An investigation of an anthrax outbreak in Makoni District Ward 22 and 23 in Zimbabwe

CURRENT STATUS: UNDER REVIEW

Richard Makurumidze richardmakurumidze@yahoo.com
University of Zimbabwe College of Health Sciences
Corresponding Author
ORCiD: 0000-0001-6490-1818

Gombe Notion Tafara
University of Zimbabwe College of Health Sciences

Magure Tapuwa
National AIDS Council of Zimbabwe

Mufuta Tshimanga
University of Zimbabwe College of Health Sciences

DOI:
10.21203/rs.2.21296/v1

SUBJECT AREAS
Health Policy

KEYWORDS
Zimbabwe, Makoni, Outbreak, Anthrax, Bacillus anthracis
Abstract

Background: The first official clinical case of human anthrax case was made at Makoni District Medical Office on the 19th of December 2013. This followed cattle deaths which were confirmed in the laboratory to be due to anthrax. We report the clinical characteristics, distribution of anthrax cases (place and time), risk factors for contracting the disease, environmental assessment, district preparedness and response and outbreak prevention and control measures.

Methods: We conducted an outbreak investigation with the design of a 1:1 unmatched case-control study. Data were collected using a structured questionnaire. Environmental assessment, district preparedness and response and outbreak prevention and control measures were assessed using checklists through observations and key informant interviews. Data were analyzed using Stata-16. Bivariate analysis was performed to identify risk factors for contracting anthrax.

Results: Thirty-seven cases (37) and 37 controls were interviewed. All the cases had cutaneous anthrax with commonest site of eschar being the hand (43%). Most of the cases (89%) were managed according to national guidelines. Eating meat from a from a cattle slaughtered due unknown illness or died alone \[OR = 7.00, 95\%CI(2.06-23.82)\], skinning \[OR = 5.04, 95\%CI(1.77-14.36)\], cutting meat \[OR = 5.32, 95\%CI(1.91-14.77)\], cooking meat \[OR = 3.42, 95\%CI(1.32-8.91.)\], source of from other villagers [vs butchery, \(OR = 14.85, 95\%CI(2.79-79.06)\)], cuts during cutting meat or skinning cattle \(OR = 3.50, 95\%CI(1.18-10.51)\), belonging to a religion which permits eating meat from a from a cattle slaughtered due unknown illness or died alone \[OR = 6.29, 95\%CI(1.85-21.39)\] were associated with contracting anthrax. Having heard of anthrax before was protective against contracting anthrax \[OR = 0.35, 95\%CI (0.13-0.93)\]. The district was ill-equipped and delay to respond to the outbreak.
Conclusion: The anthrax outbreak resulted from contact with and consumption of infected cattle meat. The district delayed and was not prepared to control the outbreak. However, the outbreak was controlled through cattle vaccination; health education and awareness campaigns. The district should strengthen its emergence preparedness and response capacity, revive zoonotic committees, conduct awareness campaign during the high-risk period and improve the surveillance of anthrax during high risk periods.

Introduction

Anthrax is a bacterial infection caused by the spore forming Bacillus anthracis, a Gram positive, rod shaped bacterium [1]. Globally, approximately 2,000–20,000 human cases of anthrax occur each year [2]. Anthrax in humans is often a result of consumption of infected meat from livestock and wildlife [1]. The most common cases of anthrax in humans are cutaneous while inhalation and gastrointestinal are less frequent [1]. During the past three decades, there has been a progressive global reduction in the number of reported cases of anthrax in livestock and this might be attributed to response by to national programs [2]. Anthrax is still endemic in most African countries and the majority experience at least one outbreak per year. In South Africa, the annual number of outbreaks is less than 5 and occasionally zero, despite the continued occurrence of the disease in wildlife in the various parks [3]. Good control programs have been established in Botswana, Zimbabwe and Zambia, but the disease remains well known in the latter two countries at least [3].

In Zimbabwe anthrax is still a disease of public health importance because annually sporadic outbreaks are reported in many parts of the country [4, 5]. The disease was first diagnosed in 1898 in the Matabeleland Region with the largest recorded outbreak in humans and possibly the largest among animals having occurred in 1978–1980 during the peak of the Liberation War. The disease spread over time from area to area, until six of
the eight provinces were affected and over 10,000 human cases and 182 human deaths were documented. Human cases were secondary to an unprecedented outbreak in cattle. The outbreak in the cattle was due to cessation of cattle vaccination which was caused by the war. The number of cases of anthrax recorded during this period was far high than the previous years which usually records a dozen or less cases annually [6-10]. Since then sporadic outbreaks have been reported in many parts of the country. Over the years, compulsory dipping of cattle in the rural (communal) areas led to the decrease in the number recorded of outbreaks. However, with the current deterioration of the economic environment which has led to poor prevention and control measures regular outbreaks are being reported.

In Manicaland Province of Zimbabwe anthrax is endemic and annually cases in cattle and humans are reported. In 2011 and 2012, 37 and 49 cases were recorded respectively. In 2012 the cases were reported from Buhera, Chipinge, Mutare and Mutasa Districts in the province [11]. In 2013, human anthrax cases were reported in Makoni District. The first case was reported on the 19th of December 2013 by the District Medical Office. The case was from Ward 22, Rugoyi Village. The case occurred after the victim had consumed meat from cattle that had died alone. The District Veterinary Department reported cattle deaths in the same area and the first having occurred on the 6th of December 2013. The Veterinary Department collected specimens from the cattle that were dying and sent them to the Provincial Veterinary Laboratory where a laboratory diagnosis of anthrax was made. From the 19th of December 2019, more cases of human anthrax were reported in the district coming from several villages in Ward 22 and 23. We investigated the anthrax outbreak in Makoni District Ward 22 and 23 and here we report the clinical characteristics, distribution anthrax cases (place and time), risk factors for contracting the disease, environmental assessment, district preparedness and response and outbreak prevention
and control measures.

Methods

Study design

We conducted an outbreak investigation using an unmatched 1:1 case-control study. The study population were residents of Makoni District Ward 22 and 23. A case was defined as any person in Makoni District Ward 22 and 23 who developed a disease which manifested by itching of the affected area, followed by a painful lesion which became papular, then vesiculated and eventually developed into a depressed black eschar between 19 June 2013 and 29 January 2014. A control was defined as any person in Makoni District Ward 22 and 23 who never developed a disease which is manifested by itching of the affected area, followed by a painful lesion which became papular, then vesiculated and eventually developed into a depressed black eschar between 19 June 2013 and 29 January 2014. Cases were identified from the line lists that was available at Makoni Rural Hospital which services the two wards and through active case findings in the community. Controls were selected from the neighborhood of cases in same villages. Any person who was diagnosed with chickenpox, skin drug reaction, acute skin disease or other disease which mimics anthrax were excluded from the study.

Data collection

Data were collected using an interviewer administered questionnaire. Review of medical records was done to assess how cases were managed. An Integrated Disease Surveillance Response (IDSR) checklist was used to assess the emergency preparedness response of the district [12]. An Environmental health assessment was done to assess how carcasses were buried, availability of dip tanks and adequacy of grazing land. Key informant interviews were conducted with the District Medical Officer, District Veterinary Officer,
District Environmental Health Office and the Environmental Health Technicians (EHTs) at Makoni Rural Hospital.

Data analysis

The data were analyzed using Stata 16 [13]. Cases and controls baseline characteristics were compared using frequencies, proportions and Chi – square. To assess risk factors for contracting anthrax bivariate analysis was conducted using logistic regression at 95% confidence interval and significance level of 5% (p < 0.05).

Permissions and ethical considerations

The permission to carry out the study was sought from the Manicaland Provincial Medical Director, Makoni District Medical Officer, Local Headman and Councilor. The study was approved ethically by the Health Study Office within the Ministry of Health and Child Care which coordinate the Zimbabwe Field Epidemiology Training Programme. Written consent was obtained from every participant prior to entry into the study. For participants under 18 years consent was sought from parents or guardians. No names were written on the data collection tools. Confidentiality was assured and maintained.

Results

Baseline Characteristics of cases and controls

We interviewed 37 cases and 37 controls. The median age for cases and controls were 34 years (Q₁: 22; Q₃:42) and 28 years (Q₁:25; Q₃:46) respectively. Males constituted 73% (27) of cases and 70.3% (26) of controls. Most of both cases (67.6%) and controls (59.5%) had secondary education and above. Most of both cases and controls were also not employed (59.5%). Generally, the baseline characteristics for cases and controls were comparable (Table 1).
### Table 1
Baseline characteristics of cases and controls for the anthrax outbreak in Makoni District Ward 22 and 23 in 2014

| Characteristic | Categories                  | Controls | Cases | p-value (χ²) |
|---------------|----------------------------|----------|-------|--------------|
| Sex           | Female                     | 11 (29.7)| 10 (27.0)| 0.797       |
|               | Male                       | 26 (70.3)| 27 (73.0)|             |
| Median Age    | 28 (Q₁:25;Q₃:46)           | 34 (Q₁:22;Q₃:42)| 0.998*      |
| Marital Status| Has partner                | 15 (40.5)| 22 (59.5)| 0.104       |
|               | No partner                 | 22 (59.5)| 15 (40.5)|             |
| Education     | Primary and below          | 15 (40.5)| 12 (32.4)| 0.469       |
|               | Secondary and above        | 22 (59.5)| 25 (67.6)|             |
| Employment    | Employed                   | 5 (13.5)| 9 (24.3)| 0.343       |
|               | Peasant farmer             | 10 (27.0)| 6 (16.2)|             |
|               | Unemployed                 | 22 (59.5)| 22 (59.5)|             |
| Religion      | Traditional churches       | 18 (48.7)| 19 (5.4)| 0.330       |
|               | Apostolic                  | 13 (38.1)| 8 (21.6)|             |
|               | Others                     | 6 (16.2)| 10 (27.0)|             |

*Traditional churches – Anglican, Methodist, Roman Catholic and Reformed Church of Zimbabwe

**Wilcoxon rank-sum**

### Clinical characteristics

All the 37 cases reported a depressed eschar and the other signs and symptoms experienced are summarized in the Fig. 1.

Most of the depressed eschar affected the hands (41%) while back of the trunk was least affected (Fig. 2).

Three of the interviewed cases were admitted in hospital and they spent 2, 5 and 12 days respectively. None of the cases had any laboratory tests done including test for anthrax when they presented to health facilities. Thirty four cases (89%) were managed according to national guidelines on the management of anthrax (Doxycycline for mild cases and Benzyl or Procaine Penicillin for severe cases) [14]. Eleven of the cases admitted being aware of and tried to use traditional herbs to treat anthrax before going to the health facilities. The mentioned traditional or local herbs included Chikohwa, Muzeze, Changamire, Gakakava, Chimutara and leaves of gumtree.

All the 37 cases had never had anthrax disease before. One person died due to suspected anthrax disease. The person never reported to a health facility. According to witnesses he developed an eschar on the chest wall which was followed by swelling of the left arm and
shortness of breath. The victim was known to have been involved in skinning of cattle and consumed roasted meat during skinning. He died at age of 40 years on the 13th of January 2014. This gave the outbreak a case fatality rate of 0.016 (1/64).

Distribution of cases - place

The anthrax outbreak affected Ward 22 and 23 of Makoni District. The two wards had 64 cases of anthrax reported in total and Ward 23 was the worst affected with 78% (50) of the cases. Of the 37 cases interviewed, 28 were from Ward 23 and 9 from Ward 22. Twenty-six (26) villages were affected in the two wards. Figure 3 shows the spot map of the outbreak.

Distribution of cases - time

The findings from the field investigation showed that the first cattle death occurred on the 12th of June 2013 and the first reported human case was on the 19th of June 2013. The case sought medical attention at Makoni Rural Hospital and was referred to Rusape District Hospital which further referred the case to Mutare Provincial Hospital where a clinical diagnosis of cutaneous anthrax was confirmed. Sporadic cattle death occurred between June and October, but the situation worsened starting end of November and in December 2013 when cattle deaths and human cases increased significantly. The human anthrax cases reached a pick in mid-January 2014. The last case was reported on the 29th of January 2014. These field findings were contrary to the report by the District Veterinary Office and District Medical Office. The District Veterinary Office reported that the first cattle death occurred on the 6th of December 2013 and the District Medical Office reported that the first case of anthrax was reported on the 21st of December 2013. Figure 4 shows the epidemiological curve of the outbreak.

Risk factors for contracting anthrax
On bivariate analysis (Table 2) sex, marital status, religion, level of education and hide preparation were not associated with contracting anthrax in humans in our setting. Eating meat from a cattle slaughtered due unknown illness or died alone [OR = 7.00, 95% CI (2.06–23.82)], skinning [OR = 5.04, 95% CI (1.77–14.36)], cutting meat [OR = 5.32, 95% CI (1.91–14.77)], cooking meat [OR = 3.42, 95% CI (1.32–8.91)], source of from other villagers [vs butchery, OR = 14.85, 95% CI (2.79–79.06)], cuts during cutting meat or skinning [OR = 3.50, 95% CI (1.18–10.51)] and belonging to a religion which permits eating meat from a cattle slaughtered due unknown illness or died alone [OR = 6.29, 95% CI (1.85–21.39)] were associated with contracting anthrax in our setting. Having heard of anthrax before was protective against contracting anthrax [OR = 0.35, 95% CI (0.13–0.93)] in our setting.
### Table 2

Risk factors for contracting anthrax in Makoni District Ward 22 and 23 in 2014

| Risk factor          | Categories                     | Controls | Cases | Odds Ratio | 95% Confidence interval |
|----------------------|--------------------------------|----------|-------|------------|-------------------------|
| Sex                  | Female                         | 11 (29.7)| 10 (27.0)| 1          |                         |
|                      | Male                           | 26 (70.3)| 27 (73.0)| 1.14       | 0.42–3.14               |
| Marital Status       | Has partner                    | 15 (40.5)| 22 (59.5)| 1          |                         |
|                      | No partner                     | 22 (59.5)| 15 (40.5)| 0.46       | 0.18–1.18               |
| Education            | Primary and below              | 15 (40.5)| 12 (32.4)| 1          |                         |
|                      | Secondary and above            | 22 (59.5)| 25 (67.6)| 1.42       | 0.55–3.68               |
| Employment           | Employed                       | 5 (13.5)| 9 (24.3)| 1          |                         |
|                      | Peasant farmer                 | 10 (27.0)| 6 (16.2)| 0.33       | 0.07–1.48               |
|                      | Unemployed                     | 22 (59.5)| 22 (59.5)| 0.56       | 0.16–1.93               |
| Religion             | a Traditional churches         | 18 (48.7)| 19 (5.4)| 1          |                         |
|                      | b Apostolic                    | 13 (38.1)| 8 (21.6)| 0.58       | 0.20–1.74               |
|                      | Others                         | 6 (16.2)| 10 (27.0)| 1.58       | 0.48–5.24               |
|                      | b Ate meat                     | 17 (46.0)| 4 (10.8)| 1          |                         |
|                      | Yes                            | 20 (54.0)| 33 (89.2)| 7.00       | 2.06–23.82              |
| Source of meat       | Butchery                       | 11 (29.7)| 2 (5.4)| 1          |                         |
|                      | Other villagers                | 10 (27.0)| 27 (73.0)| 14.85      | 2.79–79.06              |
|                      | Own cattle                     | 6 (16.2)| 6 (16.2)| 5.5        | 0.84–36.20              |
|                      | Missing                        | 10 (27.1)| 2 (5.4)| -          |                         |
| Cutting meat         | No                             | 20 (54.1)| 7 (18.9)| 1          |                         |
|                      | Yes                            | 17 (45.9)| 30 (81.1)| 5.32       | 1.91-14.77             |
| Skinning             | No                             | 29 (78.4)| 15 (40.5)| 1          |                         |
|                      | Yes                            | 8 (21.6)| 22 (59.5)| 5.04       | 1.77–14.36              |
| Cooking              | No                             | 23 (62.2)| 12 (32.4)| 1          |                         |
|                      | Yes                            | 14 (37.8)| 25 (67.6)| 3.42       | 1.32–8.91               |
| Cut                  | No                             | 31 (83.8)| 22 (59.5)| 1          |                         |
|                      | Yes                            | 6 (16.2)| 15 (40.5)| 3.50       | 1.18 - 10.51            |
| Hide preparation     | No                             | 26 (70.3)| 21 (56.8)| 1          |                         |
|                      | Yes                            | 11 (29.7)| 16 (43.2)| 1.80       | 0.69-4.70              |
| Heard of anthrax     | No                             | 10 (27.0)| 19 (51.4)| 1          |                         |
|                      | Yes                            | 27 (77.0)| 18(48.6)| 0.35       | 0.13–0.93               |
| d Religion which     | No                             | 33 (89.2)| 21 (56.8)| 1          |                         |
| permits              | Yes                            | 4 (10.8)| 16 (43.2)| 6.29       | 1.85-21.39             |

**a** Traditional churches – Anglican, Methodist, Roman Catholic and Reformed Church of Zimbabwe

**b** Ate meat from a from cattle slaughtered due unknown illness or died alone

**c** Developed cuts during skinning or cutting meat

**d** Religion which permits eating meat from cattle slaughtered due to unknown illness or died alone

### Environmental assessment

An estimation of 180 cattle died in both Ward 22 and 23. The exact number could not be ascertained since the Veterinary Department was not on the ground. Reports of death of other animals other than cattle were also reported and these included goats, pigs and chicken and the actual numbers were also not ascertained. Most of the cattle that died were not buried properly and the burials were not supervised. Animal carcass were seen left on open spaces which allowed dogs and vultures to consume them. Most sites where
cattle deaths occurred where not disinfected with chloride of lime. Reports of people throwing infected meat in the nearby Osborne Dam were also made. There was a game reserve in Ward 22 and close to Osborne Dam which bordered some of the villages affected by anthrax. Cattle from the surrounding villages mixed and grazed in the same areas with the game animal because the game reserve fence was not intact. Generally, there was inadequate grazing land and pastures in both Ward 22 and 23. Most of the grazing land had short grass. Ward 23 bordered Mutasa District which experienced an anthrax outbreak in the previous year and cattle from the two districts shared grazing land. A former Army Base which was no longer functional was noted in Ward 22 near Makoni Rural Hospital.

District preparedness and response

The rural hospital which services the two wards had adequate stock of drugs (Doxycycline for mild cases and Benzyl or Procaine Penicillin for severe cases) used to treat anthrax during the outbreak period. This was assessed using the stock cards as of 31 November 2013. The EHTs on the field had no personal protective equipment (overalls / work suits, gumboots and heavy-duty gloves) to protect themselves. Only 40kgs of chloride of lime was provided. The EHTs were also not provided with allowances. There was no information, education and communication (IEC) materials during the early stages of the outbreak response and only became available later. The district had no an Emergency preparedness response plan and the zoonotic committees were not functional. The cumulative period of the outbreak was seven months. Concrete response started after 6 months despite the first case having been reported in June 2013. The line list of cases was incomplete.

Outbreak prevention and control measures
The District started concrete outbreak control measures on the 21st of January 2014. The team dispatched to institute outbreak control measures comprised of two EHTs, Veterinary Officer and a Public Health Officer from the Zimbabwe Field Epidemiologic Training Programme. Health education was offered at 15 out the 16 primary and secondary schools in both wards. A meeting was organized through the Chief of the area with Village Heads of the two wards. Of the 53 Village Heads 14 managed to attend the meeting were health education, advocacy and lobbying to control the outbreak were discussed. At total of 5896 people were reached with health education in both wards. Active case finding was conducted in the community and a total of 8 cases were identified. An outreach clinic to treat new cases and review old cases at was also conducted at Dope Secondary School in Ward 22. Disinfection of areas where cattle deaths occurred was done to prevent future outbreaks by destroying the spore with sodium of lime. Of the estimated 180 cattle deaths only 20 sites in 6 of villages were disinfected. The team also assisted in supervised burial of new cattle deaths and reburial of carcass which were disposed improperly. Two butcheries in the wards were barred from selling meat during the outbreak period. Slaughtering of cattle was stopped for the butcheries and in the surrounding communities. Dried meat was confiscated from the villages. The amount of meat confiscated and destroyed was not be ascertained since there was no scale to weigh the meat. The Veterinary Department vaccinated the cattle against anthrax in the wards. The registered number cattle at the three wards dip tanks was about 5000 of which 4000 were vaccinated (80%). The department also stopped issuing of permits for cattle movement.

Discussion

This anthrax outbreak affected both humans and cattle. Cattle which were slaughtered or died due to unknown illnesses were the source of infection while meat was the vehicle of transmission. Most of the cases of human anthrax were cutaneous with the hands most
affected. The case fatality rate was low. The following were found to be risk factor for contracting anthrax eating meat from cattle which were slaughtered or died alone due to unknown illnesses, source of meat from other villagers, skinning, cutting and cooking meat, cuts/ abrasions during skinning or cutting meat and belonging to religion which permits eating meat from cattle slaughtered or died alone due to unknown illnesses. Having heard of anthrax before was protective of contracting the disease. The carcasses of the dead cattle were incorrectly buried, and disinfection of sites were the animals died was not done. The district was not prepared to handle the outbreak. The outbreak was prolonged, and it took time for the district to institute control measures.

The anthrax eschar was more common in hands. This was consistent with the findings from other studies [15, 16]. This is because hands are used for handling meat and are at higher risk of developing abrasions, bruises and cuts which creates the route for entry of the anthrax spores. The case fatality rate for this outbreak was very low. The finding is consistent with other studies which have also recorded low fatality cases in anthrax outbreaks [17, 18]. The low case fatality rate in anthrax outbreaks might be due to the fact that the commonest form anthrax i.e. cutaneous anthrax has the least mortality rate as compared to other form of anthrax [1]. In our study all the interviewed cases had cutaneous anthrax and the victim who died in this outbreak might have developed respiratory anthrax based on the described symptoms and signs. Respiratory anthrax has a higher mortality as compared to cutaneous anthrax [19, 20].

The following were found to be risk factor for contracting anthrax eating meat from a dead animal, skinning, cutting and cooking meat, cuts/ abrasions during skinning or cutting meat and religion which permits eating meat of a dead animal. These finding are consistent with other studies done locally and might be due to similarity of practices [15, 21, 22]. The reason why having cuts or abrasions was associated with contracting anthrax
is due to the fact that during the process of preparation of meat cuts and abrasions are likely to develop and these creates access routes for the spores to the sub-dermal tissue [1]. Belonging to a religion which permits eating meat from animals which died on their own was associated with contracting anthrax. These finding is however not consistent with other study done locally where one’s religion belief on consumption of meat from a dead animal was a was not associated with contracting anthrax [15, 21]. Having heard of anthrax before was protective against contracting anthrax in our study. This is because those who heard of anthrax will be aware of the modes of transmission, signs and symptoms and preventive measures so they will not put themselves at risk [23].

The environment assessment showed some factors which increased the risk of anthrax in the area. There were inadequate grazing land and pastures in the affected areas. This outbreak started a few months before the rainy season, a period typically associated with lack of grazing grass. During this period the grass will be short which predisposes grazing cattle to ingestion of the anthrax bacilli due to overgrazing [24, 25]. Anthrax spores can survive for a long period of time in conducive soil conditions [26]. The presence of an army base in one of the affected wards raises the possibility of anthrax having been introduced to the area as part of bioterrorism during the liberation struggle [27]. One of the wards also bordered a game reserve. The sharing of grazing land with game often result in transmission of anthrax to livestock [28].

The outbreak was prolonged, and it took time for the district to institute control measures. The district delayed starting outbreak control measures. This might have been caused by several reasons. The district did not have an Emergency preparedness response plan and had no adequate resources to use which included protective clothing. Chloride of lime which is used for disinfection of sites where cattle died is corrosive. The zoonotic committees which are key in quick identification of zoonotic diseases were not functional
both at district and local level. As soon as the district started to institute outbreak control measures the outbreak did not prolong further. The massive health education and awareness campaigns conducted could have significantly contributed to the end of the outbreak [17, 21].

**Strength of the study**

Our study had most of the components of outbreak investigation practically implemented. A team was set up and prepared for the outbreak field work. A case definition was established which was used to identify, count and line list cases. We described the outbreak in terms of person, place and time together with risk factor analysis. Outbreak control and preventive measures were instituted, results disseminated and later the outbreak was controlled.

**Limitations**

However, our investigations had limitations. There was no laboratory diagnosis of anthrax in humans but laboratory confirmation in animals was performed. Of the 64 cases recorded in both Ward 22 and 23, we only managed to interview 39. We could not interview other cases due to distant. The small sample size affected the precision of our point estimates. Recall bias could have affected our results since data was collected after exposure and cases are usually more likely to remember the exposures more than controls.

**Conclusion**

Eating meat from cattle that were slaughtered due unknown illness or died alone were the source of infection for the outbreak. All cases had cutaneous anthrax and the majority were managed according to national guidelines on anthrax. Eating meat from cattle slaughtered due unknown illness or that were dying alone, skinning, cutting and cooking
meat, having cuts during skinning or cutting meat and belonging to a religion which permits eating meat from cattle slaughtered due unknown illness or that were dying alone were among factors associated with contracting anthrax. Having heard of anthrax before was protective against contracting anthrax. The district delayed and was not prepared for the outbreak. Zoonotic committees were not functional and there was weak coordination between the health and veterinary departments during the outbreak response.

From our investigation findings, we recommended the following: strengthen of district capacity and health workers training in epidemic preparedness and response; improvement in the surveillance efforts on anthrax during the high-risk period; motorizing the EHTs; health education on anthrax in the community during high risk period and activation of zoonotic committees.

Abbreviations
CI
confidence interval, OR—odds ratio, EHT—Environmental Health Technician

Declarations

Acknowledgments

We would like to acknowledge the following for the support we received during the outbreak investigation: Ministry of Health and Child Care, Health Studies Office; University of Zimbabwe Department of Community Medicine; National AIDS Council of Zimbabwe; Center for Disease Control Zimbabwe; Manicaland Province Medical Directorate, Makoni District Medical Office, Makoni District Veterinary Department and all the study participants.

Authors’ contributions

RM was responsible for the conception of the problem, design, collection, analysis and
interpretation of data and writing the first draft article. NTG was responsible for the conception of the problem, design, interpretation of data and critical review of the final article. TM was responsible for the design, interpretation of data and critical review of final article. MT had oversight of all the stages of the research and critically reviewed the final draft for academic content. All the authors read and approved the final version of the manuscript.

**Availability of data and materials**

The data which were used this outbreak investigation report are not available on the public domain and anyone interested in using the data for scientific purpose is free to request permission from the Corresponding Author; Dr Richard Makurumidze, University of Zimbabwe College of Health Sciences, Department of Community Medicine. Email: richardmakurumidze@yahoo.com

**Funding**

No funding was obtained for this study

**Ethics approval and consent to participate**

The study was approved ethically by the Health Study Office within the Ministry of Health and Child Care which coordinate the Zimbabwe Field Epidemiology Training Programme. Written consent was obtained from every participant prior to entry into the study.

**Competing interests**

The authors have no competing interests.
Consent for publication

Not applicable

Author details

1. University of Zimbabwe College of Health Sciences, Department of Community Medicine, Harare, Zimbabwe
2. National AIDS Council, Harare, Zimbabwe

References

1. World Health Organization (WHO). Anthrax in humans and animals. 4th Edition. Geneva, Switzerland; 2008.
2. World Health Organisation (WHO). Guidelines for the Surveillance and Control of Anthrax in Human and Animals. Department of Communicable Diseases Surveillance and Response; 1998.
3. South Africa Department of Health. Guidelines on Management and Control of Human Anthrax. 2018;
4. Chikerema SM, Pfukenyi DM, Matope G, Bhebhe E. Temporal and spatial distribution of cattle anthrax outbreaks in Zimbabwe between 1967 and 2006. Trop Anim Health Prod. 2012;44: 63–70. doi:10.1007/s11250-011-9888-z
5. Chikerema SM, Murwira A, Matope G, Pfukenyi DM. Spatial modelling of Bacillus anthracis ecological niche in Zimbabwe. Prev Vet Med. 2013;111: 25–30. doi:10.1016/j.prevetmed.2013.04.006
6. Wilson JM, Brediger W, Albright TP, Smith-Gagen J. Reanalysis of the anthrax epidemic in Rhodesia, 1978-1984. PeerJ. 2016;2016: 1978–1984. doi:10.7717/peerj.2686
7. Davies JC. A major epidemic of anthrax in Zimbabwe. Cent Afr J Med. 1982;28: 291–8.
8. Davies JC. A major epidemic of anthrax in Zimbabwe. The experience at the Beatrice Road Infectious Diseases Hospital, Harare. Cent Afr J Med. 1985;31: 176-80.
Available: http://www.ncbi.nlm.nih.gov/pubmed/4084971

9. Davies JC. A major epidemic of anthrax in Zimbabwe. Part II. Cent Afr J Med. 1983;29: 8-12. Available: http://www.ncbi.nlm.nih.gov/pubmed/6861201

10. Nass M. Anthrax Epizootic in Zimbabwe, 1978 - 1980: Due to deliberate Spread. Physicians Soc Responsib. 1992; 198-209.

11. Mafaune, H, N T Gombe MT. Factors Associated with Contracting Anthrax in Manica Bridge Ward 24 Mutasa Distric. Zimbabwe F Epidemiol Train Program. 2012;

12. World Health Organization (WHO). Integrated Disease Surveillance and Response (IDSR) Technical Guideline 2010.

13. StataCorp. Stata Statistical Software: Release 16. Coll Station TX StataCorp LLC. 2019;

14. Ministry of Health and Child Care (MoHCC). Zimbabwe Anthrax Control Guidelines in Humans and Animals. 2012;

15. Gombe NT, Nkomo BM, Chadambuka A, Shambira G, Tshimanga M. Risk factors for contracting anthrax in Kuwirirana ward, Gokwe North, Zimbabwe. Afr Health Sci. 2010;10: 159–164.

16. Patassi AA, Saka B, Landoh DE, Agbenoko K, Tamekloe T, Salmon-Ceron D. Detection and management of the first human anthrax outbreak in Togo. Trop Doct. 2016;46: 129-134. doi:10.1177/0049475515622331

17. Opare C, Nsiire A, Awumbilla B, Akanmori BD. Human behavioural factors implicated in outbreaks of human anthrax in the Tamale municipality of northern Ghana. Acta Trop. 2000;76: 49-52. doi:10.1016/S0001-706X(00)00089-9
18. E Takawira, L Charimari MT. An outbreak investigation of Anthrax in Rushinga District of Mashonaland Central Province in Zimbabwe. 2004;

19. Brachman PS. Inhalation Anthrax. Ann N Y Acad Sci. 1980;353: 83–93.
doi:10.1111/j.1749-6632.1980.tb18910.x

20. Jernigan JA, Stephens DS, Ashford DA, Omenaca C, Topiel MS, Galbraith M, et al. Bioterrorism-related inhalational anthrax: The first 10 cases reported in the United States. Emerg Infect Dis. 2001;7: 933–944. doi:10.3201/eid0706.010604

21. Chirundu D, Chihanga S, Chimusoro A, Chirenda J, Apollo T, Tshimanga M. Behavioural factors associated with cutaneous anthrax in Musadzi area of Gokwe North, Zimbabwe. Cent Afr J Med. 2011;55. doi:10.4314/cajm.v55i9-12.63640

22. Mwenye KS, Siziya S, Peterson D. Factors associated with human anthrax outbreak in the Chikupo and Ngandu villages of Murewa district in Mashonaland East Province, Zimbabwe. Cent Afr J Med. 1996;42: 312—315. Available: http://europepmc.org/abstract/MED/9130412

23. Chikerema SM, Matope G, Pfukenyi DM. Awareness and attitude toward Zoonoses with particular reference to anthrax among cattle owners in selected rural communities of Zimbabwe. Vector-Borne Zoonotic Dis. 2013;13: 243–249. doi:10.1089/vbz.2011.0916

24. Mongoh MN, Dyer NW, Stoltenow CL, Khaitsa ML. Risk Factors Associated with Anthrax Outbreak in Animals in North Dakota, 2005: A Retrospective Case-Control Study. Public Health Rep. 2008;123: 352–359. doi:10.1177/003335490812300315

25. Epp T, Waldner C, Argue CK. Case-control study investigating an anthrax outbreak in Saskatchewan, Canada - Summer 2006. Can Vet J. 2010;51: 973–978.

26. Dragon DC, Rennie RP. The ecology of anthrax spores: tough but not invincible. Can Vet J = La Rev Vet Can. 1995;36: 295–301. Available: http://www.ncbi.nlm.nih.gov/pubmed/7773917
27. Pile JC, Malone JD, Eitzen EM, Friedlander AM. Anthrax as a potential biological warfare agent. Arch Intern Med. 1998;158: 429-434. doi:10.1001/archinte.158.5.429

28. Muturi M, Gachohi J, Mwatondo A, Lekolool I, Gakuya F, Bett A, et al. Recurrent Anthrax Outbreaks in Humans, Livestock, and Wildlife in the Same Locality, Kenya, 2014-2017. Am J Trop Med Hyg. 2018;99: 833-839. doi:10.4269/ajtmh.18-0224

Figures

![Signs and symptoms experienced by cases](image)

**Figure 1**

Symptoms and signs experienced by cases during the anthrax outbreak in Makoni District Ward 22 and 23 in 2014
Figure 2

Sites of depressed eschar in cases during the anthrax outbreak in Makoni District

Ward 22 and 23 in 2014
Figure 3

The spot map of anthrax outbreak in Makoni District Ward 22 and 23 in 2014
Figure 4

The epidemiological curve for the anthrax outbreak in Makoni District Ward 22 and 23 in 2014.