An investigation of an anthrax outbreak in Makoni District, Zimbabwe

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Abstract

Background: In Zimbabwe, anthrax continues to be a disease of public health importance with sporadic outbreaks reported in many parts of the country annually. A human anthrax outbreak occurred in Makoni District Ward 22 and 23 between June 2013 and February 2014. The human anthrax outbreak followed cattle deaths in the wards, which were laboratory confirmed to be due to anthrax. We report the clinical characteristics, distribution of anthrax cases (places, person 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 case-control study. Cases and controls were frequency matched against sex. Data were collected using a structured interviewer-administered questionnaire. Environmental assessment, district preparedness and response and outbreak prevention and control measures were assessed using a checklist, observations and key informant interviews. Multivariable logic regression analysis was performed to identify independent risk factors associated with contracting anthrax.

Results: Of the 64 cases, 37 cases and 37 controls were interviewed. All the cases had cutaneous anthrax with the commonest site of eschar being the hand (43%). Most of the cases (89%) were managed according to national guidelines. On multivariable analysis, source of meat from other villagers [vs butchery, OR = 15.21, 95% CI (2.32-99.81)], skinning [OR = 4.32, 95% CI (1.25-14.94)] and belonging to a religion which permits eating meat from cattle slaughtered due to unknown illness or butchered after an unobserved death [OR = 6.12, 95% CI (1.28-29.37)] were associated with contracting anthrax. The district was poorly resourced and delayed to respond to the outbreak.

Conclusion: The described anthrax outbreak resulted from contact and consumption of infected cattle meat. The district office response was delayed and was not prepared to control the outbreak. However, the outbreak was eventually controlled through cattle vaccination; health education and awareness campaigns. The district should strengthen its emergency 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 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 contact with 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 the response by national programs [2]. Anthrax is still endemic in most African countries, and the majority experience at least one
outbreak per year [3]. In South Africa, the annual number of outbreaks is less than five and occasionally zero, despite the continued occurrence of the disease in wildlife in the various parks [4]. Effective control programs have been established in Botswana, Zimbabwe and Zambia, but the disease remains well known in the latter two countries at least [4].

In Zimbabwe, anthrax is still a disease of public health importance because annually, sporadic outbreaks are reported in many parts of the country [5,6]. It usually occurs during the dry (July to October) and early to mid-wet summer (November to February) periods [7]. The disease was first diagnosed in the country in 1898 in the Matabeleland region. 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 liberation struggle war. The number of cases of anthrax recorded during this period was far higher than the previous years, which usually record less than a dozen cases annually [8–10]. Since then sporadic outbreaks have been reported regularly in many parts of the country. The has been further exacerbated by the current deterioration of the economic environment in the country, which has led to poor implementation of prevention and control measures.

In 2013, human anthrax cases were reported in Makoni District, Ward 22 and 23 and starting in June. The District Veterinary Department reported cattle deaths in the same area during the same period. We investigated the anthrax outbreak in Makoni District Ward 22 and 23, and here we report the clinical characteristics, distribution of anthrax cases (place person and time), risk factors for contracting the disease, environmental assessment, district preparedness and response and outbreak prevention and control measures.

**Methods**

**Study setting**

The study was conducted in Manicaland Province, Makoni District, Ward 22 and 23 in Zimbabwe (Additional File 1). In Manicaland Province of Zimbabwe anthrax is endemic and annually cases in cattle and humans are reported. In 2011 and 2012, 37 and 49 human anthrax cases were recorded respectively. In 2012 the human anthrax cases were reported from Buhera, Chipinge, Mutare and Mutasa Districts in the province [11].

**Study design**

We conducted an outbreak investigation using a 1:1 case-control study. Cases and controls were frequency matched according to sex. 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 where there was confirmed laboratory diagnosis of anthrax in cattle who developed a disease which was 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 the 19th of June 2013 and the 29th of January 2014. A
control was defined as any person in Makoni District Ward 22 and 23 where there was confirmed
laboratory diagnosis of anthrax who never developed disease with similar symptoms during the same
time period. The cases were identified from the line list that was available at Makoni Rural Hospital,
which services the two wards and through active case findings in the community. Since data from most
of the cases were collected retrospectively, we collected address information (village, ward, headmen,
nearest school) from the hospital line list and used it to follow-up cases for data collection in the
community. Active case finding was through snow-balling and the community outreach clinic we
conducted, and these new cases were added to the outbreak line list. Any person who was diagnosed
with chickenpox, skin drug reaction, acute skin disease or other diseases which vaguely mimics anthrax
were evaluated clinically and excluded from the study. We selected our controls from the neighbourhood
of the cases. From the household of the case, we approached the nearest homestead in any direction,
looking for a control of similar sex. If at the homestead, there was no one, refused or no control of the
required sex we repeated the same process until we found a control.

Sample size

A minimum sample of size of 66 (33 controls and 33 cases) was required assuming 95% two-sided
confidence level, 80% power, the proportion of controls with exposure 59.7%, the proportion of cases with
exposure 91.94% and the least extreme odds ratio to be detected being 7.7 [12].

Data collection

Data were collected using an interviewer-administered questionnaire. The questionnaire collected data on
demographic, medical, risk factors for contracting and knowledge on anthrax. Review of outpatient
medical records was conducted to get extra medical information on history, including presenting
symptoms, physical examination (signs) and how the cases were managed. An Integrated Disease
Surveillance Response (IDSR) checklist was used to assess the emergency preparedness response of the
district [13]. 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 Officer and the
Environmental Health Technicians (EHTs) at Makoni Rural Hospital.

Data analysis

The data were analyzed using Stata 16 [14]. Cases and controls categorical baseline characteristics were
compared using frequencies, proportions and Pearson's Chi-square test. The median age was calculated
for both cases and controls, and the Wilcoxon rank-sum test was used to assess if there was a difference.
We performed unconditional univariable and multivariable logistic regression to identify factors
associated with contracting anthrax. The sex variable, which was used for frequency matching, was
included in the regression modelling. For the multivariable regression, we employed a hierarchical
approach. We included in the multivariable model all variables associated with P-value <0.1 in the univariable analyses. A stepwise backward elimination was used, and all variables having a p-value < 0.05 were retained in the final model.

Anthrax in animals - diagnosis and case definition

In Zimbabwe, the recommended diagnostic procedure in animals is blood smear from a nipped ear or peripheral blood fixed with alcohol for staining and microscopy. On microscopy Giemsa stain it shows purple-stained bacilli with red capsules while Gram stain shows the typical square-ended gram-positive rods [7]. The clinical diagnosis in animals was suspected if an animal presented with the following any one of the following signs and symptoms: cease feeding and drinking, staggering and falling, tremor, convulsions, massive oedema, swollen neck region lymph nodes, difficulty in breathing, bleeding from all orifices due to failure of blood clotting or sudden death.

Permissions and ethical considerations

The permission to carry out the study was obtained 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, assent was gained by discussing verbally with the minor about the study and depending with age and level of understanding, consent was also sought from the parents or guardians. No names were written on the data collection tools. Confidentiality was assured and maintained.

Results

Anthrax in animals

The findings from the field investigation showed that the first cattle death occurred on the 12th of June 2013. Sporadic cattle death occurred between June 2013 and October 2013, but the situation worsened end of November 2013, and most of the cattle deaths occurred in December 2013. The Veterinary Department collected specimens from a few cattle that were dying and were sent to the Provincial Veterinary Laboratory on the 24th of December 2013 where a laboratory diagnosis of anthrax was confirmed. The anthrax diagnosis in the rest of the animals was clinical. 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 on the deaths of other animals other than cattle were made and these included goats, pigs and chicken but the actual numbers were not ascertained.

Anthrax in humans

a) Study participants
Through active surveillance and from the hospital line list, we identified 64 cases in both Ward 22 and 23; all were "probable" based on their clinical characteristics and epi-linkage to animal cases that were laboratory confirmed. Of the 64 cases, we managed to reach and interview 37 of them.

**b) Baseline Characteristics of cases and controls**

We interviewed 37 cases and 37 controls. The median age in years for cases and controls was 34 (interquartile range-IQR: 22 – 42) and 28 (IQR: 25 – 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 the cases and controls were 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 ($\chi^2$) |
|----------------|------------------|----------|--------|-------------------|
| Sex            | Female           | 11 (29.7)| 10 (27.0)| 0.797             |
|                | Male             | 26 (70.3)| 27 (73.0)|                |
| Median Age (IQR)| 28 (25 – 46)    | 34 (22 – 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       | a Traditional churches| 18 (48.7)| 19 (54)| 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, IQR: Interquartile range

**c) Case Fatality Rate**

One community death suspected to have been due to anthrax disease was reported. 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 the skinning of cattle and consumed roasted meat during skinning. He died at the age of 40 years on the 13th of January 2014. This gave the outbreak an estimated case fatality rate of 0.016 (1/64).

**d) Clinical characteristics**

All the 37 cases had never had anthrax disease before and reported a depressed eschar. The other signs and symptoms experienced are summarized in Figure 1.
Most of the depressed eschar affected the hands (41%) while the back of the trunk was least affected (Figure 2).

Three of the interviewed cases were admitted in a hospital, and they spent 2, 5 and 12 days respectively. None of the cases had any laboratory tests done, including the 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) [7]. 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.

de) 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.

df) Distribution of cases - time

The first reported probable human anthrax case was on the 19th of June 2013. This first human anthrax 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. The human anthrax cases started to increase in December 2013 rapidly, and a peak was reached 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 human anthrax was reported on the 21st of December 2013. Figure 4 shows the epidemiological curve of the outbreak.

g) Risk factors for contracting anthrax

On multivariable analysis, only source of meat from other villagers [vs butchery, OR = 15.21, 95% CI (2.32-99.81)], skinning [OR = 4.32, 95% CI (1.25-14.94)] and belonging to a religion which permits eating meat from a cattle slaughtered due to unknown illness or died alone [OR = 6.12, 95% CI (1.28-29.37)] were associated with contracting anthrax during the outbreak setting (Table 2).

Table 2: Bivariate and multivariable logistic regression for factors associated with contracting anthrax in Makoni District Ward 22 and 23 in 2014
| Variables          | Categories                   | Controls | Cases  | OR     | 95% CI      | p-value     | aOR  | 95% CI      |
|--------------------|------------------------------|----------|--------|--------|-------------|-------------|------|-------------|
| Sex                | Female                       | 11 (29.7)| 10 (27.0) | 1      |             |             | 1.14 | 0.42 - 3.14 |
|                    | Male                         | 26 (70.3)| 27 (73.0) | 1.14   | 0.42 - 3.14 | 0.797       |      |             |
| Marital Status     | Has partner                  | 15 (40.5)| 22 (59.5) | 1      |             |             | 1    |             |
|                    | No partner                   | 22 (59.5)| 15 (40.5) | 0.46   | 0.18 - 1.18 | 0.106       |      |             |
| 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 | 0.469       |      |             |
| Employment         | Employed                     | 5 (13.5) | 9 (24.3) | 1      |             |             |      |             |
|                    | Peasant farmer               | 10 (27.0)| 6 (16.2) | 0.33   | 0.07 - 1.48 | 0.352       |      |             |
|                    | Unemployed                   | 22 (59.5)| 22 (59.5) | 0.56   | 0.16 - 1.93 |             |      |             |
| Religion           | a Traditional churches       | 18 (48.7)| 19 (5.4)  | 1      |             |             |      |             |
|                    | Apostolic                    | 13 (38.1)| 8 (21.6)  | 0.58   | 0.20 - 1.74 | 0.337       |      |             |
|                    | Others                       | 6 (16.2) | 10 (27.0) | 1.58   | 0.48 - 5.24 |             |      |             |
|                     | b Ate meat                   | No       | 17 (46.0)| 4 (10.8)| 1           |             |      |             |
|                    | Yes                          | 20 (54.0)| 33 (89.2)| 7.00   | 2.06 - 23.82| 0.002       |      |             |
| 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| 0.001       | 15.21| 2.32 - 99.81|
|                    | Own cattle                   | 6 (16.2) | 6 (16.2) | 5.5    | 0.84 - 36.20| 7.25        | 0.84 - 62.57|
|                    | Missing                      | 10 (27.1)| 2 (5.4)  | -      | -           | -           | -    | -           |
|                     | c Cutting meat               | No       | 20 (54.1)| 7 (18.9)| 1           |             |      |             |
|                    | Yes                          | 17 (45.9)| 30 (81.1)| 5.32   | 1.91 - 14.77| 0.002       |      |             |
| Skinning           | No                           | 29 (78.4)| 15 (40.5)| 1      |             |             |      |             |
|                    | Yes                          | 8 (21.6) | 22 (59.5)| 5.04   | 1.77 - 14.36| 0.001       | 4.32 | 1.25 - 14.94|
| Cooking            | No                           | 23 (62.2)| 12 (32.4)| 1      |             |             |      |             |
|                    | Yes                          | 14 (37.8)| 25 (67.6)| 3.42   | 1.32 - 8.91 | 0.012       |      |             |
|                     | d Cuts                       | No       | 31 (83.8)| 22 (59.5)| 1           |             |      |             |
|                    | Yes                          | 6 (16.2) | 15 (40.5) | 3.50   | 1.18 - 10.51| 0.024       |      |             |
| Hide preparation   | No                           | 26 (70.3)| 21 (56.8)| 1      |             |             |      |             |
|                    | Yes                          | 11 (29.7)| 16 (43.2)| 1.80   | 0.69 - 4.70 | 0.229       |      |             |
| Heard of anthrax   | No                           | 10       | 19      | 1      |             |             |      |             |
Environmental assessment

Most of the cattle that died were not buried properly, and the burials were not supervised. Animal carcasses were seen left on open spaces which allowed dogs and vultures to consume them. Reports of people throwing infected meat in the nearby Osborne Dam were 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 communities mixed and grazed in the same areas with the game animals 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 area 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 an 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 the 31st of November 2013. The EHTs on the field had no personal protective equipment (overalls/work suits, gumboots and heavy-duty gloves) to protect themselves. The rural hospital had only 40 kgs of chloride of lime for use to disinfect sites where animal carcasses died. 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 Emergency preparedness response plan, and the zoonotic committees were not functional. The cumulative period of the outbreak was seven months. The concrete response started after six 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 21\textsuperscript{st} of January 2014. The team dispatched to institute outbreak control measures comprised of two EHTs, Veterinary Officer and a Public Health Officer from the University of Zimbabwe, Field Epidemiology 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. A 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 conducted at Dope Secondary School in Ward 22. Disinfection of areas where cattle deaths occurred was done with sodium of lime. The team also assisted in the supervised burial of new cattle deaths and reburial of carcasses 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 during the period.

\textbf{Discussion}

The described anthrax outbreak in Zimbabwe affected cattle and transmission to humans. Cattle slaughtered due to unknown illness or butchered after an unobserved death were the source of infection. 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 factors for contracting anthrax; source of meat from other villagers, skinning, and belonging to a religion which permits eating meat from cattle slaughtered due to unknown illness or butchered after an unobserved death. The carcasses of the dead cattle were incorrectly buried. 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 than other body parts. This was consistent with the findings from other studies [12,15]. 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 [16,17]. 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 forms of anthrax [1]. In our study, all the interviewed cases had cutaneous anthrax, and the victim who died in this outbreak might have developed either gastrointestinal or respiratory anthrax both which have higher mortality as compared to cutaneous anthrax [18,19].

The following were found to be risk factors source of meat from other villagers, skinning and religion, which permits eating meat from cattle slaughtered due to unknown illness or butchered after an
unobserved death. These findings are consistent with other studies done locally and might be due to the similarity of practices [12,20,21]. The reason why skinning was associated with contracting anthrax is that during the process, cuts and abrasions are likely to develop, and these create access routes for the spores to the sub-dermal tissue [1]. Belonging to a religion which permits eating meat from animals slaughtered due to unknown illness or butchered after an unobserved death was associated with contracting anthrax. This finding is however not consistent with another local study where one's religious belief on the consumption of meat from cattle slaughtered due to unknown illness or butchered after an unobserved death was not associated with contracting anthrax [12,20].

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 a 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 [22,23]. Anthrax spores can survive for a long period if the soil conditions conducive [24]. 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 [25]. One of the wards also bordered a game reserve. The sharing of grazing land with game often results in the transmission of anthrax to livestock [26].

The outbreak was prolonged, and it took time for the district to institute control measures. The district delayed in 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 personal protective equipment (PPE). The district used chloride of lime to disinfect sites where animal carcasses died. The practice is no longer recommended because chloride of lime is rapidly neutralized by organic matter. Moreover, chloride of lime is corrosive, carcinogenic, unstable and potentially explosive, which makes its use without proper PPE dangerous [1,3]. Now the recommended approach is to bury animal carcasses deep down the ground. 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 [16,20]. Studies have shown that awareness and knowledge on anthrax modes of transmission, signs and symptoms and preventive measures among community members reduce exposure to risk factors [27].

**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 fieldwork. 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. According to the Zimbabwe guidelines, collection of humans specimens may not be necessary if diagnosis of anthrax has already been confirmed in animals from the area of the outbreak. The collection of specimens is also not encouraged because there is a danger of contamination and transmission of the anthrax bacilli if the collection is not supervised and specimens improperly handled. 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 distance and feasibility. We also did not compare the demographic characteristics of the interviewed cases to all cases to assess similarity and possible bias of our sample. 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. We did not collect information on controls non-responders. Characteristics of those who did not respond could have influenced our results.

Conclusion

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 the high-risk period and activation of zoonotic committees with the Veterinary Department participating fully.

Declarations

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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 the 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@gmail.com

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**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. Assent was obtained for children less than 18 years.

**Competing interests**

The authors have no competing interests.

**Consent for publication**

Not applicable

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2. National AIDS Council, Harare, Zimbabwe

**Abbreviations**

CI – confidence interval, OR – odds ratio, EHT – Environmental Health Technician

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Figures
Figure 1

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

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 the 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

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