those who were not on long term medication were less likely to develop an adverse event than those who were on long term medication (COR 0.4, 95% CI, 0.2-0.8).

At multivariate analysis, age was significantly associated with developing an adverse event. Participants aged 20-29 years (AOR 4.7; 95% CI: 2.0–10.2), 30-39 years (AOR 3.7; 95% CI: 1.8–7.4) and 40-49 years (AOR 2.8; 95% CI 1.3–5.0) were more likely to develop an adverse event compared to those above 50 years old. Odds of developing an adverse event increased with decreasing age as shown in Table 2.

Table 2: Factors associated with adverse events following AstraZeneca COVID-19 vaccination

Variables	Adverse event, n (%)	No adverse event, n (%)	COR (95% CI)	AOR (95% CI)
Age group (years)				
≥50	56 (20)	42 (48)	1.0	1.0
20–29	64 (22)	9 (10)	5.3 (2.4–11.9)	4.7 (2.0–10.2)
30–39	95 (33)	18 (21)	3.9 (2.1–7.5)	3.7 (1.8–7.4)
40–49	71 (25)	19 (22)	2.8 (1.5–5.3)	2.8 (1.3–5.0)
Sex				
Male	143 (50)	55 (63)	1.0	1.0
Female	143 (50)	33 (38)	1.7 (1.02–2.7)	1.6 (0.93–2.6)
Nationality				
Non–Ugandan	281 (98)	84 (96)	1.0	1.0
Ugandan	5 (2)	4 (5)	0.37 (0.098–1.4)	0.6 (0.1–2.4)
Have chronic illnesses				
Yes	73 (26%)	30 (34)	1.0	1.0
No	213 (75	58 (66)	0.7 (0.4–1.2)	0.4 (0.2–1.2)
Currently on any long-term medication				
Yes	44 (24)	62 (71)	1.0	1.0
No	142 (76)	26 (30)	0.4 (0.2–0.8)	0.7 (0.4–1.3)
Ever had previous reactions to vaccinations				
Yes	17 (6)	2 (2)	1.0	1.0
No	251 (88)	79 (90)	0.3 (0.09–1.7)	0.6 (0.1–2.6)
Not sure	18(6)	7 (8)	0.3 (0.09–1.7)	0.5 (0.1–2.9)
Usually have reactions to any medicine				
Yes	37 (13)	10 (11)	1.0	1.0
No	249 (87)	78 (89)	0.9 (0.4–1.8)	0.8 (0.3–1.7)
Illness at the time you received the COVID-19 vaccine				
Yes	40 (14)	7 (8)	1.0	1.0
No	246 (86)	81 (92)	1.6 (0.6-3.9)	1.0 (0.4–3.1)

Note: COR= Crude Odds Ratio, AOR= Adjusted Odds Ratio

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Discussion

In our study, 77% of the participants reported having experienced an adverse event after receiving either dose of the vaccine. The most commonly experienced adverse events were injection site events, headache and fever. Most adverse events had an onset within 3 days of receiving the vaccine and most events lasted between 1-3 days. In addition to that, those aged 20–29 years, 30-39 years and 40-49 years were more likely to develop adverse events than those aged ≥50 years. No serious adverse events were reported.

Most participants in our study revealed that they experienced an adverse event after either dose of the vaccine. Based on reports for most vaccines, an immune response is induced after AstraZeneca vaccination (21–23). These immune responses can lead to adverse events and these events occur in different persons differently (23,24). In a prospective single-cohort study in Ethiopia among health workers to assess for adverse events after receiving the Oxford-AstraZeneca vaccine, 68% of the participants reported an adverse event (25). Despite a difference in the study designs, the results were similar. Similarly, in Togo, 72% of participants reported at least one adverse event after vaccination with AstraZeneca vaccine (ChAdOx1 nCoV-19 vaccine). However, in an online cross-sectional study assessing for self-reported adverse events in Bangladesh, 51% of the participants reported having experienced an adverse event after receiving a dose of the Oxford-AstraZeneca (Covishield) vaccine (26). This proportion might have been lower due to the nature of the study. In an online interview, a participant may not be able to freely express their symptoms. On the contrary, in a more engaging mode of communication such as phone interviews used in this study, participants may be led on to remember or recall some of the adverse events experienced. Furthermore, in an online interview, the participants may respond hurriedly thereby missing out on some adverse events experienced.

We also compared proportions of individuals who experienced adverse events with other vaccines. An online cohort study in the United States analyzing with participant-reported adverse events after COVID-19 vaccination revealed that 65% reported an adverse effect after receiving Pfizer–BioNTech COVID-19 vaccine (BNT162b2) and 80% after Johnson % Johnson vaccine (27). A large-scale community-based study in the United Kingdom reported an even much lower rate of 33.7% (28). The variation may be due to the difference in study design and the heterogeneity of the populations. Some evidence has pointed towards ethnic differences and vulnerability to adverse events following vaccination (29).

We found that the most commonly reported adverse events included injection site events, fever, headaches, and general body weakness. This is because the vaccine instructs the body immune system to react in certain ways including increases in blood flow more at the injection site, so more immune cells can circulate, and it raises the body temperature. This is consistent with other studies that reported similar reported adverse events among the population (27,30–32). In most cases, adverse events are expected and people receiving the vaccine need to be sensitized. This helps to provide assurance and prepare them psychologically. Furthermore, health workers were also trained in managing adverse events as most are expected.

No serious adverse events were reported in our study. We believe this is due to short-lived, self-limiting symptoms that are mild or moderate in severity. Most adverse events were self-resolved with none requiring inpatient hospitalization, resulting in death, a permanent/ persistent disability or a congenital anomaly. A study in Ethiopia on adverse events among health care workers who received the Oxford/ AstraZeneca vaccine noted similar results to our study (25). Several studies have also reported no serious adverse events following vaccination with AstraZeneca (28,33). In China, a meta-analysis of 12 different vaccines at phase 3 level of clinical trials revealed higher odds of serious adverse events following at least one dose of mRNA vaccines (AOR: 1.47; 95% CI: 0.65–3.3) compared to those who received at least one dose of non-replicating viral vector vaccine (AOR: 0.76; 95% CI: 0.62–0.93) and inactivated vaccines (AOR: 0.79, 95% CI: 0.62–1.00) (34). However, the same study revealed that no solid evidence indicated that COVID-19 vaccines directly caused serious adverse events.

In our study, individuals aged 20–29 years, 30-39 years and 40-49 years were more likely to develop adverse events than those aged ≥50

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years. Furthermore, the odds increased with decreasing age. This may be due to higher reactogenicity among younger people than their older. Younger individuals tend to have a more active immune system which wanes with increasing age (35). Similarly, several studies have noted increasing odds of adverse events among younger individuals following administration of AstraZeneca COVID-19 vaccine and other COVID-19 vaccines (25,31,33,36). A comparative study among 3 different vaccines noted similar results (37). However, older individuals might report less adverse events as they often dismiss them as symptoms of old age. This has been shown in a non-COVID-19 related study (38). This implies that adverse events among elder individuals should be well-probed. Furthermore, older individuals and their caretakers where necessary should be sensitized to always seek medical advice where adverse events present.

Study limitations

First, phone interviews were voluntarily responded to by individuals; thus, they might not have been objective. Second, the data collected might also have been subjected to recall bias as a few weeks had passed for some participants before they were subjected to the questionnaire. This was addressed through proper explanation of the study purpose and detailed probing without leading the participants onto what to say during the interview. We also called back participants to seek for clarity in case it was necessary. Use of a prospective study would alleviate this study limitation.

Conclusions

Most individuals experienced at least one adverse event after receiving either dose of the AstraZeneca COVID-19 vaccine. The most common adverse events were injection site events, headache and fever. No serious adverse events occurred. Younger age (<50 years) was significantly associated with developing an adverse event compared to those aged 50 years and above.

Recommendations

We recommend the use of the AstraZeneca COVID-19 vaccines in Uganda to help curb the spread of the COVID-19 infection based on its safety.

Conflict of Interest

The authors declare that they had no competing interests.

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Knowledge, Attitudes, and Practices on Anthrax among affected Communities, Kazo District, South-western Uganda, May 2022

Authors: Shaban Senyange[1*], Edirisa Junior Nsubuga[1], Daniel Kadobera[1], Benon Kwesiga[1], Lilian Bulage[1], Alex R. Ario[1]
Institutional affiliations: [1]Uganda Public Health Fellowship Program, Uganda National Institute of Public Health, Kampala, Uganda
***Correspondence**:
Email: ssenyange@musph.ac.ug, Tel: +256-774-654-777

Summary

Background: Anthrax is a priority zoonotic disease in Uganda. Despite health education about the risks of anthrax from eating meat from carcasses, some districts in Uganda, including Kazo District, experience repeated anthrax outbreaks associated with this risk factor. We assessed knowledge, attitudes, and practices (KAP) around anthrax in previously-affected communities in Kazo District.

Methods: We conducted a mixed-methods study in six villages in Kazo District from May 23–June 4, 2022. We administered structured questionnaires to 200 systematically-sampled community respondents aged ≥18 years about anthrax-related KAP and experiences with livestock loss. We conducted three KAP-based focus group discussions with community members identified as anthrax case-patients in previous outbreaks and those whose animals died suddenly in the previous year. We assessed overall knowledge through a set of eight questions on anthrax; species affected, signs and symptoms, transmission and prevention in humans and animals. We scored participants' responses to KAP questions as "1" (correct) or "0" (incorrect); adequate knowledge score was ≥4. Qualitative data were analyzed using content analysis.

Results: Among respondents, 65% were female; mean age was 45 years. In total, 94% had heard of anthrax and 73% knew transmission could occur through eating meat from carcasses. Overall, 77% of respondents had adequate knowledge about anthrax. Only 16% had lost their livestock suddenly in the last year; of these, 21% consumed the meat and 53% buried the carcasses. Qualitative data indicated that farmers did not vaccinate livestock against anthrax due to cost and difficulty accessing vaccine and veterinary services. Poverty and limited access to protein were cited as drivers for consuming meat from carcasses despite the risk.

Conclusion: Good awareness about anthrax among residents of a repeatedly-affected community in Uganda did not translate to safe practices. It may be difficult for communities in affected areas to forego opportunities to eat meat from animals they find dead, even when they suspect possible danger. Consideration of alternate preventive approaches and messaging, such as compensating farmers for anthrax-positive carcasses in exchange for permitting safe animal disposal, might reduce risk in high-risk communities.

Introduction

Anthrax is a bacterial disease of public health and economic importance endemic in many agricultural parts of the world(1) . It is a zoonotic disease caused by *Bacillus anthracis*, an aerobic, gram-positive and spore forming bacterium that belongs to the family Bacillaceae (2).The disease affects herbivorous animals (wild and domestic) and humans (3), (2). Livestock get infected through ingestion or inhalation of spores from contaminated soil, water, or pastures with the clinical course of the infection ranging from acute to chronic (3) Ingested spores are transformed in vivo into vegetative bacilli that cause disease. When the animal dies, the contaminated carcasses and infectious fluids re-contaminate the environment. The sporulation makes *Bacillus anthracis* resistant to degradation in the environment, and spores can persist for extended periods of time, even under adverse conditions (4).

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Human infections often result from handling and/or consuming meat of infected livestock (5). There are three main forms of human anthrax infection, depending on the route of exposure: cutaneous, gastrointestinal, and pulmonary (inhalational) anthrax. Cutaneous anthrax is the most common and accounts for approximately 95% of cases (6). Between one and 12 days after exposure, clinical signs of cutaneous anthrax infection appear as one or more painless, itchy papules or vesicles on the skin, typically on exposed areas such as the face, neck, forearms, or hands. Within 7-10 days of the initial lesion, the papule forms an ulcer, which subsequently crusts over, forming a painless black eschar that is the hallmark of cutaneous anthrax. Localized swelling, painful swollen regional lymph nodes, and systemic symptoms may also be present (7). Without treatment, the case-fatality rate of cutaneous anthrax is 20% (6); however, it can also self-resolve.

In Africa, anthrax remains a major problem except in South Africa where it continues to be at a low sporadic incidence probably as a result of the livestock owners taking the central role of control (8). Continuous sporadic outbreaks of the disease have been reported in a number of countries in the sub-Saharan Africa including Uganda in the recent years (3). Anthrax is among the top seven priority zoonotic diseases in Uganda and neighbouring East African countries (9), (10). Uganda is particularly susceptible to zoonotic diseases due to its exceptional biological diversity and escalating population density that brings humans and animals into increasing interaction (11). Uganda has been reporting anthrax cases and deaths in humans and animals, including wildlife, since at least 1959 (12). Outbreaks have been reported from every region of Uganda, mostly among communities that rear cattle (13) . Surveillance data in Uganda in 2018 revealed 186 reported human cases and 721 reported livestock deaths due to anthrax (13).

Anthrax is known to cause devastating socio-economic impact in various ways, including animal disease, loss of productivity, loss of income for livestock dependent populations, human morbidity and mortality (14). The disease perpetuates poverty and causes emotional trauma, especially among the poor populations whose livelihoods depend on pastoral farming (15). In addition, due to destruction of infected animals, household food security is often affected and farmers experience large financial losses (16). In addition, most households, and families may consume and sell some of the meat from anthrax infected animals in order to minimize losses associated with death of animals that should ideally be safely disposed off (17), (18). This is worsened by the absence of compensation schemes for livestock losses in resource-limited settings.

A number of factors such as changing rainfall patterns, soil disturbance, increased animal and human populations, poor grazing systems and human behaviour, poor anthrax surveillance and weak control programs have been reported to be associated with outbreaks of anthrax (19). Interaction of wildlife with livestock and humans has also been reported as a key predisposing factor of anthrax among humans and livestock. The disease usually reoccurs in areas where there has been a previous outbreak, making vaccination one of the recommended form of control (1), (20). Previous studies have shown that poor perceptions, cultural norms, beliefs, and practices of local communities play key roles in the persistence of anthrax outbreaks.

During January 2017 – December 2018, recurrent outbreaks of anthrax in both animals and humans were reported in four districts, namely: Zombo and Arua in Northen Uganda, Kween in Eastern Uganda and Kiruhura in Western Uganda (21). Recommendations following these investigations frequently focus on health education to the community about not eating meat from animals found dead. However, given the repeated and consistent outbreaks, the knowledge around the rationale for this recommendation as well as the willingness and feasibility of implementing this recommendation is unclear.

This study assessed the knowledge, attitudes, and practices regarding Anthrax among the affected communities in Kazo Dis-

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trict to improve our understanding of what people know about anthrax and conduct a deeper investigation into why the affected communities eat meat from animals that they find dead.

Methods

Study area

The study was conducted in Kazo District, located in South-western Uganda. It was curved out of the greater Kiruhura District as of financial year2019/2020.The district covers a land area of 1551 sq. km with a population of 217,600. It is in the Masaka-Ankole cattle corridor. The predominant economic activity is livestock keeping and crop growing. It is bordered by Kyegegwa District in the North, Ibanda District in the West, Kiruhura District in the East and South, Kamwenge in the North West and Sembabule in the North East, all of which are located in the cattle corridor of Uganda (22). The cattle corridor covers approximately 40% of Uganda's land surface, stretching from north-east, through central to southwest Uganda. It is characterised by livestock production, scarce water and pastures. Although it is one of the country's most fragile ecosystems and vulnerable to climate change, it remains relevant to national and local food security (23).

Study design

We utilized a mixed-method design employing both quantitative and qualitative methods. We conducted Focus Group Discussions (FGDs) and house-to-house surveys during May 23 to June 4, 2022. We conducted three FGDs, with 6-12 persons targeted per group. The first two FGDs comprised of persons who were confirmed or probable cases in previous anthrax outbreaks. The purpose of these FGDs was to assess if these people were aware of the risks of eating animals that were found dead, and if so, reasons they or their relatives continue to consume meat from animals that are found dead.

For the third FGD, we included a random sample of persons who had animals that had died suddenly during the previous year. The purpose of this FGD was to understand specifically what was done with the animal carcasses, if they perceived any risk associated with slaughtering or eating them, and how that risk influenced what they did with the carcasses.

For the community survey, sample size was estimated based on knowledge about health risks from eating meat from animals that they found dead. We purposively selected six villages that experienced an anthrax outbreak in humans linked to consumption and/or preparation of meat from an animal found dead during the last outbreak in 2018. We worked with Village Health Teams (VHTs) to develop a full list of households and performed systematic sampling to select and interview 200 households in six villages in Engari Sub-county, Kazo District (estimated based on 87% of persons knowing that there is a risk of illness when they eat animals that they find dead, 95% confidence interval). Heads of households were sought on the day of the visit to the village and were replaced by the household next door if not available at the time of the visit. If replacement occured, the subsequent household was the one that would have been sampled had the original household *not* been replaced. The study investigators trained two data collectors from the community to conduct the surveys and FGDs in the local language with support from VHTs.

Using an interviewer administered structured questionnaire, we collected information on socio-demographics (age, sex, marital status, religion and occupation), information on knowledge (causes, species affected, transmission, signs and symptoms, prevention and control); attitude (opinion about anthrax disease) and practices (meat consumption, slaughter and butchering carcasses, carcass management and vaccination of animals).

Data analysis

Survey data were entered, cleaned and analyzed using Microsoft® Excel and STATA. We performed univariate analysis for socio-demographics and characteristics associated with knowledge, attitude and practices. Data from the knowledge, attitudes, and practices survey was reported quantitatively using frequencies for each of the questions. Responses for each domain were summarized into categories to represent different levels of knowledge, attitudes, or practices around anthrax-related issues.

Overall knowledge on anthrax was assessed through a set of eight questions related to knowledge on anthrax (heard of anthrax, species affected, signs and symptoms in animals, transmission in animals, prevention in animals, signs

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and symptoms in humans, transmission in humans, prevention and control in humans). We allotted participants´ response as “1” for a correct response and “0” for an incorrect response. To assess for knowledge on anthrax, individual respondent scores were summed for variables pertaining to these items. The median was calculated and used as the cut off score. Respondents with a score less than the median for knowledge were considered to have inadequate knowledge.

We performed bivariate and multivariate analysis and ran logistic regression to explore association between socio-demographic characteristics, attitudes and practises and knowledge scores. Statistical significance was set at p-value < 0.05. Variables that were found to be significant at bivariate analysis were entered into the model for multivariate analysis.

Variables with p<0.1 in bivariate analysis were included in the logistical regression model using a backward stepwise method. At the multivariate analysis level, p<0.05 showed statistically significant associations between Knowledge and the independent variables. We tested the model using Hosmer–Lemeshow goodness of fit test.

Qualitative data were transcribed and coded in Microsoft® Word (Ms Word) and analysed for content along thematic areas. In transcribing the FGDs, the narratives were re-read, compared to audio files and group consensus of investigators was reached for verification of themes. Illustrative comments and quotations that clearly represented themes were quoted verbatim.

Ethical approval

This activity was a response to a public health emergency thus approved as a non-research by the Office of the Associate Director for Science, United States Centers for Disease Control and Prevention, (US CDC). We obtained verbal informed consent from respondents 18 years and above. In addition to the parent’s consent, we obtained a verbal assent from respondents aged below 18 years. We stored all completed questionnaires in a secure location and stored the electronic data in a password -protected laptop to avoid disclosure of respondents’ personal information. Data were shared strictly with the investigation team.

Results

Socio-demographic characteristics

In total, 200 people participated in the community survey. Most of the participants (129; 65%) were female, 132 (40%) were between the ages of 31 and 50, and 110 (55%) were both livestock and crop farmers (Table 1).

Table 1: Socio-demographic characteristics of study participants in Kazo District, May 2

* mean age of respondents is 45 years

Characteristic	Frequency (n=200)	Percent
District		
Kazo	200	100
Subcounty		
Engari	200	100
Parish		
Kantaganya	122	61
Kyengando	48	24
Engari	30	15
Village		
Rupyani cell	76	38
Kashitamo cell	48	24
Kihumuro cell	31	16
Bukiro 1 cell	15	8
Kantaganya cell	15	8
Kitongore cell	15	8
Age group of respondents (years) *		
18–30	51	26
31–50	80	40
≥51	69	35
Sex		
Female	129	65
Male	71	36
Marital status of respondent		
Married	141	71
Singe	52	26
Separated	7	4

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Characteristic	Frequency (n=200)	Percent
Religion of respondent		
Protestant	107	54
Catholic	70	35
Born Again	15	8
Moslem	6	3
SDA	2	1
Occupation of household head		
Only livestock farming	4	2
Only crop farming	78	39
Both livestock and crop farming	110	55
Others	8	4
Animals kept		
Goats	71	62
Cattle	45	40
Pigs	43	38
Sheep	16	14

Participant's knowledge about anthrax

One hundred eighty-eight (189; 94%) of respondents knew/had heard about anthrax. Of those who knew/ had heard about anthrax, 81 (43%) had received information from other farmers, 76 (40%) from either friends, colleagues or relatives. One hundred thirty-one (70%) knew that anthrax affects both animals and humans, and 119 (63%) didn't know any sign of anthrax in animals. One hundred thirty-nine (139; 74%) participants did not know how animals get infected with anthrax, while 42 (22%) knew that animals can get infected with anthrax while grazing in contaminated environment. Most participants (82; 44%) didn't know how anthrax can be prevented in animals, however, 56 (30%) reported that vaccinating animals and not grazing them in contaminated pastures can prevent them from contracting anthrax. Most (136; 73%) respondents knew that anthrax can be transmitted to humans by eating meat from an animal that died suddenly, and 102 (54%) reported eschar and body swelling (100; 53%) as signs of anthrax in humans.

The overall assessment of knowledge regarding anthrax revealed that 154; 77% had adequate knowledge about anthrax (Table 2).

Table 2: Score of participant's knowledge about anthrax in Kazo District, May 2022 (n=200)

Variable	Frequency	Percent
Heard of anthrax		
Yes (1)	188	94
No (0)	12	6
Species affected		
Knowledgeable (1)	131	65.5
Not knowledgeable (0)	69	34.5
Signs and symptoms animals		
Knowledgeable (1)	51	25.5
Not knowledgeable (0)	149	74.5
Transmission Animals		
Knowledgeable (1)	48	24
Not knowledgeable (0)	152	76
Prevention Animals		
Knowledgeable (1)	94	47
Not knowledgeable (0)	106	53
Signs and symptoms Humans		
Knowledgeable (1)	122	61
Not knowledgeable (0)	78	39
Transmission in humans		
Knowledgeable (1)	157	78.5
Not knowledgeable (0)	43	21.5
Prevention in Humans		
Knowledgeable (1)	147	73.5
Not knowledgeable (0)	53	26.5
Total knowledge score		
0	12	6
1	10	5
2	9	4.5
3	15	7.5
4	33	16.5
5	46	23
6	35	17.5
7	27	13.5
8	13	6.5
Knowledge composite		
Adequate (Total score ≥4)	154	77
Inadequate (Total score <4)	46	23

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Participant's attitudes and practices towards anthrax

Of the 188 respondents who knew or had heard about anthrax, 179 (95%) thought that anthrax is a serious disease. One hundred fifty-five (155; 83%) thought that vaccination of animals could prevent anthrax in animals. Eighty-six (64%) of the respondents reported to have never vaccinated their animals against anthrax. Nearly all respondents (186; 93%) thought it was not safe to eat meat from animals that died suddenly, nor cut up the carcasses of animals that have died suddenly (188; 95%). Of the respondents, 36 (26%) reported that animals die suddenly once a year in their community. A small number of respondents (19; 16%) reported having lost their animals suddenly in the last year; of these, 4 (21%) reported consuming the meat. Nineteen (10%) respondents reported having suffered from anthrax before; among these, eschar was the most reported sign they presented with (11; 58%), and 13 (68%) said that it occurred after eating meat from an animal that died suddenly, and cutting up an animal that died suddenly (19;100%), (Table 3).

Table 3: Participant's attitudes and practices towards anthrax, Kazo District, May 2022, (n=200)

Characteristic	Frequency	Percent
Do you think anthrax is a serious disease? *		
Yes	179	95.2
Not sure	8	4.3
No	1	0.5
Do you think that vaccination of animals can prevent anthrax in animals? *		
Yes	155	82.5
Not sure	25	13.3
No	8	4.2
How often do you vaccinate your animals against anthrax? †		
Once a year	12	75.0
I don't know	3	18.3
Never	1	6.2
Have you ever given your animals any vaccine? ‡		
Yes	49	36.3
No	86	63.7
How often do you vaccinate your animals against anthrax? §		
Once a year	23	3.2
Never	6	3.2
More than once a year	1	19.4
I don't know	1	74.2
Have any of your animals died suddenly in the last 1 year? ¶		
No	98	83.8
Yes	19	16.2
If yes to having any of your animals that died suddenly, what action did you take? **		
Buried the carcass	10	52.6
Consumed meat from the dead animal	4	21.1
Reported to the area veterinarian	4	21.1
Other	1	5.3

Continued from page 20

Characteristic	Frequency	Percent
How often do other people's animals die suddenly in your community? ††		
Once a year	36	25.9
Twice a year	10	7.2
Once a month	3	2.2
Others	12	8.6
Not sure	78	56.1
Do you think it is safe to cut up the carcasses of animals that have died suddenly? ‡‡		
No	188	94.5
Yes	9	4.5
Not sure	2	1.0
Do you think it's safe to eat meat from an animal that died suddenly?		
No	186	93.0
Yes	11	5.5
Don't know	3	1.5
Have you ever eaten meat from an animal that died suddenly?		
No	143	71.9
Yes	41	7.5
Not sure	15	20.6
How often do you eat the meat of animals that died suddenly? §§		
Once a year	9	32.0
Twice a year	4	14.0
Others	15	54.0
Have you/any of your family members suffered from anthrax before?		
No	177	88.5
Yes	19	9.5
Not sure	4	2.0

Characteristic	Frequency	Percent
What symptoms/signs did you/the person present with? **		
Eschar	11	57.9
Itching	6	31.6
Vomiting	2	10.5
Others	13	68.4
How did you/ the person contract anthrax? **		
Cut up a dead animal that died suddenly	19	100.0
Ate meat from an animal that died suddenly	13	68.4
Carried meat from an animal that died suddenly	5	26.3
Other	1	5.3
What action did you take when the person was ill? **		
Took myself /the patient to the nearest health facility	17	89.5
Bought medicine from a drug shop	3	15.8
Took myself/patient to the traditional healer	1	5.3
Did you tell anyone that the person contracted anthrax and fell ill? **		
Yes	19	100.0
Did you tell anyone that the person contracted anthrax and fell ill? **		
My family	16	84.2
My neighbours	14	73.7
Other village farmers	4	21.0
VHT	3	15.8
Others	5	26.3
What grazing method do you practice? ¶¶		
Tethering	58	55.8
Paddocking	44	42.3
Communal grazing	15	14.4
Others	1	1.0

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Characteristic	Frequency	Percent
Where do you water animals from?		
At home in a water trough	62	53.9
From my private watering point	27	23.5
From a communal watering point	23	20.0
Others	3	2.6
Can you identify meat from an animal that has died suddenly?††		
Yes	92	66.2
No	47	33.8

*Sample size is 188, †Sample size is 16, ‡Sample size is 135, §Sample size is 31, ¶Sample size is 117 **Sample size of 19, ††Sample size 139, ‡‡Sample size 199, §§Sample size 28, ¶¶ Sample size 104 *** Sample size 114

Results from the qualitative part of the community assessment on anthrax

Our results focused on six major themes; Participants' prior knowledge of anthrax; Actions after animals died suddenly; Perceived risk of eating meat from animals found dead; Reasons for eating meat from animals found dead; Vaccinating against anthrax; Prevention.

Participants' prior knowledge of anthrax

Participants were knowledgeable about the existence of anthrax in the community, its nature and how it presents. Their knowledge of anthrax comes from previous/past experiences for those who had contracted anthrax. The signs of anthrax in humans most noted were skin lesions, fever, headache, loss of appetite and black scabs (eschars). Knowledge of the symptoms of anthrax in animals was limited but for those with knowledge, discharge of blood through body orifices, difficulty in breathing, and sudden death were the known signs; "When I got infected, I first felt a fever, then I got a skin lesion. The skin lesion became a small hole that turned into a fluid filled blister on the finger. The skin peeled off then there was a small black thing inside. I also lost my appetite…." reported by a respondent in FGD2. Another respondent from FGD 3 revealed that: "…..for you to know that the cow is sick, it fails to eat, it has difficulty breathing, and dies in a few days….". Additional reports from a respondent in FGD 2 were: "the cow after dying has blood in the nose and anus, the meat is too red and the intestines do not look normal; they look burnt….".

Participants were knowledgeable about the transmission of anthrax, reporting that it is through touching or eating meat from an animal that has died suddenly; "Touching the meat or eating the meat of a cow that died suddenly without protection" reported by a respondent in FGD3. Another respondent from FGD 2 revealed that: "I slaughtered the animal and ate it. That is how I contracted the disease". A deeper discussion also brought up the concept of external transmission by moving infected animal across border districts; "Our biggest challenge is with business people who move animals from various places at night stealthily. Before you know it there is another outbreak" as reported by a respondent in FGD3.

Participants had varied responses regarding the seasonality of anthrax. Most participants reported that animal deaths occur during the dry seasons in the months of June/July. A respondent from FGD2 reported that: "Anthrax usually breaks out during the month of July. When pastures dry up, cows easily pick up the bacteria from the soils". Some respondents argued that it was during the wet season; "From June to September when rains become heavy" as reported by a respondent from FGD3.

Actions after animal died suddenly

Participants had varied actions towards an animal that died suddenly, some of which were protective, while others were risky. For the risky actions, participants mentioned that such meat will end up at the market, the animal is butchered and the meat sold; "When a cow dies even if the owner knows that it has died of anthrax, he/she refuses to eat it and calls other people to sell it to them so they can

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benefit a little" as reported by a respondent from FGD3. In some cases, fed to the dogs; "I slaughtered an animal. It's not that it was appealing to eat, so after slaughtering it, I carried the meat home. I had taken it for the dogs" reported a respondent from FGD1.

For protective actions, they reported digging a pit of 5ft and burying the carcass and in some cases burning the carcass; "We were trained to dig a deep hole of 5ft, put tarpaulin and then bury the cow" reported a respondent from FGD2. Additional reports from a respondent in FGD2 were; "We are advised us that if one doesn't want to bury the dead cow, they can buy petrol and burn it".

Perceived risk of eating meat from animals found dead

Participants had varied perceptions regarding the risk of consuming meat from dead animals. Some participants especially those in the group which had previously confirmed/ probable cases, were worried about contracting anthrax. "…From that time, I told myself, a dead cow is not something to eat" as reported by a respondent from FGD1. Additional information reported from a respondent in the same group were: "…So, I want to encourage my fellows here to stay away from dead cows".

Other participants were not worried about contracting anthrax because they have learnt how to prepare it before eating to reduce the risk. "We are advised to first roast it very well before cooking. However, as village people, we don't usually do that, we roast a bit and cook and eat" as reported by a respondent from FGD2.

Reasons for eating meat from animals found dead

Participants pointed out that low income levels and poverty were the major drivers for consumption of meat from animals that die suddenly. "Low-Income levels and poverty is the reason why we eat that meat" reported by a respondent from FGD2. The participants revealed that the meat from a dead animal is often sold at a reduced price compared to 'normal' meat. "That meat is cheaper" as reported by a respondent from FGD3.

The participants also pointed that that sometimes consumers end up eating such meat without their knowledge, stating that this meat makes its way to the market with the knowledge of the butchers. Additional reports by a respondent from FGD3 were: "Butchers mix the normal meat and the meat of the cow that has died suddenly. So customers buy bad meat without their knowledge".

Vaccination of animals

Most participants reported knowing about the anthrax vaccines, and that most animals were vaccinated in 2018. The participants reported that the vaccines are costly and not readily accessible. "With vaccination as a farmer you cannot access the vaccine and administer it individually. You have to call the authorities to come and do a vaccination" as reported by a respondent from FGD3. Another respondent from FGD2 reported that: "There was an announcement that whoever has cows and even asked for money UGX 3,000 per cow to vaccinate the cows. The vaccine was coming from the District in Kazo. So yes, we did it". Additional information reported from a respondent from FGD3 revealed that: "Vaccination took place, but when they started asking for money, some people stopped vaccinating".

Whereas most participants agreed that vaccination can prevent anthrax in animals, there was a lack of knowledge as to how often these vaccines are to be administered to their animals. "We were told that we should vaccinate every 3 months" as reported by a respondent from FGD2.

Prevention

Participants made suggestions on anthrax prevention that were mainly directed to the government. They included;

Community training and sensitization through area veterinarians. "I request that you continue training us more in anthrax on how it is spread, its symptoms and to handle a dead cow sot that we can also go and spread the news to other people" as reported by a respondent from FGD2.

Provision of free vaccination and mechanism to ensure all animals are vaccinated. "…So we request the government to put in place mechanisms to ensure that all animals are vaccinated" as re-

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ported by a respondent from FGD1.

Strict measures with local authorities to ensure proper carcass management. “I would like the government to arrest and prosecute the people whose animals die suddenly and go ahead and sell them for human consumption” as reported by a respondent from FGD1. Another respondent from FGD2 revealed that: “…report to the Chairman LC 1 or the veterinary doctor so they can bury it after testing to know the cause of death”.

Compensation schemes for farmers who have lost their animals to such outbreaks. “I am of the view that the government through programs like National Agricultural Advisory Services (NAADs) should always come in to support farmers who have lost their cows to disease outbreaks like anthrax. For example, when one loses two animals, at least government should give back one cow” as reported by a respondent from FGD3.

Discussion

Human behaviour has a significant role in influencing anthrax transmission. This behaviour is influenced by the knowledge, attitudes and practices of affected communities. This study aimed to assess the knowledge, attitudes, practises and consumption of meat of animals found dead in communities previously affected by anthrax in Kazo District, South-Western Uganda. The survey results indicated good awareness about anthrax among respondents. Even though 94% stated that they knew/had heard about anthrax, 43% had received information from other farmers, 40% from either friends, colleagues or relatives. This means that the most respondents are more likely to have poor access to media information and poor comprehension and compliance to health education messages. The study showed that most respondents accessed information from friends rather than public media. This is likely to interfere with public health messages as community members share misconceptions and myths surrounding the disease. This is as observed by Taverne (24) who postulated that disease epidemics arrive `ahead of themselves since interpretations and the social effects usually precede the disease itself.'

Even though 70% of the respondents knew that anthrax affects both humans and animals, there was a better understanding of anthrax in humans; susceptibility of humans to anthrax, signs of anthrax in sick human beings and common routes of transmission. The survey revealed a poor understanding of anthrax in animals; 63% didn’t know any signs of anthrax. Most respondents also didn’t know how animals get infected with anthrax; however, they reported on the importance of vaccination as a preventive measure. The qualitative results demonstrated a poor understanding of the disease overall in the community, especially regards signs and symptoms in animals and the seasonality of anthrax. These study findings are consistent with those of Gombe *et al (18)* and Mebratu *et al (25)*. On the contrary, Opare`s study (26) showed that most respondents did not know the causes of anthrax but recognised the signs and symptoms of anthrax and the potential effectiveness of vaccinations.

Among human population, veterinarians, livestock farmers, any person that handles animal products (such as butchers, wool sorters, tannery workers, etc.), and laboratory personnel are the highest risk group (27). Predominantly, most houses kept livestock. Correspondingly, the high levels of knowledge were not found to be consistent with the attitudes and practices of respondents in this study. Case in point; while quantitative data indicated that most respondents (73%), knew that anthrax could be transmitted to humans by eating meat from an animal that died suddenly, 21% of the respondents who lost their animals in the past year consumed the animal. The qualitative data revealed that the majority of community members believed that when meat is smoked and cooked for a long time, the bacteria die and the meat is safe for consumption. Contrary to this finding, the study done by Gombe *et al* in Zimbabwe revealed that respondents disagreed with statements that overcooking infected meat kills anthrax bacteria (18).

From the qualitative survey, respondents indicated that they did not think eating meat from an animal that has died suddenly was risky be-

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cause of how they prepare the meat, but also because they usually do not see any symptoms among themselves whenever they consume meat from diseased carcasses. This perceived low susceptibility to anthrax is likely to lead to risky meat consumption behaviours. This perception seems to be consistent with the propositions of the Health Belief Model, which proposes that persons who perceive a low risk of developing a health problem are unlikely to engage in behaviours to reduce their risk of developing the particular health problem (28).

According to qualitative data obtained, practises such as selling and consumption of meat from animals that have died suddenly were perpetuated by poverty and limited access to meat protein. The quantitative data indicated that livestock and farming were the main source of livelihood for the people of Engari Sub-county. Therefore, loss of cattle leads to economic losses and increases the likelihood of selling infected meat in order to make financial recoveries. This is worsened by the fact that farmers are not compensated for cattle losses. Consumption and selling of carcasses in which the animals died from anthrax was reported by other studies; this is not only to make financial return but also as a source of protein (29), (26), (19), (18).

Routine vaccination policy is one of the better strategies for prevention and control of anthrax (6). The “greater Kiruhura District” is endemic for anthrax but the vaccination status in Kazo district was not satisfactory. Majority of respondents, 95% felt that anthrax was a serious disease and 83% of them believed that vaccination could prevent the disease in animals; however, 64% have never vaccinated their animals. This is supported by a study conducted in Ghana which indicated that high levels of knowledge about vaccination had not been actualised into practices by farmers in Tamale Municipality. Qualitative information suggested that very few farmers had their animals vaccinated. Participants in the focus group discussions cited various reasons for failure to have their animals vaccinates; inability to pay for vaccination, difficulty in accessing the vaccine and inadequate access to veterinary services in their communities. Likewise, in a review paper by Siamudaala et al (2006), inadequate technical and administrative support, erratic funding and supply of logistics were cited as major constraints of anthrax control in Zambia (17).

Disposal of the carcass of animals is a source of concern for anthrax transmission. According to the World Health Organisation, in most countries, the preferred method of disposal of an anthrax carcass is incineration(2). Controlled heat treatment or “rendering” has been proposed, and where neither of these approaches is possible, for example owing to lack of fuel, burial is the remaining less satisfactory alternative. Of the farmers who lost their animals suddenly, only 53% buried their animals. From the qualitative data, it was still common for community members to slaughter and eat meat from animals that have died suddenly. Therefore, when cattle died, it was butchered and shared right from where it died. Incineration was rarely practiced. However, history has many examples of new outbreaks following disturbance of old burial sites. Periodic reports of viable anthrax spores at burial sites of animals that died many years previously, and incidents and outbreaks in animals associated with such sites, have testified to the unreliability of burial procedures for long-term control of the disease. Disturbance of such sites, for example by ploughing or laying drainage presumably brings the spores to the surface. Carnivores and birds play a vital role to drag contaminated meat over the areas, thus, increasing ground contamination with anthrax spore. Dog themselves are resistant to anthrax but acts as a mechanical vector from field to household (30). In general, regarding the KAP of the respondents on anthrax, we observed that knowledge was better than attitude, and attitude was better than practise.

Study limitations and strengths

The study could be prone to recall bias because participants were asked about knowledge, attitudes, practices, exposure to deceased animals, as well as disease symptoms that occurred about 4 years prior to the interview date. Our findings may contain information errors related to desirability bias in which knowledgeable respondents may have stated what was desirable rather than what they engaged in. Adherence to good practice in livestock production and anthrax control was self-reported by the respondents rather than

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observed by the investigators. Despite the limitations, by triangulation of quantitative and qualitative findings, we strived to ensure internal validity and reliability. Our investigation therefore highlights elements that would expose the community to anthrax in the event of an outbreak.

Conclusion

In general, the KAP of the participants towards anthrax was low. Though there was good awareness about anthrax among the respondents, this did not translate to good practice. Although majority of the community members had an idea about anthrax and its symptoms in humans, there was a knowledge gap about anthrax in animals. There was no consistent understanding of the disease among the participants because they did not get consistent, adequate, and continuous health messages regarding the disease. Meat consumption practices were found to be high risk for anthrax as it is still common for community members to either slaughter, consume, sell, or share meat from animals that have died suddenly. These practices are mostly driven by social factors such as poverty and socio-economic losses incurred by loss of cattle and cultural practices.

Recommendations

We recommended enhanced public health education and targeted interventions with one health approach by relevant government bodies is highly recommended for effective prevention and control of anthrax. We recommend that community sensitisation campaigns and messaging could be improved to not only the health hazards of consuming meat from animals that have died suddenly, but also avoiding slaughtering/handling of carcasses. For persons in the animal industry involved should be educated on the importance of wearing personal protective equipment during the process, especially when dealing with dead animals from unknown causes. Animal owners should ensure sick and or dying animals are not skinned, slaughtered or butchered for meat consumption. Animal meat inspectors would play a key role in ensuring that the meat supplied at the butchers is clean and safe for human consumption.

Controlling infection of anthrax in animals is key to control of human anthrax. Good veterinary practice, burying of animal carcasses, use of effective decontamination and disinfection procedures and educating animal owners on anthrax in animals, say, identifying the disease in animals, what to do and what not to do, actions to take when an animal dies suddenly, will improve outcomes in the area. This includes notifying the area veterinarian to guide on how to dispose of the dead animal properly. The district health office should identify a focal point, such as a trained VHT or community animal health worker, to whom community members can report when animals die suddenly and who can guide them on the proper actions to take to prevent anthrax exposures.

It is necessary to ensure increased public awareness on the importance of vaccination of the livestock population along with sufficient coverage of the anthrax vaccine that will make a large contribution to the control of anthrax outbreaks. There must be targeted and strategic annual vaccination campaign of animals in previously affected communities, coupled with improved public health awareness campaigns aimed at promoting active participation by the general public in the control of the disease.

Conflict of interest

The authors declare that they have no conflict of interest

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Investigation of Human Tungiasis, Sheema District, Uganda, November 2021 - February 2022

Authors: Sherry Rita Ahirirwe[1*], Patience Mwine[1], Lilian Bulage[1], Benon Kwesiga[1], Richard Migisha[1], Daniel Kadobera[1], and Alex R. Ario[1]

Institutional affiliations

[1]Uganda Public Health Fellowship Program, National Institute of Public Health, Kampala, Uganda

***Correspondence:** Tel +256707064889, Email: sahirirwe@musph.ac.ug

Summary

Background: No formal surveillance system exists in Uganda for tungiasis, and outbreaks are frequently reported through media. On 27 January 2022, a news alert reported a jiggers' outbreak in Sheema District, Southwestern Uganda. We investigated to establish the magnitude of the problem and identify possible exposures associated with infestation to inform control measures.

Methods: We defined a confirmed case as visible *Tunga penetrans* in the skin of a resident of any of 6 villages in Bwayegamba Parish in February 2022. A suspected case was self-reported *T. penetrans* infestation during the three months preceding the interview. We visited all households in the 3 most affected villages in Bwayegamba Parish to identify cases and conducted interviews to identify possible exposures. We assessed socio-economic status, house construction, mitigation measures against jiggers, and observed participants (feet, clothes, nails, walking barefooted) and their environments for hygiene. A 'yes' response to any one hygiene variable was considered 'poor hygiene'. We conducted one case-control study comparing case-households (with ≥1 case) with control-households (without any cases), and one comparing individual cases (suspected and confirmed) to neighbourhood controls.

Results: Among 278 households, we identified 60 case-patients, among whom 34 (57%) were male. Kiyungu West was the most affected village (attack rate=31/1,000). Cases had higher odds of being male (OR_{MH}=2.3, 95%CI=1.3-4.0), ≤20 years of age (OR_{MH}=2.0, 95%CI=1.1-3.6), unmarried (OR_{MH}=2.97, 95%CI=1.7-5.2), unemployed (OR_{MH}=3.28, 95%CI=1.8-5.8), and having poor personal hygiene (OR_{MH}=3.73, 95%CI=2.0-7.4) than controls. In the household case-control study, case-households had higher odds of having dirty or littered compounds (OR_{MH}=2.3, 95% CI=1.2-4.6) and lower odds of practicing mitigation measures against jiggers (OR_{MH}=0.33, 95% CI=0.1-0.8) than control-households.

Conclusion: Males, unemployed persons, and poor personal or household hygiene increased odds of tungiasis in this outbreak. Multi-sectoral, tailored interventions that improve standards of living could reduce risk of tungiasis in this area. Adding tungiasis to national surveillance reporting tools could facilitate early identification of future outbreaks.

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Background

Tungiasis is a parasitic skin infection due to infestation with the female sand flea, *Tunga Penetrans* (1). The female sand flea has piercing and sucking mouth parts that it uses to suck the blood and burrow into the skin of its host (2). It thrives in sandy and dusty dry environments, such as those in sub-Saharan Africa (1). It penetrates into skin creating a nodular swelling where it feeds on the host's blood while growing in size. It's posterior end remains exposed to the air through which about 100-200 eggs are shed over a period of 2 weeks. Fertilized eggs once hatched develop into larvae and pupae. This stage takes about 2-3 weeks before they develop into adults capable of jumping from the ground onto the skin of the host (1-3). Infestation is usually limited to the feet since the flea cannot jump very high (1). However, other parts of the body, such as the hands, elbows, buttocks, and genitals, can similarly be infested, for instance, in situations where humans sleep on the floor (1, 4). Illness causes itching, oedema, swelling, pain, and desquamation at the site of infestation (4, 5). If left untreated, tungiasis can lead to other bacterial infections, tetanus, gangrene, inability to walk, and a great loss in quality of life (4, 6).

In 2011, a jiggers outbreak in Eastern Uganda was reported to affect 20,000 people, of whom 20 died (7). In 2012, the Uganda Ministry of Health (MOH), cognisant of the disease's burden, constituted a task force responsible for its eradication in the Eastern and North Eastern regions of the country (8). However, little progress has been made due to a lack of surveillance data on tungiasis. It is still not among the reportable neglected tropical diseases in the Health Management Information System (HMIS) tools as identified by the Sustainability Plan for Neglected Tropical Diseases (NTDs) Control Program 2020-2025 (9). The disease continues to spread in rural communities in Uganda due to a number of individual factors, such as high levels of poverty and environmental factors, such as presence of animal reservoirs for the flea (1, 10).

On 27 January 2022, a jiggers' outbreak was reported in Sheema District, located in South Western Uganda. The news alert indicated that 80 families in 5 villages in Bwayegamba Parish, Kigarama Subcounty were affected (11). We investigated to establish the magnitude of the problem and identify exposures associated with infestation in order to inform evidence-based control measures.

Methods

Outbreak area

Sheema District is a relatively new district in South Western Uganda that was curved out of Bushenyi District in 2010 (Figure 1). The District is administratively divided into 3 Counties, 14 Sub-counties, and 41 Parishes. Kigarama, the affected sub-county comprises 7 Parishes and 97 Villages (12). The District has a projected 2012 population of 220,300 people (13). The main economic activities in the District include crop and livestock farming (13).

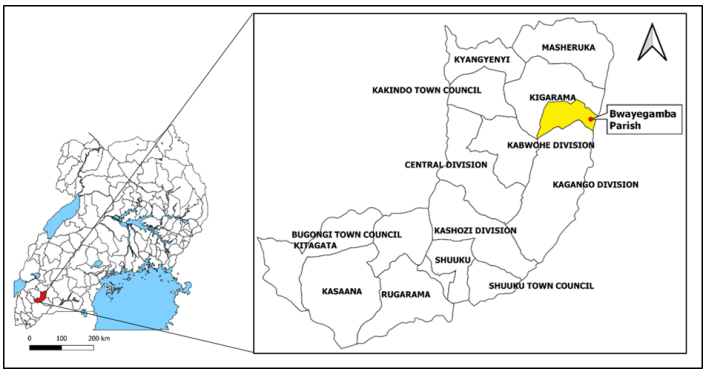

Figure 1: Map of Sheema District showing the location of Bwayegamba Parish, Kigarama Sub-county

Case definition and finding

We defined a confirmed case as presenting with itching, pain, a burrow at the site of infestation with visible presence of *Tunga penetrans* in the skin (dark papule with a central pit) of any household member resident in Bwayegamba Parish in February 2022. We defined a suspect case as reporting of being infested with *T.penetrans*, with visible scars on the feet or any other part of the body in a period of three months before the time of interview by any resident of Bwayegamba Parish. This time period was chosen because it takes approximately 6–8 weeks from eggs hatching to the time a female sand flea grows in size

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and releases its eggs outside the host body (3).
We actively searched for cases in six out of 14 villages in Bwayegamba Parish known to have cases, namely: Kiyungu West, Rwakahitsi, Kikuto I, Kiyungu East, Nyamiko, and Mwengura. With the guidance of area Local Council I (LC I) chairmen and members of Village Health Teams (VHTs) of affected villages, we visited homes of case-households in the affected villages. We used a standardized tool to line-list cases and conducted interviews with case-patients or their parents as necessary to understand patient history and risk factors.

Descriptive epidemiology
We described the line-listed case-patients by person, place, and time. We constructed an epidemic curve to show the distribution of cases over the study period of November 2021 to February 2022. We computed attack rates by sex, age, and village using population projections from the Uganda Bureau of Statistics (UBOS) (12). We drew a choropleth map to show the most affected villages in the Parish. Maps were developed using Quantum Geographic Information System (QGIS) software version 3.16 with administrative shapefiles from UBOS hosted on the United Nations Office for the Coordination of Humanitarian Affairs' (UNOCHA) Humanitarian Data Exchange (HDX) online database (15).

Hypothesis generation interviews and environmental assessment
We visited the homes of 12 households located in three of the six affected villages, namely; Mwengura, Kiyungu East, and Nyamiko, and assessed sanitation and hygiene by observing household compounds, surroundings and housing conditions (floors, walls), keeping animals that could act as reservoirs, and knowledge of ways to get rid of jiggers. We walked around the homes and the neighbourhoods to identify environmental conditions that are conducive to the fleas. The factors that were found to affect 30% of the cases during hypothesis generation were further assessed using a case-control study design.

Case-control studies
To test the hypotheses, we conducted unmatched case-control studies at the household and individual level. Households with one or more cases were classified as case-households and those without any household members infested as control-households. We conducted interviews among case-households and control-households in the three most affected villages, namely: Kiyungu West, Rwakahitsi, and Kikuto I in Bwayegamba Parish. Control-households were identified within the same villages as case-households. We visited all 383 households in the three most affected villages and interviewed 278 households with an adult present at the time of the interview. Out of these, we identified 41 case-households and 237 control-households. In total, we interviewed 412 people. We collected and compared data regarding socio-demographic characteristics of cases in case-households and controls in control-households. Data regarding the case-control studies was collected using Kobo collect (14), downloaded as a Microsoft Excel file and analyzed using Epi-Info version 7.2.5.0 and STATA version 14.2. For the household case-control study, we assessed whether neighbors were infested during the study period, house walls, floor, compound, keeping animals, animal shelter, distance to water source, and ownership of a list of 15 household items, including electricity, radio, television, table, chair, sofa set, bed, cupboard, refrigerator, mobile phone, computer, bicycle, motorcycle, car, and animal drawn cart. We then used principal component analysis to predict wealth index scores premised on ownership of the above 15 household items. We used this to generate a composite household wealth index of two levels (lower and upper). We created composite binary variables for categories used to assess house walls (cracked, rough), house floors (earthen, dusty, cracked), and household compound (dirty, littered). We also assessed mitigation measures against jiggers which was defined as using a pin or needle to remove the sand flea from infested body parts immediately after it is seen. For the individual case-control study, we assessed sex, age group, education, occupation, marital status, and personal hygiene. We generated composite binary variables for age group, education, occupation, marital status, and personal hygiene (dirty feet, dirty clothes, long nails, walking bare-

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footed). Mantel-Haensel odds ratios and p-values derived from two by two tables were used to determine the associations of exposures with jigger infestation at 95% confidence intervals.

Ethical Considerations

The Ministry of Health, through the Director General of Health Services, gave the directive to conduct this study. We further sought administrative clearance from the District health office before conducting the study. We additionally obtained clearance from the office of the Director for Science, US Centers for Disease Control and Prevention (CDC), who determined that this study was in response to a public health problem and therefore non-research. All participants were asked to give verbal informed consent, and parents were asked to give consent and assent for their children before interviews. Only households with an adult present at the time of the interview were interviewed. To ensure anonymity, all information was coded with a unique identifier. Study participants were assured of confidentiality as only team members had access to the data.

Results

Descriptive epidemiology

Out of 278 households visited, we identified 41 (15%) case-households. Among 412 household members, 60 (15%) were either currently infested (n=32/60, 53%) or reported ever being infested (n=28/60, 47%) in a period of three months preceding the date of interview. Males (AR/1,000 population = 13) and people in age groups 21-40 (AR/1,000 population = 16) and 41+ (AR/1,000 = 17) were most affected by jigger infestations in the six villages of Bwayegamba Parish. Village attack rates ranged from 2-31 per 1,000 population (Figure 2).

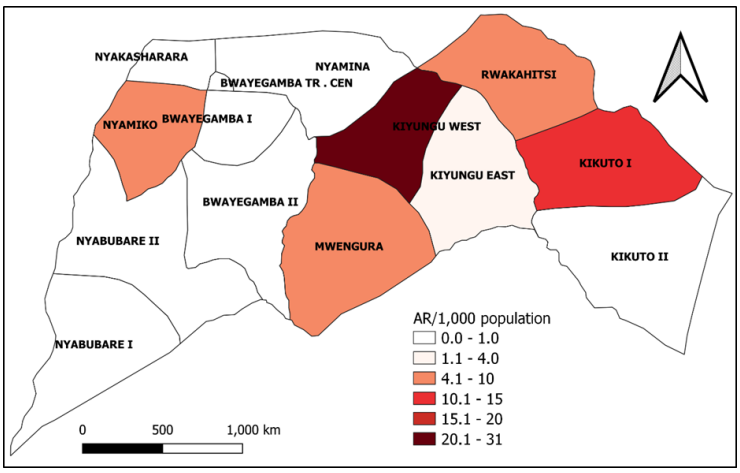

Figure 2: Attack rates by village during a tungiasis outbreak investigation, Bwayegamba Parish, Sheema District, Uganda, November 2021–February 2022

The majority of participants were most recently infested in February 2022 (n=23/60) (Figure 3).

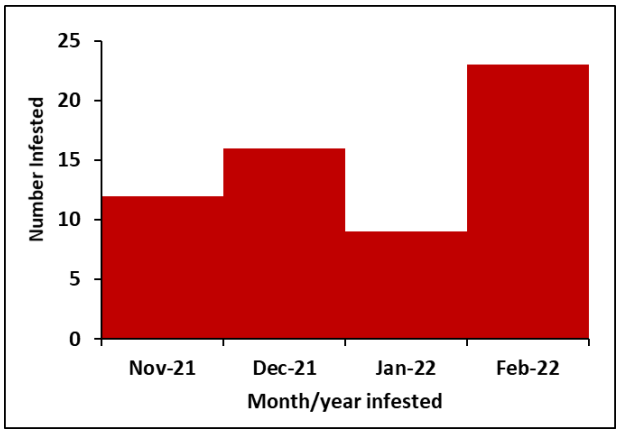

Figure 3: Epicurve of case-patients during a tungiasis outbreak investigation, Bwayegamba Parish, Sheema District, Uganda, November 2021–February 2022

Hypothesis generation findings

The study was conducted during a semi-dry season. We observed poor sanitation and hygiene, characterised by littered and dirty compounds, people wearing visibly dirty clothes, having long dirty nails and walking barefooted with muddy feet. Similarly, the majority of houses had earthen floors, which may provide a sandy environment conducive to the flea.

We hypothesized that factors such as household member infested in the past three months (n=10/12, 83%), household member currently infested with jiggers

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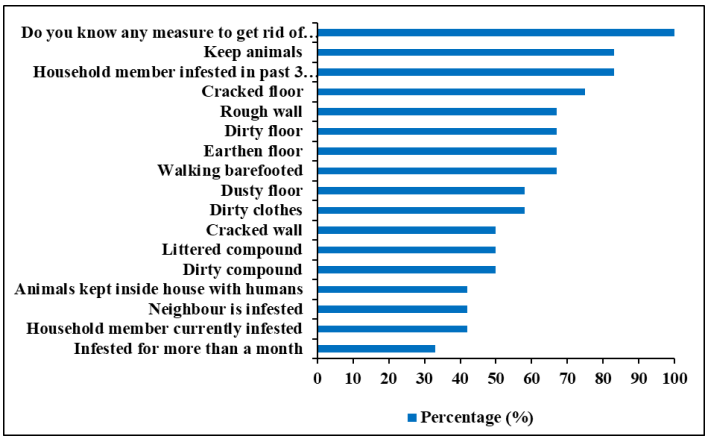
(n=5/12, 42%), keeping animals (n=10/12, 83%), housing animals inside main house (n=5/12, 42%), earthen floor (n=8/12, 67%), cracked floor (n=9/12, 75%), dirty floor (n=8/12, 67%), dusty floor (n=7/12, 58%), rough wall (n=8/12, 67%), cracked wall (n=6/12, 50%), littered and dirty compound (n=6/12, 50%) were associated with being a case-household. Individual factors such as having been infested for more than one month (n=4/12, 33%), knowledge of any measure for getting rid of jiggers (n=12/12, 100%), walking barefoot (n=8/12, 67%), and wearing dirty clothes (n=7/12, 58%) were associated with being a case (Figure 4).

Figure 4: Hypothesis generation interview findings during a tungiasis outbreak investigation, Bwayegamba Parish, Sheema District, November 2021–February 2022



Case-control studies' findings

Description of case-households and control-households during an outbreak investigation of jiggers, Sheema District, Uganda, November 2021–February 2022

Compared to control-households, most case-households fell within the upper wealth quintile (n=24 (59%), p=0.059), reported practicing mitigation measures against jiggers (n=36 (88%), p=0.019), had higher proportions of cracked and rough house walls (n=31 (76%), p=0.04), littered and dirty compounds (n=20 (49%), p=0.013) and kept animals (n=25 (61%), p=0.009). Both case (n=36 (88%)) and control-households (n=176 (74%), p=0.06) had earthen, dusty and cracked floors. Most case-households (n=30 (73%)) and control households (n=156 (66%), p=0.356) kept their animals in a separate shelter outside the main house. Most case-households (n=34 (83%)) and control-households lived within 500m of a water source (n=175 (74%), p=0.214) (Table 1).

Table 1: Household exposures vs. household infestation with jiggers during a tungiasis outbreak investigation, Bwayegamba Parish, Sheema District, November 2021 – February 2022

Household exposure (N=278)	Case-HHs* (N=41) n (%)	Control-HHs* (N=237) n (%)	OR_{M-H}†	95% CI‡	P-value
Wealth quintile					
Upper	24 (59)	101 (43)	ref	0.26 - 1.03	0.059
Lower	17 (41)	136 (57)	0.53		
Practice mitigation measures§					
Yes	36 (88)	166 (70)	ref	0.11 - 0.82	**0.019**
No	5 (12)	71 (30)	0.33		
Neighbour infested					
No	23 (56)	164 (69)	ref	0.88 - 3.46	0.099
Yes	18 (44)	73 (31)	1.75		
Wall					
Not cracked or rough	10 (24)	98 (41)	ref	1.04 - 4.86	0.04
Cracked or rough	31 (76)	139 (59)	2.18		
Floor					
Not Earthen, dusty or cracked	5 (12)	61 (26)	ref	0.98 - 7.44	0.06
Earthen, dusty or cracked	36 (88)	176 (74)	2.49		
Compound					
Not littered or dirty	21 (51)	168 (71)	ref	1.17 - 4.57	**0.013**
Littered or dirty	20 (49)	69 (29)	2.31		
Keeps animals					
No	16 (39)	48 (20)	ref	0.2-0.82	**0.009**
Yes	25 (61)	189 (80)	0.4		
Animal shelter					
Outside main house	30 (73)	156 (66)	ref	0.32 - 1.46	0.357
Inside main house	11 (27)	81 (34)	0.71		
Water source					
≤ 500m	34 (83)	175 (74)	ref	0.23 - 1.34	0.214
> 500m	7 (17)	62 (26)	0.58		

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*HHs = Households
†OR_{M-H} = Mantel Haensel Odds Ratio
‡CI = Confidence Interval
§Practice mitigation measures = using a pin or needle to remove the sand flea from infested body parts immediately it is seen

Description of cases and controls during an outbreak investigation of jiggers, Sheema District, Uganda, November 2021–February 2022

Compared to controls, a higher proportion of cases were male (n=34/60, 57%, *p*=0.003), with a mean age of 30.1 (SD = ±21) years. Most cases (n=38/60, 63%) and controls (n=273/352, 78%, *p*=0.018) fell within the 21+ age group. Compared to controls, most cases (n=31/60, 52%, *p*=<0.001) were unmarried and unemployed (n=33/60, 55%, *p*=<0.001). Compared to controls, a higher proportion of cases had poor personal hygiene (n=47/60, 78%) vs. (n=173/352, 49%, *p*=<0.001). Among cases, 35% (n=21/60) of them reported to have been infested with jiggers for a period of more than one month (Table 2).

Table 2: Individual exposures vs. being infested with jiggers during a tungiasis outbreak investigation, Bwayegamba Parish, Sheema District, November 2021 – February 2022

Individual exposure (N=412)	Cases (N=60) n (%)	Controls (N=352) n (%)	OR_{M-H}*	95% CI†	P-value
Sex					
Female	26 (43)	223 (63)	ref		
Male	34 (57)	129 (37)	2.26	1.3-3.96	**0.003**
Age group					
1-20	22 (37)	79 (22)	2	1.1-3.57	**0.018**
21+	38 (63)	273 (78)	ref		
Education level					
Did not attend school	14 (23)	56 (16)	0.62	0.32-1.24	0.157
Attended school	46 (76)	296 (84)	ref		
Marital status					
Single/never married	31 (52)	93 (26)	2.97	1.69-5.22	**<0.001**
Married/ widowed/ divorced	29 (48)	259 (74)	ref		
Occupation					
Employed	27 (45)	70 (20)	ref		
Unemployed	33 (55)	282 (80)	3.28	1.84-5.84	**<0.001**
Comorbidity					
No	47 (78)	270 (77)	ref		
Yes	13 (22)	82 (23)	0.91	0.46-1.74	0.782
Poor personal hygiene					
No	13 (22)	179 (51)	ref		
Yes	47 (78)	173 (49)	3.73	1.98-7.38	**<0.001**

*OR_{M-H} = Mantel Haensel Odds Ratio
†CI = Confidence Interval

Factors associated with jiggers' infestation at household level, during an outbreak, Sheema District, Uganda, November 2021–February 2022

Case-households had lower odds of practicing mitigation measures against jigger infestation (OR_{MH}=0.33, 95%CI= (0.1-0.8) than control-households. Case-households had higher odds of living in homes with littered or dirty compounds (OR_{MH}=2.31, 95%CI= (1.2-4.6) than control-households (Table 1).

Factors associated with jiggers' infestation at individual level, during an outbreak, Sheema District, Uganda, November 2021–February 2022

Cases had higher odds of being male (OR_{MH}=2.26, 95%CI= (1.3-4.0)), in the 1-20 years age group (OR_{MH}=2, 95%CI= (1.1-3.6)), unmarried (OR_{MH}=2.97, 95% CI= (1.7-5.2)), unemployed (OR_{MH}=3.28, 95%CI= (1.8-5.8)), and having poor personal hygiene (OR_{MH}=3.73, 95%CI= (2-7.4)) than controls (Table 2).

Discussion

This investigation aimed at establishing the magnitude of tungiasis in Sheema District and identifying exposures associated with infestation in order to inform evidence-based control measures. Our results show that at household level, poorly maintained compounds were associated with infestation. At the individual level, being male, aged 1–20 years, unemployed, and having poor personal hygiene were associated with tungiasis. Whereas, practicing mitigation measures was significantly protective against infestation.

At the household level, having littered or dirty compounds was significantly associated with tungiasis. This finding is similar to other studies which found that the occurrence of tungiasis was associated with littered compounds (10, 16). Poorly main-

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tained compounds and environments around the home may attract animals such as cats, dogs, goats, and pigs which have been identified as reservoirs of the sand flea (1, 17) thereby propagating the vector. The Ministry of Health, through VHTs, should continue supporting rural communities to improve sanitation by sweeping compounds and digging garbage compost pits to help keep away stray animals, which act as reservoirs for the vector.

At the individual level, cases had significantly higher odds of being male. This is in agreement with a study conducted in Eastern Uganda which found males were most affected (18) and a study in Nigeria which found males having the highest number of viable tungiasis lesions (19). This result may be explained by gender differences in personal hygiene and grooming. Females generally bathe more often than males and this may result in them noticing and removing the flea as soon as they can.

Similarly, we found that poor personal hygiene such as wearing dirty clothes, having dirty feet, having long nails, and walking barefooted was significantly associated with tungiasis. This is similar to other studies that also found an association between poor personal hygiene and being infested with jiggers (10, 16, 20, 21). However, since our study found that the majority of households lived within 500m of a water source, lack of access to water may not account for the observed poor personal hygiene. Poor personal hygiene may therefore be due to individual or behavioural characteristics and shows a great need for continuous health education by VHTs about frequent washing and bathing, through which one may notice embedded fleas and remove them. A study conducted in Kenya found that frequent washing with soap may reduce severity of tungiasis (22) while a randomised control trial in Madagascar found that frequent wearing of shoes and using Zanzarin, a plant-based repellent, prevents infestation (23).

Furthermore, we found that more than a third of cases were infested for a period of greater than one month. Long infestation periods may point to the role of people in the propagation of the vector within their environments when the eggs are released, as modelled by a study conducted in Eastern Uganda which showed that more than seven new jigger infections could be caused by a single individual (24). This emphasises the need for continuous health education and awareness raising campaigns about the removal and prevention of infestation with the sand flea.

We found that being in the 1–20-year age group was significantly associated with tungiasis. This finding agrees with other studies which found the highest prevalence among 1–15 year age category (19, 22, 25). However, due to differences in age categories, this result should be interpreted with caution as those who are older than 15 years of age may be in a better position to notice embedded fleas and remove them compared to those younger than 15 years of age. Children are most likely to be found walking barefooted and playing in soils that are contaminated with the sand flea. Besides the pain, walking impairment, and deformed nails (5), tungiasis has other debilitating effects among children. A study conducted in Rwanda, for instance, identified tungiasis as a reason for absenteeism from school among school going children (26) while a study in Kenya found a lower quality of life among children with tungiasis (27). Thus, implementing multi-pronged interventions that focus on improving household living conditions may in turn help children attain a better quality of life.

In addition, being unemployed was significantly associated with tungiasis. This could be due to impairing effects of tungiasis such as pain, itching, combined with shame and stigma that prevent case-patients from seeking medical care (1, 28, 29). Tackling social factors like employment and increasing income has been shown to lead to greater attainment in health outcomes (30, 31). Similarly, an increase in income implies that households may have money available to buy soap to use while bathing. Therefore, the Ministry of Health should liaise with other ministries and government departments to ensure improvement in the health and social-economic status of rural communities.

On the other hand, households that practiced mitigation measures against jiggers were significantly protected against infestation. Mitigation measures, defined here as the immediate removal of the sand flea from infested body parts once it is noticed, are essential in reducing the suffering inflicted by tungiasis (1). This agrees with other studies that found that using a pin or needle to

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remove the sand flea was protective against tungiasis (10). Therefore, MOH through VHTs, should raise awareness about the immediate removal of embedded fleas to reduce the severity of tungiasis in affected villages.

Lastly, the number of tungiasis cases fluctuated over the four-month study period. However, there was no way to declare an outbreak as surveillance data and reporting thresholds are lacking. Presently, there's no direct provision for reporting tungiasis using the HMIS tools as it is lumped under "other NTDs". MOH largely relies on media reports to identify outbreaks before responding, which may not be ideal for affected communities. Thus, we call for a change in national policy towards reporting, surveillance, funding, and management of tungiasis as one of the important NTDs as recognised by the Sustainability Plan for Neglected Tropical Diseases Control Program 2020–2025 (9). The Ministry of Health should integrate tungiasis as part of HMIS reporting to enable monitoring of interventions and prompt responses.

Study limitations

The main limitation of this study is that recall and social desirability bias raise doubts about the use of self-reported data (32, 33). The suspect case definition required participants to recall whether they had been infested three months before the day of interview. Such memory questions are likely to introduce recall bias as well as social desirability bias for participants or households that did not have currently have an infested member. Additionally, our suspect case definition largely relied on participants' local knowledge of what jigger infestation is. We counteracted this by using the local term (*"emira"*) for jigger infestations in the Runyankore language, which is spoken in Sheema District. This being a case-control study, we were unable to determine causality. However, we identified exposures that increased the odds of infestation with jiggers in Sheema District.

Conclusion and recommendations

Males, those who are unemployed, those in the age group 1–20 year and those who have poor personal hygiene were significantly associated with tungiasis in this outbreak. Households with littered or dirty compounds were significantly associated with infestation, whereas those that practiced mitigation measures against jiggers were protected against infestation. This calls for designing targeted interventions towards affected groups with improvements in household living conditions. There's a need for continuous health education and awareness raising on the prevention of jigger infestations in rural communities. This can be done through existing structures such as VHTs in order to reach and help greatly affected individuals, especially those that have been infested for long periods. Accordingly, the Ministry of Health should fast track the distinct inclusion of tungiasis in HMIS reporting of neglected tropical diseases in order to avail surveillance data needed to identify future outbreaks.

Conflict of Interest

The authors declare that they had no competing interests.

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Voluntary Male Medical Circumcision Service Uptake among Men over 20 Years of Age during Flexi and Regular Hours, Central Uganda, 2018- 2019

Authors: Sarah Elayeete[1*], Immaculate Atuhaire[1], Gerald Pande[2], Benon Kwesiga[1], Steven Kabwama[1], Alex R. Ario[1,2]

Institutional affiliations

[1]Uganda Public Health Fellowship Program, Uganda National Institute of Public Health, Kampala, Uganda, [2]Ministry of Health, Kampala, Uganda

Correspondence*: Email: selayeete@musph.ac.ug, Tel:+256-782-948-872

Summary

Background: Voluntary male medical circumcision (VMMC) in Uganda was only offered during regular hours (8:00am to 5:00pm and only week days) from 2010-2017. However, VMMC uptake among men aged 20+ years was low. To scale uptake VMMC among men 20+ years, 'flexi-hour clinics' were rolled out in Kampala and Wakiso districts in 2018. Flexi-hour clinics expanded the hours during which VMMC was offered to after 5:00pm on weekdays, including weekends, and holidays. However, no study has compared VMMC service use in flexi and regular hour clinics. We described and compared patients' profiles who received VMMC during flexi and regular hours in four facilities. We also assessed trends in VMMC service use to determine ways to improve targeted uptake of VMMC.

Methods: Demographic data were retrieved from the electronic medical records for clients aged 20+ years in both flexi (n=1,984) and regular hour (n=5,077) clinics during 2018 to 2019. Where individual level information was missing from the electronic database, we reviewed medical registers to complete the data. We described men who received VMMC during flexi or regular hours using frequencies and percentages. We compared demographic characteristics of men receiving VMMC during flexi or regular hours as a proportion of all men who received VMMC service from 2018-2019 using a two-sample t-test. To assess trends in VMMC use over time, we assessed overall and quarterly changes in VMMC use at each clinic as a proportion of all clients accessing VMMC service over time and in each quarter.

Results: A total of 7,061 men received VMMC services during flexi and regular hour clinics. Among all men who received VMMC, 1,984 (28%) used flexi-hours. Of the 1,984 men who got VMMC service during flexi hours, 940 (47%) were married or cohabiting, 1,267 (64%) were

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aged between 20-29 years, and 1,785 (90%) were employed. A higher proportion that used VMMC during flexi hour verses regular hour were married/cohabiting (47% vs 44%; p=0.003), had no education (26% vs 22%; p=0.0004), and came from Eastern region (17% vs 13%; p=<0.0001). Men receiving VMMC during flexi hours were non-significantly older than men receiving VMMC service during regular hours (median age 27 vs 26 years, p=0.37). Overall, there was an overall decline in VMMC uptake by 6% during regular hours and 30% decline during flexi hours.

Conclusion

More than a quarter of men aged 20+ received VMMC services during flexi-hours. There were modest demographic differences between men using flexi-hours versus regular hours. Expanding flexi-hour VMMC clinics to other parts of the country may be beneficial in improving uptake.

Introduction

Voluntary medical male circumcision (VMMC) is the complete surgical removal of the foreskin as a one-time primary prevention intervention that reduces the risk of heterosexual transmission of HIV from a female partner to the male by approximately 60 percent (1-4). It offers men substantial lifelong partial protection against the acquisition of HIV and a number of other sexually transmitted diseases (1-4). As a result, the World Health Organization (WHO) and Joint United Nations Programme on HIV/AIDS (UNAIDS) recommended VMMC as a new HIV prevention intervention among men in regions with high HIV prevalence and low rates of male circumcision (5).

Based on WHO recommendations, the Uganda Ministry of Health adopted VMMC policy in 2010 as part of HIV prevention package (6) with a goal of achieving 80% circumcision coverage among men aged 15 to 49 years by 2020 (7). Initially, VMMC was only offered during regular business hours (9 am to 5 pm Monday through Friday). However, in 2015, the circumcision prevalence rate among men aged 30 years or older remained generally low (26%), compared to 69% among men under 20 years of age. In order to scale up uptake of VMMC services among men 20+ years, 'flexi-hour clinics' were rolled out in Kampala and Wakiso districts in 2018. Flexi-hour clinics occur at the same sites as regular hour clinics. However, they are generally operating from 5 pm to 10:00 pm on weekdays and weekends. On the other hand, regular-hour clinics typically operate from 8:00am to 5:00pm and only weekdays. As a result, flexi-hour clinics typically operate 42 hours per week while regular clinics generally operate 50 hours per week

Although flexi-hour clinics had been implemented since 2018, no evaluation had assessed VMMC service uptake and how men getting circumcised during flexi-hours compared to those who get circumcised during regular hours across demographic characteristics such as age, marital status, religion, occupation, place of residence, tribe, and education level. We described and compared' profiles of men who received VMMC during flexi and regular hours at four clinics in Kampala and Wakiso districts. We also assessed trends in VMMC service use to determine ways to improve targeted uptake of VMMC.

Methods

Study setting and design

We conducted a secondary data analysis of individual level data collected from only health facilities offering VMMC services during both flexi and regular hours for the period 2018 to 2019. The facilities included: Kisenyi, Kajjansi, Kiira and Wakiso Health Center four (HC IVs). We considered all the data generated during 2018-2019.

Study variables, data source, and data collection

Data on demographic characteristic (Age, marital status, employment status, education level, religion and region of origin), site type (flexi or regular), time of circumcision, and underlying health conditions were retrieved from the electronic database (electronic medical records) for men attending clinics during both flexi and regular hours. Where individual level information was

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missing from the electronic database, health facilities were visited and VMMC medical registers were reviewed and individual data on demographic characteristics, VMMC modality, time of circumcision, and underlying health conditions were abstracted. We defined VMMC service use as the number of eligible men who voluntarily underwent VMMC during flexi or regular-hours in the study period. We defined flexi hours as 5:00pm on wards, weekends, holidays, and through mobile services exclusively at the convenience of the clients. While regular hours were 8:00am to 5:00pm and from Monday to Friday.

Data management and analysis

We analysed data using Stata version 14. We described men who underwent VMMC during flexi and regular hours by their demographic characteristics using frequencies and percentages. Demographic characteristics of men who received VMMC during flexi were compared to the demographics of men who received during regular hours as a proportion of all men who received VMMC from 2018-2019 using a two-sample t-test. To assess for trends in VMMC use, changes in overall, and quarterly VMMC use at each clinic was assessed as a proportion of all clients accessing VMMC service over time and during each quarter.

Ethical considerations

We utilized VMMC surveillance data with no identifying information. We abstracted individual clients VMMC data with permission from facility administrators. In addition, the Office of the Associate Director for Science, U.S. Centres for Disease Control and Prevention, determined this project as a non-human subject's research that will be in response to a public health problem with the primary intent of public health practice (epidemic disease control).

Results

Socio–demographic characteristics of men aged <20 who received* Voluntary medical male circumcision *during flexi and regular hours, Uganda, 2018-2019

A total of 7,061 men under went VMMC during both flexi and regular hours. Of those, 1,984 (28%) of the men used VMMC during flexi hours and 5,077 (72%) of the men used VMMC service during regular hours (Table 1).

Among 1,984 men who received VMMC service during flexi hours, 940 (47%) were married or cohabiting, 1,259 (63%) had attained secondary education, and 1,785 (90%) were employed. The median age of men who underwent VMMC during flexi hours was 27 years. Among 5,077 men who received VMMC during regular hours, 2,235 (44%) were married, 3,374 (66%) had attained secondary education and 4,531 (89%) were employed. The median age of men who received VMMC during regular hours was 26 years (Table 1)

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Table 1: Socio-demographic characteristics of men who received voluntary medical male circumcision service during flexi or regular hours Central Uganda, 2018-2019

Characteristics	Reported VMMC Clinic				
	Total	Flexi-hour		Regular hour	
	N	n (col%)		n (col%)	
Overall	7061	1984		5077	
Age (Median age)		27		26	
Age in complete years					
20-29	4556	1267	(64)	3289	(65)
30-39	1862	543	(27)	1319	(26)
40-49	515	138	(7)	377	(7)
50 +	128	36	(2)	92	(2)
Marital status					
Divorced/separated	40	18	(1)	22	(0)
Married/cohabiting	3175	940	(47)	2235	(44)
Single	3846	1026	(52)	2820	(56)
Level of education					
None/pre-primary	1633	511	(26)	1122	(22)
Secondary	4633	1259	(63)	3374	(66)
Tertiary	795	214	(11)	581	(11)
Employment status					
Unemployed	745	199	(10)	546	(11)
Employed	6316	1785	(90)	4531	(89)
Religion					
Muslim	193	60	(3)	133	(3)
Anglican	2518	722	(36)	1796	(35)
Catholic	3208	856	(43)	2352	(46)
Pentecostal/others	1142	346	(17)	796	(16)
Region					
Northern	412	154	(8)	258	(5)
Central	3928	995	(50)	2933	(58)
Eastern	973	334	(17)	639	(13)
Western	1748	501	(25)	1247	(25)

Comparison of demographic characteristics of men who received VMMC service during flexi and regular hours, Central Uganda, 2018-2019

Among all men who received VMMC services, a higher proportion that used them during flexi hours vs regular hours were married or cohabiting (47% vs. 44%, p=0.003), had no education (26% vs 22%, p=0.0004), and came from Eastern region (17% vs 13%, p=<0.0001) (Table 2). A lower proportion of men who received VMMC services during flexi hours vs regular hours came from Central Region (50% vs 58%, p=<0.0001). In addition, men who underwent VMMC during flexi hours were non-significantly older than men who underwent VMMC during regular hours (median age 27 years vs 26 years, p=0.37) (Table 2).

Continued from page 40

Table 2: Comparison of demographic characteristics of men who received VMMC during flexi and regular hours, Central Uganda, 2018-2019

Characteristics	Reported VMMC Clinic					
	Total N	Flexi-hour n (col%)		Regular hour n (col%)		P-Value
Overall	7061	1984		5077		
Age (Median age)		27		26		0.37
Age in complete years						
20-29	4556	1267	(64)	3289	(65)	0.44
30-39	1862	543	(27)	1319	(26)	0.39
40-49	515	138	(7)	377	(7)	1.00
50 +	128	36	(2)	92	(2)	1.00
Marital status						
Divorced/separated	40	18	(1)	22	(0)	<0.0001
Married/cohabiting	3175	940	(47)	2235	(44)	0.003
Single	3846	1026	(52)	2820	(56)	<0.0001
Level of education						
None/pre-primary	1633	511	(26)	1122	(22)	0.0004
Secondary	4633	1259	(63)	3374	(66)	0.02
Tertiary	795	214	(11)	581	(11)	1.00
Employment status						
Unemployed	745	199	(10)	546	(11)	0.22
Employed	6316	1785	(90)	4531	(89)	0.22
Religion						
Muslim	193	60	(3)	133	(3)	1.00
Anglican	2518	722	(36)	1796	(35)	0.42
Catholic	3208	856	(43)	2352	(46)	0.02
Pentecostal/others	1142	346	(17)	796	(16)	0.31
Region						
Northern	412	154	(8)	258	(5)	<0.0001
Central	3928	995	(50)	2933	(58)	<0.0001
Eastern	973	334	(17)	639	(13)	<0.0001
Western	1748	501	(25)	1247	(25)	1.00

Trends in voluntary male medical circumcision uptake among men aged 20 and above during flexi and regular hours, Uganda, 2018-2019

Overall, from 2018-2019, VMMC uptake during regular hours decreased by 6% while VMMC uptake during flexi-hours decreased by 30%. We observed an increase in the number of men who received VMMC service from the first quarter through the second quarter of 2018 during both regular and during flexi hours. There was a 30% increase in VMMC service uptake during flexi hours and a 50% increase in regular hours between the first and second quarter of 2018 (Figure 1). This was followed by a general decline during the following quarters for both clinics.

Table 3: Overall trends in VMMC service uptake during flexi and regular hours, Central Uganda, 2018-2019

Service hours	Total	2018	2019	Reduction rate (%)	P-Value
Flexi hours	1984	1290	694	30	<0.0001
Static hours	5077	2692	2385	6	<0.0001

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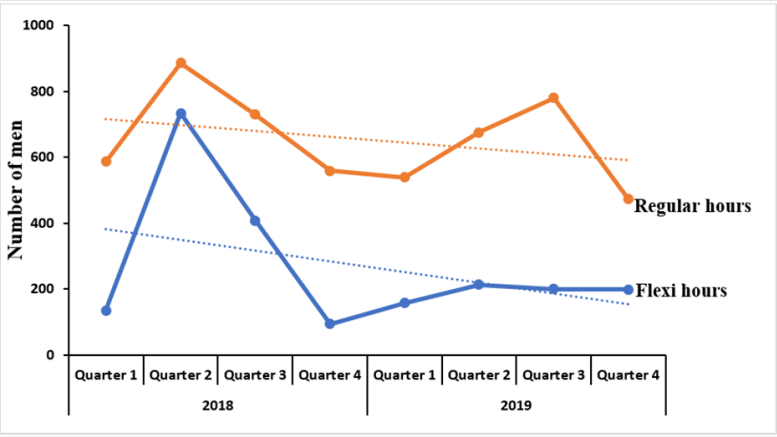
Figure 1: Trends in VMMC service uptake during flexi and regular hour clinics, Central Uganda, 2018 -2019



Discussion

Understanding the use of VMMC during flexi- hours and the types of clients who use flexi- vs regular hours for VMMC is important in ensuring that needs are being met for VMMC for the public. We found that men mostly use VMMC service during regular hours than flexi hours. There was no significant age difference between men who received VMMC during flexi hours compared to men who received VMMC during regular hours. The men who received VMMC during flexi hours were more likely to be married/cohabiting than men who received VMMC during regular hours. In addition, men who received VMMC during flexi hours were more likely from Eastern regions than men who received VMMC during regular hours.

In Uganda, compared to regular hour clinics, flexi hour clinics were rolled out barely two years from the evaluation period. The 28% reported usage of VMMC service among men aged 20+0 years during flexi hour clinics indicates that, once community-based services are closer or to the convenience of the consumers, they are easily used (8), and may also reflect the time it takes men exposed to the service to decide to pursue VMMC service and use it. A qualitative study of behaviour change pathways to VMMC in Zimbabwe highlighted the dynamic nature of demand for VMMC, which involves a man's progression through multiple stages of change over time (9). In addition, a scale up program of VMMC service uptake reached more clients three years post-intervention period compared to the proportion of clients reached the year immediately following program implementation (10).

A study conducted in Tanzania showed that, periodic mobile VMMC service delivery and interpersonal motivational advisors/mentors were promising strategies for promoting VMMC uptake among older clients aged 20 years or older, compared with routine services (11). In addition, a study on the influence of service delivery on age found that the proportions of males within the age group 20–24 years accessing VMMC services during mobile service were significantly higher than those accessing routine services (12). In contrast, we found no significant age difference between men who received VMMC during flexi hours and men who received VMMC during regular hours, with more men within age group 20-29 years receiving VMMC service during both regular and flexi hours. The big turn up for VMMC among men aged 20-29 years during both regular and flexi hour clinics could be attributed to the fact that youth are very adventurous in trying out new things (13). Although our study did not explore older males concerns in regard to undergoing VMMC during flexi hours, it could also be that the VMMC messages are more appealing to the youth than the older men

Married men were more likely to undergo VMMC during flexi hours. Although this study did not explore men's perspectives on the choice of sites, one possible explanation for this, is that married men often perceive themselves to be at higher risk of getting infected with HIV due to exposure to frequent unprotected sex with their spouses; hence, wanting circumcision as an HIV prevention strategy (14). Another possible explanation is that women always influence their male partners decisions of the method and where to undergo circumcision (15, 16). In addition, married men believed that VMMC protects their sexual partners from the risk of Human Papilloma Virus (HPV) associated with cancer of the cervix (16, 17) and this could be a driver to undergoing VMMC during flexi hours.

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While it has been suggested earlier that men's perception of risk of getting infected with HIV may play a role in men's willingness to undergo VMMC, it is not clear whether the same explanation may apply for the willingness of men from some regions undergoing VMMC during flexi hours. We found that men from Eastern region were more likely to undergo VMMC during flexi hours than during regular hours. It is possible that the demand to undergo VMMC during flexi hours for men from this region could be associated to the role of social and cultural identity (21) on their knowledge and decisions on whether or not they would adopt the intervention. Men from regions with knowledge of the practice of both traditional and medical circumcision tended to perceive circumcision positively and not stigmatized (22).

Study limitations

We acknowledge the following limitations in line with the study. Firstly, the quantitative nature of the study while using only demographic variables without individual perspectives and environmental factors didn't allow in depth exploration of knowledge and perceptions as well as attitudes of men towards undergoing VMMC during flexi or regular hours.

Conclusion

We found that the demographic profile of men who received VMMC during flexi hours differed from men who received VMMC during regular hours. Flexi hours are convenient for particular groups of people and should therefore be encouraged. We recommend an in-depth-qualitative study to understand the declining trends of VMMC service use in both flexi and regular hour clinics.

Ethical Considerations

We utilized VMMC surveillance data with no identifying information. We abstracted individual clients VMMC data with permission from facility administrators. In addition, the Office of the Associate Director for Science, U.S. Centers for Disease Control and Prevention, determined this project as a non-human subject's research that will be in response to a public health problem with the primary intent of public health practice (epidemic disease control)

Conflict of Interest

The authors declare that they had no competing interests.

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Assessment of Oral Pre-exposure Prophylaxis Eligibility and Use among Persons at Substantial Risk of HIV Acquisition, Uganda, 2017-2021

Authors: Sarah Elayeete[1*], Gerald Pande[2], Benon Kwesiga[1], Daniel Kadobera[1], Steven Kabwama[1], Alex R. Ario[1]
Institutional affiliations
[1]Uganda Public Health Fellowship Program, Uganda National Institute of Public Health, [2]Ministry of Health, Kampala, Uganda
Correspondence*: Email: selayeete@musph.ac.ug, Tel:+256-782-948-872

Summary

Background: In 2017, Oral pre-exposure prophylaxis (PrEP) was rolled out by the Uganda Ministry of Health (MOH) for high-risk populations at substantial risk of HIV infection (HRPs). In this strategy, HIV-negative individuals are screened for oral PrEP eligibility. Eligible high-risk individuals are offered pre-PrEP counselling, and those who accept are initiated, with subsequent follow-up visits for refills. However, no study has evaluated eligibility and uptake of oral PrEP since its roll-out. We assessed for oral PrEP eligibility, use, and associated factors among HRPs, Uganda, 2017-2021.

Methods: HRPs demographics, oral PrEP eligibility, oral PrEP initiation and refill dates were retrieved from PrEP tracker system for July 2017-May 2021. We conducted descriptive analysis of all HRPs screened for oral PrEP eligibility and oral PrEP use Modified Poisson regression was applied to identify factors associated with oral PrEP eligibility and use.

Results: Overall, 7,727 HRPs were screened for oral PrEP eligibility. Out of these, 3,156 (41%) were identified oral PrEP-eligible for whom 1,900 (60%) were female and 1,392 (44%) were sex workers. Among HRPs identified as oral PrEP-eligible, 2,409 (76%) were initiated on oral PrEP. Of these, 1,513 (63%) were female, 2,136 (89%) were from Central Region, and 1,188 (49%) were sex workers. Being a male (vs. female) HRPs was associated with increased oral PrEP eligibility (IRR=1.2, 95% CI: 1.02-1.41; p=0.03). HRPs in discordant relationship (vs. sex workers) were strongly associated with increased oral PrEP eligibility (IRR=3.6, 95% CI: 2.65-4.85; p<0.0001). Being married or cohabiting (vs. single) was associated with increased oral PrEP use (IRR=1.3, 95% CI: 1.01-1.6; p=0.04). Older HRPs aged 50 years and above had a reduced rate of oral PrEP eligibility (RR=0.4, 95%CI: 0.26-0.56; P<0.0001) and oral PrEP use (RR=0.3, 95%CI: 0.17-0.67; P=0.002).

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Conclusion: Despite low rate of oral PrEP eligibility among people at substantial risk of HIV infection, oral PrEP use was high. Married or cohabiting HRPs had an increased rate of oral PrEP use, suggesting a role for partner support. Intensified efforts may be needed to promote partner support to ensure oral PrEP use among HRPs.

Introduction

Oral Pre-exposure Prophylaxis (PrEP) is the use of ARV drugs by HIV-uninfected persons to prevent HIV infection and has been shown to reduce HIV transmission in both clinical trials and community-based studies (1-4) . Oral PrEP using tenofovir (TDF) and emtricitabine (FTC) as a once-daily pill is highly effective against HIV infection (5); however, the degree of effectiveness depends mainly on uptake and continuity (6). The World Health Organization (WHO) recommends the use of oral PrEP for HIV-negative persons at high risk of infection (7), including key populations (KPs) such as female sex workers (FSW), fisherfolk (FF), serodiscordant couples (SDC), men who have sex with men (MSM), and adolescent girls and young women (AGYW) (7-9).

In Kampala, HIV prevalence among MSM was estimated at 13.7% and 31.3% among FSW in 2012 (10). Other studies estimated HIV prevalence among people who inject drugs (PWID) at 34% (11). The higher prevalence of HIV infection among these populations was due to high-risk sexual behaviors (12, 13). In 2017, the Uganda Ministry of Health (MOH) rolled out oral pre-exposure prophylaxis (PrEP) for high-risk populations (5). In this strategy, HIV-negative individuals were screened for oral PrEP eligibility and eligible HRPs were offered pre-PrEP counselling and those who accept were initiated on oral PrEP (14, 15).

Although correct and consistent use of oral PrEP is effective in preventing HIV infection for high-risk population groups at substantial risk of HIV infection, important questions remain about oral PrEP use among people at substantial risk of HIV acquisition in Uganda. We assessed oral PrEP eligibility, oral PrEP use, and associated factors among high-risk populations at substantial risk of HIV infection in Uganda, 2017-2021.

Methods

Study setting, design, sample size consideration, and exclusion criteria

We conducted a secondary data analysis using the PrEP tracker dataset as of July 2017 to May 2021. Oral PrEP data from all health facilities in the US-CDC supported regions offering oral PrEP among high-risk populations at substantial risk of HIV infection during the study period were abstracted and included in the study. The PrEP tracker is a database created to capture all oral PrEP use data in the country these include Key populations- and other priority Populations at substantial risk of HIV acquisition like AGWY, Pregnant and Breast-feeding mothers. The database provides insights in the client's baseline and follow-up data including: numbers of oral PrEP users, demographic characteristics, oral PrEP eligibility screening data, dates of follow-up, oral PrEP eligibility, initiation dates, HIV screening, reasons for declining oral PrEP and enrolment dates. Oral PrEP data are routinely generated at health facility level using clients' registers and then uploaded into the tracker (web-based reporting). The PrEP tracking system is designed to collect monthly and quarterly data that are nationally representative of oral PrEP use across health facilities offering oral PrEP services to people at substantial risk of HIV. Oral PrEP was rolled out in 142 sites in June 2017 and we included all participants data from the start of the program up to May, 2021. We excluded all participants with missing information on oral PrEP eligibility and oral PrEP use during the study period.

Study variables, data abstraction, and analysis

We abstracted HRPs demographic data, including (sex, age, marital status, region of origin), key populations classification category (sex workers, clients of sex workers, men who have sex with men, people who inject drugs, transgender people), and priority populations category (migrant workers, fish folks, uni-formed men, discordant couples, adolescent girls and young women, truckers, people in prison and displaced persons)), HRPs oral PrEP eligibility, initiation and refill dates.

We conducted descriptive analysis of HRPs demographic characteristics using frequencies and percentages. HRPs at substantial risk of HIV infection were categorized as: "eligible or not eligible" and "oral PrEP users or non- oral PrEP users." "oral PrEP eligibility" was the percentage of HRPs meet-

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ing oral PrEP use criteria of the total screened at baseline for the study period (July, 2017-May, 2021). “oral PrEP use”-the percentage of HRPs initiated on oral PrEP at baseline of the total HRPs identified eligible. “oral PrEP non-use”- the proportion of HRPs who declined using oral PrEP of all those identified as oral PrEP-eligible.

To identify factors associated with oral PrEP eligibility and oral PrEP use among HRPs at baseline, modified Poisson regression was applied to estimate incident rate ratios (IRRs) and 95% confidence intervals of oral PrEP eligibility and use by HRPs baseline characteristics. All factors at bivariate analysis were included in the multivariate model and statistical significance was set at $P \leq 0.05$. All data analysis was done using Stata version 14.0.

Ethical considerations

We used KPs PrEP surveillance data with no identifying information We obtained oral PrEP data with permission from Makerere University School of Public Health Monitoring and Evaluation Technical Support Program (METs) who are currently custodians of HRPs oral PrEP data together with Ministry of Health (MOH). In addition, the Office of the Associate Director for Science, U.S. Centers for Disease Control and Prevention, determined this project as a non- human subject’s research that is in response to a public health problem with the primary intent of public health practice (epidemic disease control).

Results

Social-demographic characteristics of high-risk populations screened for oral PrEP eligibility and oral PrEP use at baseline in Uganda, 2017-2020

A total of 7,727 high risk populations (HRPs) were screened for oral PrEP eligibility at baseline. Of these, 3,156 (41%) were identified eligible for oral PrEP use. The majority 1,900 (60%) were female with a median age of 25 years (range: 10, 75 years). A high proportion of oral PrEP-eligible HRPs were from central region 2,821 (89%), and 1,392 (44%) were sex workers (Table 1). Among HRPs identified eligible for oral PrEP, 2,409 (76%) were initiated on oral PrEP at baseline. Out of those, 1,513; (63%) were female, most HRPs 1,127 (47%) were single, the majority 2,136 (89%) were from central region and 1,188 (49%) were sex workers (Table 1).

Table 1: Socio-demographic characteristics of high-risk populations screened for oral PrEP eligibility and oral PrEP use at baseline, Uganda, 2017-2021

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Characteristics	PrEP eligibility at baseline					PrEP use at baseline					
	N1	Yes		No		p-value	N2	Yes		Declined		p-value
		n_1 (col%)		n_1 (col%)				n_2 (col%)		n_2 (col%)		
Overall	**7,727**	**3,156**		**4,571**			**3,156**	**2,409**		**747**		
Sex												
Female	4,145	1,900	(60)	2,245	(49)	0.006	1,900	1,513	(63)	387	(52)	0.02
Male	3,582	1,256	(40)	2,326	(51)		1,256	896	(37)	360	(48)	
Age (years)												
10-19	940	387	(12)	553	(12)	<0.0001	387	281	(12)	106	(14)	<0.0001
20-29	4,061	1,726	(55)	2,335	(51)		1,726	1,332	(55)	394	(53)	
30-39	1,932	781	(25)	1,151	(25)		781	602	(25)	179	(24)	
40-49	604	221	(7)	383	(8)		221	175	(7)	46	(6)	
50 +	190	41	(1)	149	(3)		41	19	(1)	22	(3)	
Marital status												
Single	3,741	1,525	(48)	2,216	(48)	<0.0001	1,525	1,127	(47)	398	(53)	0.003
Married/cohabiting	3,023	1,078	(34)	1,945	(43)		1,078	813	(34)	265	(36)	
Divorced/separated	963	553	(18)	410	(9)		553	469	(19)	84	(11)	
Region												
Central	6,670	2,821	(89)	3,849	(84)		2,821	2,136	(89)	685	(92)	
Western	902	325	(10)	577	(13)		325	266	(11)	59	(8)	
Eastern	155	10	(0)	145	(3)		10	7	(0)	3	(0)	
Classification												
Sex worker	2,741	1,392	(44)	1,349	(30)	<0.0001	1,392	1,188	(49)	204	(27)	
Clients of sex workers	809	278	(9)	531	(12)		278	180	(7)	98	(13)	
Fisher Folks	819	304	(10)	515	(11)		304	267	(11)	37	(5)	
Migrant workers	313	94	(3)	219	(5)		94	37	(2)	57	(8)	
Uni-formed men	196	16	(1)	180	(4)		16	8	(0)	8	(1)	
Discordant couples	289	216	(7)	73	(2)		216	176	(7)	40	(5)	
*AGYW	435	191	(6)	244	(5)		191	124	(5)	67	(9)	
**MSM	385	229	(7)	156	(3)		229	181	(8)	48	(6)	
Truckers	194	64	(2)	130	(3)		64	29	(1)	35	(5)	
***Others	1,546	372	(12)	1,174	(26)		372	219	(9)	153	(21)	

§*N1=Overall total of those screened for PrEP eligibility*
§§*N2=The proportion of those identified eligible for PrEP use at baseline*
*AGYW=*Adolescent girls and young women*
**MSM=*Men who have sex with men*
***Others include= people who inject drugs, people in prison, transgender, None, non-injecting drug users, and displaced persons

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Factors associated with oral PrEP eligibility among high risk populations screened at baseline, Uganda, 2017-2021

Male HRPs were strongly associated with increased oral PrEP eligibility compared with their female counter parts (IRR=1.2, 95% CI: 1.02-1.41; P=0.03) (Table 2). Being divorced or separated compared with being single was associated with increased oral PrEP eligibility (IRR=2.0, 95% CI: 1.67-2.29; P=<0.0001). HRPs from Eastern verses central region were associated with 30% reduced rate of oral PrEP eligibility (P=<0.0001). HRPs in discordant relationships were strongly associated with increased PrEP eligibility compared with sex workers (IRR=3.6, 95% CI: 2.65-4.85; P=<0.0001) (Table 2).

Table 2: Factors associated with Oral PrEP eligibility among high risk populations at substantial risk of HIV infection screened at baseline, Uganda, 2017-2021

Characteristics	Oral PrEP eligibility at baseline					Unadjusted		Adjusted	
	N_1	Yes		No		†IRR (95% CI)	p-value	IRR (95% CI)	p-value
		n_1 (col%)		n_1 (col%)					
Overall	**7,727**	**3,156**		**4,571**					
Sex									
Female	4,145	1,900	(60)	2,245	(49)	1.00 (Ref)		1.00 (Ref)	
Male	3,582	1,256	(40)	2,326	(51)	0.6 (0.58-0.69)	<0.0001	1.2 (1.02-1.41)	0.03
Age (Years)									
10-19	940	387	(12)	553	(12)	0.9 (0.82-1.09)	0.45	1.1 (0.89-1.23)	0.5
20-29	4,061	1,726	(55)	2,335	(51)	1.00 (Ref)		1.00 (Ref)	
30-39	1,932	781	(25)	1,151	(25)	0.9 (0.82-1.02)	0.13	0.9 (0.81-1.04)	0.2
40-49	604	221	(7)	383	(8)	0.8 (0.65-0.93)	0.006	0.8 (0.66-0.98)	0.03
50 +	190	41	(1)	149	(3)	0.4 (0.26-0.53)	<0.0001	0.4 (0.26-0.56)	<0.0001
Marital status									
Single	3,741	1,525	(48)	2,216	(48)	1.00 (Ref)		1.00 (Ref)	
Married/cohabiting	3,023	1,078	(34)	1,945	(43)	0.8 (0.73-0.89)	<0.0001	0.9 (0.84-1.06)	0.35
Divorced/separated	963	553	(18)	410	(9)	2.0 (1.69-2.26)	<0.0001	2.0 (1.67-2.29)	<0.0001
Region									
Central	6,670	2,821	(89)	3,849	(84)	1.00 (Ref)		1.00 (Ref)	
Western	902	325	(10)	577	(13)	0.1 (0.04-0.18)	<0.0001	0.1 (0.07-0.25)	<0.0001
Eastern	155	10	(0)	145	(3)	0.7 (0.67-0.89)	<0.0001	0.7 (0.61-0.82)	<0.0001
Key population classification									
Sex worker	2,741	1,392	(44)	1,349	(30)	1.00 (Ref)		1.00 (Ref)	
Clients of sex workers	809	278	(9)	531	(12)	0.5 (0.43-0.59)	<0.0001	0.5 (0.41-0.63)	<0.0001
Fisher Folks	819	304	(10)	515	(11)	0.6 (0.49-0.67)	<0.0001	0.6 (0.47-0.71)	<0.0001
Migrant workers	313	94	(3)	219	(5)	0.4 (0.32-0.54)	<0.0001	0.4 (0.33-0.59)	<0.0001
Uni-formed men	196	16	(1)	180	(4)	0.1 (0.05-0.14)	<0.0001	0.1 (0.05-0.15)	<0.0001
Discordant couples	289	216	(7)	73	(2)	2.9 (2.18-3.78)	<0.0001	3.6 (2.65-4.85)	<0.0001
*AGYW	435	191	(6)	244	(5)	0.8 (0.62-0.93)	<0.0001	0.8 (0.65-0.99)	0.05
**MSM	385	229	(7)	156	(3)	1.4 (1.15-1.77)	<0.0001	1.3 (0.97-1.66)	0.08
Truckers	194	64	(2)	130	(3)	0.5 (0.35-0.65)	<0.0001	0.5 (0.35-0.70)	<0.0001
***Others	1,546	372	(12)	1,174	(26)	0.3 (0.27-0.35)	<0.0001	0.3 (0.28-0.39)	<0.0001

*AGYW=*Adolescent girls and young women*
**MSM=*Men who have sex with men*
***Others*= people who inject drugs, people in prison, transgender, None, non-injecting drug users, and displaced persons
†*IRR=Incidence rate ratio*

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Factors associated with oral PrEP use among eligible high-risk populations at substantial risk of HIV infection at baseline in Uganda, 2017-2021

Male HRPs were strongly associated with increased oral PrEP use compared with female HRPs (IRR=1.7, 95% CI: 1.27-2.36; P=0.001) (Table 3). HRPs at substantial risk of HIV infection aged 50 years and older were associated with 70% reduced rate of using oral PrEP at baseline compared with younger HRPs aged 20-29 years (p=0.002). Being married or cohabiting was significantly associated with increased oral PrEP use compared with being single (IRR=1.3, 95% CI: 1.01-1.58; P=0.04). Divorced or separated HRPs were strongly associated with increased oral PrEP use (IRR=1.7, 95% CI: 1.24-2.22; p=0.001). HRPs from Eastern verses central region were strongly associated with increased oral PrEP use (IRR=1.8, 95% CI: 1.33-2.56; P=<0.0001) (Table 3).

Table 3: Factors associated with oral PrEP use among eligible high-risk populations at substantial risk of HIV infection at baseline, Uganda, 2017-2021

Characteristics		Oral PrEP use at baseline				Unadjusted		Adjusted	
	N_2	Yes		No		IRR (95% CI)	p-value	IRR (95% CI)	p-value
		n_2 (col%)		n_2 (col%)					
Overall	**3,156**	**2,409**		**747**					
Sex									
Female	1,900	1,513	(63)	387	(52)	1.00 (Ref)		1.00 (Ref)	
Male	1,256	896	(37)	360	(48)	0.6 (0.54-0.75)	<0.0001	1.7 (1.27-2.36)	0.001
Age (Years)									
10-19	387	281	(12)	106	(14)	0.8 (0.61-1.01)	0.06	0.8 (0.64-1.09)	0.19
20-29	1,726	1,332	(55)	394	(53)	1.00 (Ref)		1.00 (Ref)	
30-39	781	602	(25)	179	(24)	1.0 (0.81-1.21)	0.95	0.9 (0.77-1.22)	0.80
40-49	221	175	(7)	46	(6)	1.1 (0.79-1.59)	0.5	1.2 (0.81-1.75)	0.37
50 +	41	19	(1)	22	(3)	0.3 (0.14-0.48)	<0.0001	0.3 (0.17-0.67)	0.002
Marital status									
Single	1,525	1,127	(47)	398	(53)	1.00 (Ref)		1.00 (Ref)	
Married/cohabiting	1,078	813	(34)	265	(36)	1.1 (0.91-1.29)	0.38	1.3 (1.01-1.58)	0.04
Divorced/separated	553	469	(19)	84	(11)	2.0 (1.52-2.55)	<0.0001	1.7 (1.24-2.22)	0.001
Region									
Central	2,821	2,136	(89)	685	(92)	1.00 (Ref)		1.00 (Ref)	
Western	325	266	(11)	59	(8)	0.7 (0.19-2.90)	0.67	0.9 (0.23-4.16)	0.9
Eastern	10	7	(0)	3	(0)	1.4 (1.08-1.94)	0.01	1.8 (1.33-2.56)	<0.0001
Key population classification									
Sex worker	1,392	1,188	(49)	204	(27)	1.00 (Ref)		1.00 (Ref)	
Clients of sex workers	278	180	(7)	98	(13)	0.3 (0.24-0.42)	<0.0001	0.2 (0.11-0.25)	<0.0001
Fisher Folks	304	267	(11)	37	(5)	1.2 (0.85-1.80)	0.26	0.8 (0.54-1.33)	0.47
Migrant workers	94	37	(2)	57	(8)	0.1 (0.07-0.17)	<0.0001	0.1 (0.04-0.12)	<0.0001
Uni-formed men	16	8	(0)	8	(1)	0.2 (0.06-0.46)	<0.0001	0.1 (0.04-0.31)	<0.0001
Discordant couples	216	176	(7)	40	(5)	0.8 (0.52-1.09)	0.14	0.6 (0.37-0.89)	0.01
*AGYW	191	124	(5)	67	(9)	0.3 (0.23-0.44)	<0.0001	0.4 (0.26-0.52)	<0.0001
**MSM	229	181	(8)	48	(6)	0.6 (0.46-0.92)	0.02	0.4 (0.28-0.71)	0.001
Truckers	64	29	(1)	35	(5)	0.1 (0.09-0.24)	<0.0001	0.1 (0.04-0.15)	<0.0001
***Others	372	219	(9)	153	(21)	0.2 (0.19-0.32)	<0.0001	0.2 (0.14-0.26)	<0.0001

*AGYW=*Adolescent girls and young women*
**MSM=*Men who have sex with men*
***Others=*people who inject drugs, people in prison,* transgender, None, non-injecting drug users, and displaced persons
†*IRR=Incidence rate ratio*

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Discussion

This study found high oral PrEP use among high-risk populations at substantial risk of HIV infection at baseline. Female HRPs were often eligible oral PrEP users at baseline. Old age was strongly associated with reduced rate of both oral PrEP eligibility and oral PrEP use. Married or cohabiting HRPs were strongly associated with increased oral PrEP use. These findings indicate willingness to use oral PrEP among high-risk populations at substantial risk of HIV infection.

High oral PrEP use at baseline has also been documented in previous studies that assessed oral PrEP acceptability among other key populations in East and Southern Africa (16). Oral PrEP use among HRPs is possibly because high-risk population groups perceived themselves to be at increased risk of HIV acquisition. A study among fishing communities in Uganda, reported a link between risk perception and acceptability to use oral PrEP (17). Because of the risky sexual behaviours among these population categories, this might explain the high oral PrEP use among them.
Female high-risk populations being more likely to be eligible oral PrEP users during this study, may be because most of our study participants were sex workers who possibly consider themselves to be at increased risk of HIV and other sexually transmitted infections due to involvement in sex work with multiple sex partners (18). Several of these observations were also reported in a study on HIV vulnerability among Sub-Saharan African migrants (19). In addition, since most of our study participants were married, another possible explanation for female being more likely to be eligible oral PrEP users could be that women had regular sexual partners of whom they never trusted and therefore considered using oral PrEP to protect themselves while sustaining their relationships. The importance of showing trust by having unprotected sex in relationships have widely been reported elsewhere (20, 21).
The connection between old age and oral PrEP use has been reported in other studies as an effect of high risky sexual behaviours among older people (22). In a cohort study conducted in Amsterdam, it was found that the rate of oral PrEP use was highest among men aged 40 years and older (15). However, in this study, HRPs aged 50 years and older were associated with reduced rate of oral PrEP use at baseline. This could be attributed to the lower proportion of older HRPs identified eligible for oral PrEP use in our study and could have possibly perceived themselves to be at lower risk of HIV infection. It has been documented that understanding the risk associated with high risky behaviour is the first step to oral PrEP use (23, 24).

Married or cohabiting HRPs were associated with oral PrEP eligibility and use at baseline. In many parts of Africa, the risk of HIV acquisition is known to be high among married or cohabiting couples especially where intimate partner violence exists (25). The risk of HIV infection among married couples is increased due to gender inequalities (26, 27). Gender inequalities, particularly in communities where men are allowed to have extra marital relationships (28) render women vulnerable to HIV infection from their husbands (29-31). As a result, women opt to use oral PrEP as a way of protecting themselves from contracting HIV from their partners. Another possible explanation is that women's sexuality is often controlled by their husbands or male partners (32) such that refusing sex becomes difficult, because marriage is believed to be more respectable than divorce, and therefore, oral PrEP becomes a means to keep the peace in a marriage.

Study strengths and limitations

Our study utilizeda national oral PrEP dataset for high risk populations at substantial risk of HIV acquisition with differing oral PrEP use rate levels, thus giving us a nationwide outlook regarding oral PrEP eligibility and use. However, the study solely depended on secondary data and could not be used to analyse behaviour or attitude over a period of time. Secondly, we assessed for only oral PrEP eligibility and oral PrEP use rather than preference to continue using oral PrEP, for this reason, we could not account for any dropout rates. Further studies requiring primary data are needed to better understand willingness to continue PrEP and HRPs at substantial risk of HIV infection.

Conclusion

Despite low rate of oral PrEP eligibility among HRPs, this study found that oral PrEP use was high among this population category. Married or cohabiting persons had increased odds of PrEP use in Uganda during

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2017-2021, suggesting a role for partner support. Intensified efforts may be needed to promote partner support to ensure PrEP use among high-risk populations in the country.

Conflict of Interest

The authors declare that they had no competing interests.

Acknowledgments

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Effectiveness of a Group-based Education and Monitoring Program Delivered by Community Health Workers to Improve Control of High Blood Pressure in Island Districts of Lake Victoria, Uganda, February-March 2022

Authors: Andrew Kwiringira[1*], Richard Migisha[1], Lilian Bulage[1], Benon Kwesiga[1], Daniel Kadobera[1], George Upenytho[2], and Alex R. Ario[1]
Institutional affiliations: [1]Uganda Public Health Fellowship Program, Kampala, Uganda, Uganda National Institute of Public Health, Kampala, Uganda, [2]Department of Community Health, Ministry of Health, Kampala, Uganda
***Correspondence:** Email: akwiringira@musph.ac.ug, Tel: +256775997741

Summary

Background: Identifying and treating high blood pressure is critical to preventing a wide range of health problems; however, communities with poor access to healthcare may be unaware of their hypertension. While use of community health workers (CHWs) can address gaps in human resources for health, CHWs in Uganda have not been used previously for blood pressure (BP) screening and management. We report results of an initiative to train CHWs to evaluate BP and to administer group-based education in remote Kalangala and Buvuma island districts of Lake Victoria, Uganda, February-March 2022.
Methods: We randomly selected 42 of 212 villages in two island districts. We trained 84 island-based CHWs on measuring BP for 5 days. From February-March 2022, CHWs visited all households in the selected villages and invited all adults ≥18 years to be screened for high blood pressure. We used the World Health Organization's STEPwise tool to collect data on demographic and behavioral characteristics and BP measurements. High blood pressure was defined as systolic BP (SBP) ≥140 mm Hg and/or diastolic BP (DBP) ≥90 mm Hg over three read-

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ings. CHWs created and led support groups of up to 20 persons for individuals identified with high blood pressure at baseline. These support group meetings were conducted every two weeks for three months. At each group meeting, CHWs re-measured BP and administered self-management and lifestyle education to the participants.
The paired t-test was used to compare mean values of systolic blood pressure (SBP) and diastolic blood pressure (DBP) before and after the intervention. Generalized estimating equations (GEE) were used to model longitudinal changes in BP.
Results: We trained 84 CHWs to measure BP and deliver the intervention package. Among 2,016 community members, 570 (28.3%) had high blood pressure; of these, 63 (11.1%) had a previous diagnosis of hypertension. The prevalence of high blood pressure was higher among persons older than 40 years. Sex, education, alcohol use, and tobacco smoking were not associated with hypertension. The comparison of systolic blood pressure (SBP) and diastolic blood pressure (DBP) before and after the intervention revealed significant reductions in both parameters (-7±14 and -3±10 mmHg, respectively). GEE showed decreases of -1.133 (SBP) and -0.543 mmHg (DBP)/fortnight.
Conclusion: High blood pressure was common but undiagnosed. The CHW-led group-based self-management and education for controlling high blood pressure was effective in island districts in Uganda. Scaling up the intervention in other hard-to-reach districts could improve control of high blood pressure on a large scale across Uganda.

Introduction

Hypertension (high blood pressure) is a leading contributor to the global burden of disease and premature death, accounting for approximately 9.4 million deaths annually [1] As of 2015, the prevalence of hypertension was 26.4% among adults aged 18 to 64 years in Uganda, but only 7.7% of persons with hypertension were aware of it [2]. The prevalence of undiagnosed high blood pressure is higher in areas where there is limited access to healthcare facilities and essential medicines [3], such as island districts of Lake Victoria. Most households in these island districts live beyond the targeted five kilometres maximum from the nearest health facility [4].

The use of community health workers (CHWs) has been identified as one strategy to address inaccessibility to healthcare facilities and to address the gaps in human resources for health [5]. However, the role of CHWs and their contributions in many countries, including Uganda, is largely limited to maternal and child health as well as prevention and treatment of infectious diseases [6]. Although some studies have shown the effectiveness of CHWs in management of hypertension [7, 8], these studies were intensive, costly, highly structured, and time-consuming individual-based interventions.

Population-level public health measures such as increased awareness of hypertension and lifestyle modifications are generally considered more cost-effective means of controlling hypertension than treatment-oriented programs [9], which most developing countries lack capacity to implement on a large scale [10]. Our approach of using a CHW-led group-based education and blood pressure monitoring program is a potentially cheaper alternative to managing hypertension in disadvantaged and hard-to-reach areas. This project incorporated comprehensive data collection at baseline and during the intervention which enabled us to assess the effect of the intervention and to assess the strength and challenges of implementing the program. We determined whether a CHW-led group-based education and monitoring program for the management of high blood pressure is effective in a hard-to-reach setting.

Methods

Project setting and population: The project was conducted in two island districts of Lake Victoria: Buvuma and Kalangala district, neither of which have inland territory. Most households in these island districts live beyond the targeted five kilometers maximum from the nearest health facility [4]. Health facilities are also inadequately equipped to provide screening and management of hypertension [11] and health workers are not always available in this setting [12]. In each district, we randomly selected one parish from each of 7 sub counties using a random number generator and we randomly selected 3 villages from

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each of the 7 selected parishes using a random number generator. All selected villages were included in the cross-sectional survey.

Sample size: The estimated prevalence of high blood pressure in Uganda was 26% among persons 18 years of age or older [2]. Our sample size was calculated to detect a mean difference of 6 mm and 2 mm Hg in systolic and diastolic blood pressure from baseline to endline. To do this, we needed to enroll 296 individuals with high blood pressure.

Project implementation design: The project employed a pre-post intervention design without comparison group. Initially, a baseline community-based survey was conducted by CHWs to identify participants with high blood pressure, followed a CHW-led group-based education and blood pressure monitoring intervention administered to participants identified to have high blood pressure at baseline.

Baseline survey: Prior to commencing the study, we trained 84 CHWs to measure BP, deliver a group-based self-management and education over a 5-day course. We trained all CHWs who were already working in the selected villages. The training focused on education about high blood pressure and how to manage it, adherence to medications, and lifestyle changes, such as increasing physical activity and following a healthier diet. CHWs then invited all residents ≥ 18 years to participate in the cross-sectional survey. CHWs conducted house-to-house notification and encouragement to ensure that all residents ≥ 18 years are informed about the survey. CHWs approached participants at their homes, provided a written participant information sheet. We used the World Health Organization's STEPwise tool to collect data on demographic and behavioral characteristics and BP measurements [13]. CHWs measured Blood Pressure (BP) after the participant had been seated quietly for at least 15 minutes. Three measurements were taken at 3-minute intervals using the appropriate cuff size and a calibrated digital automatic BP monitor according to the WHO STEPS protocol [25]. All participants with systolic BP (SBP) 140 mm Hg and/or diastolic BP (DBP) 90 mm Hg over three readings were informed they may have high blood pressure and were advised to visit a clinician to have their BP re-checked.

Intervention: CHWs created and led group-based self-management and education support groups of up to 20 individuals identified with high blood pressure at baseline. These group meetings, each lasting ~90 minutes, were held every 2 weeks for 3 months within the villages in which the participants resided. No incentive was given to the participants to join the group meetings. At each group meeting, CHWs re-measured BP and delivered education about high blood pressure and how to manage it, in the local language. This included details about adhering to medications and the importance of making lifestyle changes, such as increasing physical activity and following a healthier diet. Pictorial flipcharts were used as education aids, and handouts regarding high blood pressure control were provided to participants to use at home. We held four focus group discussions (FGDs) with CHWs and eight FGDs with residents who attended the group meetings; four FGDs with an average of 11 participants each and two FGDs with an average of 9 CHWs were held in Buvuma District. In Kalangala District, we conducted four FGDs with an average of 10 attendees each and two FGDs with an average of 9 CHWs each. FGDs were held with participants to learn more about the difficulties in diagnosing, treating, and controlling hypertension. FGDs were conducted with CHWs to explore the experiences, strength, and challenges of implementing the intervention. FGDs with participants explored the perceptions of the level of support obtained from the CHWs and their experiences in managing their high blood pressure.

Outcomes: The outcomes of this study were prevalence of high blood pressure. Change in SBP and DBP from baseline, measured in accordance with the WHO STEPS protocol [25]. CHWs experiences, strength and challenges of implementing the intervention and the participants perceptions of the level of support obtained from the CHWs and their experiences in managing their high blood pressure.

Data analysis: We analyzed data in STATA version 16 (Statcorp, College Station, TX, USA). Prevalence of high blood pressure was reported as proportion estimated in STATA. We used modified Poisson regression to assess

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factors associated with high blood pressure. We used Paired t-test to compare mean values of SBP and DBP before and after the intervention. Generalized estimating equations (GEE) were used to model correlated and longitudinal data for investigating the predictors of longitudinal changes in BP after controlling the confounding factors. Factors with P values ≤0.05 were considered as significant. Thematic analysis of focus group discussions was used to investigate the mechanisms of impact.

Ethics approval and consent to participate

We obtained permission from the Ministry of Health (MOH) and sought administrative clearance from District Health Officers to conduct this evaluation. The Office of Science, U.S. Centers for Disease Control and Prevention, determined that the primary intent of this evaluation was public health practice. It was determined therefore to not be human subject research. We sought verbal consent from all respondents before data collection. Participants were told that their participation was voluntary and that there would be no negative consequences if they refused to participate. During data collection, respondents were assigned unique identifiers instead of names to protect their confidentiality. Participants who were found to have high blood pressure were referred to the health workers. Information was stored in password-protected computers and was not shared with anyone outside the investigation team.

Results

Baseline survey

Characteristics of participants

Of the 2,016 participants, 1,201 (59.6%) were female, 1,076 (53.3%) were aged between 20 to 39 years, and 857 (43.4%) had attained at least secondary school education. The average age of participants was 35.1 years (Standard Deviation = 13.1).

Prevalence of high blood pressure

Variable	High blood pressure (Percent)	High blood pressure		Unadjusted PR (95% C.I)	Adjusted PR* (95% C.I)
		Yes	No		
Age					
18-19	13.9	25	155	1.00	
20-29	20.4	134	524	1.46 (0.96-1.95)	1.40 (0.90-1.91)
30-39	27.5	115	303	1.51 (1.01-2.15)	1.53 (1.03-2.03)
40-49	35.7	137	247	2.50 (1.24-5.30)	2.65 (1.29-5.46)
>50	41.2	155	221	3.51 (1.74-7.10)	3.61 (1.79-7.29)
Sex					
Female	28.1	337	864	1.00	
Male	28.6	233	582	0.88 (0.69-1.11)	1.10 (0.91-1.23)
Education					
Primary	29.8	231	543	1.00	
None	28.9	106	261	0.97 (0.80-1.17)	0.96 (0.79-1.17)
Secondary	27.9	174	450	0.93 (0.79-1.10)	1.01 (0.85-1.18)
University	23.5	59	192	0.79 (0.61-1.00)	0.83 (0.65-1.06)
Alcohol use					
Yes	29.4	169	406	1.00	
No	27.8	401	1,039	0.95 (0.81-1.10)	0.96 (0.82-1.11)
Tobacco use					
Yes	31.2	34	75	1.00	
No	28.1	536	1,371	0.90 (0.67-1.20)	1.06 (0.77-1.47)

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Effect of the intervention on high blood pressure control
Out of 570 participants identified with high blood pressure at baseline, 552 (97%) were included in the intervention program. Out of 18 participants who declined to participate in the intervention, 12 frequently travelled out of their districts and 6 were immobilized at their homes. Overall, approximately 15 participants attended each of the meetings. Overall, each participant attended at least 5 meetings. The average duration of meetings was 76.6 min (SD 21.0).

The comparison of SBP and DBP at baseline and after the intervention program are presented in Table 3. After the intervention, significant reductions in SBP (-6.86 ± 13.61 mmHg) and DBP (-2.66 ± 9.96 mmHg) were seen (P < 0.001).

Table 3. Systolic and diastolic blood pressure before and after the intervention during a CHW-led group-based education and monitoring program in island districts of Lake Victoria, Uganda, 2021

					95% CI Difference	
Variable	**Before**	**After**	**Difference**	**P-value**	**Lower**	**Upper**
SBP	143.15±14.36	136.29±13.81	-6.86±13.61	<0.001	-8.78	-4.94
DBP	96.37±9.67	93.97±7.89	-2.66+9.91	<0.001	-3.95	-1.45

SBP: Systolic blood pressure; DBP: Diastolic blood pressure

After adjusting for confounding variables like age, sex, alcohol use, tobacco use, GEE showed that SBP and DBP decreased about 1.133 and 0.028 mmHg/fortnight, respectively (Table 4).

Table 4. The effect of the intervention on changes in blood pressure overtime during, CHW-led group-based education and monitoring program in island districts of Lake Victoria, Uganda, 2021

	Systolic Blood Pressure			Diastolic Blood Pressure		
Fixed factors	**Beta**	**Std. Error**	**p**	**Beta**	**Std. Error**	**P**
Participation time (fortnight)	-1.133	0.035	<0.001	-0.543	0.028	0.002

Participants perceptions of the level of support obtained from the community health workers and their experiences in managing their high blood pressure
The most compelling reason for participants to attend the meetings was to learn more about high blood pressure and how to manage it. Participants stated that the information they received from their health care providers about how to control hypertension was basic, consisting mostly of prescriptions for medication.

"I attended group meetings to learn about high blood pressure, our health workers don't give us enough information when we go to clinics, they write drugs and only tell you how to swallow them." — participant

Participants stated that the meetings provided them with knowledge about high blood pressure and how to manage it through simple and practical lifestyle changes such as diet, exercise, and medication adherence.

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"I got knowledge on high blood pressure, mainly knowledge on how to control it and we used simple behaviour change approaches like diet, physical exercise and drug adherence." — participant

The lack of medication distribution during the meetings was a major topic of discussion among the participants. Participants expected medications to be distributed and they expressed their belief that providing medications would increase attendance at meetings. Participants reported that the high cost of medication was a barrier to maintaining BP control.

''We thought we were going to be getting high blood pressure drugs in our group meetings but we didn't, attendance can be high if drugs are given" — participant

Participants who attended meetings suggested that the program should be improved by providing medications during meetings, including free blood sugar monitoring, home visits, reminders to attend meetings and ensuring convenient meeting locations in addition to blood pressure monitoring.

Community health workers' experiences, strength, and challenges of implementing the intervention

CHWs expressed their support for the meetings and the importance of continuing them in their communities. Participants suggested that future meetings could benefit from the inclusion of previous participants, the provision of blood pressure medications, and the incorporation of home visits. CHWs also reported that training, and supportive supervision of them during the intervention were important enablers to intervention implementation.

"We should include our participants who are self-managing their BP in the next program and allow them share their experience, then it motivates other members in the program."—CHW

"If we visit people's homes and check their blood pressure at least once in a month they will focus on diet control and exercise."— CHW

"They will definitely come to our meetings if we give them blood pressure tablets."— CHW

"The training and supportive supervision helped equipped us with adequate knowledge and skills necessary to implement the intervention."' —CHW

Discussion

The prevalence of high blood pressure was high but undiagnosed in island districts of Lake Victoria in Uganda in 2022. The only factor found to be associated with high blood pressure was age. The comparison of systolic blood pressure (SBP) and diastolic blood pressure (DBP) before and after the intervention revealed significant reductions in both parameters. During the evaluation of intervention implementation, CHWs reported that the training they had received increased their skills. Supportive supervision was also identified as helpful during the program delivery.

Only 11% of participants with high blood pressure were aware that they had hypertension. This is lower than the 28% awareness reported in urban settings in Uganda [14]. The high prevalence of undiagnosed high blood pressure in island districts of Lake Victoria may be due to limited access to healthcare facilities and essential medicines [3]. Most households in these island districts live beyond the targeted five kilometers maximum from the nearest health facility [4]. Health facilities are also inadequately equipped to provide screening and management of hypertension [11] and health workers are not always available in rural and remote settings [12]. More so, people in rural settings do not go for routine medical checkup and seek health services only when they are very sick [15]. Training the CHWs in monitoring BP and providing education enables a reorganization of health tasks to improve access [16].

In our study, we did not find associations between high blood pressure and some of the factors that have often be identified to be associated with high blood pressure, such as tobacco use [17] and alcohol use [18]. This may be due to differential patterns of alcohol use in remote islands, compared with other settings [19]. In addition, smoking is uncommon in our setting and our sample size may have had an impact on our ability to identify associations with smoking and high blood pressure. Our findings are consistent with a national non-communicable disease risk factor survey [2], con-

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ducted in Uganda that also found only age to be associated with high blood pressure. This implies that there must be other risk factors for high blood pressure in the Ugandan setting, other than those assessed using the WHO STEPS protocol deployed in both surveys. Indeed, obesity and diabetes were found to be associated with high blood pressure in Uganda [20]. Elsewhere, genetics have also been documented as a risk factor for high blood pressure [21]. Our baseline survey focused on identifying modifiable risk factors of high blood pressure that were targeted through life-style modification sessions delivered by CHWs.

This study showed that a group-based education and monitoring program delivered by CHWs was effective in lowering blood pressure. Despite the fact that this was only a three-month intervention, the blood pressure of the participants was reduced.
In addition to the education provided to intervention participants, their blood pressure was measured at each session. This ongoing monitoring may have empowered participants to determine whether and how their lifestyle changes resulted in tangible benefits [22]. This method also provides motivation to keep or adopt new behavioral changes [22], which may be one of the intervention's success mechanisms. This suggests that BP surveillance itself can help control BP in regions with poor access to healthcare. In addition, the program included several evidence-based components for improving blood pressure control, such as medication adherence [23], regular blood pressure monitoring [22], and encouraging lifestyle changes such as increased physical activity [24].

Our findings are consistent with other studies that showed the effectiveness of CHWs in control of high blood pressure [7, 8, 25]. However, these studies involved intensive, time-consuming individual-based interventions. Our approach of using a group-based intervention provides an effective and potentially cheaper alternative to managing high blood pressure in hard-to reach settings. Another aspect of CHWs role in management of high blood pressure was referring participants with high blood pressure to the health workers. In such communities where health-seeking behaviour is poor [15], and people only visit health facilities when they have serious symptoms, CHWs played a critical role of referring participants with high blood pressure for further management. Qualitative data from focus groups provides understanding of the factors that influence the causal relationship between implementation and outcome in the real world [26], and can guide scaling up the program in other settings. For example, CHWs reported that training, and supportive supervision were important enablers to intervention implementation and participants reported that dietary changes, especifically salt reduction, and frequent blood pressure monitoring as beneficial. These evidence-based components [27, 28], should be prioritised in scale up of similar programs.

Study strengths and limitations
The inclusion of process measures from the start of the intervention allowed for measurement of implementation and process measures throughout the study, which was a major strength of this study. There are some limitations to our study that may influence the interpretation of our findings. First, the 3-month intervention was relatively short. Because of this, we cannot determine whether there is a long-lasting improvement in controlling high blood pressure from our group-based education and monitoring program. Second, some of the reduction in BP observed may be attributable to the Hawthorne effect, whereby participants alter behaviors just because they are being observed. Third, inability to generalize findings to urban settings in Uganda because the study sample size was limited to rural island districts in Uganda.

Conclusion
High blood pressure was common but undiagnosed in island districts of Lake Victoria. The CHW-led group-based self-management and education for improving the control of high blood pressure was effective in reducing both SBP and DBP and is potentially feasible. There is considerable po-

tential to scale up across rural Uganda and potentially other resource-limited regions in other countries.

Conflict of Interest

The authors declare that they had no competing interests.

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Patterns of tuberculosis case notification and treatment outcomes in the context of COVID-19 pandemic: analysis of national surveillance data, January 2019 - June 2021

Authors: Veronicah Masanja[1,2]*, Robert Kaos Majwala[2], Stavia Turyahabwe[2], Doreen Nsimiire Gonahasa[1], Benon Kwesiga[1], Daniel Kadobera[1], Lilian Bulage[1], Alex Riolexus Ario[1]

Institutional affiliations

[1]Uganda Public Health Fellowship Program,Uganda National Institute of Public Health, Kampala, Uganda, [2]National TB and Leprosy Control Program, Ministry of Health, Kampala, Uganda

***Correspondence:** Tel: +256775511542, Email: vmasanja@musph.ac.ug

Summary

Background: Tuberculosis case notification and outcomes monitoring are critical for TB control but can both be disturbed by interruptions to normal health system functioning. The first major wave of COVID-19 in Uganda occurred during August-December 2020. The government-imposed lockdown measures during March-June 2020 in which residents were required to stay at home. Kampala was particularly affected by the lockdown. We investigated trends and distribution of TB case notification rates (CNR) and treatment success rates (TSR) during January 2019-June 2021 to determine the effect of COVID-19 epidemic and associated lockdown.

Methods: We analysed TB case notification and treatment success data for January 2019 -June 2021 from the Uganda District Health Information Software version2 (DHIS2) and disaggregated them by region. We also collected data on the COVID-19 cases and compared COVID-19 cases with the TSR, and CNR trends over the period. We computed the CNR per 100,000 population, defined as number of notified TB cases/100,000 population. TSR was defined as the proportion of

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patients initiated on TB treatment that successfully completed treatment or cured. We described the quarterly trends and distribution of CNR and TSR pre (January 2019-March 2020) and during COVID-19 (April 2020-June 2021). We used interrupted time series analysis to determine the significance of the trends before and during COVID-19. We defined time periods by year (2019, 2020, or 2021) and quarter (Q).
Results: The overall TB CNR between January 2019 and June 2021, was 165/100,000; TSR was 79.4%. CNR ranged from 166.2/100,000 pre COVID-19 to 164/100,000 during COVID-19. CNR declined significantly by 22% (p=0.042, CI= [-41.4, -1.1]) from January 2020 to April 2020, concurrent with the lockdown and rising COVID-19 cases and was primarily driven by the sharp decline from 426/100,000 to 265/100,000 in Kampala City. This was followed by a significant quarterly increase in the national CNR of 16/100,000 (p<0.001, CI= [10.0,21.6]), and 39/100,000 (p=0.01, CI= [15.66,62.32]) in Kampala. TSR increased significantly by 1.6% (p≤0.0001,95%CI 1.3-1.9%) quarterly.
Conclusion: CNR appeared to be affected by the initial lockdown but recovered quickly. However, this decline was heavily driven by declines in CNR in Kampala District. Kampala CNR trends are not reflective of the rest of the country during 2019-2021 and should be examined separately. TSR increased over time but was still below the 90% target. There is need to focus on continuity of TB care interventions in future in areas heavily affected by lockdowns.

Background

Both tuberculosis (TB) and COVID-19 were declared pandemics by the World Health Organisation (WHO) and currently have sustained community transmission globally (1). Before COVID-19 pandemic, TB was the leading cause of death from an infectious disease globally (2). While COVID-19 caused over 3 million deaths in a little over one year in 2020, TB caused 1.4 million deaths out of approximately 10 million new cases reported annually (3-5). However, the epidemiological interaction between TB and COVID 19 are still complex and unclear (6, 7). In response to the pandemic, policies such as lockdowns and reassignment of health infrastructure, staff, finances, and equipment such as the TB diagnostic GeneXpert machines have been widely adopted to contain the pandemic. These policies greatly affected access to and delivery of essential TB services in 2020 (6, 8, 9). According to data reported by WHO from 84 countries, there was a 21% reduction in TB case notification from 6.3 million cases in 2019 before the pandemic to about 4.9 million cases in 2020 in the 10 high burden TB countries including Uganda (9). The WHO modelling and analysis of the impact of reductions in the performance of TB detection and care on the TB mortality showed that an estimated 1.4 million additional TB deaths may occur between 2020-2025 as a direct consequence of the COVID-19 pandemic (8-10).

On the 21st of March 2020, Uganda, one of the 30 high burden TB and TB/HIV countries (11) confirmed her first COVID-19 case. By late June 2021, the country had recorded nearly 80,000 cases and 1,725 deaths (12). Following the confirmation of the first case, Uganda closed its borders except for cargo and goods transported by trucks. This was followed by suspension of public transport and restrictions on private transport on the 25th of March 2021, and nationwide curfew from 7pm to 6:30am on the 30th of March 2020. Additionality, TB diagnostic equipment such as GeneXpert machines were moved from their respective health facilities to COVID-19 diagnostic units, while some MDR TB units were repurposed to serve as COVID-19 isolation and treatment units. These reassignments, coupled with restrictions in movement, and psychological fear of contracting the disease in health care facilities were feared to have compromised diagnostic treatment of TB as well as TB and COVID-19 coinfections, hindering the Uganda National TB and Leprosy Program's efforts for TB control in the country (1, 6, 13).

Due to the pressure and demand that COVID-19 put on the health systems, people with TB were likely to face limited access to diagnostic and treatment services, which may have consequently resulted in adverse outcomes (1). Additionally, both COVID-19 and TB are associated with considerable social impacts such as stigma, isolation, and discrimination (5, 6, 14, 15). Seeking health care had been deferred because of social distancing measures, as well as community fears

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that health facilities may be infected and therefore risky (1). Although anecdotal reports suggested that these restrictions and changes may have had serious effects on health service seeking and delivery, there were limited data on its effect on TB services including TB case notification and treatment outcomes in Uganda. We analysed the nationwide TB surveillance data for the period of January 2019 to June 2021 (5 quarters before and 5 quarters during the COVID-19), to assess the indirect effect of COVID-19 on TB case notifications and treatment outcomes in Uganda.

Methods

Study setting

We conducted a cross-sectional study using TB surveillance data reported by all TB diagnostic units in all districts in Uganda. We calculated and assessed the TB Case Notification Rates (CNR), TB Treatment Success Rates (TSR), and number of COVID-19 cases at both national and regional level.

Uganda has 135 districts and 11 cities distributed across the 15 different regions in Uganda. The 15 regions include; Acholi, Ankole, Bugisu, Bukedi, Bunyoro, Busoga, Kampala, Karamoja, Kigezi, Lango, North Central, South Central, Teso, Toro, and West Nile.

Study design, data source, and description of the tuberculosis surveillance system

We performed a descriptive analysis of routinely collected surveillance data on TB obtained from the electronic District Health Information Software version 2 (DHIS2) from January 2019 to June 2021 in Uganda and calculated TB CNR and TSR for the pre-COVID-19 (January 2019-March 2020) and after COVID-19 (April 2020-June 2021) periods. The DHIS2 is an open source, web based software platform for data collection, management, and analysis (16, 17). The DHIS2 was released in 2006 and adopted in Uganda in January 2011 at the National level, before it was rolled out throughout the country in July 2012 (18). Data on the diagnosed TB patients is entered into the different registers at the health facilities. These include the laboratory registers (TB, Presumptive TB, and Unit TB). This data is then summarised into the weekly HMIS Form 033 every end of week, the monthly HMIS 105 form, and the quarterly HMIS 106 report. The weekly, monthly, and quarterly reports are submitted to the biostatistician for entry into the DHIS2, which is accessed by the Ministry of Health (MoH).

Study variables, data abstraction, analysis

We extracted data from DHIS2, which was obtained from the HMIS Form 106 (19). The HMIS Form 106 is a report on outpatient department (OPD) attendances, diagnoses, maternal and child health (MCH), HIV/AIDS, laboratory, stock status of essential drugs and supplies, and finances among others (19), which is completed and submitted to the MoH through DHIS2 at the end of every quarter. We extracted data on the treatment success rate and number of TB cases notified, expected TB cases, and percentage TB cases by sex for the pre and during COVID-19 period. We defined the CNR as the number of cases per 100,000 population, and TSR as the proportion of patients initiated on TB treatment that successfully completed treatment or cured. We used the expected TB cases and incident TB cases to calculate the proportion of expected TB cases notified and obtained the line list of monthly COVID-19 cases reported at both national and regional level.

We extracted data from the DHIS2 and exported into Microsoft Excel for cleaning and imported into Epi-info version 7.2.4 for analysis. Data on the quarterly expected TB cases, incident TB cases, percentage of notified TB cases by sex, proportion of expected TB cases notified, the CNR and TSR were summarised in tables. We computed CNR and TSR and presented them in line graphs to show the national and quarterly trends in TB CNR and TSR in Uganda before and during the COVID-19 pandemic. The treatment outcomes were classified according to the National TB control guidelines as adopted from the WHO guidelines for TB diagnosis and case definition (20). We constructed logistic regression models to examine the trends and assess the significance of these trends.

We used interrupted single group time-series analysis (ITSA) with segmented regression analysis (21, 22) to evaluate the effect of COVID-19 on the quarterly CNRs in Uganda. We estimated and presented the coefficients of ordinary least-squares (OLS) regression

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and produced Newey–West standard errors to handle the autocorrelation and possible heteroscedasticity (22). A p-value less than 0.05 was considered as statistically significant for all analyses. We considered the April-June 2020 as the period in which the intervention started because the first case of COVID-19 and initial lockdown were declared in the last weeks of the January-March 2020 quarter, which may not have had a noticeable impact.

Results

National trends of case notification rates for all tuberculosis cases and all forms per 100 000 population, January 2019-June 2021

Generally, there was a fluctuating trend in the national TB case notification rates between January 2019-June 2021. However, there was a 22% decline in the April-June 2020 quarter, where the CNR decreased from 161/100,000 in January -March 2020 quarter to 133/100,000 in April 2020 quarter (Table 1). A total of 164,427 incident (new and relapse) TB cases were notified during January 2019 -June 2021, with an average quarterly notification rate of 165/100,000 population. Half (82,320) of the total incident cases were reported in each of the COVID19 periods. The highest quarterly notification rate was 190/100,000 in the quarter of April-June 2021 in the later quarters of the COVID-19 pandemic, while the lowest was 133/100,000 in quarter of April 2020, in the first quarter of COVID-19 and lockdown declaration. About two thirds (79.9%) of the expected TB cases were notified pre-COVID-19 while 79.4% was notified during the COVID-19 pandemic. Consistent with the lowest CNR (133/100,000) and first quarter of COVID-19 and lockdown declaration in Uganda, the quarter of April 2020 had the lowest number of incident TB cases notified (12,871), which was only 61.6% of the expected TB 20,896 cases in the same quarter. TB cases notified between January 2019-June 2021 were majorly males (62%), which was almost twice as high as the females. This was consistent in all quarters pre and during COVID-19 period (Table 1)

Table 1:Quarterly Expected and Incident TB Cases, proportion of expected TB cases notified, proportion of notified cases by sex, Case Notification rates and Treatment success rates in Uganda, January 2019-June 2021

Period	Estimated	Incident	% Notified of expected Incident TB cases	% Male	% Female	CNR/100,000	% TSR
Jan-19	20154	16746	83.1	62.0	37.6	169	71.9
Apr-19	20154	16127	80.0	62.0	37.6	161	73.8
Jul-19	20896	18099	86.6	62.0	37.6	188	74.7
Oct-19	20896	14948	71.5	62.1	37.9	152	75.8
Jan-20	20896	16400	78.5	64.1	35.9	161	79.3
Apr-20	20896	12871	61.6	63.5	36.5	133	81.1
Jul-20	20585	15801	76.8	62.2	37.8	159	83.2
Oct-20	20585	15819	76.8	63.0	37.0	160	83.6
Jan-21	20585	18238	88.6	61.4	38.4	178	85.2
Apr-21	20585	19217	93.4	60.5	39.7	190	85.3
Average	**20623**	**16427**	**79.7**	**62.0**	**38.0**	**165.1**	**79.0**

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terrupted time series regression analysis of the national trends of TB case notification rates in Uganda, January 2019–June 2021

The CNR at the beginning of the observation period pre-COVID-19 was at 171.2 cases per 100,000. There was a decrease in the CNR of 2.5 cases/100,000 (p=0.270, CI = [-7.5, 2.5]) per quarter pre-COVID-19, although this decline was not statistically significant. In the immediate quarter (April-June 2020) after the declaration of COVID-19 and lockdown, there was a statistically significant decline of 21.3 cases/100,000 (p<0.042, CI = [-41.5, -1.1]) in the national CNR. This was followed by a statistically significant sustained quarterly increase of 15.8 cases/100,000 (p<0.001, CI = [10.0, 21.6]) in national TB CNR in the subsequent quarters during COVID-19 (Table 2).

Table 2: Interrupted Time Series Analysis for Impact of COVID-19 on the National, Kampala and Outside Kampala quarterly TB Case notification rates, January 2019-June 2021

Parameter	Coefficient	95% CI	p value
National			
Intercept β_0	171.2	[156.8 -185.6]	<0.0005
Baseline trend β_1	-2.5	[-7.5 2.5]	0.270
Level change after intervention β_2	-21.3	[-41.5 -1.1] **	0.042
Trend change after cap β_3	15.8	[10.0 21.6] ***	0.001
Kampala			
Intercept β_0	504.4	[485.9 522.9] ***	<0.0005
Baseline trend β_1	-24.90	[-38.3 -11.5] ***	0.004
Level change after intervention β_2	-77.70	[-182.5 27.2]	0.120
Trend change after cap β_3	39	[15.7 62.3] ***	0.006
Elsewhere/outside Kampala			
Intercept β_0	168.3	[153.8 182.8] ***	<0.0005
Baseline trend β_1	-2.31	[-7.3 2.7]	0.306
Level change after intervention β_2	-20.48	[-40.6 -0.3] **	0.047
Trend change after cap β_3	15.46	[9.6 21.3] ***	0.001

*Significant association at *** p<0.01, ** p<0.05, * p<0.1

Trends of TB case notification rates at national level and Kampala, January 2019–June 2021

At the start of the observation period pre-COVID-19, there was an estimated CNR of 171.2 cases per 100,000 at the national level, 168.3 cases/100,000 for other districts outside Kampala, and 504.4 cases/100,000 in Kampala. The CNR appeared to decrease slightly every quarter prior to COVID-19 and lockdown declaration. However, the decrease in trend of CNR was only significant in Kampala. For each quarter, the CNR significantly decreased by 24.90 cases/100,000 per quarter in Kampala. Although there was a decreasing trend in CNR at the National level of 2.5 cases/100,000(p=0.270, CI= [-7.5-2.5] and 2.31 cases/100,000 (p=0.306 CI= [-7.3- 2.7]) per quarter elsewhere outside Kampala, this decrease was not significant. In the first quarter of the COVID-19 and lockdown declaration, there appeared to be a statistically significant decrease in quarterly CNR of 21.30 cases/100,000 (p<0.05, 95% CI = [-41.5, -1.1]) at national level and 20.48 cases/100,000 (p<0.05, 95% CI = [-40.7, -0.31]) in other districts outside Kampala. However, despite the 77.70 cases/100,000 (p=0.120, 95%CI= [-182.5 27.2]) decrease in CNR, the decrease was not statistically significant in Kampala. This was followed by a statistically significant increase in CNR of 39 cases/100,000 (p<0.01, 95% CI = [15.66, 62.34]) in Kampala, 15.46 cases/100,000 (p<0.01, 95% CI = [9.66, 21.26])

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outside Kampala and 15.80 cases/100,000 (p<0.01,95% CI = [10.04, 21.56]) at the National level per quarter in the subsequent quarters during COVID-19. (Table 2).

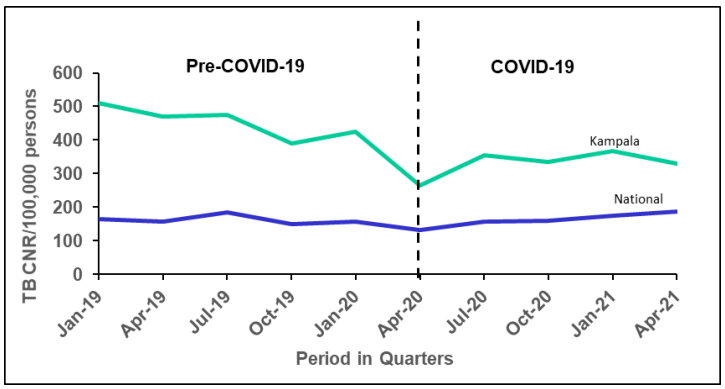

Figure 2: National and Kampala CNR trends before and during the COVID-19 pandemic in Uganda, January 2019-June 2021

Trends of TB case notification rates by region before and during the COVID-19 pandemic

Generally, there was no noticeable change in TB CNR at national level throughout the study period, pre and during COVID-19. However, the regional trends showed a 27.5% decline in TB CNR in Kampala, and a 10.8 increase in TB CNR in Karamoja during the COVID-19 pandemic.

Interrupted time series regression analysis of the regional trends of TB case notification rates in Uganda, January 2019–June 2021

There was a general decline in TB CNR in quarters pre and immediately after the COVID-19 outbreak declaration across all regions in Uganda, while there was a general increase in the subsequent quarters during the COVID-19 pandemic in majority of the regions. However, CNR were generally consistent in Karamoja, Lango, Teso, and West Nile regions throughout the study period both pre and during COVID-19 (Table 3).

Majority of the regions in Uganda experienced a decline in the TB case notification rates before the emergence of the COVID-19 pandemic and related lockdowns. However, these declines were not statistically significant in majority of the regions except for Acholi, Kampala, and Kigezi regions. The TB CNR at the start of the observation period was 255 cases/100,000 (CI = [211.4–298.3]) in Acholi, 504 cases/100,000(CI = [485.9 522.9]) in Kampala, and 158 cases/100,000 in Kigezi (CI= [140.5–174.7]). There was a statistically significant decrease in CNR every quarter pre-COVID-19, decreasing quarterly by 21.7 cases/100,000 (p=0.010, CI = [-36.1-7.3]) in Acholi, 24.9 cases/100,000(p=0.004, CI = [-38.3-11.5]) in Kampala and 11.6 cases/100,000 (p=0.005, CI = [-18.2- -5.0]) in Kigezi region (Table 3).

In the immediate quarters after the COVID-19 pandemic there was a statistically significant quarterly decline of 26 cases/100,000 (p=0.038, CI = [-49.1–1.9]) in Ankole and 59 cases/100,000 (p=0.001, CI = [-84.9-33.7]) in North Central region. The remaining 12 regions experienced declines in the CNR every quarter during the early quarters of COVID-19 but these were not statistically significant. Contrary to the 14 regions that experienced declines in quarterly CNR, Acholi experienced an increase in CNR by 39 cases/100,000 (p=0.145, CI = [-18.2-96.9]), although this increase was not statistically significant (Table 3).

Unlike the immediate quarters following outbreak of COVID-19 in Uganda where majority of the regions experienced a decline in CNR, there was a sustained general increase in CNR across the different regions in Uganda in the subsequent months after the COVID-19 and lockdown declaration, except Karamoja which had a 4.2 cases/100,000 (p=0.828, CI = [-49.4 – 41.0]) non-statistically significant decline in the CNR per quarter. In the majority of the regions (11/15), the increase in CNR was statistically significant while there was no significant change in Lango, Teso, and West Nile. The CNR significantly increased per quarter by 26 cases/100,000 (p=0.012, CI = [8.2 – 43.8]) in Acholi, 14 cases/100,000(p=0.001, CI = [8.2 – 20.4]) in Ankole, 5 cases/100,000 (p=0.012, CI = [1.6 – 8.7]) in Bugisu, 15cases/100,000(p=0.032, CI = [1.7 – 27.2]) in Bukedi, 17cases/100,000 (p=0.031, CI = [2.2 – 32.6]) in Bunyoro, 12 cases/100,000 (p=0.008, CI = [4.4 – 19.5]) in Busoga, 39 cases/100,000(p=0.006, CI = [15.7 – 62.3]) in Kampala, 22 cases/100,000 (p=0.001, CI = [13.3 – 30.2]) in Kigezi, 20cases/100,000 (p=0.003, CI = [9.6 – 30.8]) in North Central, 29 cases/100,000(p<0.001, CI = [18.6 –

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38.9]) in South Central, and 27cases/100,000 (p=0.004, CI = [12.3 – 42.3]) in Toro (Table 3).

Table 3: Interrupted time series regression analysis for the impact of COVID-19 on the regional trends of TB Case Notification rates in Uganda, January 2019-June 2021

Parameter	Coef-	95% CI	p value
Acholi Region			
Intercept β_0	254.9	211.4–	<0.0005
Baseline trend β_1	-21.7	-36.1-7.3	0.010
Level change after intervention β_2	39.4	-18.2-96.9	0.145
Trend change after cap β_3	26.0	8.2 – 43.8	**0.012
Ankole			
Intercept β_0	119.3	112.0–	<0.0005
Baseline trend β_1	-2.4	-7.7– 2.9	0.314
Level change after intervention β_2	-25.5	-49.1–1.9	0.038
Trend change after cap	14.3	8.2–20.4	0.001
Bugisu			
Intercept β_0	98.6	91.9–	<0.0005
Baseline trend β_1	2.7	-1.4–6.8	0.156
Level change after intervention β_2	-18.7	-38.6–1.2	0.061
Trend change after cap	5.1	1.6–8.7	0.012
Bukedi			
Intercept β_0	69.7	36.4–102.9	0.002
Baseline trend β_1	-3.2	-14.6-8.2	0.522
Level change after intervention β_2	-3.9	-37.5–29.7	0.79
Trend change after cap	14.5	1.7–27.2	0.032
Bunyoro			
Intercept β_0	169.4	151.2–	<0.0001
Baseline trend β_1	-1.9	-8.2– 4.4	0.489
Level change after intervention β_2	-48.1	-99.2–3.0	0.061
Trend change after cap	17.4	2.2–32.6	0.031
Busoga			
Intercept β_0	105.5	95.4–115.6	<0.0001
Baseline trend β_1	-0.3	-4.3– -3.7	0.859
Level change after intervention β_2	-14.9	-32.3–2.5	0.081
Trend change after cap β_3	11.9	4.4-19.5	0.008
Kampala			
Intercept β_0	504.4	485.9–522.9***	<0.0001
Baseline trend β_1	-24.90	-38.3 - 11.5 ***	0.004
Level change after intervention β_2	-77.70	-182.5–27.2	0.120
Trend change after cap β_3	39	15.7–62.3 ***	0.006
Karamoja			
Intercept β_0	318.3	261.5–375.1	<0.0001
Baseline trend β_1	11.6	-8.7–31.9	0.211
Level change after intervention β_2	-11.9	-123.3–99.5	0.803
Trend change after cap β_3	-4.2	-49.4–41.0	0.828
Kigezi			
Intercept β_0	157.6	140.5–174.7	<0.0001
Baseline trend β_1	-11.6	-18.2– 5.0	0.005
Level change after intervention β_2	-19.2	-43.3–4.9	0.099
Trend change after cap β_3	21.8	13.3–30.2	0.001
Lango			
Intercept β_0	242.4	188.6–296.2	<0.0001
Baseline trend β_1	-6.2	-25.1–12.6	0.450
Level change after intervention β_2	-14.9	-82.1–52.2	0.606
Trend change after cap β_3	18.7	-5.0–42.4	0.101
North Central			
Intercept β_0	160.1	151.2–168.9	<0.0001
Baseline trend β_1	1.8	-1.7–5.4	0.245
Level change after intervention β_2	-59.3	-84.9–33.7	0.001
Trend change after cap β_3	20.2	9.6–30.8	0.003

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Parameter	Coefficient	95% CI	p value
South Central			
Intercept β_0	233.3	210.2–256.4	<0.0001
Baseline trend β_1	-6.5	-15.3–2.3	0.122
Level change after intervention β_2	-23.1	-53.9–7.7	0.116
Trend change after cap β_3	28.7	18.6–38.9	<0.0001
Teso			
Intercept β_0	92.4	70.6–114.2	<0.0001
Baseline trend β_1	-1.3	-9.3–6.7	0.707
Level change after intervention β_2	-23.2	-57.9–11.6	0.155
Trend change after cap β_3	9.6	-2.9-22.1	0.109
Toro			
Intercept β_0	155.0	138.5–171.5	<0.0001
Baseline trend β_1	-5.4	-14.4–3.7	0.199
Level change after intervention β_2	-15.0	-47.3–17.2	0.298
West Nile			
Intercept β_0	166.0	108.1–223.8	<0.0001
Baseline trend β_1	6.7	-13.7–26.9	0.459
Level change after intervention β_2	-22.5	-82.7–37.8	0.397
Trend change after cap β_3	2.9	-23.9–29.8	0.798

*Significant association at $p<0.05$ **Marginally significant association at $p\geq0.05<0.1$

Trends of the treatment success rate in Uganda, January 2019-June 2021

Generally, there was a steady increase in the TSR between January 2019-June 2021, which may imply that COVID-19 had no impact on the treatment outcomes (Figure 3). The average TSR was 79% between January 2019-June 2021 (Table 1). Contrary to the CNR where we saw a decline, there was a 1.8% increase in TSR from 79.3% in the quarter of January 2020 to 81.1% in the quarter of April 2020 when the movement restriction was instituted in Uganda.

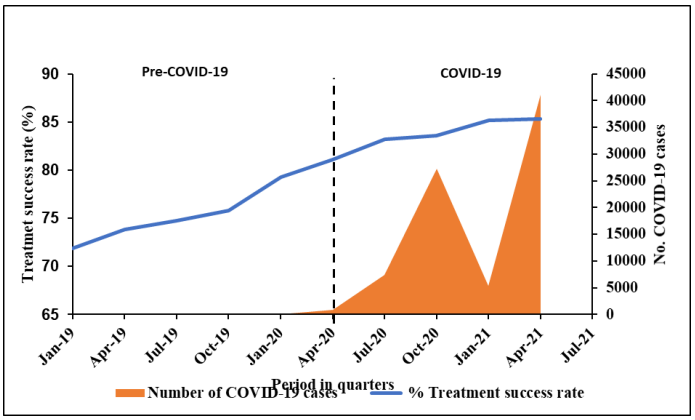

Figure 3: Quarterly Trends in TB Treatment Success Rates Before and During the COVID-19 Pandemic in Uganda, January 2019-June 2021

Interrupted time series analysis of effect of COVID-19 on treatment success rate

There was a general increase in the national TSR between January 2019 to June 2021. The TSR at the start of the observation period was 71.74% (p=CI= [70.91-72.57]). There was a statistically significant 1.68 percentage (p<0.0001, CI= [1.18-2.18]) increase in TSR per quarter before the COVID-19 outbreak in Uganda. In the quarter of April -June 2020 when the movement restrictions were put in place, there was a non-statistically significant 1.46 (p=0.225, CI= [-1.18-4.10]) percentage increase in TSR per quarter. This was followed by a statistically significant sustained decline in the TSR where we found a 0.64 percentage quarterly decrease (p=0.016, CI= [-1.11-0.17]) (Table 4).

Table 4: Interrupted Time Series Analysis for Impact of COVID-19 on TB treatment success rate in Uganda, January 2019-June 2021

TSR	Coeff	SE	t	p>|t|	[95% CI]
Time	1.68***	0.204	8.22	0.000	[1.18 - 2.18]
Intervention	1.46	1.079	1.35	0.225	[-1.18 4.10]
Time since intervention	-0.64**	0.192	-3.33	0.016	[-1.11 -0.17]
Intercept	71.74***	0.340	210.98	0.000	[70.91 -72.57]

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Discussion

COVID-19 has not only led to the loss of millions of human lives but also affected delivery of health services directly or indirectly across the globe (7, 23). We analysed the quarterly trends of TB case notification rates and treatment success rates before and after the COVID-19 pandemic in Uganda from January 2019- June 2021.
In this study, there was a general decline in the national CNRs and a steady increase in TSR in Uganda between January 2019-June 2021. The study showed that fewer cases were notified during the pandemic than the reported number of cases in the absence of the pandemic. The decline in TB CNRs was in the first quarter of the COVID-19 pandemic and lockdown in Uganda. These findings are consistent with studies from the United States, Malawi, Taiwan, Korea, and Ethiopia (24-28). However, we found that after the initial decline immediately after the declaration of the COVID-19 pandemic and related movement restrictions, the TB CNRs gradually increased through the subsequent quarters between April 2020-June 2021. Despite the increase in TB cases notified in the last quarters of the COVID-19 pandemic, the CNRs and overall number of TB cases reported was lower during the COVID-19 period compared with the pre-COVID-19 period. This is also consistent with findings from Spain, Malawi and 9 other countries (10, 23, 28).

Although the incidence of TB in Uganda has decreased steadily over the years (4, 29), a 22% decrease in TB CNRs in the immediate quarter after declaration of the COVID-19 pandemic and lockdown measures is larger than predicted by the ITSA model. This could be attributed to different factors. First, the decline in TB CNR may be due to reduced transmission associated with the wide use of face masks, social distancing and restrictions in movement(6, 7, 25, 30). Studies have shown a 10% reduction in TB transmission in high burden TB countries due to social distancing and use of masks (10). However, the 22% immediate decline in the TB CNR in Uganda may also suggest additional factors such as interruption in TB contact tracing and preventive therapy. It could also be due to poor access to TB care services due to movement restrictions and rechannelling of health facility resources from TB care to COVID-19 treatment. This agrees with a study in the United States that showed an overall decline

Further analysis of the regional CNRs shows that although the pre-COVID-19 decline was not statistically significant at the national level and the other 12 regions, it was statistically significant in Acholi, Kampala, and Kigezi regions. Contrary to the pre-COVID decline, we found a statistically significant decline in the national CNR in the first quarter of the COVID-19 and lockdown declarations in Uganda. However, a deep dive into the data shows that this decline was only statistically significant in the Ankole and North central regions. Contrary to the baseline period and the period immediately after the declaration of COVID-19 outbreak and lockdown where we saw general reductions in CNR, the following quarters showed a positive and sustained increase in CNRs across all regions except Karamoja which had a non-statistically significant decrease in CNR. In this period, we found a sustained increase in CNR which was statistically significant at the national level and in majority of the regions except Lango, Teso, and West Nile where the increase was not statistically significant.

We hypothesize that these variations in CNR during the observation period may be due to the uneven enforcement of COVID-19 control measures across the different regions in Uganda. Urban areas like Kampala and North Central could have had a blend of application of restrictions compared to other areas. Additionally, this could be due to some mitigation measures in other areas such as the TB emergency response in the North and Eastern regions in Uganda compared to other regions that did not have these interventions. We also hypothesize that the recovery performance from COVID-19 lockdown in the later quarters of COVID-19 pandemic and lockdown declarations were due to several innovations by the National TB and Leprosy program (NTLP) in collaboration with implementing partners in the different regions (29). The innovations included the community awareness screening and testing (CAST-TB) campaign in some regions where over 1500 missing TB cases were diagnosed and started on treatment, intensified active case finding, quality improvement collaboratives, in-

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stallation of mobile digital X-ray machines for active TB case finding, and intensive private sector and media engagement among others (29).

Study Limitations

Our study had some limitations. First, we used routinely collected surveillance data with the inherent limitations of retrospective data and its potential to over or underestimate the TB cases notified depending on likelihood of data entry errors. However, being a national data set, reflects a good picture of the general trends in the TB CNRs across the country in the study period. Second, the study period was limited to a few quarters before and during the COVID-19 pandemic, thus not allowing for the assessment of the longer-term outcomes, however, these may be assessed in the later stages of the pandemic. Finally, several factors may have played a role in the decline in the TB CNRs yet our study was not in position to distinguish between the effects of COVID-19 preventive measures and the delays in disease diagnosis. However, we can comfortably note that may have several unknown consequences on TB care and outcomes based on findings from several studies globally.

Conclusion

COVID-19 had an immediate substantiated effect on TB CNR in Uganda. The effect varied across the different regions. However, the initial COVID-19 related decline in TB CNRs was not sustained as there was a quick recovery seen in the later quarters of the pandemic and lockdown.

Conflict of Interest

The authors declare that they had no competing interests.

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