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Anthrax outbreaks: a warning for improved prevention, control and heightened awareness

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Introduction

Anthrax is a zoonotic disease caused by the gram-positive spore-forming bacterium *Bacillus anthracis*. It primarily affects domestic and wild herbivores (such as cattle, sheep, goats, bison, deer, antelope and hippos) and in those species it is usually fatal. It is distributed globally and remains enzootic in many regions of the world, particularly sub-Saharan Africa, Asia and Central and South America (World Health Organization (WHO), 2008). The overall disease burden and economic impact of anthrax in livestock is not fully known; however, epizootics occur every year, resulting in the deaths of hundreds to thousands of animals, and disease transmission to humans. Humans are most often infected from exposure to infected animals or their products such as meat, animal hides, bones and other materials. It is estimated that there are 2 000 to 20 000 human anthrax cases occurring annually worldwide (Martin, 2010).

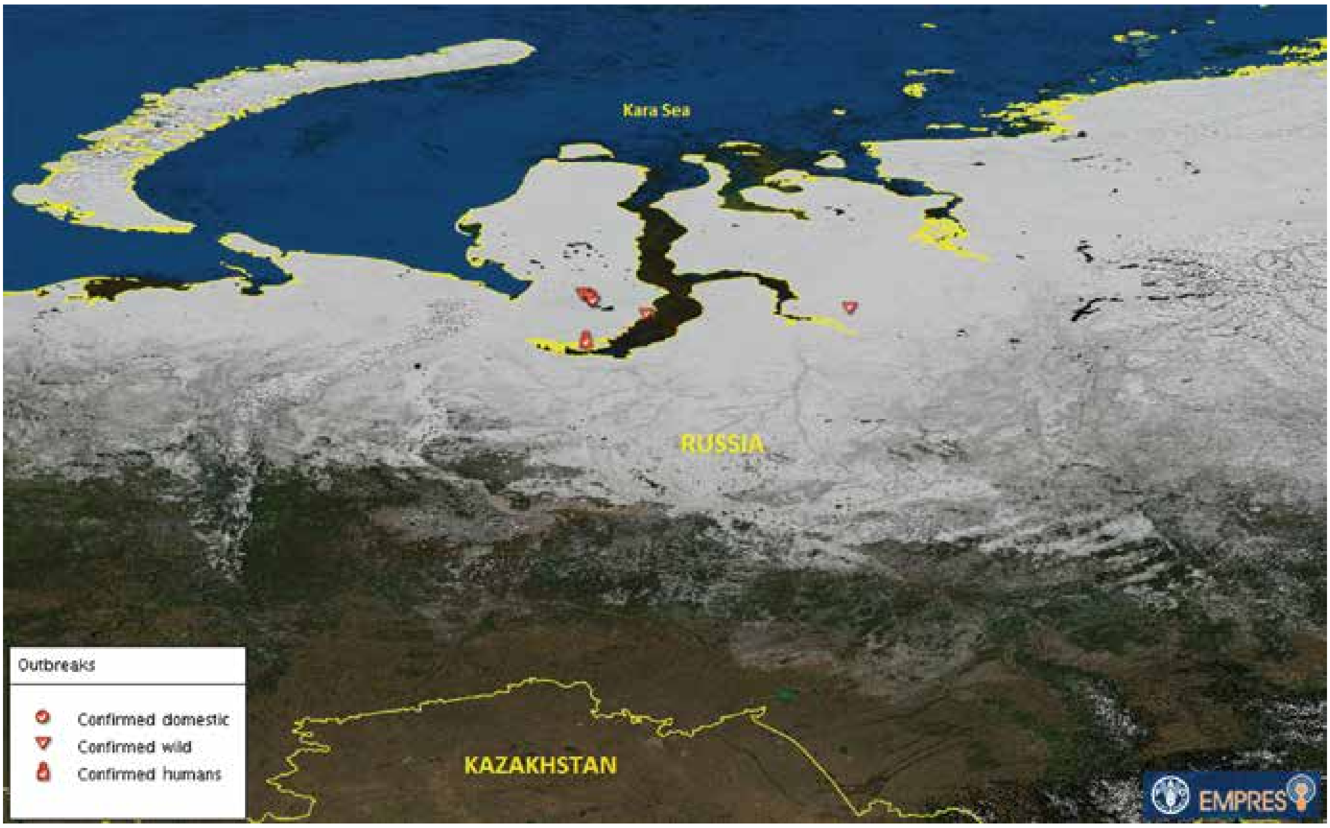
A cluster of anthrax outbreaks was reported in July 2016, occurring in reindeer in the Yamal-Nenets Autonomous Okrug, a district of the Russian Federation, with over 2 600 animals reported infected, and with human cases resulting from exposure to the infected animals (Figure 1). Prior to this event, there had been no anthrax outbreaks reported in the affected region since 1941 (Organisation for Animal Health (OIE), 2016a). This outbreak is one of several that have been reported in 2016 from various countries in different regions of the world (Figure 2). Some of these outbreaks have occurred in countries where anthrax has not been reported in recent history. These newly reported outbreaks raise concerns that anthrax may be re-emerging in those areas, potentially linked to changing climatic conditions which may favour the occurrence of the disease. Likewise, there are multiple new or continuing anthrax outbreaks that have been reported from countries worldwide where the disease occurs with regularity.

The recurrence of anthrax outbreaks in many parts of the world warrants more attention for heightened awareness and effective control measures to prevent anthrax infection in animals and limit its transmission to humans. It is necessary in an endemic country, or any region that may have conditions conducive to anthrax outbreaks or a history of outbreaks, to maintain vigilance to prevent, detect and respond to outbreaks in those regions, as they may recur in those areas after an absence of several years or more.

The infectious cycle of anthrax

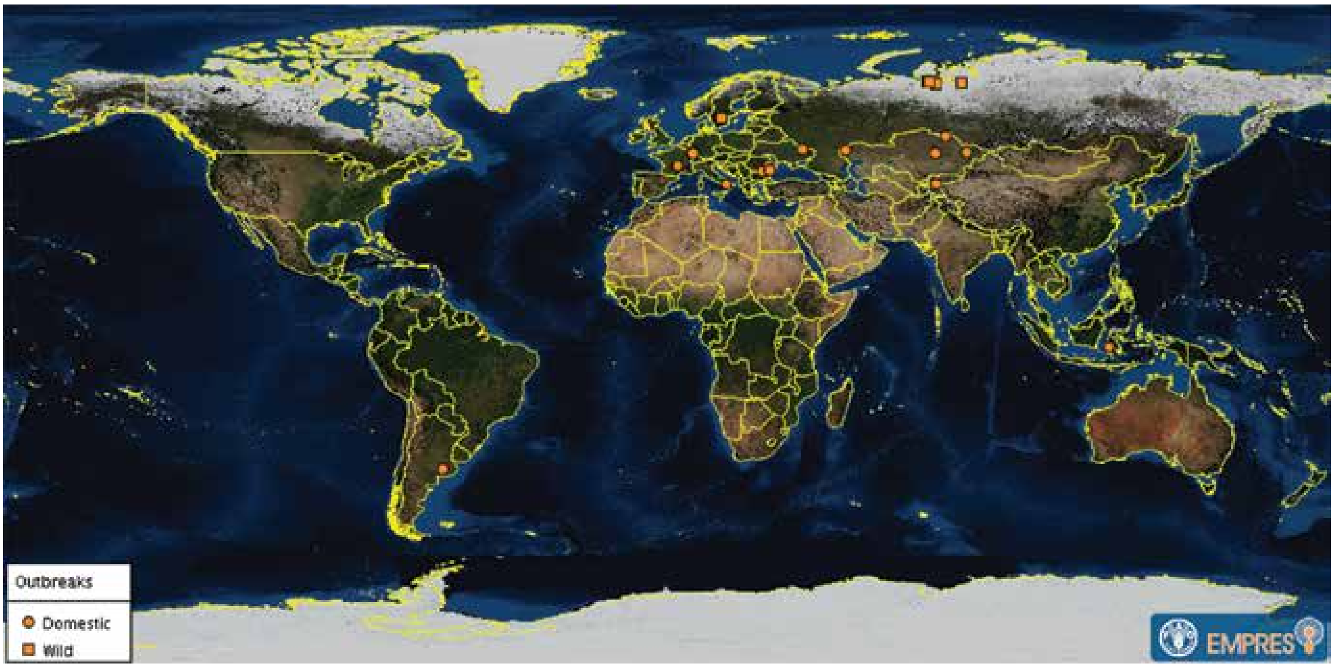
The primary reservoir for anthrax is the soil. Grazing animals are thought to become infected when they ingest *B. anthracis* spores on vegetation in an area where the soil or water sources are contaminated by the spores. Vegetative bacilli are shed in blood and other discharges from infected animals that are dying or dead, and those bacilli then sporulate and contaminate surrounding soil and water, where they complete this cycle of infection (Figure 3) (WHO, 2008). Animal outbreaks are often associated with low-lying areas with soil that has high moisture, calcium and organic content and alkaline pH (Van Ness, 1971; Dragon, 1995; Hugh-Jones, 2009). The spores can persist in the soil for prolonged periods of time and under extreme environmental and climatic conditions (Manchee, 1981). Environmental factors such as temperature and precipitation patterns have been shown to be the main determinants for the onset of anthrax outbreaks. Outbreaks may be triggered in areas where the soil is contaminated with spores from previous anthrax-infected animal carcasses by natural events such as prolonged periods of hot, dry weather that follow heavy rains and flooding, or with the onset of rains ending a period of drought; therefore, anthrax outbreaks may have a seasonal pattern. Other factors that may trigger outbreaks include the disruption of the soil through digging or excavation, or by landslides or dust storms. Insect activity has been implicated in the spread of anthrax outbreaks, including both transmission of disease by biting flies or by carrion flies who spread contamination onto vegetation which is then consumed by browsing animals (WHO, 2008; Hugh-Jones, 2009).

Figure 1. Anthrax outbreak locations in the Yamal-Nenets Autonomous Okrug, Russia, July–August 2016



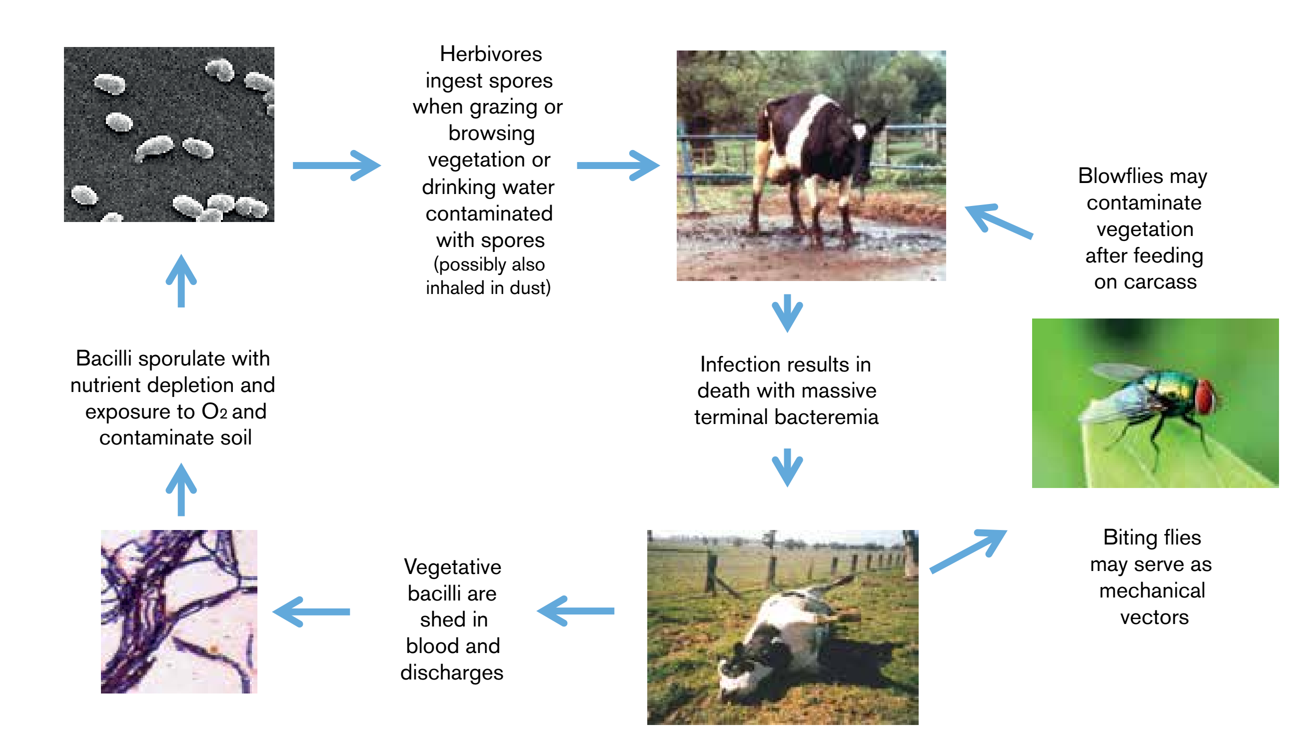
Source: EMPRES-i

Figure 2. Anthrax outbreaks in livestock and wildlife reported from 1 January to 31 August 2016



Source: EMPRES-i

Figure 3. Ecological cycle for anthrax



Adapted from WHO, 2008.

Source: Picture credits from top left and proceeding clockwise, Centers for Disease Control and Prevention (CDC); Centers for Disease Control and Prevention (CDC); http://www.edupic.net/index.html; Danelle Bickett-Weddle, Iowa State University; U.S. Dept. of Agriculture - Animal and Plant Health Inspection Service (APHIS).

Recent anthrax outbreaks

The Yamal-Nenets outbreak in reindeer in Russia was reported as starting on 16 July 2016, and was confirmed on 25 July, with notification to OIE on 5 August. The region is one with a pastoralist population of reindeer herders whose livelihoods are centred around the grazing reindeer herds. Five different outbreak areas in the region were initially reported from the Yamal peninsula, and on 18 August a sixth outbreak was reported from the region east of the Gulf of Ob. A total of 2 657 cases were reported out of a total herd in the region of approximately 111 000 susceptible animals (2.39 percent), with reported case fatality in the reindeer of 88.67 percent (OIE, 2016a). Human cases, including fatal cases, were reported among human contacts with the animals, including cases of gastrointestinal anthrax in those who consumed meat or blood from the reindeer.

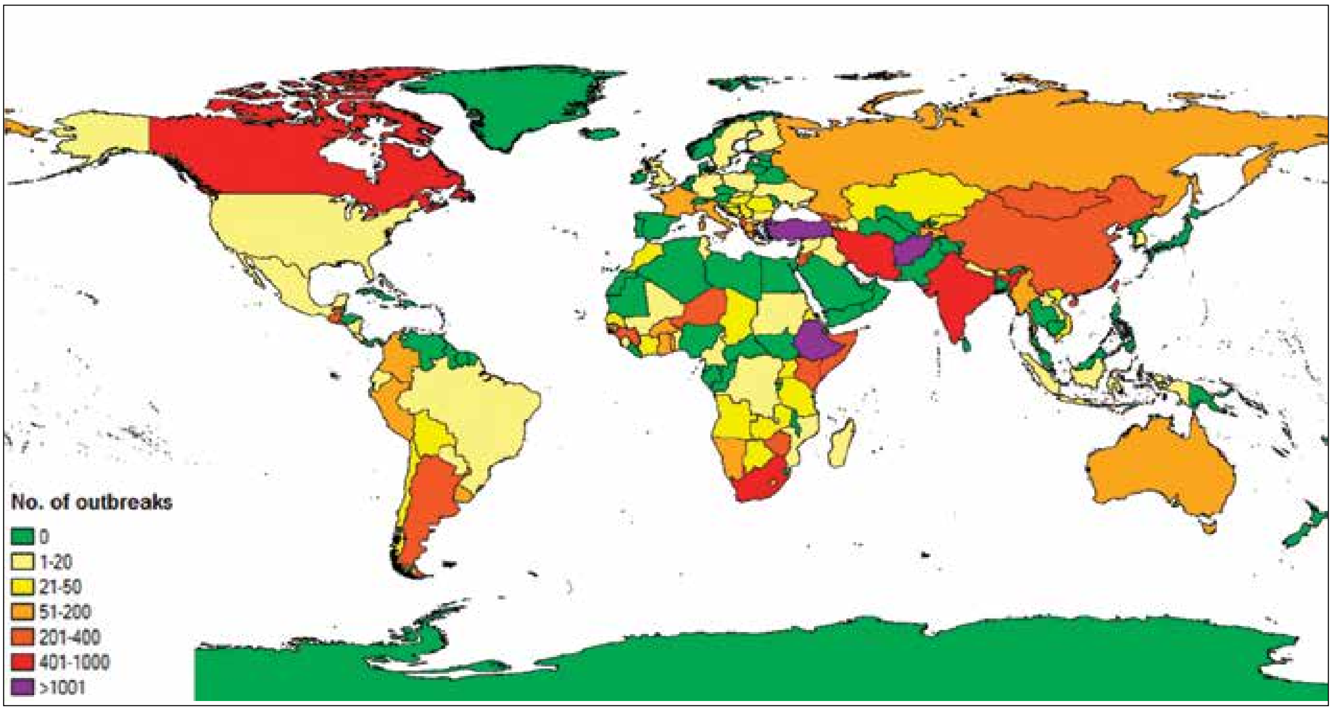
The response to contain the outbreak in animals has included reactive vaccination of the susceptible herds, treatment of affected animals, implementation of surveillance outside the affected region, quarantine and containment to prevent movement of potentially infected animals or animal products, disposal of carcasses of affected animals by incineration and other methods, and use of disinfectant-spraying trucks to treat contaminated soil (ProMED, 2016a; OIE, 2016a). Annual preventive vaccination campaigns have been announced for the future to reduce the risk for recurrence of outbreaks. Human cases have been provided with treatment and hospitalization, and at-risk persons who may have been exposed to anthrax have been provided with antimicrobial prophylaxis or vaccination and relocated to unaffected locations.

Although the number of animals reported as affected in this outbreak has attracted substantial attention, the size of the outbreak is not unique, and previous outbreaks during the twentieth century have been reported affecting tens of thousands or even a million animals within a single country in a single year (Beyer and Turnbull, 2009). Moreover, anthrax outbreaks occur sporadically in Russia, with outbreaks frequently reported from one or more districts in any particular year. This outbreak, however, occurred in a region from which anthrax had not been reported for 75 years, and is suspected to have been the result of abnormally warm temperatures which melted the permafrost. As anthrax outbreaks in enzootic areas typically follow a prolonged hot dry period preceded by heavy rains or rains which end a long dry period, the abnormally warm temperatures and permafrost thaw may have been similar to these kinds of environmental conditions or soil disturbances associated with anthrax outbreaks elsewhere.

Other outbreaks have been reported from regions where anthrax is not considered to be an existing threat to animal health, and globally, such instances may be observed in almost any given year (Figure 2). For example, several outbreaks were reported over a two-week period in cattle and horses from a cluster of farms in southeastern Sweden in July 2016 (OIE, 2016b). Subsequent anecdotal data reported suggest that there may have been unrecognized cases occurring sporadically in the region, as the area was known for "summer sickness" (piroplasmosis/babesiosis), but cases were not always confirmed by laboratory diagnosis. It, therefore, is possible that previous anthrax cases may have occurred but went undetected (ProMED, 2016b).

Anthrax outbreaks continue to occur with regularity in countries considered to be enzootic; however, there may be cases that appear in districts or regions on a more sporadic frequency where several years may pass between reports of cases in affected animals or in humans. For example,

Figure 4. Anthrax outbreaks reported in livestock, wildlife and humans, January 2005 to August 2016



Source: FAO

Box 1. Managing anthrax outbreaks

When an outbreak occurs, several immediate actions can be used to curb mortalities and limit the spread of anthrax infection. These include:

- vaccinate all susceptible animals in affected premises and surrounding premises. Based on the degree of vaccine potency and the severity and duration of the outbreak, more than one booster shot can be administered in the course of the outbreak;
- restrict/trace movement of livestock and animal byproducts from infected premises. Particular attention should be given to monitoring distribution of skins and hides from infected animals;
- use antibiotics to treat affected animals and, if necessary, exposed livestock to stop any incubating infections. Anthrax is very responsive to antibiotic treatment if this is administered early in the course of the infection;
- dispose of infected carcasses safely, and disinfect and decontaminate associated ground and all contaminated equipment and tools;
- conduct an epidemiological investigation to promptly identify the source of infection and to localize the outbreak;
- practise intensive surveillance and monitoring in areas surrounding the infected premises for early detection of additional anthrax cases.

General guidance on control of anthrax can be found in:

- World Health Organization (WHO). 1998. *Guidelines for the surveillance and control of anthrax in humans and animals*, 3rd edition.
- Organisation for Animal Health (OIE) 2007 *Terrestrial animal health code*, Appendix 3.6.6.
- WHO/OIE/FAO. 2008. *Anthrax in humans and animals*, 4th edition.

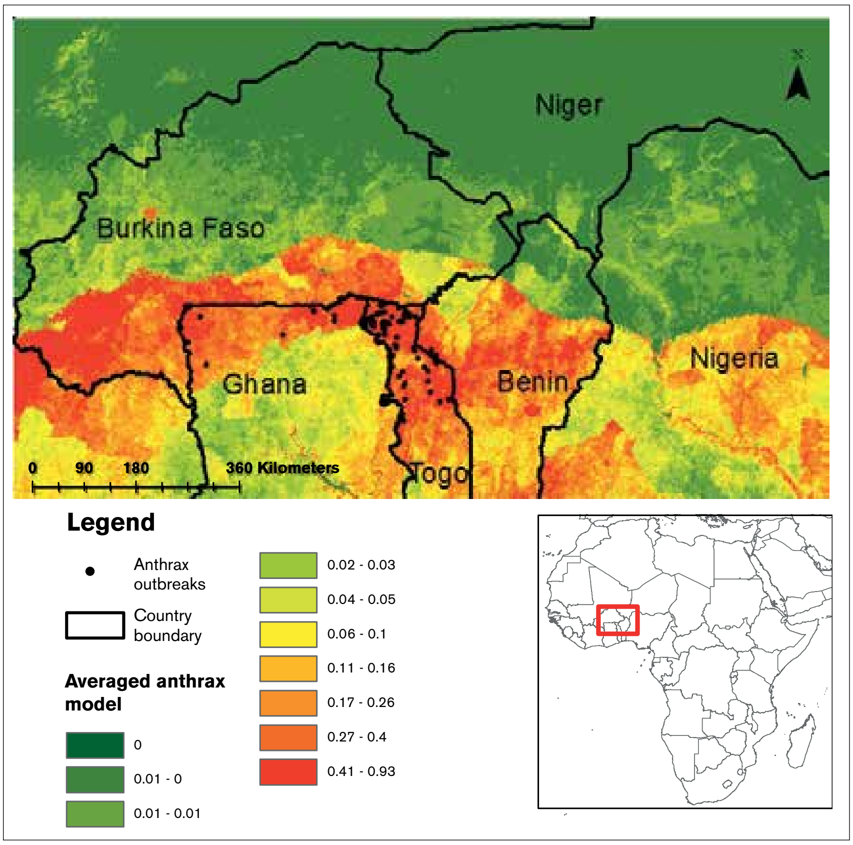
Source: FAO, 2011.

in Bangladesh anthrax has been reported in cattle and humans since 1980, and cases may be reported during any month of the year (Samad and Hoque, 1986). In 2008 and 2009, animal anthrax outbreaks were reported from 58 of the 64 districts in the country, and while some districts have outbreaks almost every year, in others they may occur only once every five years or more (Food and Agriculture Organization of the United Nations (FAO)/ OIE, 2010).

Africa continues to be plagued with recurrent anthrax outbreaks affecting both animals and humans. For the past 3 years, many countries in West and Central Africa including Benin, Burkina Faso, Ghana, the Niger and Togo have been frequently adversely affected by human and animal anthrax. In this region the majority of outbreaks occur between January and May, during the dry season and at the start of the wet season. The persistence of anthrax in the subregion can be explained, in part, by factors specific to the persistence of the pathogen in the soil, environmental conditions, and the lack of vaccination services and proper disposal of carcasses of infected animals. Socio-cultural practices at the community level such as slaughtering of sick animals or salvage butchering of dead animals, and eating or handling the meat from these infected animals, contribute to the recurrence of human anthrax cases.

In Eastern Europe and Central Asia, many

Figure 5. Predicted suitable ecological niche for anthrax outbreaks in West Africa



Source: FAO

countries including Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, and Uzbekistan consistently report animal and human anthrax cases occurring mainly on borders areas. As occurs in many locations worldwide, identification and reporting may be more sensitive for human cases than for animal cases and, therefore, human case reports may serve as an indicator for the presence of animal disease (Navdarashvili, 2015). Most cases of human anthrax in the region are reported during May to November, with a peak during July to August. This is believed to be associated with the movements of animals from summer grazing to winter grazing lands where grass growth is slight and the animals consume greater amounts of soil, and where they are stressed by migration.

Prevention and control measures

Surveillance, vaccination of livestock and proper disposal of livestock carcasses are the most efficient ways of preventing and controlling anthrax infection in domestic herds, which also limits its transmission to humans.

An important step in the implementation of anthrax control is the acquisition of data or information about the occurrence of the disease. Field data related to the characteristic of the pathogen, its ecology and determinants of its natural occurrence are very useful initial tools to livestock producers and veterinary services dealing with anthrax disease outbreaks. Surveillance data and risk modelling studies can be effectively used to identify areas where natural livestock cases of anthrax are likely to occur, and to guide the conduct of vaccination and public awareness programmes. These areas should also have an effective reporting system in place so that all unexpected livestock deaths during the period at risk for anthrax must be reported to the veterinary authorities for immediate investigation. Field veterinarians should have the ability to make the diagnosis on-site or a good liaison with the laboratory services to ensure diagnosis without delay. Veterinary services and public health authorities should cooperate to integrate disease surveillance data. This shared data will give a more complete picture of disease presence, and may identify regions where no animal cases are reported but where there are human anthrax cases, indicating the presence of disease in animals.

Anthrax can be prevented in livestock species through vaccination, which is the principal tool used for controlling anthrax in livestock. The mainstay for vaccination in livestock has been the avirulent live spore Sterne vaccine since it was first introduced (Turnbull, 1991); this vaccine or other similar avirulent live spore vaccines should be used between two to four weeks prior to the onset of an expected outbreak season. The vaccine may also be used to stop an ongoing outbreak in a susceptible animal population, and vaccination of affected herds has reduced mortality during an outbreak beginning eight days after vaccine administration (Fox, 1977). Interruption of anthrax vaccination programmes in endemic areas is a risk factor for both animals and humans.

Appropriate and safe disposal of dead animals, bedding and other contaminated materials, and subsequent disinfection and decontamination of all possible surfaces that can harbour anthrax spores are key steps in limiting the spread of anthrax and contamination of the environment. The ideal method of disposal of an anthrax carcass is incineration (Stoltenow, 2015; WHO, 2008). Where this method is not possible, deep burial is the alternative. Unlike burial, burning has the advantage of destroying anthrax spores and reducing the number of spores available in the environment and, therefore, reducing the chance of spores resurfacing years later.

Awareness for anthrax outbreaks

Given the important zoonotic implication of anthrax, villagers and community farmers at risk must be aware of the hazards of anthrax. Coordinated efforts are needed at the community level to promote utilization of veterinary services and vaccination of livestock to protect animal health and livelihoods of livestock owners, to promote proper disposal practices and to avoid slaughtering sick animals for consumption to protect human health.

Slaughtering sick animals and eating/handling meat from infected animals is a socio-cultural issue involving monetary motivations including the protection of farmer livelihoods. This issue needs to be addressed with effective community approaches and solutions to persuade community leaders and residents to avoid slaughtering infected animals and eating/handling meat from infected animals. Persons in the community must be educated about using personal protective equipment during the slaughtering of animals and handling of meat and skins. Increasing public awareness among rural households is effective but it would need to be coupled with other measures such as financial incentives or compensation for loss of animals to promote reporting, proper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carcass disposal, and utilization of anthrax vaccine. Close follow-up by local public health and veterinary services is also needed.

FAO response and analysis of anthrax outbreaks

FAO is working with various stakeholders to advance practical knowledge and response in countries experiencing significant outbreaks or where the disease is endemic. FAO promotes capacity building in and provides technical support through the Organization's Technical Cooperation Programme. The control strategies promoted by FAO in endemically-infected countries aim to prevent disease in susceptible species, using long-term vaccination as the main tool.

At the request of countries, FAO deploys joint missions with OIE and WHO to assess the disease situation and assist in developing an appropriate strategy for prevention and control of futures occurrences of the disease.

In addition, public awareness, targeted educational programmes and collaboration between the veterinary and public health sectors are promoted to facilitate more effective and rapid prevention of the disease in humans.

FAO has been very active in promoting the regional approach for cooperation and networking to facilitate cross-border coordination and build synergy and efficiency in anthrax control.

FAO's collaborative efforts in response to anthrax outbreaks and other zoonotic diseases in some countries (e.g. Bangladesh, Tajikistan, Uganda) have been good examples of "One Health in Action". Complementary activities at the community level, where local veterinary and public health services interact and cooperate, have facilitated the control of anthrax and other diseases through locally adapted approaches for improving surveillance, enhancing community awareness and delivering effective vaccination campaigns.

FAO collects and analyses data available in its Global Animal Disease Information System (EMPRES-i) to develop global maps of countries affected by anthrax. Data analysed include OIE-World Animal Health Information Database (WAHID) periodical data, and data on confirmed anthrax outbreaks in livestock, wildlife and humans provided by FAO field officers and field mission reports, national authorities and media reports. Figure 4 represents a distribution map identifying countries by numbers of outbreaks reported from 2005 to 2016. However, information on presence and distribution of anthrax, particularly at the global level, is impacted by variable sensitivity of disease surveillance systems, the relative strength of veterinary services, and by under-identification and underreporting of disease; therefore, any mapping is likely to be under-representative of the true disease distribution.

FAO additionally performs anthrax risk modeling studies to identify risk factors for anthrax occurrence in endemic regions. In a preliminary study (Pittiglio *et al.*, manuscript under preparation) of anthrax in West Africa, including Benin, Burkina Faso, Ghana, the Niger and Togo, a set of spatial environmental and climatic variables and different spatial niche modelling approaches were used to identify main determinants of anthrax occurrence and predict at-risk areas. The main predictors selected by the averaged model were: livestock density, precipitation during the coldest three months of the year, soil type and vegetation index. Other important predictors were mean diurnal range and elevation. The areas predicted to have the most suitable conditions (high-risk areas) are shown in Figure 5, and were primarily along the border between southern Burkina Faso, northern Ghana, northern Togo and northern Benin, suggesting a west to east belt of suitable habitat across these countries – a distribution pattern similar to previously published patterns (Blackburn, 2015).

Conclusion and recommendations

Although the true worldwide incidence of anthrax is unknown, official reports show that the disease is enzootic in many countries and that sporadic outbreaks are common. Experience shows that countries with inadequate veterinary and public health facilities, and areas where it is difficult to implement control programmes are the most affected.

The repeated occurrence of anthrax in livestock with spillover to humans suggests that improved prevention and control measures are needed to protect both animal and human health. These include:

- a preventive strategy involving annual vaccination of susceptible livestock animals (usually cattle, sheep and goats) in areas prone to the disease using quality-assured vaccines;
- an effective surveillance system both in the public health and the veterinary sectors to ensure earliest reporting and investigation of sudden death in livestock and wildlife;
- prompt disposal of dead animals, bedding and contaminated materials and control of scavengers;
- increased public awareness and observation of principles of general hygiene, including use of personal protective measures by people who may have contact with diseased or dead animals;
- enforcement of regulations pertaining to anthrax control including quarantine.

Anthrax provides a good platform for a One Health approach which can be operationalized through locally adapted approaches for prevention and control. These efforts should be supported by enhanced intersectoral collaboration and coordination between the veterinary and medical authorities, particularly at the field level, for information and report exchange, integration of surveillance data, joint case investigations, coordination of community awareness messaging and implementation, and effective delivery of vaccination campaigns.

Significant progress has been achieved in understanding the disease, but further research is required at both the national and regional levels, to improve understanding of the disease's ecology under natural conditions, so that potential risk factors can be identified and high-risk areas for anthrax occurrence can be defined. The use of risk assessment and modelling studies such as risk modelling and ecological niche modelling can be extremely helpful to develop regional and local level risk maps for anthrax outbreaks. They can also help to identify temporal patterns and specific environmental factors that may be used to predict when outbreaks may be likely to occur and can guide implementation of prevention and control strategies (Blackburn, 2015; Mullins, 2013).

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