Ajadi, B. Adediwura, S. Morakinyo, M. & Bakenne, H. Anthrax preparedness and mitigation strategies: lessons from global incidents for Nigeria's approach and prevention. *Global Biosecurity. 2023; 5(1)*

Review Article

Anthrax preparedness and mitigation strategies: lessons from global incidents for Nigeria's approach and prevention

Ajadi, B.[1] Adediwura, S.[2] Morakinyo, M.[1] & Bakenne, H.[1]

[1] Faculty of Pharmacy, Obafemi Awolowo University, Ile-Ife, Nigeria.

[2] Department of Microbiology, Obafemi Awolowo University, Ile Ife, Nigeria

Abstract

In July 2023, the Federal Ministry of Agriculture and Rural Development (FMARD) in Nigeria officially reported the first occurrence of animal anthrax disease in Niger State. Anthrax, caused by *Bacillus anthracis*, poses a significant infectious threat and is transmitted through contact with infected animals and by-products. Anthrax knows no borders, and our exploration of its global incidence reveals both commonalities and divergences in how nations confront this threat. These insights emphasize the importance of cattle immunization, quarantine, proper disposal techniques, strict adherence to quarantine regulations, and the use of personal protective equipment. Collaboration between public health and animal health authorities is crucial, along with epidemiological studies and surveillance. Additionally, vaccination and early diagnosis tools should be prioritized. Nigeria's outbreak response should focus on these lessons to enhance preparedness and mitigation strategies. Further research at all levels is recommended to improve understanding and prediction of anthrax outbreaks.

Key words: Anthrax; Preparedness; Mitigation; Nigeria

Background

Anthrax is a serious infectious disease that is classified as a bioterrorist weapon caused by *Bacillus anthracis,* a gram-positive spore-forming rod bacteria surrounded by capsules [1]. Anthrax produces toxins through the pXO1 virulence plasmid [2]. Contracted via contact with infected animals or their byproducts, it enters through the skin (cutaneous anthrax), lungs (pulmonary anthrax), or gut (gastrointestinal anthrax), and then germinates into the active form [3]. Germination releases toxins causing ulcers, hemorrhage, edema, necrosis, and death [3]. Gastrointestinal anthrax affects livestock and occasionally humans through contaminated byproducts, and presents with ulcers, pharyngitis, and gastrointestinal issues [3]. Inhalation of spores leads to inhalational anthrax, characterized by toxin-induced cell death, septic shock, and systemic disease [3].

On July 17, 2023, the Federal Ministry of Agriculture and Rural Development (FMARD) in Nigeria officially reported the first occurrence of animal anthrax disease on a farm in Niger State. This marks the first case in Nigeria since the West African outbreak began in Ghana in June 2023 [4]. Anthrax is endemic in several parts of the world, including the Americas, Sub-Saharan Africa, Central and Southwestern Asia, and Eastern Europe.

In this paper, we aim to extract lessons from international anthrax management practices, offering insights to shape Nigeria's prevention and mitigation strategy. We present a review of anthrax outbreaks globally and seek to apply this knowledge to fortify Nigeria's anthrax prevention measures.

Global Incidents and Responses

In 2016, the Yamal-Nenets anthrax outbreak in Russia led to 2,657 animal infections, and one human infection who subsequently died, which were caused by contact with these animals or by consuming contaminated meat or blood [5,6]. Similarly, a large anthrax epidemic in Rhodesia (now Zimbabwe) between 1978 and 1984, saw thousands of cattle affected and over 10,000 human cases [5]. The

measures taken to manage the anthrax outbreak were alike in both nations. They involved treating affected animals, implementing surveillance beyond the affected area, limiting the movement of potentially infected animals and animal products, disposing of dead affected animals through burning, and the use of disinfectant-spraying trucks to treat contaminated soil [5]. While most affected humans fully recovered with penicillin therapy, the inability to sustain control measures contributed to the further spread of the anthrax epidemic in Rhodesia [7]. The reanalysis by Wilson et al. [7] subsequently revealed that the anthrax outbreak in Rhodesia was a biological warfare event.

Anthrax outbreaks in other nations such as Canada, the USA, and Haiti have been primarily attributed to occupational exposure [8]. In Canada, most anthrax outbreaks in the early 20th century in southern Ontario and Quebec were linked to pastures contaminated by liquid waste from textile factories that used imported animal materials [8]. Similarly, in the USA, from 1944 to 1994, the majority of human anthrax infections were cutaneous in nature, and due to occupational exposure of textile workers to contaminated goat hair used when making waterproof linings for men's coats [8]. In Canada, the incidence of anthrax significantly decreased after the introduction of federal legislation in 1952, which mandated the disinfection of these imported materials [8]. While the majority of patients in both countries recovered with penicillin therapy, some died due to misdiagnosis and other factors [8]. Between 1963 and 1974 in Haiti, 194 cases of cutaneous and inhalation anthrax among those involved in goat skin product manufacturing may be attributed to the ineffective maintenance of animal vaccination programs, among other reasons [8].

Veterinary anthrax has been documented in Mexico, Europe, North Central Victoria in Australia, and South Africa [7,8]. When Europeans observed the ongoing spread of anthrax in their livestock, they initiated control programs, which eventually led to the development of vaccines starting in 1920. However, Mexico did not fully recognize the threat of veterinary anthrax until 1999, allowing the disease to persist without proper control measures [7,8]. In South Africa, anthrax was first identified in 1842, and it continued to spread until 1923, when vaccination of vulnerable herds was initiated, resulting in a significant reduction in animal anthrax cases [7]. In 1997, an anthrax outbreak affected approximately 83 farms in North Central Victoria, Australia. [8]. Effective responses were implemented to prevent further disease spread. Affected herds were isolated, infected carcasses were securely wrapped in plastic and incinerated, locations where animals died were thoroughly disinfected with 5% formaldehyde, and individuals entering affected areas were provided with protective gear and footwear that was disinfected before leaving the premises. Additionally, vaccinating susceptible herds played a crucial role in achieving proper control [8].

Lessons from global incidence to guide Nigeria's approach

Anthrax, being a zoonotic disease, is transmissible from animals to humans. An outbreak requires prompt response and mitigation to prevent its spread. Drawing insights from the approach to mitigating anthrax during previous outbreaks in other countries will guide Nigeria's approach to minimizing the effect of the endemic disease. Most naturally occurring human anthrax cases in endemic countries are related to exposure to infected animals or their byproducts. Therefore, control of animal anthrax reduces human risk. Experience shows that countries with inadequate veterinary and public health facilities and areas where it is difficult to implement control programs are the most affected.

As seen in the response to the Yamal-Nenets outbreak in Russia 2016, livestock vaccination was the principal tool used in controlling anthrax [5]. Nigeria's approach should ensure that vaccination and quarantine of suspected livestock are prioritized. Medical personnel should have access to appropriate vaccines, such as the avirulent live spore Sterne vaccine [9]. The Sterne strain is relatively avirulent; however, immunization with the Sterne strain is capable of stimulating a protective immune response [10]. The Sterne strain is currently the dominant strain worldwide for immunizing domestic animals against anthrax and has been used for this purpose since the late 1930s [10]. It is administered to animals at a dose containing up to 10 million viable spores. The Sterne strain has an excellent safety record and is used safely worldwide by laboratory personnel involved in its production and by hundreds of thousands of veterinarians [10]. The Nigerian government should work with global organizations to invest in research into broad-spectrum vaccines that cover variants of anthrax. In addition to this, herdsmen and veterinarians should receive authoritative information on animal vaccine use to break the cycle of transmission.

Nigeria's government should enforce proper and safe carcass disposal, as this is critical in controlling anthrax outbreaks in affected areas, as inappropriate carcass disposal seeds the soil with spores and increases the risk for future outbreaks. Global

recommendations for carcass disposal are that carcasses should be burned in place, using a pyre or other method that leaves only ash and allows the destruction of the contaminated soil [11]. When a carcass cannot be burned, global recommendations are to bury it deeply [11]. The historic practice of adding lime should be avoided as lime increases soil calcium levels, which is conducive to B. *anthracis* spore survival and increases the likelihood of future outbreaks [12].

To prevent disease spread, quarantine is essential, as it limits contact between affected and non-affected herds, thereby preventing the occurrence of future outbreaks. The Nigeria Centre for Disease Control (NCDC) should collaborate with the Department of Veterinary and Pest Control Services under the FMARD and the Emergency Center for Transboundary Animal Disease (ECTAD) of the Food and Agriculture Organization (FAO) to enforce quarantine in susceptible areas to contain the outbreak. Personal protective equipment (PPE) should also be used by people who handle and dispose of infected animals, thus minimizing the risk of exposure. This includes gloves that can be disinfected or disposed of, long sleeves and pants, and footwear suitable for the terrain to be disinfected.

Public health and animal health agencies must collaborate to heighten awareness among medical and animal health communities, as well as among herdsmen and other inhabitants of at-risk areas. Timely delivery of information to herdsmen or livestock farmers on proper carcass disposal, and appropriate use of PPE, and recognition of clinical anthrax, should be enforced. If exposure is recognized, appropriate antibiotics should be administered by medical providers. Villagers and community farmers, who are the primary target of this outbreak, should be educated on the social-cultural practices of slaughtering sick animals. Also, eating or handling meat from infected livestock should be discouraged, as this contributes to outbreak reoccurrence.

There is need for global collaboration of people working together in all sectors to attain optimal health for humans, animals, and the environment - One Health. This is crucial, as the health of people is closely connected to that of animals and the environment [13]. By understanding this complex interaction, we can develop approaches that ensure not only healthy humans but also those of other sectors [13]. This approach will involve communication across the public health, veterinary, and environmental sectors to address the root causes of disease and to create sustainable solutions to promote health, prevent pandemics, and address environmental concerns [13]. Efforts can be geared towards making policies and enforcing laws that take all sectors into consideration.

Lastly, conducting epidemiological investigations and intensive surveillance around infected sites can help localize a disease outbreak. Nigeria should adopt this approach to reduce deaths and limit the infection's spread. More research at national and regional levels is recommended to understand anthrax ecology better and identify risk factors. Risk assessment and modelling studies, such as risk modelling and ecological niche modelling, can aid in creating regional risk maps for anthrax outbreaks, predicting likely outbreak times, and guiding prevention and control efforts.

Conclusion

Drawing from global anthrax incidents, Nigeria can strengthen its anthrax preparedness and mitigation efforts. Key lessons include prioritizing cattle immunization and quarantine, effective disposal methods such as burning or deep burial of carcasses, strict adherence to quarantine regulations, PPE use, and collaboration between public health and animal health authorities are all necessary for reducing exposure and transmission. Early detection relies on epidemiological studies and robust surveillance. Nigeria should encourage cooperation for continuous vaccination, educate farmers and the public, enforce proper handling of ill animals, mandate disinfection of imported animal products, and ensure access to early diagnostic tools, collectively fortifying its defenses against anthrax.

References

1. Boutiba-Ben Boubaker I, Ben Redjeb S. *Bacillus anthracis*: causative agent of anthrax. Europe PMC. 2001, 79(12):642-646.
2. William A. Bower, Katherine A. Kendricks, Antonio R. Vieira, et. al. What is Anthrax? MDPI. 2022, 11(6), 690. doi: 10.3390/pathogens11060690
3. Kamal SM, Rashid AK, Bakar MA, Ahad MA. Anthrax: an update. Asian Pac J Trop Biomed. 2011;1(6):496-501. doi:10.1016/S2221-1691(11)60109-3
4. Nigeria Centre for Disease Control and Prevention. Confirmation of Anthrax Outbreak in Nigeria.NCDC. July 17, 2023.

https://ncdc.gov.ng/news/491/confirmation-of-anthrax-outbreak-in-nigeria

5. Sean Shadomy, Ahmed El Idrissi, Eran Raizman, Mirko Bruni, Elisa Palamara, Claudia Pittiglio and Juan Lubroth. Anthrax outbreaks: a warning for improved prevention, control, and heightened awareness. VOL 37 — September 2016;
6. Stella E, Mari L, Gabrieli J, Barbante C, Bertuzzo E. Permafrost dynamics and the risk of anthrax transmission: a modelling study. Scientific Reports. 2020;10(1). doi:10.1038/s41598-020-72440-6
7. Wilson JM, Brediger W, Albright TP, Smith-Gagen J. Reanalysis of the anthrax epidemic in Rhodesia, 1978-1984. PeerJ. 2016 Nov 10;4:e2686. doi: 10.7717/peerj.2686. PMID: 27867766; PMCID: PMC5111893.
8. Levin RE. Anthrax: History, Biology, Global Distribution, Clinical Aspects, Immunology, and Molecular Biology. Bentham Science Publishers; 2015.
9. Turnbull, P.C.B. 1991. Anthrax Vaccines: past, present and future. Vaccine, 9(8): 533-39
10. Anthrax Sterne strain (34F2) of Bacillus anthracis. CDC. https://www.cdc.gov/anthrax/resources/anthrax-sterne-strain.html
11. World Health Organization. Anthrax in humans and animals. 4th ed. 2008. [cited 2020 Jan 31]. Available from: https://www.who.int/csr/resources/publications/AnthraxGuidelines2008
12. Himsworth C.G. 2008. The danger of lime use in agricultural anthrax disinfection procedures: the potential role of calcium in the preservation of anthrax spores. Can Vet J.;49:1208–10
13. One Health Basics | One Health | CDC. https://www.cdc.gov/onehealth/basics/index.html

How to cite this article: Ajadi, B. Adediwura, S. Morakinyo, M. & Bakenne, H. Anthrax preparedness and mitigation strategies: lessons from global incidents for Nigeria's approach and prevention. *Global Biosecurity. 2023; 5(1).*

Published: December 2023

Global Biosecurity is a peer-reviewed open access journal published by University of New South Wales.