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Anthrax Outbreak Investigation among Humans and Animals in Northern Ghana: Case Report

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Authors' contributions

This work was carried out in collaboration between all authors. Author JKAW did the study design and wrote the protocol. Authors JKAW, PAA, MA, TA, SB and JLO did the statistical analysis and literature searches while analyses of study were by authors JKAW, PAA, SB and MNA. All authors read and approved the final manuscript.

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Case Study

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ABSTRACT

Background: Anthrax is a bacterial infection that affects both animals and humans. It is caused by gram positive bacterium, *Bacillus anthracis*. It is an acute, specific infectious disease of mainly grass eating animals including cattle, sheep, goats and pigs and common in areas where livestock are raised. It affects humans when exposed to the fur, blood or carcass of an infected animal. A single case of anthrax in any given geographical area has the potential to result in an outbreak in both humans and animals if not handled effectively and in a timely manner. Anthrax disease occurrence is irregular in the northern regions of Ghana with yearly outbreaks.

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Case Presentation: We report an outbreak investigation of anthrax in both humans and animals in April, 2013. The outbreak was from Gbengo community in the Bawku West district of Upper East Region of northern Ghana. There were three human deaths due to this particular outbreak, representing a case fatality rate of 0.032 (per 1000 of a total district population 94,034). Laboratory confirmed anthrax (*Bacillus anthracis*) with a very high case fatality rate (100%) also affected domesticated herbivorous mammals (17 cattle 3 sheep, 2 goats) of all ages and sexes.
Conclusion: The case revealed that anthrax outbreaks remain a major problem in northern Ghana with high case fatality rate. It also highlights the importance of forecasting anthrax outbreak. In response, public health action to anthrax control with continued public health programming to avert future outbreaks is needed. In addition, both health systems and veterinary services need to collaborate in anthrax surveillance for early case detection and response to prevent deaths.

Keywords: Anthrax; outbreak; human, infectious disease; fatality rate, Ghana.

1. BACKGROUND

Anthrax is a life threatening infectious disease that affects all warm blooded animals including humans [1]. Anthrax is caused by *Bacillus anthracis* which is irregularly distributed worldwide in places where repeated outbreaks occur [2,3]. Outbreaks of Anthrax occur more frequently in developing countries like Ghana as compared to developed countries [4,5]. Rasko and colleagues in 2011 observed that there are 89 known strains of anthrax with the most widely recognized being the virulent Ames strain [6]. The virulent Ames strain was detected in September, 2001 anthrax attacks in the United States, when some individuals were sent anthrax through the mailing or postal system [6,7].

Bacillus anthracis are gram positive bacterial spores which are soil-borne with a long life span. Thus, the spores are usually present at animal burial sites of anthrax-killed animals for many decades. For example, anthrax spores have been known to re-infect animals over 70 years after burial sites of anthrax-infected animals were disturbed [8,9]. Anthrax spores can be found on all continents including the Antarctica [6]. It mostly infects wild and domesticated herbivorous mammals which ingest or inhale the spores while grazing. Ingestion has been reported to be the most common route by which herbivores contract anthrax [10,11]. Carnivorous predators living in the same environment may become infected themselves. Humans usually become infected with anthrax via the oral, cutaneous or pulmonary routes [12,13]. Infection in humans could occur during direct contact with domesticated livestock, hunting, butchering or during food preparation and handling. Exposure to blood and other tissues from anthrax infected animals via inhalation or direct inoculation through broken skin has been noted to cause anthrax [13]. Direct contact with anthrax spores from an animal's fur, hide or wool has also been found to cause anthrax [12,13].

The clinical presentation or post-mortem analysis is critical stages that aid in identifying a suspected outbreak especially in low resource settings like Ghana. A suspected case of anthrax in animals occurs when the animal suffers a sudden death accompanied with one of the following signs; absence of rigor mortis (legs not stiff), heavy bleeding from the nose, mouth and other natural orifices, subcutaneous swellings, rapid bloating and dark non-clotting blood [14]. In humans, anthrax presents with an acute onset which can manifest in various forms such as cutaneous, gastro-intestinal, inhalation and meningeal [15-17]. The cutaneous manifestation of anthrax is the commonest which occurs after contact with anthrax spores [15]. This results in a development of a skin lesion which evolves over 2 to 6 days after contact with the spores from a papular through a vesicular stage. This often leads to the formation of a depressed black eschar invariably accompanied by oedema that may be mild or extensive [15,18]. However, systemic forms are sporadic and manifest through the gastrointestinal, pulmonary or meningeal systems. Gastrointestinal manifest-tations occur after 2 to 5 days after ingesting infected meat which is usually characterized by nausea, vomiting, anorexia and fever [19,20]. Pulmonary (inhalation) anthrax occurs after inhaling *Bacillus anthracis* spores which often present as a brief prodrome resembling acute viral respiratory illness, followed by rapid onset of hypoxia, dyspnoea and hyperthermia with X-ray evidence of mediastinal widening [16,21,22]. Additionally, it has been reported that acute onset of a high fever possibly with convulsions, loss of consciousness and other meningeal signs are consistent with meningeal inflammation [23,24]. Anthrax disease when detected at the early stages of the infection, some strains

respond well to antibiotic treatment [25,26]. There are also effective vaccines against anthrax infection [27-29].

Over the past 12 years anthrax outbreaks have been irregular in the three northern regions of Ghana with 65% of the districts in the three regions reportedly having recorded at least one outbreak of anthrax disease in livestock resulting in human deaths from 2000 to 2012 [30]. Within that period, 272 cases of human anthrax had been suspected, 18 confirmed with 15 deaths. In the Upper East Region (UER) of Ghana, there were anthrax outbreaks in cattle at Bongo-Soe and Bongo-Ayopia between February and March of 2013 [31,32].

The Upper East Regional Health Office was notified of the outbreak in Gbengo community through news websites. Other radio, television and news media houses in the country similarly reported of the outbreak including deaths of cattle and humans in Gbengo community. According to the report, the village has experienced sudden deaths in animals due to a strange disease unknown to them. There was no prior official report to the regional health office to these news reports; neither from the district health officials nor the veterinary services. The news item created public anxiety and debate with all attention drawn to the health authorities in the region. A team was immediately mobilized and tasked by the Regional Director of Health Services to investigate into the causes of the unusual deaths and confirm the alleged anthrax outbreak in the Bawku West district. Even though anthrax outbreak was suspected, this was not officially confirmed by any official investigation. The outbreak investigation team set out to investigate the suspected outbreak with the following specific objectives: To clinically diagnose the suspected anthrax cases in both animals and humans, to determine the extent of the possible outbreak, to identify the source of the infection, identify the populations at risk, to determine the anthrax vaccination coverage in animals and to implement control and preventive measures. It also sought to determine rainfall figures in the area for the first quarter of the year.

2. METHODS

2.1 Study Area

Gbengo is a sub-district in the Bawku West district in UER (Fig. 1a and 1b) of northern Ghana. It shares a common border with Burkina Faso to the north, East Mamprusi district to the south, Bawku Municipal to the east and Nabdam district to the west. The district has a total land area of 1,070sq km with a human population of 94,034. The livestock in the district include: 26,679 cattle, 28,542 sheep, 34,167 goats and 3,567 donkeys [33]. The people of Bawku west district depend largely on livestock for both socio-cultural and economic purposes.

Fig. 1a

Fig.1b

2.2 Study Design

The investigation adopted the One Health Approach [34]. That is, involvement of the regional health system and veterinary service in UER. The regional director of health services, regional director of agriculture and the regional veterinary officer took part in the investigation. The One Health Approach recognizes that the health of humans, animals and ecosystems are interconnected. The approach involves applying a coordinated, collaborative, multidisciplinary and cross-sectoral approach to address potential or existing risks that originate at the animal-human-ecosystems interface [34].

The investigation involved a review of past reports of outbreak investigations in UER as well as an in-depth analysis of data collected between February and April 2013 as a result of the outbreak. Two Focused Group Discussions (six in each group) were held with livestock farmers and local community members. A total of seven interviews with a cross-section of the community members from grazing sites and livestock farmers were conducted to provide an account of what happened to their animals and humans in Gbengo community for the past two months. Six interviews were also conducted with various stakeholders (i.e. district director of health, district and regional veterinary officers, and district and regional disease control officers).

Three case definition categories were used in the investigation to determine suspected, probable and confirmed cases. A case is said to be suspected when it is compatible with the clinical description and has an epidemiological link to confirmed or suspected animal cases (or contaminated animal products) from February 16, 2013 to April 18, 2013 in and around Gbengo community in Bawku West district. A probable case is a suspected case that has a positive reaction to allergic skin test (in non-vaccinated individuals) and a confirmed case was defined as a suspected case that is laboratory-confirmed. This was done by using a laboratory process called venipuncture: Collection of blood from a vein located in the cubital fossa or the dorsum of the hand. The blood sample is then sent to a laboratory where serology tests are done to isolate *Bacillus anthracis*. Active case searches were also conducted in the communities based on the case definitions.

Veterinary records on anthrax vaccination coverage in the area and the history of anthrax outbreaks in the area as well as rainfall figures for the period were reviewed. Disease line list in the district hospital from February to April 2013 was also reviewed.

2.3 Laboratory Investigations

The team collected sample from a dead young bull in Gbengo on the 6th April to the regional laboratory and confirmed positive for anthrax through the isolation of *Bacillus anthracis.*

2.4 Data Analysis

The results of the outbreak investigation were categorized into four thematic areas which include: Animal anthrax, Human anthrax, Veterinary records and Rainfall pattern. We performed descriptive analysis of the outbreak data by person, place and time. The findings are presented as frequency distributions, percentages, mean ± SD, range, and rates (attack rates, case-fatality rates etc.).

3. RESULTS

3.1 Animal Anthrax

The total population of animals in the outbreak community - Gbengo was 214 cattle, 247 sheep 302 goats, 84 donkeys, 27 dogs and no record of pigs. Gbengo community is a Muslim community. All age groups of cattle were affected during the outbreak period with the 6-8 years age group been the most affected, 41.2% (7/17) and 3-5 years age group least affected 5.9% (1/17). This is shown in Fig. 3. Also, all sex groups were affected with males mostly affected 64.7% (11/17). However, there was no significant difference between mortality in males and females. This is illustrated in Fig. 4. All livestock (cattle, sheep and goats) were affected in the outbreak except donkeys that were spared. Mortality in cattle was 7.9% (17/214) and that of sheep and goats were 1.2% (3/247) and 0.7% (2/302) respectively as shown in Fig. 5. We could not characterize deaths in other livestock by age and sex nor develop an Epi curve because livestock farmers could only give accurate data on casualties in cattle other than sheep and goats.

The outbreak started in February with a cattle death on the 16th and 21st of February 2013. It increased to two deaths on March 2, 2013 and dropped again to one death each on the 3rd, 7th

8th, 10th and 11th March 2013. The deaths increased to two on March 17 and dropped again to one each on the 20th, 22nd, 23rd and 25th March 2013. On April 4th and 6th 2013, there was also a death each reported. There has since been no death reported after April 6, 2013 (Fig. 3).

Interviews with livestock farmers revealed that their animals grazed on their farms around the community and drank at the nearby White Volta River. It was revealed that since the predominant religion in the area is Islam, dead carcasses were immediately buried since it is a taboo to eat them. Most dead animals are buried at the river bank as it was easier to excavate. They could not recall how many goats and sheep died as more value is placed on cattle than the other animals.

3.2 Human Anthrax

The investigation revealed that Gbengo community in the Bawku West district had three confirmed cases of human anthrax out of six suspected cases. There were three (3) deaths giving a case fatality rate of 50%. The anthrax mortality rate was 0.032 (per 1000 of a total district population 94,034). One (1) out of the six cases was a female. All the cases were from the Gbengo community (Fig. 2).

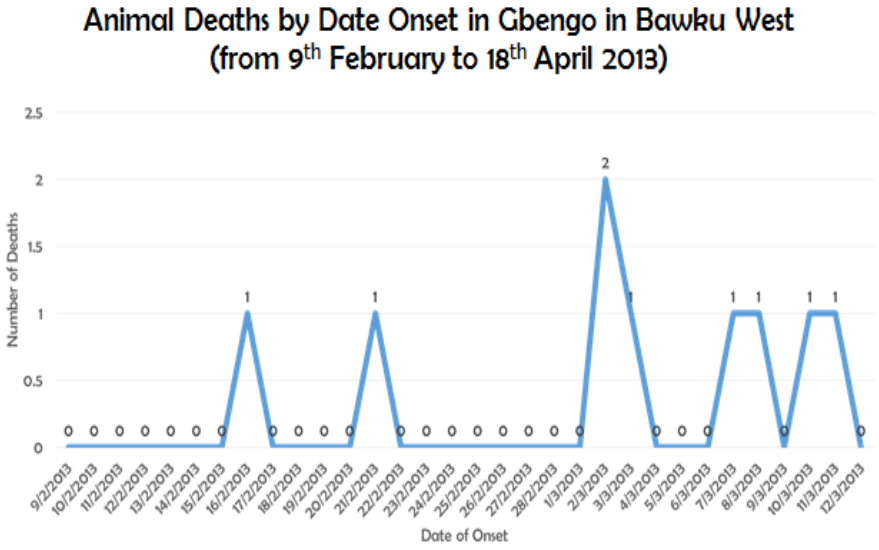

Fig. 2. Epi curve

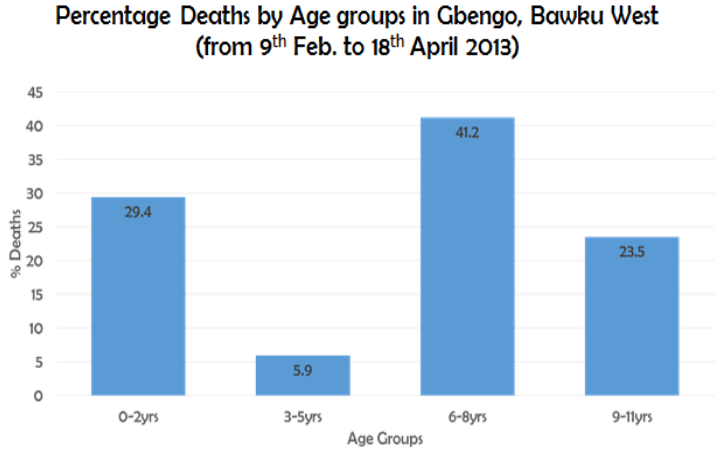

Fig. 3

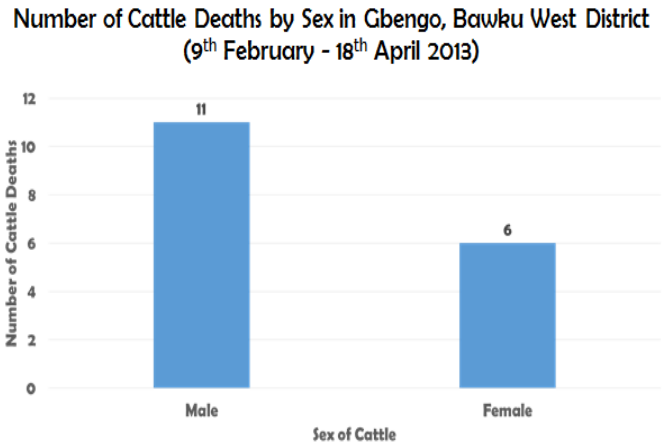

Fig. 4

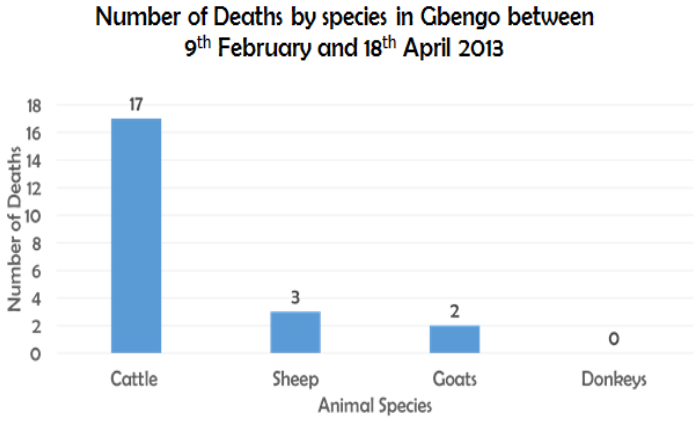

Fig. 5

3.3 Veterinary Records

A review of veterinary records revealed that UER has had yearly outbreaks of anthrax. There was an anthrax outbreak in March, 2012 in Googo, a community which is about 12 km away from Gbengo the current outbreak village. The most recently confirmed anthrax outbreak occurred in Bongo district the previous month, March 2013 in the same region. It was also observed from the records that animals in Gbengo have not been vaccinated for over 10 yrs (Table 1). The region has not had any programmed vaccination for several years except ad hoc vaccinations during outbreaks targeted at the outbreak area and its surrounding.

3.4 Rainfall Pattern in the Outbreak Area, April 2013

Our investigations also revealed that there were two rainfall figures recorded during the first quarter of 2013 in the area. These were 42 mm and 6 mm on the 1st and 18th March, 2013 respectively. This is shown in Table 2.

3.5 Focus Group Discussion and Other Stakeholder Interviews

During our FGD and stakeholder interviews, we observed that both health system and community-related challenges, mainly poor surveillance activities (notifications and reporting) by staff in the region which was largely attributed to low staff strength and limited capacity and lack of anthrax vaccination in animals due mainly to logistical problems. We also noticed that livestock farmers have over the years benefited from free vaccination services and thus shy away from fee payment for anthrax vaccination. Additionally, group and family ownership of animals poses a major problem for livestock when they are to be either vaccinated or treated for fee payment.

Table 1. Vaccination coverage of animals in Bawku West District 2000- April 2013

Anthrax vaccination 2000 – 2013: Bawku West District, April 2013						
Year	**Cattle**	**Sheep**	**Goats**	**Pigs**	**Dogs**	**Donkeys**
2000	x	x	x	X	X	X
2001	x	x	x	X	X	X
2002	x	x	x	X	X	X
2003	x	x	x	X	X	X
2004	x	x	x	X	X	X
2005	x	x	x	X	X	X
2006	x	x	x	X	X	X
2007	x	x	x	X	X	X
2008	185	x	x	X	X	X
2009	x	x	x	X	X	X
2010	x	x	x	X	X	X
2011	x	x	x	X	X	X
2012	3,752	513	86	47	96	16
2013	1,240	307	161	0	65	28

X= No vaccinations carried out in the animal species in the corresponding year
Source: Veterinary Service Department, Upper East Region

Table 2. Rainfall recorded during the 1st quarter of 2013

Month	**1st Week**	**2nd Week**	**3rd Week**	**4th Week**
January	0	0	0	0
February	0	0	0	0
March	42 mm	0	6 mm	0
April	0	0	0	0

Source: Meteorological Service Department

4. DISCUSSION

Anthrax outbreak in humans in the Upper East region has always been associated with livestock infection. In recognition of the complex interplay of social, behavioural, cultural, economic, human, animal and environmental health factors in the causation and transmission of anthrax in northern Ghana, a One Health Approach methodology was used in this investigation. This is one of the most effective approaches to curb anthrax and other zoonotic diseases [34]. The number of deaths reported both in livestock and humans were an accumulation from February to April 2013. We noticed that communal and family ownership of kraals have been a challenge to the treatment and vaccination of livestock especially cattle. While most cattle owners are not able to respond to routine veterinary activities as there is inadequate veterinary staff available, the available staff lacks necessary logistics making service delivery a challenge. From the findings, the lack of vaccination of livestock against anthrax for many years is a major risk factor for periodic outbreaks. This is particularly worrying considering that the vaccine is locally produced and should be available. This makes education of livestock farmers on vaccination an important component of any control and prevention measure in northern Ghana. Anthrax disease is more common in developing countries where there is lack of widespread veterinary or human public health programmes [35]. Unfortunately, in Ghana, there has not been a sustainable anthrax vaccination programme in animals, a situation which has left Gbengo community over ten years without vaccination coverage. This lack of vaccinations leaves a highly susceptible animal and human population in the outbreak area to anthrax infection.

The importance of educating farmers to take livestock as a business and learn to invest in it through routine treatment and vaccination especially against anthrax disease must be stressed. The poor attitude of livestock farmers to avail their animals for vaccination was evident in the Focus Group Discussions (FGDs) and is one of the factors that militated against the control of the disease. In addition, the unwillingness of cattle farmers to pay for vaccination of their livestock was also noted.

Since anthrax disease affects animals and humans, it should be seen as a health development priority that requires a multi-sectorial approach, a strategy that requires the collaboration of various ministries and other international agencies. This is because elimination of anthrax in northern Ghana using the One Health Approach is only effective if there is better sectorial balance among existing groups and networks, especially between veterinarians and physicians, and increased participation of environmental and wildlife health practitioners, as well as social scientists and development actors [32,36]. It is imperative for the strengthening of veterinary and medical services by including relevant stakeholders in policy formulation and priorities in the decision making process towards control and prevention measures.

Consistent with previous studies by Hampson and his colleagues [37], we observed that the outbreak in Gbengo has affected domesticated herbivorous mammals (cattle sheep, goats) of all ages and sexes and has caused 100% deaths in all livestock that were known to be infected. Ingestion is thought to be the most common route by which herbivores contract anthrax [38]. Livestock in this community are free range and thus are highly exposed to anthrax spores. Though there were donkeys and dogs in the community, there were no records of their infection. There is evidence that anthrax is rare in dogs and cats too [39,40]. However, though donkeys are susceptible to anthrax, they remain uninfected in the community because they might not have come into contact with the spores.

We observed that even though some forms of anthrax respond well to antibiotic treatment, the cases were not reported to the veterinary services or the Ghana Health Services for attention which could have prevented some deaths. Three human deaths out of six reported cases in humans were confirmed to be due to anthrax even though potentially additional deaths may have occurred outside healthcare facilities.

Outbreaks originating from soil borne infections primarily occur in the warm season [41]. Epidemics tend to occur in association with periods of marked climatic or ecological changes such as heavy rainfall, flooding or drought [42,43]. We observed that Gbengo recorded two rainfall episodes in March. This could have caused a change in the climate causing grasses to sprout out and with animals grazing so close to the soil thereby ingesting or inhaling anthrax spores and getting the infection.

It is therefore important that community members are educated on the dangers of anthrax and its prevention. We also observed that even though there seem to be collaboration between the health services and the veterinary services, this is weak and needs to be addressed. During the outbreak, there was a ban on slaughtering and movement of livestock in the region to prevent further spread.

5. STUDY LIMITATIONS

The outbreak investigation had some limitations as a period of less than 3 months was quite short. Secondly, the refusal of some of the community members to divulge information was a setback and limitation.

6. CONCLUSION

The investigation revealed an outbreak of laboratory confirmed anthrax (*Bacillus anthracis*) with a very high case fatality rate (100% in animals and 50% in humans) in Gbengo community. There are still major challenges with anthrax outbreaks such as lack of awareness among community members, high poverty levels and irregular vaccination of livestock. Livestock vaccination rates can be improved by taking advantage of the local production of the vaccine to increase coverage. Annual outbreak of the disease and poor vaccination coverage in northern Ghana is a major problem that needs urgent attention by all stakeholders (e.g. Ghana Health Service, Ministry of Agriculture and Veterinary Service). A One Health Approach calls for collaboration and communication among stakeholders in order to utilize the synergies in anthrax control. In addition, improve anthrax surveillance and response preparedness is urgently needed to increase early case detection and reduce fatality. Increasing public information and education on the diseases etiology is important.

CONSENT

Verbal consent was sought from community members and livestock farmers before interviews were conducted. Permission was also granted by the Bawku West District Hospital, veterinary and health departments at both district and regional levels before records were reviewed.

ETHICAL CONSIDERATIONS

This study was conducted as part of health system strengthening and surveillance

improvement in the Upper East Region. Official permission was obtained from the Regional Director of Health Services. Verbal consent was sought from community members and livestock farmers before interviews were conducted. Permission was also granted by the Bawku west district hospital, veterinary and health departments before records were reviewed. We ensured the confidentiality of all participants in the study by use of de-identified and coded data.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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