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Anthrax outbreak associated with Sleeping on the hides of cattle that died suddenly in Amudat District, Uganda, Dec 2023–Jun 2024

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Summary

Background: On December 28, 2023, a suspected case of anthrax was reported at Karita Health Centre IV in Amudat District. Samples collected and tested confirmed an anthrax outbreak later in March, 2024. We investigated to assess its magnitude, identify exposure sources, and recommend control and prevention measures.
Methods: We defined a suspected cutaneous anthrax case as an individual with skin lesions (vesicles or eschars) plus ≥ 2 of the following symptoms: itching of skin, reddening of skin, swelling around the lesions, or regional lymphadenopathy from December 2023 to June 2024. A confirmed case was a suspected case that tested PCR-positive for *Bacillus anthracis*. We identified cases through house-to-house search and patient record reviews. Human and animal samples were collected and tested, alongside an environmental assessment. We conducted an unmatched control to identify factors associated with anthrax transmission. We used logistic regression to identify the risk factors.
Results: We identified 102 suspected cases (7 confirmed); none died. All cases were cutaneous anthrax. The outbreak lasted 7 months and peaked in March, 2024. The overall attack rate (AR) was 167/100,000 with males (AR=201/100,000) more affected than females (AR=132/100,000). The odds of infection were higher among persons who slept on the hides of animals (OR=11, 95% CI:2.6-47) and those who were involved in slaughter (OR=5.3,95%CI:1.8-15). There was a dose-response effect for persons who slaughtered, skinned and carried (OR=19, 95% CI:2.6-136), slaughtered and carried (OR=13,95%CI:2.2-78) and those who slaughtered and skinned (OR=8.1,95%CI:2.1-31). Scattered bones and abandoned animal skins were observed indicating possible widespread death of animals which points to existence of environmental anthrax spore in the soils.
Conclusion: This cutaneous anthrax outbreak, was linked to slaughtering cattle that died suddenly and sleeping on cattle hides. We recommended community education on anthrax, vaccination of animals against anthrax, and safe animal carcass disposal practices.

Introduction

Anthrax, caused by *Bacillus anthracis*, is a zoonotic disease affecting both humans and animals(1). The bacterium, an aerobic, spore-forming Gram-positive organism, enters animal hosts through grazing in contaminated areas or consuming tainted feeds. Once ingested, the spores germinate into active bacteria, causing illness(1). Humans typically contract anthrax from contact with infected livestock and their animal products, such as skin, meat, hides, and bones. Anthrax manifests in three primary forms in humans cutaneous, gastrointestinal, and inhalational—each with varying routes of exposure and different incubation periods: 2–7 days for cutaneous, 1–6 days for inhalational, and 1–6 days for gastrointestinal (2).

Cutaneous anthrax is the most frequently reported form in humans, accounting for up to 95% of cases with an untreated fatality rate as high as 20% (3,4). Globally, anthrax results in an estimated 20,000 to 100,000 cases annually, predominantly affecting impoverished rural areas (4), notably in African and Asian countries (5). The World Health Organization classifies anthrax among neglected zoonotic diseases that perpetuate poverty by impacting health and livelihoods(4).

Uganda, characterized by its diverse biodiversity and growing population, experiences frequent interactions between humans and animals, heightening the risk of zoonotic diseases(6). Between January 2017 and April 2023, Uganda documented 19 anthrax outbreaks (7) including notable occurrences in districts like Zombo, Arua, Kween, and Kiruhura in 2018(8). During this period, surveillance data recorded 186 human and 721 livestock deaths attributed to anthrax (9).

In December 28, 2023, Amudat District reported its initial suspected anthrax case involving a 10-year-old boy from Kakworobu Village. Symptoms included diarrhea, body weakness, and eschar on the shoulders after the child participated in handling and consuming meat from a cow that died suddenly. Subsequent sporadic cases emerged in early 2024, prompting Karita Health Center IV to notify district authorities of suspected anthrax cases by February 5, 2024. Following positive test results from human samples collected on March 15, 2024, the Ministry of Health intervened to support the district in investigating the outbreak. We investigated to identify the outbreak's origin, assess exposure risks, and recommend evidence-based control and prevention measures.

Methods

Outbreak setting

Amudat District is located in north-eastern Uganda, in the Karamoja sub-region. It borders Kenya to the east, Moroto District to the north, Nakapiripirit District to the west, and Kween and Bukwo Districts to the south and borders Pian Upe Wild Wildlife

Reserve. The district has ten (10) sub countries including: Amudat Town Council, Loroo, Karita Town Council, Abiliyep, Katabok, Karita, Kangorok, Lokales, Losidok, and Achorichori (Figure 1). The district has a population of approximately 157,800 (Uganda Bureau of Statistics) The people are predominantly nomadic pastoralists. Notably, the district reported its first outbreak.

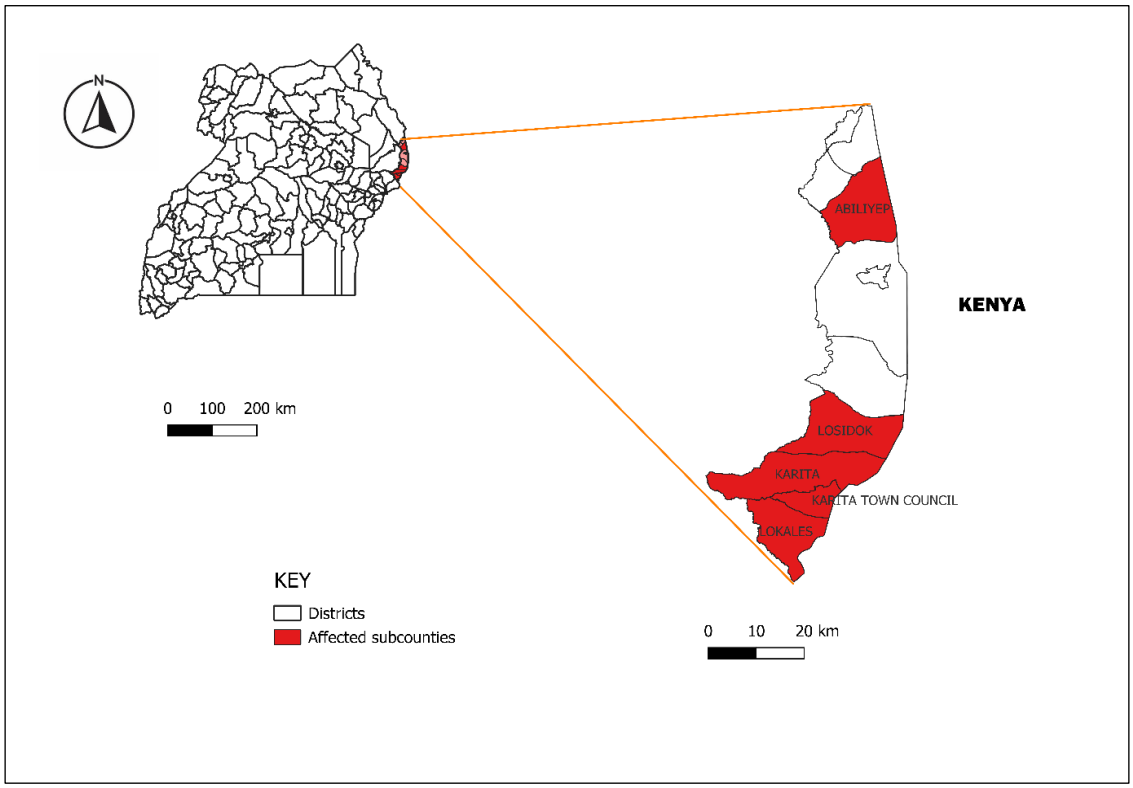

Figure 1: Location of affected sub counties in Amudat District, Uganda

Case definition and finding

We defined a suspected case as follows: cutaneous anthrax: Acute onset of skin lesions (vesicle or eschar) plus ≥2 of skin itching, reddening, and swelling, or skin lesions (vesicle or eschar) plus regional lymphadenopathy that occurred in a resident of Amudat District from December 2023 to June 2024.

A confirmed case was defined as a suspected case-patient with laboratory confirmation of *Bacillus anthracis* from a clinical sample.

To identify cases, we reviewed health facility records and conducted an active case search in the community with the help of the Village Health Team members (VHTs). We also constructed and updated a line list for this purpose.

Descriptive epidemiology

We described case patient were described by time, place, and person. An epidemic curve was developed to represent the cases over time. Using the district population

projection data from the Uganda Bureau of Statistics, we computed attack rates by age group, sex, and sub-county. Chloropthreth maps were drawn using QGIS software to show distribution of cases by place.

Laboratory investigation

A total of 24 samples (16 from humans; six from animals; and two soil samples) were collected and transferred to the testing laboratory using the hub system. Anthrax confirmation was based on the identification of *Bacillus anthracis* by real-time PCR assay.

Environmental investigations

We inspected the grazing area in Losidok Sub-county following reports from residents who indicated that they had disposed of the carcasses of cattle that had died suddenly to assess potential sources of contamination and understand the impact on the environment.

Hypothesis generation

To generate hypotheses, we conducted interviews with the six suspected cases and three confirmed cases to identify possible sources and factors associated with contracting anthrax including: participating in slaughtering animals that had died suddenly, sleeping on the hides of these animals, digging up animal remains during cultivation, and direct contact with deceased animals that had died suddenly.

Case-control study

We conducted a 1:3 unmatched case-control study to identify risk factors for anthrax infection. All confirmed and suspect cases from December 2023 onwards were enrolled. A control person was an individual who never had any signs of cutaneous anthrax from December, 2023 to the time of the investigation, resident in the same village as the case-patient or the nearest household of a case and were screened for the clinical signs and symptoms before consideration.

Crude odds ratios (OR) were computed at the bivariate level using Chi-Square to assess associations between variables. Variables showing significance were subsequently included in a multivariate logistic regression model to obtain adjusted odds ratios. For small sample sizes where any cell in a 2x2 contingency table contained less than 5 observations, Fisher's exact test was employed to ensure robustness and accuracy in statistical inference. Variables with a 95% confidence interval (CI) that excluded one or $p < 0.05$ were considered significant.

Ethical considerations

This investigation was initiated in response to a public health emergency. The Ministry of Health (MOH) authorized the investigation and the Centre for Global Health at the US Centers for Disease Control and Prevention (CDC) classified the activity as non-human research, focusing on improving public health practices and disease control. We obtained permission from the leadership of Amudat District Local Government to conduct the investigation. Respondents were informed that their participation was voluntary and

that they could withdraw at any time without any negative consequences. To ensure confidentiality, the respondents were interviewed in privacy.

Results

Descriptive epidemiology

We identified 102 case patients, of which 40 were confirmed and none died. The overall attack rate was 167/100,000 population. All the cases were cutaneous. The mean age of the 40 case patients was 24 years (range 7 months–70 years). The most affected age group was 5-20 years (attack rate: 206/100,000population), while the least affected was below 5 years age group (attack rate: 132/ 100,000population). Males constituted 63(62%) of the cases and had a higher attack rate (201/100,000 population) compared to females (132 /100,000 population). Losidok Subcounty had the highest attack rate (350/ 100,000 population), whereas Abiliyep Subcounty had the lowest attack rate (8/100,000 population). Itching (75%), swelling of skin parts (73%), and wounds with black centre (70%) were the most common signs and symptoms of illness (Figure 2).

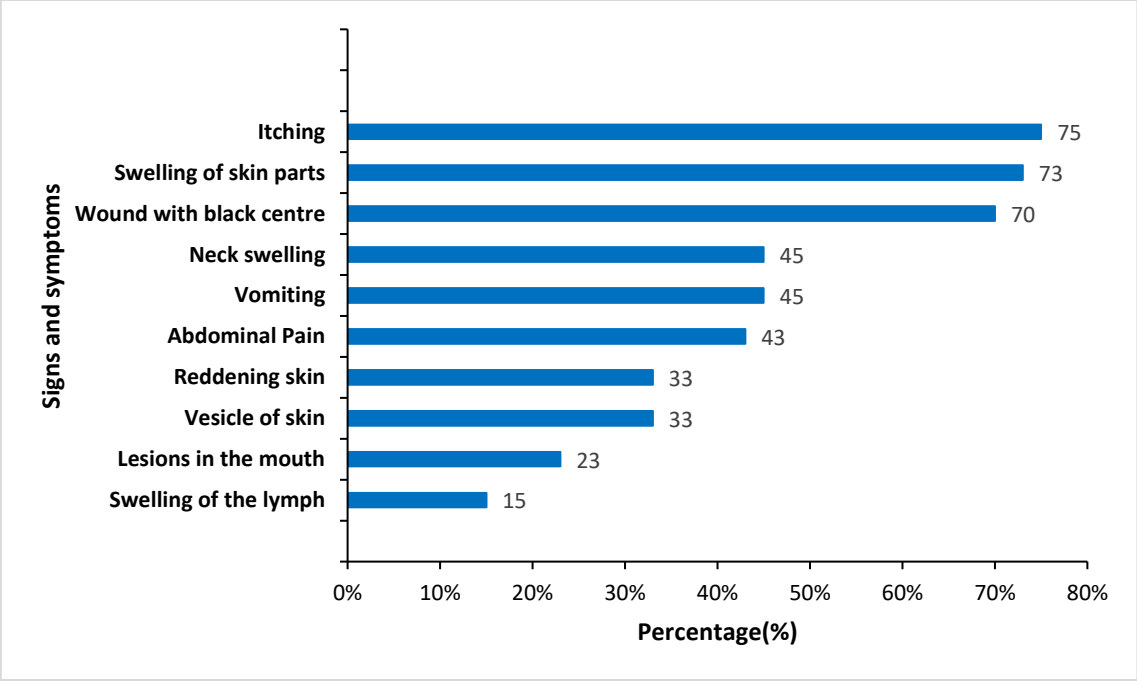

Figure 2: Distribution of clinical symptoms of anthrax case patients during an anthrax outbreak, Amudat District, December 2023-June 2024

As of the end of May 2024, a total of five sub-counties had been affected by the anthrax outbreak including Losidok, Lokales, Karita Town Council, Karita, and Abiliyep. Losidok Subcounty had the highest attack rate (350/ 100,000 population), whereas Abiliyep Subcounty had the lowest attack rate (8/100,000 population) (Figure 3)

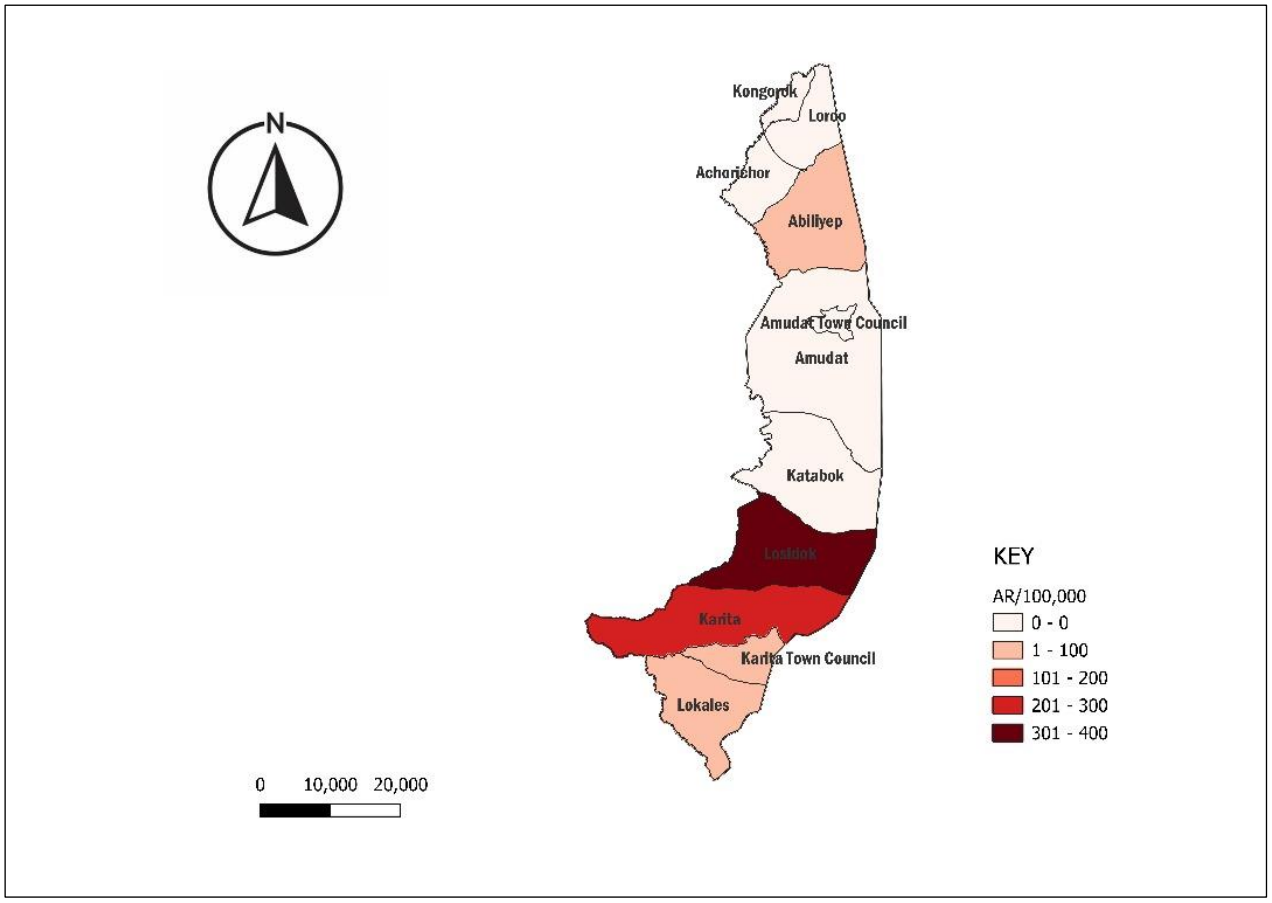

Figure 3: Attack rate of affected sub counties during anthrax outbreak in Amudat District, December 2023-June 2024.

Following the sudden death of a cow and subsequent handling and consumption of its meat on December 28, 2023, anthrax cases began to emerge. The incidence escalated over the subsequent months, reaching its peak in March 2024 with 37 cases. During this period, cattle returned from Kween District, where many animals died and were subsequently slaughtered. The meat from these carcasses was widely consumed, since in the culture of Pokots, they don't discard meat of animals that die. The epidemiological curve suggests multiple sources (Figure 4).

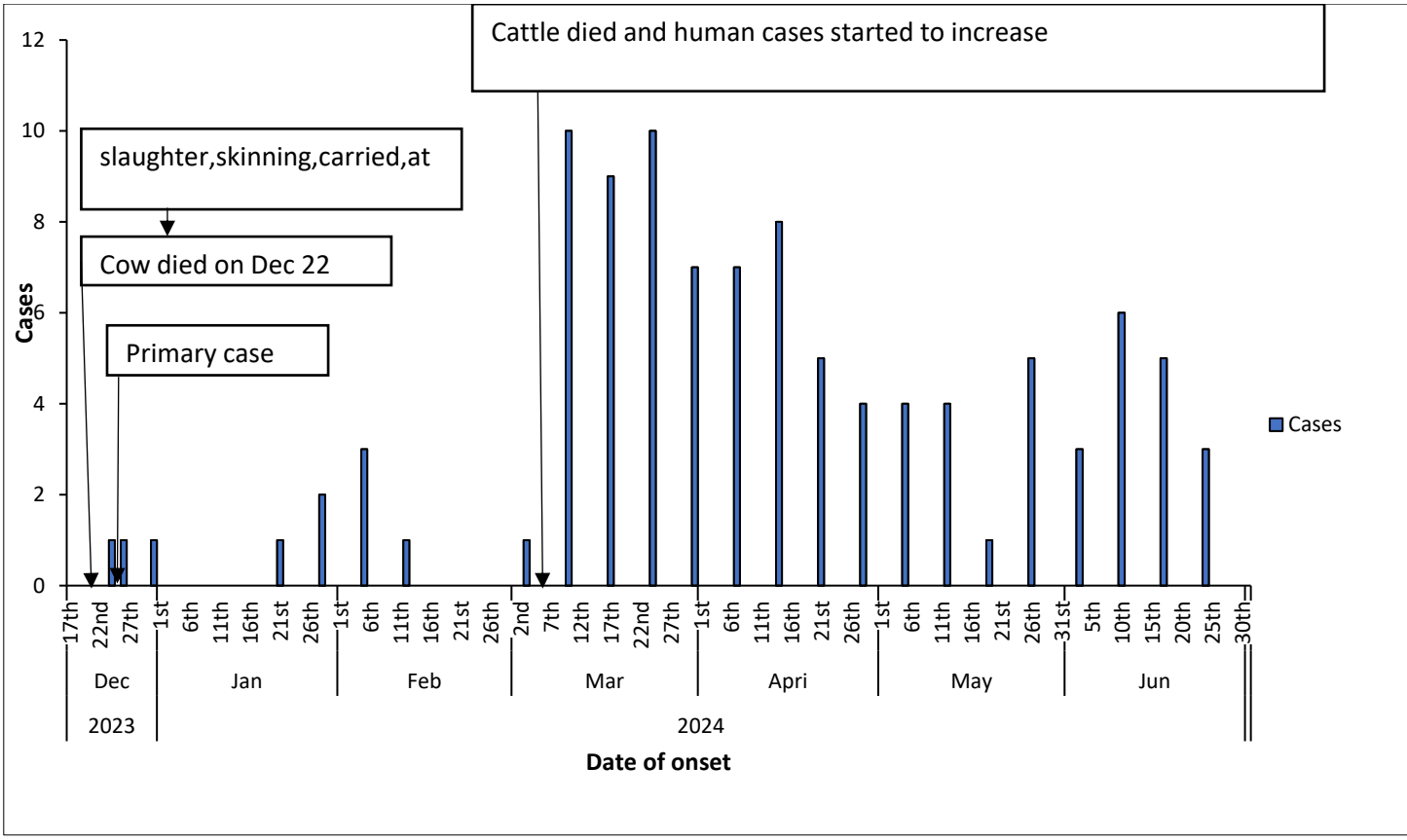

Figure 4: Distribution of a cases by the date of onset of symptoms during anthrax outbreak, Amudat district, December 2023 – June 2024

Laboratory findings

All the soil samples tested negative for *bacillus anthracis*.

Environmental assessment findings

We found scattered bones that indicated the previous disposal of cattle carcasses. We also came across discarded hides, which appeared to have been used as bedding and were found near residential areas.

Hypothesis generation

We interviewed 9 individuals in the community to obtain information about the likely exposures: 89% of respondents reported direct contact with animals that died suddenly, while 44% admitted to sleeping on the hides. Additionally, 22% of respondents mentioned involvement in digging up animal remains during cultivation. We therefore hypothesized that sleeping on cattle hides and slaughtering of cattle that died suddenly may be associated with the anthrax outbreak in Amudat District.

Case–control study findings

Residents who slept on the hide of the cattle that had died suddenly were 11 times more likely to contract cutaneous anthrax compared to those who did not (adjusted odds ratio (aOR = 11, 95% CI: 2.6-47). Furthermore, individuals who slaughtered the cattle that had died suddenly were 7.6 times more likely to develop cutaneous anthrax compared to those who did not (aOR = 7.6, 95% CI: 2.1-28) (Table1a).

Table 1a: Risk factors associated with transmission during an anthrax outbreak: Amudat District, Uganda, December 2023–June, 2024

	Number of participants			
Exposures	**Cases (%)**	**Control (%)**	**cOR (95%, CI**	**aOR (95%, CI**
Age				
< 5 years	6(30)	3(15)	Ref	
5-20 years	14(70)	17(85)	2.4(0.4-17)	3.7(1.2-11)
> 20 years	20(77)	100(97)	10(1.9-65)	20.1(3.3-121)
Sex				
Male	24(60)	55(46)	1.8(0.9-3.7)	
Female	16(40)	66(54)	Ref	
Contact with the hide				
Yes	24(60)	32(27)	4.1(1.9-8.7)	
No	16(40)	88(73)	Ref	
Dug-out animal remains				
Yes	13(32.5)	21(17.5)	2.3(1.0-5.1)	
No	27(67.5)	99(82.5)	Ref	
Sleeping on the hide of a dead cattle				
Yes	12(30)	3(2.5)	16.7(4.0-96)	11(2.6-47)
No	28(70)	117(97.5)	Ref	
Skinning of the cattle				

Yes	13(32.5)	10(14.4)	5.3(2.1-13)	
No	27(67.5)	110(85.6)	Ref	
Participated in slaughtering				
Yes	33(82.5)	41(34.2)	9.1(3.7- 22)	7.6 (2.1-28)
No	7(17.5)	79(65.8)	Ref	

Compare to un exposed group (no contact with the dead cattle) individuals who engaged in the following activities had increased odds of becoming a case of anthrax: those who only slaughtered (OR=5.3, 95%CI:1.9-15), those who slaughtered and carried animal parts (OR=13, 95%CI:2.2-78), slaughtered and skinned (OR=8.1, 95%CI:2.1-31) and those who performed the 3 activities: slaughtered, carried animal parts and skinned (OR=19, 95%CI:2.6-136) (Table 2b).

Table 2b: Common group reference analysis of risk factors associated with cutaneous anthrax, Amudat District, Uganda, Dec 2023–Jun 2024

Category	Slaughtered	Slaughtered and Carried animal parts	Slaughtered and Skinned	Slaughtered, carried animal parts and Skinned	Sick	Total	OR (95% CI)
0	-	-	-	-	7	86	Ref
1	+	-	-	-	17	45	5.3(1.9-15)
2	+	+	-	-	3	6	13(2.2-78)
3	+	+	+	-	10	18	8.1(2.1-31)
4	+	+	+	+	3	5	19(2.6-136)

- No, + Yes, *statistically significant with 95% CI not including one and p<0.05*

Discussion

Following comprehensive epidemiological, laboratory, and environmental evaluations, we identified a multiple-source outbreak of cutaneous anthrax in humans linked to direct contact or handling of deceased cattle and sleeping on their hides. The findings of this investigation are consistent with prior studies on anthrax outbreaks, indicating that patients contracted the disease through contact with infected livestock or contaminated materials (10,11).

In the Pokot community, young children, particularly those involved in cattle herding, predominantly use animal skins and hides as bedding. Our investigation identified sleeping on these materials as a risk factor for anthrax. Using skins or hides from infected animals increases the likelihood of direct contact with *Bacillus anthracis* spores, especially if the animals died from anthrax. This practice aligns with findings from other

studies indicating that processing animal skins and hides for bedding can contribute to anthrax transmission among vulnerable populations(10,12).

We observed a significantly elevated risk of anthrax among individuals older than 20 years, consistent with findings from similar studies in Northern Tanzania and Uganda(10,13). This age group is more likely to engage in activities such as livestock handling, animal product processing, and agricultural work, which increase their exposure to anthrax spores.

Males were disproportionately affected by anthrax compared to females. This observation is likely due to the occupational roles primarily held by males in our study population, which involve direct contact with livestock. These roles include skinning, slaughtering, meat handling, and herding, activities that increase the risk of anthrax exposure through contact with contaminated animal products. The higher attack rate among males during anthrax outbreaks can be attributed to their predominance in these high-risk occupations. This underscores the importance of occupational exposure and traditional roles in influencing disease risk within specific demographic groups. Our findings are consistent with other studies conducted in Uganda in the previous years (14). We noted a number of children younger than 5 years among cases, owing to possible transmission from direct contact with infected parents such as touching them with unwashed hands or through shared bedding materials.

Study limitations

Some of the challenges of anthrax include its detection and surveillance. Detecting anthrax can be difficult due to the varying presentation of symptoms, especially in the case of gastrointestinal anthrax which can mimic other gastrointestinal infection, making health workers to overlook it. Additionally, the first outbreak in a region may further complicate detection and accurate reporting due to unfamiliarity with the disease and its non-specific symptoms

Conclusion

This study highlights the heightened risk of cutaneous anthrax among individuals who slaughtered or sleep on animal hides of animals that had died suddenly. To mitigate anthrax outbreaks, it is crucial to implement preventive measures such as routine vaccination of livestock, safe disposal of anthrax-infected carcasses, public awareness campaigns involving cultural and political leaders, immediate administration of antibiotics for all human anthrax cases, and enhanced surveillance systems across human, and animal sectors using the One Health approach.

Public health actions

During the investigation, we collaborated with the District Health team and local political leaders to organize community education sessions via radio talk shows, emphasizing the prevention and control of anthrax in both humans and animals. We ensured the safe burial of affected carcasses and educated the community on proper burial practices.

Additionally, we provided targeted health education to healthcare staff, focusing on the effective management of anthrax cases

Conflict of Interest
The authors declared no conflict of Interest

Author contribution
PK, HK, EN, JM BK, RM, ARA conceived and designed the study. PK, HK contributed to data collection, cleaning and analysis. EN participated in coordination of laboratory work. PK, HK, EN, JM, BK, RM, ARA took lead in developing the bulletin. All authors contributed to the final draft of the bulletin. All the authors read and approved the final bulletin.

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