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ORIGINAL RESEARCH

A Retrospective Study on the Epidemiology of Anthrax Among Livestock from 2011 to 2020 in Awi Administrative Zone, Amhara Region, Northwest Ethiopia

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Background: In Ethiopia, anthrax is the second most important zoonotic disease, next to rabies. Data quantifying occurrence and distribution of animal anthrax in Awi administrative zone of Amhara region, Ethiopia, are limited. Thus, this study was conducted to describe the distribution of animal anthrax between 2011 and 2020 in Awi zone.

Methods: This study used secondary data of animal anthrax that occurred in the Awi zone and reported to the Regional and National Veterinary Authority between 2011 and 2020.

Results: A total of 1262 cases of anthrax in animals and 324 animals that died due to anthrax were reported. The highest number of anthrax cases were reported in 2012 (n = 671), sharing 48.9% of the 10-year animal anthrax reported. However, the highest number of animal death due to anthrax (n = 104) was reported in 2014. The overall case fatality rate of anthrax was 25.67% (n = 324). The highest animal anthrax cases (n = 984; 77.97%) and deaths (n = 259; 79.94%) were recorded in Bovine. The highest cases of anthrax were registered in May (n = 313), while no anthrax case was reported during December. The highest and lowest number of animal death due to anthrax were reported during July (n = 64) and January (n = 6), respectively. The highest number of anthrax cases was reported in the hot-dry season (n = 479; 37.96%) whereas the lowest was reported during the cold-dry season (n = 30; 2.38%).

Conclusion: The current study revealed a considerable number of animal anthrax cases and deaths in Awi zone every year. Hence, it is necessary for practicing prevention strategies including immunization programs before the peak season of anthrax outbreaks.

Keywords: animal anthrax, Awi zone, Amhara region, retrospective study, Ethiopia

Introduction

Anthrax is caused by a gram-positive, endospore-forming bacterium named *Bacillus anthracis*. The disease affects animals, humans, and wildlife and is zoonotic, very importantly known for its occupational hazard. It has a worldwide occurrence, though the burden varies with regions and countries.[1] Even though anthrax is known to affect multiple species,[2,3] it principally affects domestic and wild herbivores such as cattle, sheep, goats, bison, deer, antelope, and hippos and in those species, it is usually fatal.[4] Anthrax has significant animal and public health as well as socio-economic impacts that play a substantial role in the global trade of animals and animal products.[2] This disease is among the most priority zoonotic diseases.[5,6] Animal owners in resource-limited settings are usually at high risk of contracting anthrax infection because of their animal handling practices.[7]

Different environmental, geographical, ecological, and demographic factors determine the perseverance and transmission of *B. anthracis* in an area.[6] *B. anthracis* spores usually persist in the soil under extreme environmental and climatic conditions for long periods and are a source for re-emergence of disease and transmit to animal hosts through grazing on

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B. anthracis spores contaminated areas, usually by ingestion or inhalation. Humans get infected when they are exposed to infected animals or their products such as meat, animal hides, bones, and other materials[4] as well as contact with an animal that died from anthrax.[8,9]

Anthrax is an important but neglected zoonosis in many parts of the world.[10] It is a World Organization for Animal Health (WOAH)-listed and reportable disease.[8] The disease is mainly endemic in developing countries.[11] A compiled global occurrence dataset of human, livestock, and wildlife anthrax outbreaks report revealed that a global total of 63.8 million poor livestock keepers and 1.1 billion livestock live within regions at risk for the disease.[12]

In Ethiopia, anthrax is endemic,[13,14] occurs in the dry season every year,[15] and usually, occurs as an outbreak year after year.[14] Anthrax is one of the top five important livestock diseases[16] and the second top priority zoonotic disease, next to rabies, in Ethiopia.[5,17] Anthrax remains a major problem for animals and public health in Ethiopia.[13,15] Particularly, the Amhara Regional state is frequently affected by diseases due to a humid to sub-humid environment, weak animal health services, and a lack of awareness of the community about animal anthrax case management which leads to widespread outbreaks.[18] The most efficient ways of preventing and controlling anthrax infection in domestic herds are sustainable surveillance, annual vaccination of livestock, and proper carcass disposal management. A study on spatio-temporal analysis and environmental suitability modeling of Anthrax in the Amhara Region indicated that Awi administrative zone was suitable for *Bacillus anthracis* and grouped at-risk areas for the disease.[18] An important step in the implementation of anthrax control is the acquisition of data or information about the occurrence of the disease.[4] However, data are limited to quantifying the occurrence and distribution of animal anthrax in Awi zone of the Amhara regional state of Ethiopia. The analysis of this data is very crucial to design more effective intervention strategies in the regions. Therefore, this retrospective study was conducted to describe the distribution of animal anthrax during a period from 2011 to 2020 in Awi administrative zone of Amhara Region, Northwest Ethiopia.

Materials and Methods

Description of the Study Area

The study was conducted in the Awi administrative zone of Amhara Regional State, Ethiopia (Figure 1). Amhara region (9° to 13°45'N and 36° to 40°30'E) is located in the northern part of Ethiopia, bordered by the state of Sudan to the northwest.[14] The Awi administrative zone has nine districts and three towns. Geographically, it is located at an elevation of 700–2920 meters above sea level with latitude and longitude of 11°16'N and 36°50°E, respectively. The zone has three

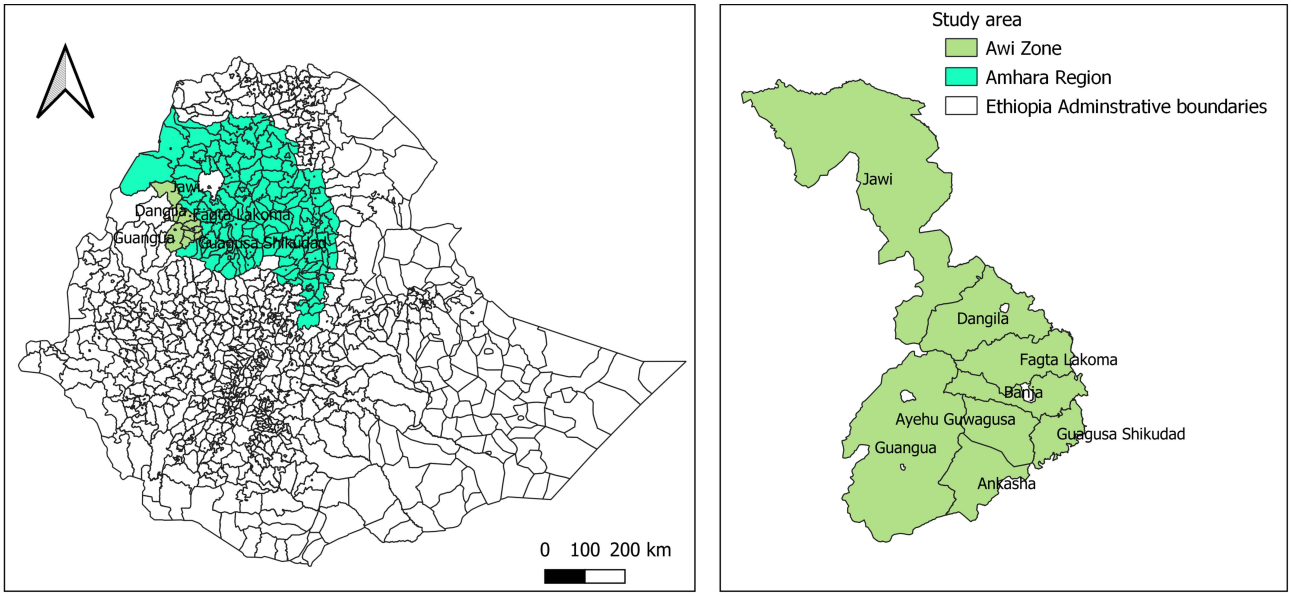

Figure 1 Map of Awi administrative zone in Amhara Region, Ethiopia. This map was developed from Ethiopian's Administrative boundaries shapefile 2021 using QGIS version 3.1.1.2.

rainfall seasons: Bega, Belg, and Kiremt. The primary rainy season, Kiremt, occurs from mid-June to mid-September. It also experiences a sporadic, secondary wet season, Belg, which often has considerably less rainfall and occurs from February to May. It receives an annual rainfall ranging from 800 to 2700 mm. During the hottest seasons, the temperature may range from 25 to 30 °C, while during the coldest; it ranges from 7 to 12 °C. Currently, the estimated livestock population of the Awi administrative zone is cattle (1,137,033), sheep (551,125), goats (130,732), horses (91,932), mules (20,517), and donkeys (79,037).[19–21]

Study Design, Population, and Data Collection

A retrospective study design was conducted from data recorded for 10 years, from 2011 to 2020. The study population was animals that are susceptible to anthrax infection. A structured data recording sheet was prepared using a Microsoft Excel worksheet. It was then used to extract data related to animal anthrax cases and deaths in the study area.

Case Definition

Clinical signs of peracute anthrax in cattle, sheep, and goats are staggering, trembling, breathing difficulty, convulsions, and death. Progression of the disease is rapid and premonitory signs may go unnoticed; often animals are found dead. After death, blood discharges from the nostrils, mouth, anus, and vulva occur and the blood may fail to clot. Acute anthrax manifests itself in high fevers (up to 42 °C), excitement, increased heart rate, deepening of respiration, followed by depression, incoordination, cessation of rumination, reduction in milk production, discolored milk (blood-tinged or deep yellow), bloody discharges, respiratory distress, convulsions, abortion, and death within 48 to 72 hours. Subcutaneous swelling and edema, usually involving the ventral aspect of the neck (brisket), thorax, shoulders, perineum, and flank, are characteristic of chronic anthrax infection.[22]

The clinical signs of anthrax in horses are loss of appetite, colic, enteritis, fever, trembling depression, and bloody diarrhea. Death usually occurs within 48 to 96 hours. Edematous, subcutaneous swellings appear on the throat, lower neck, floor of the thorax and abdomen, prepuce, and mammary gland.[22]

Anthrax cases were identified based on the clinical signs and/or blood smears (blue square-ended rods, usually in short chains, surrounded by a pinkish-red capsule). Similarly, dead animals were found with blood oozing from the natural orifices, and the rapid swelling and decomposition of carcasses were considered as death associated with anthrax.

Sources of Anthrax Data

Animal cases and deaths associated with anthrax were collected retrospectively for 10 years (2011–2020) of recorded data from each district in the Awi zone. The data were extracted from recorded databases of the passive surveillance animal disease and reported from the districts to the Regional (Amhara Regional Livestock Resources Development Promotion Agency) and National Veterinary Authority (Ministry of Agriculture). Passive animal disease surveillance is an animal owner's disease reporting system in which farmers report diseases and deaths in their livestock, but the information of that report is used by the Veterinary Authority for surveillance. Data such as species of animals sick and died, the number of cases and deaths in each district, monthly animal cases and death, and the season of the year were retrieved from the record. Anthrax is a notifiable disease, all cases and deaths associated with anthrax are mandatory to report to the Regional and National Veterinary Authority.

Data Management and Analysis

Data collected in an excel worksheet were reorganized, cleaned, and coded. Descriptive statistics mainly proportions were calculated using excel tools. Proportions were calculated to indicate the distribution of animal anthrax (including cases and deaths) in time (ie, distribution across different months, seasons, and years), animal (ie, distribution in different animal species in the 10 years), and place (distribution in different districts of the zone, the later may represent different agro-ecologies). The trend and distributions of anthrax cases by animals, place, and time were presented using graphs, and tables. The year was categorized into four seasons: rainy (June to August),

post-rainy (September to November), cold-dry (December to February), and hot-dry (March to May) seasons. The case fatality rate was determined by dividing the number of deaths due to anthrax by the number of animal anthrax cases reported.

Results

A total of 1586 animal anthrax reports were found from 2011 to 2020, of which 1262 reports were cases of anthrax and 324 were animals that died due to anthrax. The highest proportion of animal anthrax cases was reported in 2012 (n = 671; 53.12%), which share 48.9% of the 10 years of animal anthrax reports. Similarly, the highest proportion of animal death due to anthrax (n = 104; 32.10%) was reported in 2014. In contrast, the lowest proportion of animal anthrax cases (n = 6; 0.48%) and deaths (n = 1; 0.31%) were recorded in 2018. In this study, the overall case fatality rate of anthrax was 25.67% (n = 324) with which the highest case fatality rate (63.64%) was recorded in 2016 followed by 2014 (46.25%) (n = 111), and 2013 (45.50%) (n = 10) as shown in Table 1.

Among animals, the highest animal anthrax cases were recorded in bovines (n = 984; 77.97%), followed by equine species (n = 202; 16.01%). The lowest animal anthrax cases were recorded in caprine (2%). Similarly, the highest number of animal deaths due to anthrax were recorded in bovines (n = 259; 79.94%) while the lowest was recorded (n = 15; 4.63%) in ovines. Although only two anthrax cases were recorded in caprine, death associated with anthrax had not been recorded as shown in Figure 2.

In this study, the distribution of animal anthrax cases and deaths varies among districts in Awi administrative zone of the Amhara Region, Ethiopia. The highest number of anthrax cases were reported in Banja district (n = 386) followed by Ankesha district (n = 351). The highest number of animal deaths due to anthrax were reported in Banja district (n = 68) followed by Zigem district (n = 57), while the lowest number of animal deaths was recorded in Fagita Lekoma district as shown in Figure 3.

According to the 10 years of recorded animal anthrax cases and deaths, the highest cases of anthrax were registered in May (n = 313) followed by July (n = 280). The lowest number of animal anthrax cases was reported during January and no anthrax case was reported in December during the 10 years. The highest number of animal death due to anthrax was reported during July (n = 64) followed by June (n = 48). In contrast, the lowest number of animal death due to anthrax was reported in January (n = 6) as illustrated in Figure 4. Besides, the seasonal distribution of anthrax indicated that the highest number of animal anthrax cases were reported during the hot-dry season (n = 479; 37.96%) followed by the rainy season (n = 446; 35.34%). The lowest number of animal anthrax cases were recorded during the cold-dry season (n = 30; 2.38%) as shown in Figure 5.

Table 1 The Number of Cases, Deaths, and Case Fatality Rate of Anthrax in Awi Administrative Zone During 2011–2020

Year	No. of Cases (%)	No. of Deaths (%)	Case Fatality Rate (%)
2011	107 (8.48)	34 (10.49)	31.78
2012	671 (53.12)	104 (32.10)	15.50
2013	22 (1.74)	10 (3.09)	45.50
2014	240 (19.02)	111 (34.26)	46.25
2015	97 (7.69)	28 (8.64)	28.87
2016	11 (0.87)	7 (2.16)	63.64
2017	55 (4.36)	16 (4.94)	29.10
2018	6 (0.48)	1 (0.31)	16.67
2019	35 (2.77)	6 (1.85)	17.14
2020	18 (1.43)	7 (2.16)	38.89
Total	1262	324	25.67

Note: % is the proportion from the 10-year period.

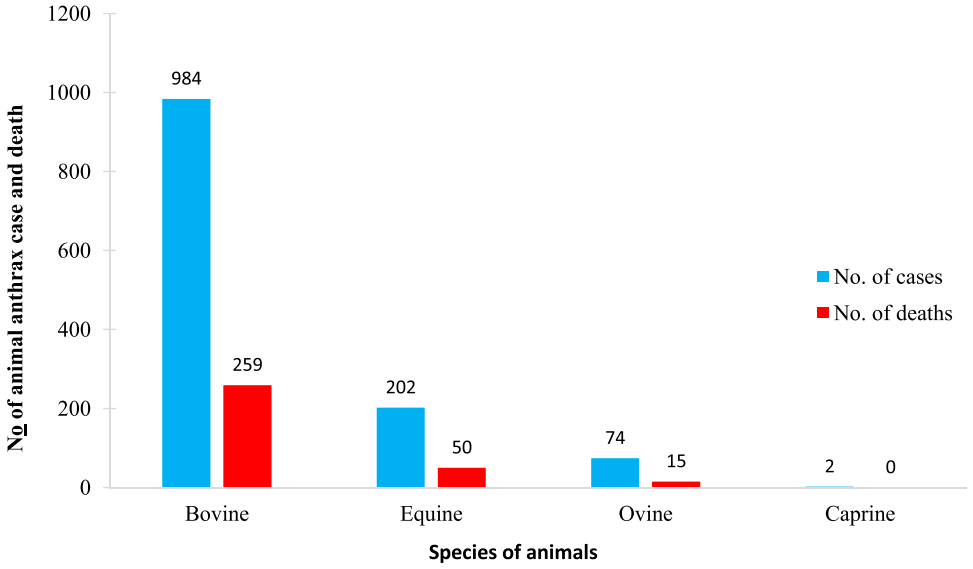

Figure 2 Distribution of animal anthrax among animal species affected in Awi administrative zone, 2011–2020.

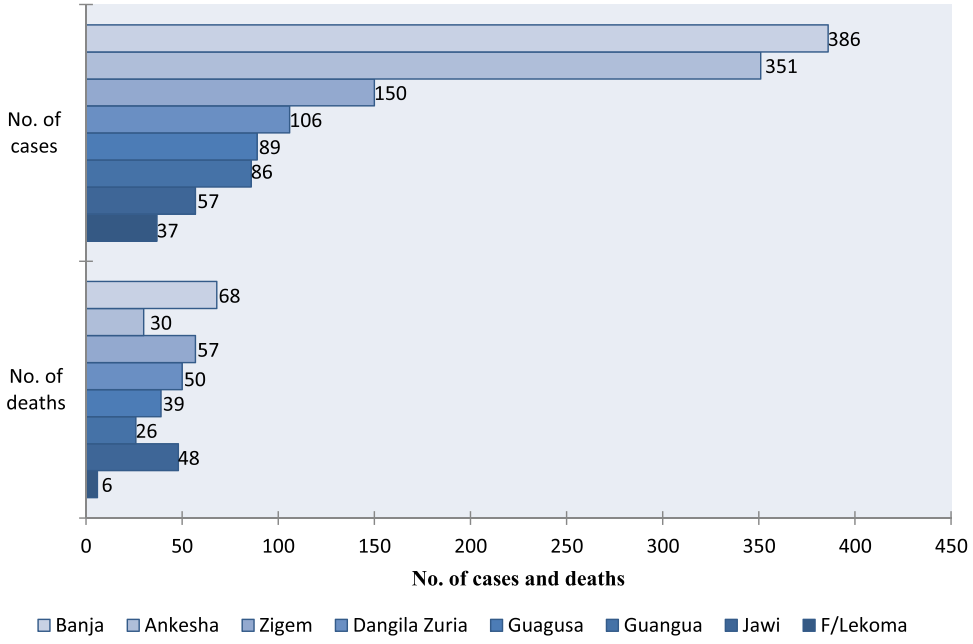

Figure 3 Distribution of animal anthrax across districts in Awi zone, 2011–2020.

Discussion

The current study revealed that from the year 2011 to 2020, a total of 1262 animal anthrax cases and 324 animal death associated with anthrax were reported in Awi administrative zone of Amhara Region, Ethiopia. In this study, the proportions of animal anthrax between 2011 and 2020 indicated that about 53.12% of animal anthrax cases were recorded in 2012. This high proportion of anthrax cases in this period might be attributed to the occurrence of the longest-dry season,[23] limited vaccination coverage,[16] and low awareness and practices to manage the disease. The lowest number of animal anthrax was recorded in 2018. This might be due to good vaccination coverage and sound case management practice by the community and professionals, and/or underreporting of cases and deaths by the local veterinary officials.

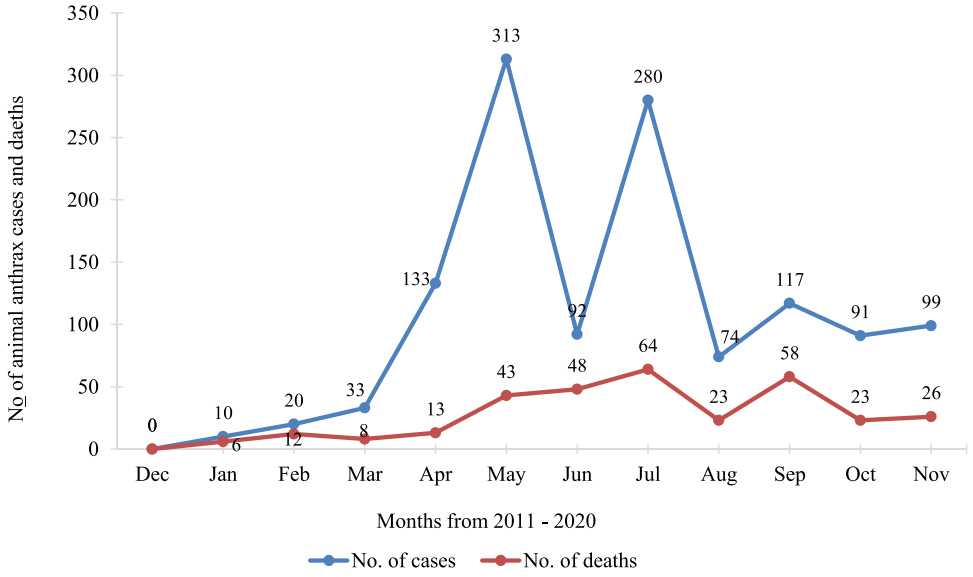

Figure 4 Monthly distribution of animal anthrax in Awi administrative zone, 2011–2020.

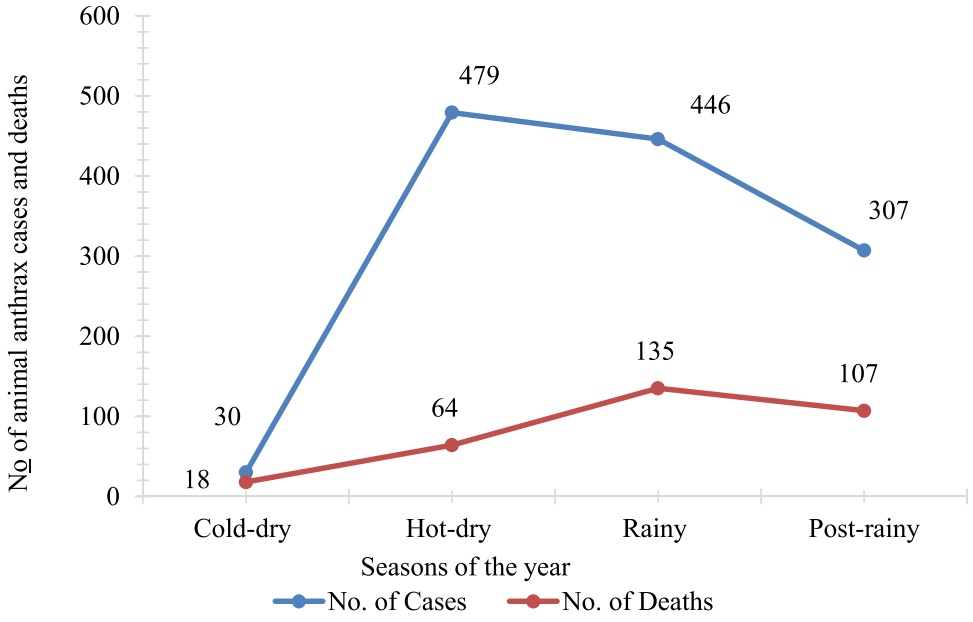

Figure 5 Seasonal distribution of animal anthrax in Awi administrative zone, 2011–2020.

Even though it is known that anthrax affects multiple species,[2] more than two-thirds of animal anthrax (77.97%) reports were recorded in bovines. Furthermore, the reported anthrax cases were very among species. These differences might be due to the grazing or browsing behavior of animals and animal owners' health-seeking behavior and attitude toward their animals.[24,25] Only two anthrax cases were recorded in caprine for the 10 years. This might be associated with the browsing behaviors of the goats which reduce the probability of getting the spore in the soil. This result is in line with other reports where anthrax occurs in all vertebrates but most common in cattle and sheep and less frequent in goats.[22] Close grazing of tough, scratchy feed in dry times, which results in abrasions of the oral mucosa, and confined grazing on heavily contaminated areas around water holes are the risk factors for the occurrence of anthrax outbreaks.[22]

In this study, variations in the proportion of cases and death associated with anthrax among districts in Awi administrative zone were reported. The highest number of anthrax cases were recorded in Banja district (386/1262),

followed by Ankesha district (351/1262), whereas the lowest number of anthrax cases were reported in Fagita Lekoma (37/1262). The highest number of animal deaths due to anthrax were reported in Banja district (68/324) followed by Zigem district (57/324). Case fatality rates were also assessed for each district and the highest (84.21%) was recorded in the Jawi district. The highest number of animal deaths due to anthrax were reported in Banja district (n = 68) followed by Zigem district (n = 57), while the lowest number of animal deaths was recorded in Fagita Lekoma district. Differences in the number of anthrax cases and deaths among districts might be due to varying climatic, soil, and temperature conditions[19,26] as well as carcass and environmental management practices following animal anthrax cases and deaths,[9,14] which will facilitate the clustering of anthrax in a specific place.[6] Although *B. anthracis* can be found worldwide, anthrax cases usually occur only in limited geographic regions. Outbreaks are most common in areas characterized by alkaline, calcium-rich soils, warm environments, and periodic episodes of flooding.[22]

Variations in the proportions of animal anthrax cases among different months and seasons of the year were observed. The highest proportion of animal anthrax cases was reported in May (24.8%) followed by July (22.19%). These findings were in line with the nature of anthrax, where most outbreaks occur during heavy rainfall following a period of prolonged drought.[27] Whereas, the lowest proportion of animal anthrax cases were found in January, as low as approximately 5 in 1000 animals. It has been recognized that environmental and climatic drivers were important factors influencing the ecology of anthrax.[28] The seasonal distribution in this study indicated that anthrax occurs in animals in both dry and cold seasons, however, the highest proportion of animal anthrax cases was reported during the hot-dry season (37.96%) whereas the lowest was recorded during the cold-dry season. During the dry season in the study areas, it was noted that the vegetation for grazing is depleted and becomes short, which leads the animals to close grazing to the ground. This significantly increases the chance of contracting *B. anthracis*. During long-dry seasons of the year, vegetation were scarce or short[7] and during heavy rainy seasons, there may be soil disturbance,[2,29] which results in ease of exposure of animals to the spores of *B. anthracis* leading to high numbers of cases or probably to outbreaks. In Ethiopia, a study reported that high numbers of anthrax were recorded during rainy seasons.[30] Furthermore, longer dry/hot seasons have the potential to induce stress on animals and hence animals' innate resistance to infections will be negatively affected. In such circumstances, low doses of *B. anthracis* spores will get the potential to initiate infection in animals.[31,32] The current study revealed that during the 10 years, there was no report of animal anthrax in December. However, a recent epidemiological investigation report indicated that the index case of anthrax that occurred in December was reported.[14]

Limitation

Given that anthrax is a notifiable disease, all cases and deaths associated with anthrax are mandatory to report to the Regional and National Veterinary Authority. However, the animal owners may not report all animal deaths to the nearest veterinary officials, which significantly underreports animals death associated with anthrax in the regular passive surveillance system. For this retrospective study, the secondary data were obtained from the monthly animal anthrax cases and death records. The record has a limitation on the quality especially data related to transmission to animals, the environment, and case management practices.

Conclusion

The current study showed that a considerable number of animal anthrax cases and deaths occurred in the Awi administrative zone, with varying degrees among different species of susceptible animals, months/seasons, and districts. In this study, the highest number of cases of anthrax was registered in May and during the hot-dry season; that calls for the need for practicing prevention strategies including immunization programs before the peak season of anthrax outbreaks.

Data Sharing Statement

The data used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Ethical Approval

Approval for retrieving and reporting the animal anthrax data reported between 2011 and 2020 was obtained from the Amhara Regional Livestock Resources Development Promotion Agency and the Ministry of Agriculture, Ethiopia.

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Author Contributions

All authors contributed to data analysis, drafting, or revising the article, have agreed on the journal to which the article will be submitted, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that they have no competing interests in this work.

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