

The Power of Bacillus Anthracis on Public Health and Bioterrorism

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Article Info	ABSTRACT
Article history: Received May, 20, 2025 Revised July, 04, 2025 Accepted August, 05, 2025	Anthrax bacteria are gram-positive, a filamentous, spore-forming bacterium, is the etiological agent of anthrax. Anthrax spreads in a variety of ways, making our ability to quickly and accurately detect the agent critical. These bacteria can cause illnesses that can lead to death if left untreated. Anthrax is critical to public health and the fight against bioterrorism and has been used as a biological weapon. The goal is to understand how anthrax bacteria, which have been used as a weapon to terrorize populations, can cause other diseases that are camouflaged when transmitted to humans.
Keywords: Bacillus, Anthrax, Bioterrorism, Virulence Factor, History	
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1- INTRODUCTION

Bacillus anthracis, gram-positive, a filamentous, spore-forming bacterium, is the etiological agent of anthrax. It is accomplished of causing a rapid and violent progressive disease commonly limited to animals [1].

Spores of *Bacillus anthracis* can persist in the environment for many decades, and possibly, centuries, given that pressure and natural conditions of heat can progressively degrade the peptidoglycan matrix of the spore cortex wall, enabling erosion and spore germination into the vegetative state. The little mass, dehydrated spores are then readily discrete through the air and can simply gain entry into the alveoli of the lungs of naïve hosts [2, 3].

In spite of the reality of anthrax such as a major concern for public health and bioterrorism, there survives a paucity of literature concerning the epidemiological trends, clinical administration, and methods of excluding *B. anthracis* environmental contamination [2, 4].

The goal is to understand how anthrax bacteria, which have been used as a weapon to terrorize populations, can cause other diseases that are camouflaged when transmitted to humans.

Anthrax Disease

Live spores of *Bacillus anthracis* are transmitted to the host through several routes, most notably skin contact, inhalation, and oral administration. Clinical symptoms of anthrax vary depending on the route of infection, from localized skin ulcers to rapidly progressing pneumonia, hemorrhagic meningoencephalitis, and ulcerative esophagitis [3].

Cutaneous anthrax is the most public form of anthrax, representative 95% of all anthrax cases. Transmission occurs when spores contact a patient's skin via a break in the skin, for instance a cut or abrasion [5].

It frequently initiates with skin infection after contact with an unclean anthrax spore-contaminated animal body or hair products and is not usually transmitted person to person. In 1-6 days, a pruritic pustule naturally forms at the exposure site, resulting in a painless ulcer and sometimes-regional lymphadenopathy [6].

Pulmonary anthrax, a severe variant of the disease, generally presents initially with non-specific clinical manifestations such as moderate cough, fever, and malaise, which may mimic an upper respiratory infection [7]. Subsequent this prodromal phase, the condition progresses very quickly to the toxemic phase where cough, chest

pain and dyspnea develop. Pulmonary anthrax can be transmitted via numerous mechanisms, but the overwhelming majority of historically reported cases are due to the inhalation of spores through industrial handling of contaminated animal products or intentional release in a form of bioterrorism [6, 8].

Gastrointestinal anthrax can manifest subsequent the oral consumption of undercooked contaminated animal meat, frequently within 3-7 days, leading to ulcerative lesions with related impeding swallowing, pharyngeal and thoracic edema, rapid progression to hemorrhaging, severe oropharyngeal swelling and fatal suffocation, to the life-threatening sores of anemia, to a slow esophageal ulcerative [6, 7, 9].

Virulence factor

One of the causes *B. anthracis* is very pathogenic is genes on plasmids that encode virulence factors responsible for anthrax progression. That has several virulence factors, namely major toxins that are lethal factor, protective antigen and edema factor [10].

These toxins are encoded through two water-soluble protein chain components called genes *lef* and *pag*. Product of gene in anthrax pathogenic system must spread from extracellular space to the host cell. Protective antigens belong to group IV ABC-type transporter ATPase proteins [11].

The toxin complexes are undergo endocytosis that recognized by host protein anthrax toxin receptors. Protective antigen that formed by anthrax toxin is one subunit of the heptameric channel. Through binding to the cellular receptors of two types, anthrax toxin can bind to protective antigen [12].

These proteins contain membrane pore formation activity, which usually forms a transmembrane channel, or pore by first binding protective antigen heptamer in the extracellular space. Protective antigens then adhere to diverse cell surface receptors. Protective antigen can bind to two anthrax toxin receptors or type I membrane proteins. [12, 13] Subsequent translocation into the cell, edema factor or lethal factor immediately interferes with host intracellular signal transduction processes. Lethal factor is a zinc-dependent metalloproteinase which inactivates mitogen-activated protein kinase. Edema factor is a calmodulin-dependent adenylate cyclase which dysregulates cellular ion homeostasis. The causal mechanism for edema and tissue damage in animals infected with *B. anthracis* has been indefinable [14].

Bioterrorism and Anthrax

After the tragic occasions of September 11, 2001, *Bacillus anthracis* was used in a sequence of bioterrorist attacks in the United States. Altogether, 22 cases of clinical anthrax were documented; 5 of these were fatal [15].

Another 5 persons working in postal facilities developed inhalation anthrax; in those cases, illness was primarily missed, and 2 of those 5 individuals died. Furthermore, 12 persons were diagnosed with cutaneous anthrax. Hundreds of thousands of persons received potentially contaminated letters through that they could have become exposed to spores of *B. anthracis* [8, 16].

Early symptoms are nonspecific that make identification of anthrax cases difficult, for instance, it did in the 2001 attacks. Certainly, in the United States, a number of emergency room physicians had not ever seen a case of anthrax and were unaware with the symptoms [17, 18].

This absence of familiarity caused delays in diagnosis in initial cases, and in three cases delay was difference between life and death. In the case of inhalation anthrax, this delay donates to a lower likelihood of cure [18, 19] Other forms of bioterrorism that effects may be both physical and psychological. This is mainly case with inhalation anthrax that has a high fatality rate. Recovery of exposed areas using treatment regimens or/ and prophylactic is resource-intensive. Health systems are not prepared for bioterrorism [20, 21].

This is because of multiplicity of bioterror agents and delayed activation and logistics of response once one of these bioterror agents is documented. Nevertheless, moves are formerly afoot to plan for bioterrorist incidents [22].

Public health officials consider that education campaigns and active surveillance systems have twofold benefit of educating the public on preventive measures in addition to providing information on prevention of disease to most vulnerable patients. Besides, if disease prevention efforts are intended at raising consciousness or using mass media campaigns, as perceived fear of disease increases, demand for preventive interventions will increase. Educated individuals will be more effective in preventing the spread of disease, such as through vaccination and promoting hygiene and sanitation practices [17, 23].

History of bioterrorism

Bacillus anthracis is one of the relatively few organisms identified to have been manipulated intentionally to reason havoc in the public arena. Nevertheless, use of *Bacillus anthracis* deceptively predates known historical records, its first predictable use as an agent of war arisen during World War I, after troops on both sides reported a loss of horses to anthrax disease. The release of *Bacillus anthracis* spores was abundant more dramatic through World War II, when a program resulted in above 100 predictable cases of anthrax among horses ,cattle and humans in China [24, 25].

The increase of *Bacillus anthracis* as a bioterror agent paralleled the political landscape of middle to latter half of the 20th century; definitely, the release spore of anthrax that arose between 1940 and 1970 was motivated by a combination of political and publicity strategies [24, 26].

In the mid-20th century, the United States supposed responsibility for development of biological weapons after it embarked on biodefense research and development creativities. In step with conservative warfare in World War II, the purpose of using biological weapons was to prevent enemies as an advanced military capability [27].

Reasonably, governments and terrorist organizations have exploited the use of psychological tactics to attain ideological goals. Use of bio agents to kill livestock for political achieve was undertaken by a good fellow in the late 20th century, probable established on the ambition to attack fear into the hearts of masses [28].

As the use of *Bacillus anthracis* as a means shifted from gathering political influence and causing extreme economic damage to a potential public health crisis, the risk of using a bio agent for ideological purposes became secondary to apparent threat by foreign terrorist organizations, predominantly from the late 1960s onward [6]. Subsequent these incidents, a sequence of policies were instituted to improve regulate bio agents and genetically modified organisms, cause the Biological Weapons Convention. Lifecycle events of anthrax in context of bioterror offer insight on how public health response systems have progressed and continue to progress because of such considerations [29].

2- CONCLUSION

Since 2001, there have been numerous anthrax incidents that can be characterized as a pathogen that could potentially be used as a bioterrorist agent.

REFERENCES

- [1] Wang, S., Suluku, R., Jalloh, M. B., Samba, A. F., Jiang, B., Xie, Y., et al. (2024). Molecular characterization of an outbreak-involved *Bacillus anthracis* strain confirms the spillover of anthrax from West Africa. *Infectious Diseases of Poverty*, 13(1), 6. <https://doi.org/10.1186/s40249-024-01156-4>
- [2] Romero-Alvarez, D., Peterson, A. T., Salzer, J. S., Pittiglio, C., Shadomy, S., Traxler, R., et al. (2020). Potential distributions of *Bacillus anthracis* and *Bacillus cereus* biovar anthracis causing anthrax in Africa. *PLoS Neglected Tropical Diseases*, 14(3), e0008131. <https://doi.org/10.1371/journal.pntd.0008131>
- [3] Hsieh, H. Y., & Stewart, G. C. (2023). Does environmental replication contribute to *Bacillus anthracis* spore persistence and infectivity in soil? *Research in Microbiology*. <https://doi.org/10.1016/j.resmic.2023.103018>
- [4] Blacksell, S. D., Dhawan, S., Kusumoto, M., Le, K. K., Summermatter, K., O'Keefe, J., et al. (2023). The Biosafety Research Road Map: The search for evidence to support practices in the laboratory—*Bacillus anthracis* and *Brucella melitensis*. *Applied Biosafety*, 28(2), 72–86. <https://doi.org/10.1089/apb.2022.0038>
- [5] Thompson, J. M., Cook, R., Person, M. K., Negrón, M. E., Traxler, R. M., Bower, W. A., & Hendricks, K. (2022). Risk factors for death or meningitis in adults hospitalized for cutaneous anthrax, 1950–2018: A systematic review. *Clinical Infectious Diseases*, 75(Suppl 3), S459–S467. <https://doi.org/10.1093/cid/ciac486>
- [6] Finke, E. J., Beyer, W., Loderstädt, U., & Frickmann, H. (2020). The risk of contracting anthrax from spore-contaminated soil: A military medical perspective. *European Journal of Microbiology and Immunology*, 10(2), 29–63. <https://doi.org/10.1556/1886.2020.00006>

- [7] Rahim, M. F., Ahmad, M. Z., Naeem, R. F., Sohoo, M. U. R., Sindhu, Z. U. D., Tahir, A. H., & Zafar, M. A. (2023). Anthrax and its impact on public health. In *Zoonosis* (Vol. 4, pp. 502–509). Unique Scientific Publishers.
- [8] Hendricks, K., Person, M. K., Bradley, J. S., Mongkolrattanothai, T., Hupert, N., Eichacker, P., et al. (2022). Clinical features of patients hospitalized for all routes of anthrax, 1880–2018: A systematic review. *Clinical Infectious Diseases*, 75(Suppl 3), S341–S353. <https://doi.org/10.1093/cid/ciac460>
- [9] Subedi, D., Pantha, S., Jyoti, S., Gautam, B., Kaphle, K., Yadav, R. K., ... & Dhakal, S. (2024). Anthrax in humans, animals, and the environment and the One Health strategies for anthrax control. *Pathogens*, 13(9), 773. <https://doi.org/10.3390/pathogens13090773>
- [10] Aoyagi, T., Oshima, K., Endo, S., Baba, H., Kanamori, H., Yoshida, M., ... & Kaku, M. (2020). Ba813 harboring *Bacillus cereus*, genetically closely related to *Bacillus anthracis*, causing nosocomial bloodstream infection: Bacterial virulence factors and clinical outcome. *PLOS ONE*, 15(7), e0235771. <https://doi.org/10.1371/journal.pone.0235771>
- [11] Belosludtseva, N. V., Uryupina, T. A., Pavlik, L. L., Mikheeva, I. B., Talanov, E. Y., Venediktova, N. I., ... & Mironova, G. D. (2024). Pathological alterations in heart mitochondria in a rat model of isoprenaline-induced myocardial injury and their correction with water-soluble taxifolin. *International Journal of Molecular Sciences*, 25(21), 11596. <https://doi.org/10.3390/ijms252111596>
- [12] Liu, W., & Nestorovich, E. M. (2021). Anthrax toxin channel: What we know based on over 30 years of research. *Biochimica et Biophysica Acta (BBA) - Biomembranes*, 1863(11), 183715. <https://doi.org/10.1016/j.bbamem.2021.183715>
- [13] Becker, L., Verdurmen, W. P. R., & Plückthun, A. (2020). Reengineering anthrax toxin protective antigen for improved receptor-specific protein delivery. *BMC Biology*, 18, Article 123. <https://doi.org/10.1186/s12915-020-00831-6>
- [14] Mendenhall, M. A., Liu, S., Portley, M. K., O'Mard, D., Fattah, R., Szabo, R., ... & Moayeri, M. (2020). Anthrax lethal factor cleaves regulatory subunits of phosphoinositide-3 kinase to contribute to toxin lethality. *Nature Microbiology*, 5(12), 1464–1471. <https://doi.org/10.1038/s41564-020-00801-1>
- [15] Tin, D., Sabeti, P., & Ciottone, G. R. (2022). Bioterrorism: An analysis of biological agents used in terrorist events. *The American Journal of Emergency Medicine*, 54, 117–121. <https://doi.org/10.1016/j.ajem.2021.12.043>
- [16] Schneider, S. N., Nguyen, T. Q., Hake, K. L., Nightingale, B. S., Mangan, T. P., Rice, A. N., & Carroll, J. C. (2024). Development of a pharmacy point-of-dispensing toolkit for anthrax post-exposure prophylaxis for Allegheny County postal workers. *Journal of Public Health Management and Practice*, 30(2), 231–239. <https://doi.org/10.1097/PHH.0000000000001654>
- [17] Ogunleye, S. C., Olorunshola, M. M., Fasina, K. A., Aborode, A. T., Akinsulie, O. C., Amoo, A., et al. (2024). Anthrax outbreak: Exploring its biological agents and public health implications. *Frontiers in Tropical Diseases*, 4, 1297896. <https://doi.org/10.3389/fitd.2024.1297896>
- [18] Chen, X., Bahl, P., de Silva, C., Heslop, D., Doolan, C., Lim, S., & MacIntyre, C. R. (2020). Systematic review and evaluation of mathematical attack models of human inhalational anthrax for supporting public health decision making and response. *Prehospital and Disaster Medicine*, 35(4), 412–419. <https://doi.org/10.1017/S1049023X20000312>
- [19] Bower, W. A., Hendricks, K. A., Vieira, A. R., Traxler, R. M., Weiner, Z., Lynfield, R., & Hoffmaster, A. (2022). What is anthrax? *Pathogens*, 11(6), 690. <https://doi.org/10.3390/pathogens11060690>
- [20] Murray, E. J., Mason, M., Sparke, V., & Zimmerman, P. A. P. (2021). Factors influencing health care workers' willingness to respond to duty during infectious disease outbreaks and bioterrorist events: An integrative review. *Prehospital and Disaster Medicine*, 36(3), 321–337. <https://doi.org/10.1017/S1049023X21000251>

- [21] Rocque, R. (2020). Bioterrorism: Are we ready for such health care emergencies? *International Journal of Nursing Education and Research*, 8(4), 554–558. <https://doi.org/10.5958/2454-2660.2020.00132.3>
- [22] Logan-Henfrey, L. (2020). Mitigation of bioterrorist threats in the 21st century. In *Bioterrorism: The History of a Crisis in American Society* (pp. 329–341). Salem Press.
- [23] Hosseini-Shokouh, S. J., Sheikhi, R. A., Hosseini, S. M. R., & Moradimajd, P. (2021). The biological weapons threats and coping strategies for health promotion. *Journal of Education and Health Promotion*, 10(1), 1–6. https://doi.org/10.4103/jehp.999_20
- [24] Finke, E. J., Beyer, W., Loderstädt, U., & Frickmann, H. (2020). The risk of contracting anthrax from spore-contaminated soil: A military medical perspective. *European Journal of Microbiology and Immunology*, 10(2), 29–63. <https://doi.org/10.1556/1886.2020.00006>
- [25] Salgado, J. R., Rabinovitch, L., Gomes, M. D. F. D. S., Allil, R. C. D. S., Werneck, M. M., Rodrigues, R. B., et al. (2020). Detection of *Bacillus anthracis* and *Bacillus anthracis*-like spores in soil from state of Rio de Janeiro, Brazil. *Memórias do Instituto Oswaldo Cruz*, 115, e200370. <https://doi.org/10.1590/0074-02760200370>
- [26] Person, M. K., Cook, R., Bradley, J. S., Hupert, N., Bower, W. A., & Hendricks, K. (2022). Systematic review of hospital treatment outcomes for naturally acquired and bioterrorism-related anthrax, 1880–2018. *Clinical Infectious Diseases*, 75(Suppl 3), S392–S401. <https://doi.org/10.1093/cid/ciac467>
- [27] Vogel, W. F. (2021). *The mighty microbe can go to war: Scientists, secrecy, and American biological weapons research, 1941–1969*. University Press of Kansas.
- [28] Oliveira, M., Mason-Buck, G., Ballard, D., Branicki, W., & Amorim, A. (2020). Biowarfare, bioterrorism and biocrime: A historical overview on microbial harmful applications. *Forensic Science International*, 314, 110366. <https://doi.org/10.1016/j.forsciint.2020.110366>
- [29] Hussain, T., Akthar, N., Aminedi, R., Danish, M., Nishat, Y., & Patel, S. (2020). Role of the potent microbial-based bioagents and their emerging strategies for the ecofriendly management of agricultural phytopathogens. In *Natural Bioactive Products in Sustainable Agriculture* (pp. 45–66). Springer. https://doi.org/10.1007/978-981-15-4890-3_3

قوة عصيات الجمرة الخبيثة على الصحة العامة والإرهاب البيولوجي

الخلاصة

بكتيريا الجمرة الخبيثة بكتيريا موجبة الجرام، خيطية، مكونة للأبواغ، وهي العامل المسبب للجمرة الخبيثة. تنتشر الجمرة الخبيثة بطرق متنوعة، مما يجعل قدرتنا على اكتشاف العامل بسرعة ودقة أمرا بالغ الأهمية. يمكن أن تسبب هذه البكتيريا أمراضا قد تؤدي إلى الوفاة إذا تركت دون علاج. تعتبر الجمرة الخبيثة بالغة الأهمية للصحة العامة ومكافحة الإرهاب البيولوجي، وقد استخدمت كسلاح بيولوجي.

تهدف هذه الدراسة الى فهم إمكانية بكتيريا الجمرة الخبيثة للإستخدام كسلاح بايولوجي في إرهاب السكان، بالإضافة الى تسببها في أعراض أخرى عند إنتقالها بين الناس.

