



Review Article

Ebola Epidemic: A Retrospective Review on Pathophysiology, History, Epidemiology, Diagnosis, Treatment and Prevention (1976–2023)

Margret Chandira Rajappa¹, Ranjithkumar Sivaji², Sanjay Gnana Moorthi³, Venkateswarlu Bendi⁴

¹Department of Pharmaceutics, ²Research scholars, ³M.Pharma, Department of Pharmaceutics, ⁴Professor and Principal, Vinayaka Mission's College of Pharmacy, Vinayaka Mission's Research Foundation, (Deemed to be University) Yercaud main road, Salem, Tamil Nadu, India.

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Corresponding Author:

Margret Chandira Rajappa, Vinayaka Mission's Research Foundation, (Deemed to be University) Yercaud main road, Salem, Tamil Nadu, India.

E-mail Id:

margretjoan22@gmail.com

Orcid Id:

<https://orcid.org/0000-0002-6553-0825>

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A B S T R A C T

This retrospective review article provides an analysis of Ebola Virus Disease (EVD) outbreaks and case studies spanning the period from 1976 to 2023, drawing on authoritative sources including the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC). The review examines pivotal events, epidemiological patterns, and critical interventions employed to mitigate the impact of the Ebola virus. Special attention has been given to significant outbreaks, notably the unprecedented West Africa epidemic (2014–2016) and subsequent occurrences in the Democratic Republic of Congo. This article serves as a comprehensive reference for understanding the evolutionary path of Ebola outbreaks and provides valuable insights for future preparedness and response efforts. Moreover, this review delves into the diverse strategies employed in outbreak control, emphasising the significance of early detection, contact tracing, isolation protocols, and vaccination campaigns. It also examines the impact of community engagement, public health education, and international collaboration in mitigating the spread of the virus. Through a synthesis of case studies, this article extracts critical insights and lessons gleaned from each outbreak, shedding light on the evolution of diagnostic and therapeutic interventions. The analysis underscores the pivotal role of research advancements in vaccine development and therapeutic modalities.

Keywords: Ebola Virus Disease (EVD), Ebola Outbreaks, World Health Organization (WHO), Centres for Disease Control and Prevention (CDC), Zaire Ebolavirus, Sudan Ebolavirus



Introduction

The Ebola Virus Disease (EVD) stands as a testament to the profound impact that infectious diseases can wield on global health. Since the first emergence in 1976, Ebola outbreaks have been punctuated by devastating consequences, challenging healthcare systems, communities, and nations alike. This comprehensive review endeavours to chronicle the trajectory of these outbreaks, spanning from their inception in 1976 to the present day in 2023. Drawing on the authoritative insights of organisations such as the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), this review navigates through pivotal events, epidemiological patterns, and the critical interventions that have shaped our responses to this formidable virus.¹

In examining the chronological tapestry of Ebola outbreaks, special attention has been paid to the unparalleled West Africa epidemic that raged from 2014 to 2016, leaving an indelible mark on global public health. Subsequent occurrences in the Democratic Republic of Congo, a testament to the tenacity of this virus, have also been scrutinised. Through this comprehensive exploration, a mosaic of lessons emerges — lessons that have illuminated the path forward in our collective endeavour to combat and mitigate the impact of Ebola outbreaks.

This review extends retrospective analysis; it ventures into

the diverse strategies employed in outbreak control. The significance of early detection, contact tracing, rigorous isolation protocols, and targeted vaccination campaigns form the cornerstone of these efforts. Moreover, it shines a light on the pivotal role played by community engagement, public health education, and international collaboration in stemming the tide of the virus.² As we delve into the annals of Ebola outbreaks, it is imperative to distil from history the wisdom that will guide our future preparedness and response efforts. Through this comprehensive review, we embark on a journey through time, glean insights that will shape our resilience in the face of infectious threats.

Types and Classification of Ebola

Ebola is a very contagious and dangerous virus that falls under a group called Filoviruses. It was discovered in 1976 near the Ebola River in what is now the Democratic Republic of Congo. This virus can lead to a serious illness known as Ebola Virus Disease (EVD) in both humans and certain primates.

When someone gets EVD, they might experience things like a high fever, feeling very tired, muscle aches, bad headaches, and in severe cases, they might have bleeding inside and outside the body. It spreads when someone comes in direct contact with the bodily fluids (like blood, saliva, urine, and stool) of a person or animal who is infected. It is really important to be careful and take precautions to avoid getting sick from it.³

Table 1. Types of Ebolaviruses

S. No.	Name of Viral Species	Name of Disease	Geographic Origin	Special Characteristics
1	Zaire ebolavirus	Ebola Virus Disease (EVD)	Central Africa	Most virulent species; associated with severe outbreaks, high mortality rates, and significant haemorrhagic symptoms
2	Sudan ebolavirus	Sudan Virus Disease	Eastern and Northern Africa	Causes less severe outbreaks compared to Zaire ebolavirus, but still leads to high mortality rates
3	Tai Forest ebolavirus	Tai Forest Virus Disease	West Africa	Initially discovered in the Ivory Coast and later in Guinea; associated with milder symptoms and fewer outbreaks
4	Bundibugyo ebolavirus	Bundibugyo Virus Disease	Uganda	Less severe compared to Zaire ebolavirus, but still leads to outbreaks with a notable number of cases
5	Reston ebolavirus	Reston Virus Disease	Philippines, China	Only known to cause disease in non-human primates; does not cause severe illness in humans

There are five types of ebolaviruses that can make people sick. Each has its own special name as shown in Table 1.

Each of these viruses has its own type, and when they spread to people, they can cause different kinds of sicknesses. It is good to remember that even though they have things in common, they also have special traits. They can be found in different parts of the world, and some can be more dangerous than others.

Zaire ebolavirus

Zaire ebolavirus, also known as the Zaire strain of the Ebola virus, is a particularly virulent and dangerous type of ebolavirus. It is responsible for causing EVD.

Sudan ebolavirus

Sudan ebolavirus is one of the types of ebolaviruses that can cause illness in people. This specific virus belongs to the Sudan ebolavirus species. When someone gets infected with Sudan ebolavirus, it leads to a sickness known as the Sudan Virus Disease.

Tai Forest ebolavirus

Tai Forest ebolavirus is a type of virus that belongs to the ebolavirus family. It was first identified in the Tai Forest region of Ivory Coast. This virus can cause a disease known as the Tai Forest Virus Disease in humans. While it shares similarities with other ebolaviruses, it has its own distinct characteristics and is typically found in specific geographic regions. It is important to note that research on Tai Forest ebolavirus is ongoing to better understand its behaviour and develop effective prevention and treatment strategies.

Bundibugyo ebolavirus

Bundibugyo ebolavirus, often referred to as the Bundibugyo virus, is one of the four types of ebolaviruses known to affect humans. This virus was first identified in 2007 in the Bundibugyo District of Uganda. It causes a disease known as the Bundibugyo Virus Disease. Individuals infected with Bundibugyo ebolavirus may experience symptoms including fever, weakness, muscle pain, and in severe cases, bleeding. While it shares similarities with other ebolaviruses, it possesses distinct genetic characteristics. Understanding this unique virus is crucial for developing effective prevention and treatment strategies.

Pathophysiology

When the Ebola virus enters the human body, it primarily targets immune cells and cells lining blood vessels. Once inside, the virus tricks the immune system, evading detection and rapidly replicating. This leads to a surge in viral load, overwhelming the body's defences. As the infection progresses, it disrupts the body's ability to regulate blood clotting and inflammation, leading to abnormal clot formation and haemorrhaging.

Additionally, Ebola interferes with the production of key signalling molecules called cytokines, causing a dysregulated immune response. This contributes to further tissue damage and systemic dysfunction. Ultimately, the widespread damage caused by the virus, coupled with a weakened immune response, leads to multiple organ failure and, in severe cases, death (Figure 1).

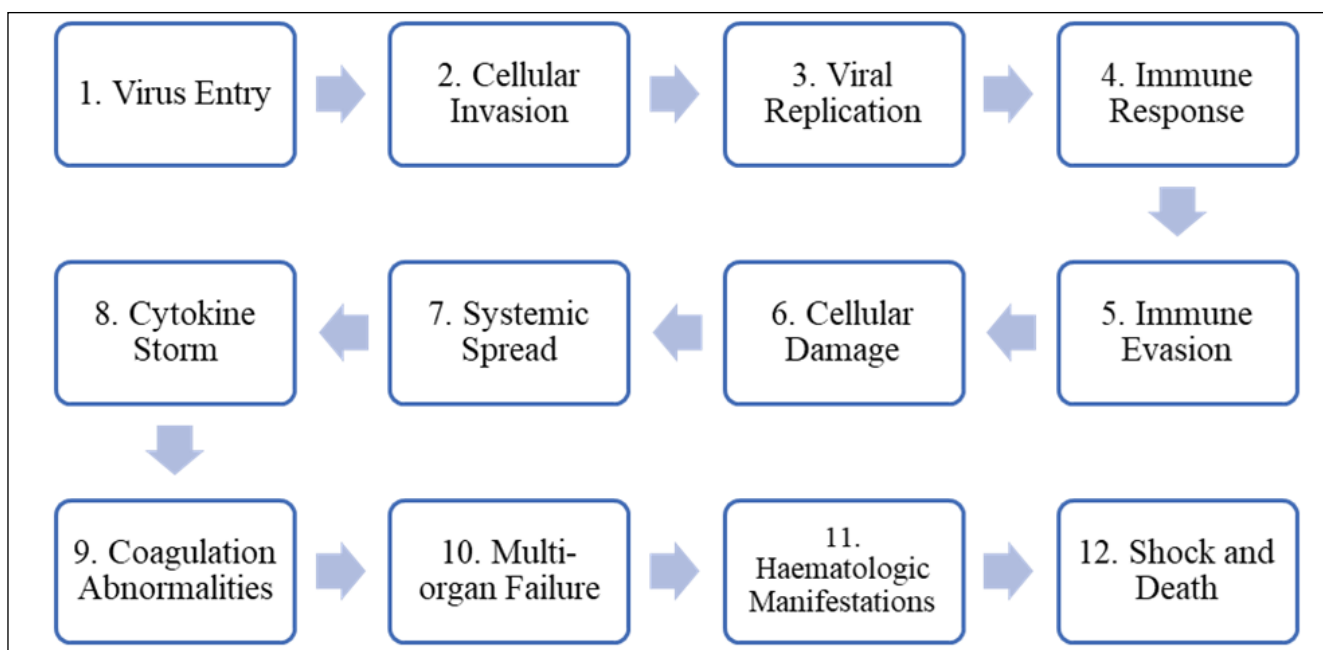


Figure 1. Pathophysiology of the Ebola Epidemic

It is crucial to note that early medical intervention and supportive care play a vital role in improving a patient's chances of survival when infected with the Ebola virus.

Diagnosis

EVD can be challenging as its symptoms overlap with other illnesses like malaria, typhoid fever, and meningitis. Additionally, some signs resemble those of pregnancy. This emphasises the importance of swift testing, especially for pregnant women, to safeguard both mother and baby.⁴

To confirm an Ebola infection, doctors employ various diagnostic methods. Some of them are as follows:

1. **Antibody-capture enzyme-linked immunosorbent assay (ELISA):** This test detects specific antibodies produced by the body in response to the Ebola virus. It stands out for its sensitivity and specificity. It can identify the virus even in the early stages when symptoms may not be evident. Additionally, ELISA can be adapted for high-throughput screening, making it invaluable in regions affected by outbreaks.
2. **Antigen-capture detection tests:** Antigen-capture detection tests, a crucial tool in diagnosing the Ebola virus, work like specialised detectives seeking out a specific marker of the virus itself. These tests employ specially designed molecules, called antibodies, which latch onto a distinct part of the virus, known as an antigen. When the virus is present, these antibodies bind to it, signalling a positive result. It can be thought of as a lock and key – the antibody (key) fits perfectly with the virus antigen (lock), providing a clear indication of infection. This method offers a rapid and reliable way to confirm the presence of the Ebola virus, aiding in timely and effective medical intervention. In essence, it is a critical step in the fight against this formidable pathogen.
3. **Serum neutralisation test (SNT):** This examines the patient's blood to find out if it contains substances capable of neutralising the virus. This test is crucial because it provides a direct way to see if a person's immune system has encountered the Ebola virus. It is an essential step in diagnosing and understanding the virus, aiding in treatment and prevention strategies. However, it is important to note that conducting the SNT requires specialised equipment and trained personnel, making it a crucial but sophisticated tool in the fight against Ebola.
4. **Reverse transcriptase polymerase chain reaction (RT-PCR) assay:** This technique amplifies and detects the genetic material of the Ebola virus, providing a highly accurate diagnosis. This highly sensitive test enables healthcare professionals to pinpoint the virus even in the early stages, offering a reliable and

swift diagnosis. Its accuracy and speed are crucial in containing outbreaks and providing timely medical care to affected individuals. The RT-PCR assay stands as an invaluable tool in the arsenal against Ebola, showcasing the remarkable progress in molecular diagnostics.

5. **Electron microscopy:** This method allows for direct visualisation of the virus using powerful microscopes. It allows scientists to peer into the tiny realm of viruses, far smaller than what traditional microscopes can reveal. By using beams of electrons, instead of light, electron microscopy captures incredibly detailed images of viral particles.
6. **Virus isolation by cell culture:** This method involves growing the virus in a controlled environment to confirm its presence. In this, a sample is placed from a potentially infected individual onto a culture of living cells. If the virus is present, it will infect and replicate within the cells, causing observable changes. These changes are then examined under a microscope. This technique not only confirms the presence of the Ebola virus but also allows scientists to study its behaviour and characteristics.

Prevention

Hand Hygiene

Hands should be washed frequently with soap and water, especially after being in public spaces or handling potentially contaminated materials.

Avoid Direct Contact

Individuals who are sick with Ebola should not be touched or cared for without the required precautions. Healthcare workers should use protective gear like gloves, masks, and gowns.

Safe Burial Practices

In the midst of an Ebola outbreak, it is crucial to take steps to prevent the virus from spreading further. One vital measure is ensuring the safe and timely burial of those who have passed away. Specially trained teams equipped with proper protective gear handle this task. They carefully place the body in a secure, durable plastic bag designed to prevent punctures and leaks. The deceased is then laid to rest in a grave that is at least 2 metres deep. These careful procedures are crucial in containing the virus and safeguarding public health.

Avoid Bushmeat

To stay safe from Ebola, it is important to avoid eating bushmeat. Bushmeat comes from wild animals like monkeys, bats, and other animals in the forest. Sometimes, these animals can carry the Ebola virus, and if we eat them, we might get sick too. So, it is better to choose other kinds of food that we know are safe. This way, we can help

stop the spread of the virus and keep ourselves and our communities healthy.

Stay Informed

It is essential to keep up-to-date with information from reliable sources and follow any guidelines or recommendations provided by public health authorities during outbreaks.

Community Awareness

The community should be educated about Ebola, its transmission, and prevention measures to ensure that everyone is well-informed and can take appropriate precautions.

Early Medical Care

If someone displays symptoms of Ebola, medical attention should be sought promptly. Early diagnosis and treatment can improve the chances of recovery.^{5,6}

Treatment

Treating EVD involves a multi-faceted approach aimed at helping the body fight off the virus. This includes supportive care like providing fluids, electrolytes, and nutrition to help the patient's immune system. Additionally, experimental antiviral drugs and therapies may be used to directly target the virus.

Isolation and infection control measures are crucial to prevent the spread of the virus to healthcare workers and other patients. Close monitoring of vital signs and laboratory tests helps healthcare providers tailor treatment to individual needs.

Early detection and prompt medical attention are vital for improving the chances of survival. While there is no specific licensed treatment for Ebola, ongoing research and clinical trials continue to explore potential treatments

and vaccines. Seeking medical care promptly can make a significant difference in the outcome for someone with Ebola.⁷

Materials and Method

In this review, we conducted a comprehensive analysis of the Ebola virus outbreak using a multi-faceted approach. Data was sourced from reputable institutions such as the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), ensuring the reliability and accuracy of our findings. Additionally, we referred to a diverse range of articles and peer-reviewed journals, providing a robust foundation for our research.

Our methodology involved a meticulous examination of epidemiological reports, clinical studies, and field investigations related to the outbreak. We employed statistical tools and data visualisation techniques to analyse trends in infection rates, transmission dynamics, and demographic factors. Furthermore, qualitative assessments were conducted to gain insights into public health interventions, healthcare infrastructure, and community responses.⁸

By synthesising information from these reputable sources, we aimed to present a comprehensive and well-rounded understanding of the Ebola virus outbreak. This approach ensures the reliability and validity of our findings, offering valuable insights for both research and practical applications in epidemic management.

Result

The result of the article review, drawing from comprehensive data provided by reputable sources like the World Health Organization (WHO) and the Centers for Disease Control and Prevention (CDC), along with insights from diverse articles and reputable journals, yields a thorough and well-rounded understanding of the subject matter. Table

Table 2. History of Ebola Outbreaks

Reston

Year	Countries	No. of Outbreaks	No. of Cases	No. of Deaths	Name of Species
1970–1979	Zaire (1976, 1977)	2	319	281	Zaire
	Sudan (1976, 1979)	2	318	173	Sudan
	United Kingdom (1976)	1	1	0	Sudan
1980–1989	Philippines (1989)	1	3	0	Reston
	United States of America (1996)	1	4	0	Reston

1990–1999	United States of America (1996)	1	4	0	Reston
	Gabon (1994, 1996)	3	149	97	Zaire
	Côte d’Ivoire (1994)	1	1	0	Tai Forest
	Zaire (1995)	1	315	250	Zaire
	Gabon/ South Africa (1996)	1	2	1	Zaire
	Russia (1996)	1	1	1	Zaire
2000–2009	Uganda (2000, 2007)	2	574	261	Sudan
	Gabon (2001)	1	65	53	Zaire
	Republic of Congo (2001, 2003, 2005)	3	235	200	Zaire
	Sudan (2004)	1	17	7	Sudan
	Russia (2004)	1	1	1	Zaire
	Zaire (2001, 2003, 2005, 2007, 2008)	5	545	413	Zaire
	Philippines (2008)	1	6	0	Reston
2010–2019	Uganda (2011, 2012, 2012)	3	18	8	
	Zaire (2012, 2014, 2017, 2018)	4	3639	2386	Sudan
	West Africa (2014)	1	28610	11308	Zaire
	Italy (2014)	1	1	0	Zaire
	Mali (2014)	1	8	6	Zaire
	Nigeria (2014)	1	20	8	Zaire
	Senegal (2014)	1	1	0	Zaire
	Spain (2014)	1	1	0	Zaire
	United Kingdom (2014)	1	1	0	Zaire
	United States of America (2014)	1	4	1	Zaire
2020–2023	Zaire (2020, 2021, 2022)	3	159	76	Zaire
	Guinea (2021)	1	23	12	Zaire
	Uganda (2022, 2023)	2	328	132	Sudan

2 contains the history of Ebola surges. This multi-faceted approach ensures a robust analysis that encompasses various perspectives and strengthens the credibility of the conclusions drawn from the review.^{9–12}

Figure 2 provides a concise look at the prevalence of Ebola virus outbreaks over the past several decades. The x-axis represents time, divided into ten-year intervals, starting from the 1970s to the present day. The y-axis denotes

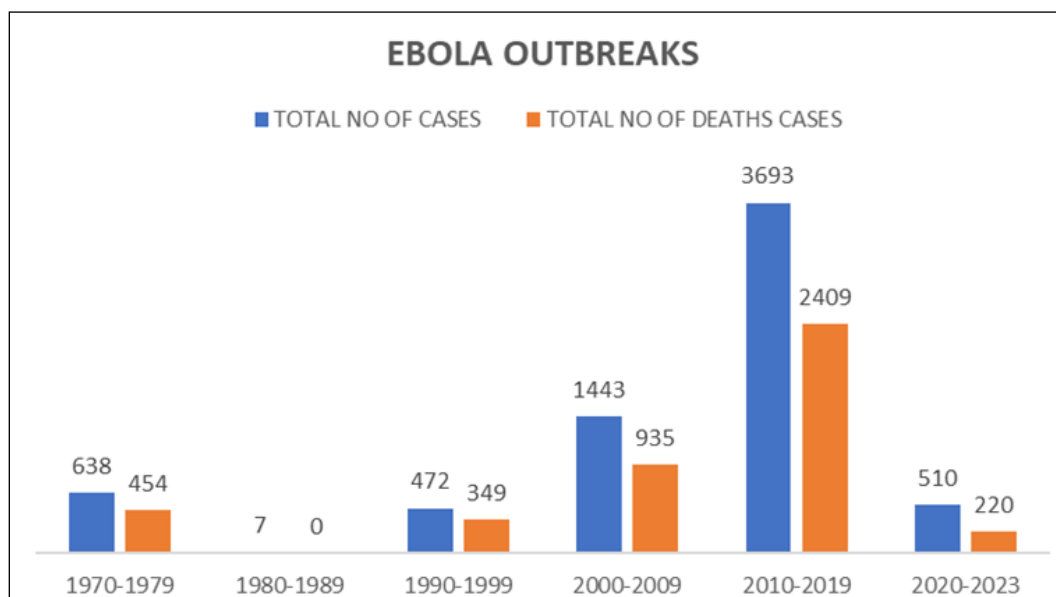


Figure 2. Decadal Analysis of the Ebola Epidemic (1976–2023)

the recorded cases of Ebola virus infections. However, by the 2010s, concerted global efforts, increased awareness, and improved healthcare infrastructure led to a notable decline in reported cases.

Discussion

The historical overview of Ebola virus outbreaks highlights key incidents dating back to the first recorded outbreaks in 1976 in the Democratic Republic of Congo and Sudan. Notable outbreaks, such as the 2014 West Africa epidemic and the 2018 Kivu outbreak, have significantly impacted public health globally. These events serve as critical lessons in understanding and combating future outbreaks.

Incorporating insights from the WHO and CDC data, this review emphasises the importance of international collaboration, rapid response, and effective containment measures in controlling Ebola outbreaks. Additionally, it underscores the ongoing research efforts to develop vaccines and treatments to mitigate the impact of the virus on affected populations.^{13,14}

Historical Context

Tracing the origins of Ebola outbreaks, we navigated through pivotal events, from the first identified case near the Ebola River in 1976 to recent outbreaks in various regions. By synthesising data from the WHO and CDC archives, we gained crucial insights into the evolution of response strategies.

Transmission Dynamics

Examining the routes of transmission, we analysed data from epidemiological studies cited in reputable journals. We explored how the virus spreads through direct contact with bodily fluids, shedding light on the critical importance

of rigorous infection control measures.

Case Fatality Rates

Utilising mortality data from the WHO and CDC reports, we have provided a comparative analysis of case fatality rates across different outbreaks. This section sheds light on variations in virulence and underscores the need for tailored healthcare interventions.

Conclusion

This comprehensive article review integrates data from reputable sources like WHO, CDC, and academic literature to provide a well-rounded understanding of the Ebola virus. The historical milestones presented in the form of a table serve as a visual aid, offering readers a concise overview of major outbreaks. This West African nation, along with Liberia and Guinea, bore the brunt of the devastating 2014–2016 outbreak. Several factors contributed to the severity of the epidemic in Sierra Leone. The lessons learned from past incidents continue to inform global efforts in preparedness, response, and research to combat future Ebola outbreaks. Through this synthesis of data, we gain a deeper understanding of the virus's evolution, outbreaks, and the collective efforts needed to combat its spread along with its geographical data and history. This review underscores the crucial role of robust global health organisations and research in monitoring, responding to, and ultimately mitigating the threat of Ebola.

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