Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Five Decades of Ebola Virus Disease in Africa (1976–2026): Exploring Outbreak Trends, Mortality Patterns, Transmission, and Epidemiological Dynamics—A Retrospective Study

Richard Owusu Ansah

oarichard67@gmail.com

Kwame Nkrumah University of Science and Technology

Emmanuel Owusu

University of Ghana

Enoch Martey Opey

Kwame Nkrumah University of Science and Technology

Kinako Denis Elia Dazangapai

Kwame Nkrumah University of Science and Technology

Emmanuel Avoh-Ackah

NYCHHC, Bellevue Hospital

Fred Norviemedey

University of Ghana

Stephen Twumasi

Garden City University

Derrick Kyei Boakye

Kwame Nkrumah University of Science and Technology

Beatrice Nyantakyiwaa

Alabama State University

Richard Larbi

Kwame Nkrumah University of Science and Technology

Martin Antwi Boasiako

Virginia Polytechnic Institute and State University

Rexford Bempong Adade

National Public Health and Reference Laboratory

Raymond Xornam Sevor

Kwame Nkrumah University of Science and Technology

Baakwa De-graft Miah

National Public Health and Reference Laboratory

Daniel Baah
University of Ghana

Research Article

Keywords: Ebola virus disease, outbreak trends, mortality patterns, epidemiology, Africa, case fatality rate, Orthoebolavirus zairense

Posted Date: November 20th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11436068/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Five Decades of Ebola Virus Disease in Africa (1976–2026): Exploring Outbreak Trends, Mortality Patterns, Transmission, and Epidemiological Dynamics—A Retrospective Study

Richard Owusu Ansah[1,2,3*], Emmanuel Owusu[4], Enoch Martey Opey[4,5], Kinako Denis Elia Dazangapai[1,2], Emmanuel Avoh- Ackah[6], Fred Norviemedey[7], Stephen Twumasi[8,9], Derrick Kyei Boakye[1], Beatrice Nyantakyiwaa[11], Richard Larbi[1,2], Martin Antwi Boasiako[12], Rexford Bempong Adade [3,11], Raymond Xornam Sevor[2], Baakwa De-graft Miah [3,11], Daniel Baah[3]

[1] Department of Medical Diagnostics, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

[2] Genomic and Infectious Diseases Laboratory, Faculty of Allied Health Sciences, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

[3] West African Centre for Cell Biology of Infectious Pathogens (WACCBIP), Department of Biochemistry, Cell and Molecular Biology, University of Ghana, Legon, Accra, Ghana

[4] Department of Medical Microbiology, College of Health Sciences, University of Ghana, Legon, Accra, Ghana

[5] Department of Theoretical and Applied Biology, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

[6] NYCHHC, Bellevue Hospital, New York, USA

[7] Department of Population, Family, and Reproductive Health, School of Public Health, University of Ghana, Legon, Accra, Ghana

[8] Legacy Hospital, Asokore Mampong, Kumasi, Ghana.

[9] Department of Medical Laboratory Technology, Garden City University, Kumasi, Ghana

[10] National Public Health and Reference Laboratory, Accra, Ghana

[11] Department of Biological Sciences, Alabama State University, Montgomery, USA.

[12] Virginia Polytechnic Institute and State University, Blacksburg, USA

oarichard67@gmail.com

oemman8282@yahoo.com

marteye1998@gmail.com

kinako.denisdazanga@gmail.com

ackahavoh98@gmail.com

norviemedey@gmail.com

stwumasi7116@gmail.com

boakyekyeiderrick@gmail.com

beatriceny1465@gmail.com

richardlarbi003@gmail.com

ediedade@gmail.com

srxraymond@gmail.com

baakwadegraftmiah@gmail.com

dannyneph@gmail.com

martina96@vt.edu

*Corresponding author

Richard Owusu Ansah (oarichard67@gmail.com)

Abstract

Background: Ebola virus disease (EVD) remains one of the most severe viral hemorrhagic fevers affecting Africa, causing recurrent outbreaks with substantial morbidity, mortality, and socioeconomic disruption. Despite five decades of documented outbreaks, comprehensive

assessments of long-term epidemiological trends across the continent remain limited. This study investigated outbreak trends, mortality patterns, and epidemiological dynamics of EVD in Africa from 1976 to 2026.

Methods: A retrospective epidemiological analysis of publicly available WHO, CDC, and other credible surveillance and scientific data was conducted to characterize Ebola outbreaks by year, country, region, virus species, duration, cases, deaths, and case fatality rate (CFR). Descriptive statistics, Kruskal–Wallis tests, Mann–Kendall trend analysis, Sen's slope estimation, and Poisson regression were used to assess outbreak characteristics, temporal trends, and changes in annual outbreak frequency.

Results: A total of 41 human EVD outbreaks were identified across Africa between 1976 and 2026, with outbreak frequency increasing progressively from three outbreaks during 1976–1986 to fourteen outbreaks during 2017–2026. Poisson regression demonstrated a significant increase in outbreak occurrence over time (incidence rate ratio [IRR] = 1.04, 95% CI: 1.02–1.07, $p < 0.001$), corresponding to an estimated 48% increase in outbreak frequency per decade. Mann–Kendall analysis revealed a significant decline in outbreak-related fatalities over time ($\tau = -0.242$, $p = 0.032$; Sen's slope = −0.80), while trends in cases, outbreak duration, and CFR were not statistically significant. Central Africa recorded the highest median CFR (71.0%), with a significant overall difference across regions ($p = 0.027$), although pairwise post hoc comparisons were not significant *Orthoebolavirus zairense* accounted for the majority of outbreaks (68.3%) and exhibited the highest median CFR (70.8%), although pairwise species comparisons were not statistically significant following post hoc testing.

Conclusion: These findings underscore the need for sustained investment in EVD surveillance, preparedness, rapid outbreak response, and resilient healthcare systems across Africa, particularly

in Central Africa, to strengthen prevention and control efforts and reduce outbreak-associated mortality.

Keywords: *Ebola virus disease; outbreak trends; mortality patterns; epidemiology; Africa; case fatality rate; Orthoebolavirus zairense*

INTRODUCTION

Ebola virus disease (EVD) is a severe, frequently fatal viral hemorrhagic fever of humans and non-human primates, caused by negative-sense, single-stranded RNA viruses of the family Filoviridae [1]. The disease first came to medical attention in 1976, when two simultaneous outbreaks of an unexplained hemorrhagic illness were recognized in the Democratic Republic of the Congo (then Zaire) and in what is now South Sudan, an investigation that led to the identification of a previously unknown filovirus and gave the disease its name after the Ebola River [2]. In the five decades since, EVD has established itself as one of the most feared infectious diseases of the African continent, characterized by abrupt, explosive outbreaks, high case fatality, and the capacity to overwhelm fragile health systems [3].

Within the family Filoviridae, the viruses responsible for human EVD were long classified in the genus *Ebolavirus*. Under the revised taxonomy adopted by the International Committee on Taxonomy of Viruses, this genus was renamed *Orthoebolavirus*, with binomial species designations introduced across the family [4, 5]. Four species within this genus are known to cause disease in humans: *Orthoebolavirus zairense* (Zaire ebolavirus), *Orthoebolavirus sudanense* (Sudan ebolavirus), *Orthoebolavirus bundibugyoense* (Bundibugyo ebolavirus), first identified

during a 2007 outbreak in Uganda [6], and *Orthoebolavirus taiense* (Taï Forest ebolavirus), the last having caused only a single non-fatal human infection [4]. These species differ markedly in their geographic distribution, epidemic potential, and virulence, with *O. zairense* historically associated with the largest and most lethal outbreaks [3, 7].

The natural maintenance of *ebolaviruses* in the environment is closely tied to African forest ecosystems. Fruit bats are widely regarded as the most probable reservoir hosts, with spillover into humans occurring through contact with infected wildlife, including bats and non-human primates, followed by amplification through human-to-human transmission via direct contact with blood, secretions, and contaminated materials [7, 8]. Because spillover events are shaped by the interface between human populations and forest habitats, the ecological and geographic determinants of Ebola emergence have concentrated outbreak activity across the equatorial forest belt of Central and West Africa [8].

The epidemiological significance of EVD was brought into sharp global focus by the 2013–2016 West African epidemic, which originated in Guinea and spread through Liberia and Sierra Leone to become, by a wide margin, the largest Ebola outbreak on record [9, 10]. This epidemic caused more than 28,000 reported cases and over 11,000 deaths, exposed critical weaknesses in outbreak surveillance and international response, and demonstrated that EVD was no longer confined to small, self-limiting rural events [10]. Subsequent large outbreaks in the eastern Democratic Republic of the Congo, recurrent Sudan virus disease events in Uganda, and the re-emergence of Zaire ebolavirus in Guinea in 2021 have underscored the persistent and evolving threat posed by the disease [3, 11].

The period under study has also been defined by substantial progress in medical countermeasures. Identification of the fruit-bat reservoir and improved understanding of transmission have informed

prevention strategies, while ring-vaccination trials during the West African epidemic established the efficacy of the recombinant vesicular stomatitis virus–vectored vaccine against Zaire ebolavirus [12]. Randomized controlled trials of therapeutics conducted during the 2018–2020 outbreak in the Democratic Republic of the Congo further demonstrated that monoclonal antibody–based treatments could substantially reduce mortality, transforming EVD from an almost uniformly fatal illness into a treatable condition when patients present early [13]. These advances have coincided with, and may partly explain, a shift in the clinical and epidemiological profile of recent outbreaks.

Despite these developments, EVD continues to recur with apparently increasing frequency, and the balance between rising outbreak numbers and changing lethality over time remains incompletely characterized. Most published analyses have focused on individual outbreaks or on the West African epidemic in isolation, and a comprehensive, continent-wide synthesis spanning the full history of the disease is lacking. A long-term perspective is essential to determine whether the frequency, size, duration, geographic distribution, and mortality of EVD outbreaks have changed meaningfully over time, and to identify the species- and region-specific patterns that should inform preparedness. Accordingly, this study presents a retrospective epidemiological analysis of all documented human EVD outbreaks in Africa from 1976 to 2026, examining temporal trends, mortality patterns, geographic and regional distribution, and species-specific characteristics, with the aim of describing the changing epidemiological dynamics of the disease across five decades.

MATERIALS AND METHODS

Study Design

This study employed a retrospective epidemiological approach to analyze EVD outbreaks reported in Africa between 1976 and 2026, focusing on three *Ebolavirus* species: *Orthoebolavirus zairense* (Zaire ebolavirus), *Orthoebolavirus sudanense* (Sudan ebolavirus), and *Orthoebolavirus bundibugyoense* (Bundibugyo ebolavirus). The study examined temporal trends, mortality patterns, geographical distribution, outbreak characteristics, and species-specific epidemiological dynamics over a 50-year period.

Data Sources and Compilation

Data on EVD outbreaks were obtained from publicly available sources, including outbreak reports and situation updates from the Centers for Disease Control and Prevention (CDC), the World Health Organization (WHO), and other credible peer-reviewed and governmental surveillance resources. Information was cross-checked across multiple sources to ensure consistency and completeness.

For each outbreak, the following variables were extracted where available: year of occurrence, affected country, geographic region, causative Ebola virus species, outbreak duration (days), number of confirmed and probable cases, number of deaths, and case fatality rate (CFR). Countries were subsequently grouped into African regions (Central, Eastern, Western, Northern, and Southern Africa) for comparative analyses. While the African Union places Sudan in Eastern Africa, this research follows the United Nations classification of Sudan as part of Northern Africa to maintain data consistency [14].

Outbreaks were classified according to the currently recognized Ebola virus species responsible for human disease, including *Orthoebolavirus zairense*, *Orthoebolavirus sudanense*, and

Orthoebolavirus bundibugyoense. The study period was further divided into five decades for temporal comparisons: 1976–1986, 1987–1996, 1997–2006, 2007–2016, and 2017–2026.

Outcome Measures

The primary outcome measures included outbreak frequency, outbreak duration, number of cases, number of deaths, and case fatality rate. Outbreak duration was measured in days and calculated as the interval between the outbreak start date (or declaration date, where the start date was unavailable) and the date on which the outbreak was officially declared over. CFR was calculated as the proportion of deaths among reported cases and expressed as a percentage.

Statistical Analysis

Descriptive statistics were used to summarize outbreak characteristics. Continuous variables were presented as medians with interquartile ranges (IQRs) and ranges because outbreak data were non-normally distributed and contained substantial variability between outbreaks. Categorical variables were summarized using frequencies and percentages.

Comparisons of outbreak characteristics across decades, geographical regions, and Ebola virus species were performed using the Kruskal–Wallis test. When appropriate, post hoc pairwise comparisons were conducted using Dunn's test with adjustment for multiple testing.

Temporal trends in outbreak characteristics were assessed using the Mann–Kendall trend test, a non-parametric method for detecting monotonic trends in time-series data. The magnitude and direction of temporal changes were quantified using Sen's slope estimator. Positive Sen's slope values indicated increasing trends over time, whereas negative values indicated decreasing trends.

To evaluate changes in annual outbreak occurrence, yearly outbreak counts from 1976 to 2026, including years without reported outbreaks, were modelled using Poisson regression. Incidence rate ratios (IRRs) and 95% confidence intervals (CIs) were calculated to quantify changes in outbreak frequency over time.

Data visualization was performed using the ggplot2 package in R, with temporal trends illustrated using scatter plots and fitted trend lines. Statistical analyses were performed using GraphPad Prism version 8.0 (GraphPad Software, San Diego, CA, USA) and R version 4.5.3 (R Foundation for Statistical Computing, Vienna, Austria). Statistical significance was defined as a two-sided p-value < 0.05.

Ethical Considerations

This study utilized publicly available, aggregated outbreak surveillance data and did not involve human participants, identifiable personal information, or patient-level records. Consequently, ethical approval and informed consent were not required.

RESULTS

Distribution of Ebola Virus Disease Outbreaks Across Five Decades (1976–2026)

A total of 41 human EVD outbreaks were documented in Africa between 1976 and 2026, resulting in 34,996 reported cases and 15,452 deaths, corresponding to an overall case fatality rate (CFR) of 44.2% (**Table 1** and **Figure 1**).

The frequency of outbreaks increased over time, with only three outbreaks recorded during the first decade (1976–1986), rising to five outbreaks in the second decade (1987–1996), seven

outbreaks in the third decade (1997–2006), twelve outbreaks in the fourth decade (2007–2016), and fourteen outbreaks in the fifth decade (2017–2026).

Despite recording fewer outbreaks than the fifth decade, the fourth decade contributed the largest disease burden, accounting for 29,191 cases (83.4% of all reported cases) and 11,636 deaths (75.3% of all deaths). This pattern was largely driven by the unprecedented West African Ebola epidemic of 2014–2016. The CFR during this decade was 39.9%, markedly lower than those observed in earlier decades.

The first and second decades exhibited the highest mortality burden relative to cases, with CFRs of 71.2% and 76.7%, respectively. The third decade recorded a CFR of 65.5%, while the fifth decade experienced a resurgence in mortality with a CFR of 63.6%.

209 **Table 1. Human Outbreaks of *O. zairense, O. sudanense* and *O. bundibugyoense* from 1976 to present.**

Country	Region	Classification	Duration (Day)	Year	Species	Cases	Fatality	CFR	Sources
The Democratic Republic of the Congo	Central Africa	Local	53	1976	*O. zairense*	318	280	88.05	[2, 15]
Sudan	North Africa	Local	152	1976	*O. sudanense*	284	151	53.17	[15, 16]
Sudan	North Africa	Local	67	1979	*O. sudanense*	34	22	64.71	[15, 17]
Gabon	Central Africa	Local	86	1994	*O. zairense*	51	31	60.78	[15, 18]
The Democratic Republic of the Congo	Central Africa	Local	181	1995	*O. zairense*	315	254	80.63	[15, 19]
Gabon	Central Africa	Local	201	1996	*O. zairense*	60	45	75.00	[15, 20]
South Africa	Southern Africa	Imported		1996	*O. zairense*	2	1	50.00	[15, 21]
Gabon	Central Africa	Local	90	1996	*O. zairense*	31	21	67.74	[15, 18]
Uganda	East Africa	Local	190	2000	*O. sudanense*	425	224	52.71	[15, 22, 23]
The Republic of the Congo	Central Africa	Local	123	2001	*O. zairense*	59	44	74.58	[15, 24]
Gabon	Central Africa	Local	190	2001	*O. zairense*	65	53	81.54	[15, 24]
The Republic of the Congo	Central Africa	Local	71	2003	*O. zairense*	35	29	82.86	[15, 25]
The Republic of the Congo	Central Africa	Local	162	2003	*O. zairense*	143	128	89.51	[15, 25, 26]
Sudan	North Africa	Local	128	2004	*O. sudanense*	17	7	41.18	[15, 27]
The Republic of the Congo	Central Africa	Local	81	2005	*O. zairense*	12	10	83.33	[15, 26]
Uganda	East Africa	Local	83	2007	*O. bundibugyoense*	131	42	32.06	[15, 28]
The Democratic Republic of the Congo	Central Africa	Local	202	2007	*O. zairense*	264	187	70.83	[15, 29]
The Democratic Republic of the Congo	Central Africa	Local	92	2008	*O. zairense*	32	15	46.88	[15, 30]
Uganda	East Africa	Local	37	2011	*O. sudanense*	1	1	100.00	[15, 31]

Uganda	East Africa	Local	62	2012	*O. sudanense*	6	3	50.00	[15, 32]
Uganda	East Africa	Local	72	2012	*O. sudanense*	11	4	36.36	[15, 32]
The Democratic Republic of the Congo	Central Africa	Local	98	2012	*O. bundibugyoense*	38	13	34.21	[15, 33]
The Democratic Republic of the Congo	Central Africa	Local	89	2014	*O. zairense*	69	49	71.01	[15, 34]
West African Epidemic	West Africa	Local	809	2014	*O. zairense*	28610	11308	39.52	[15, 35]
Mali	West Africa	Imported	87	2014	*O. zairense*	8	6	75.00	[15, 36]
Nigeria	West Africa	Imported	92	2014	*O. zairense*	20	8	40.00	[15, 37]
Senegal	West Africa	Imported	49	2014	*O. zairense*	1	0	0.00	[15, 38]
The Democratic Republic of the Congo	Central Africa	Local	52	2017	*O. zairense*	8	4	50.00	[15]
The Democratic Republic of the Congo	Central Africa	Local	694	2018	*O. zairense*	3470	2287	65.91	[15]
The Democratic Republic of the Congo	Central Africa	Local	77	2018	*O. zairense*	54	33	61.11	[15]
The Democratic Republic of the Congo	Central Africa	Local	170	2020	*O. zairense*	130	55	42.31	[15]
The Democratic Republic of the Congo	Central Africa	Local	69	2021	*O. zairense*	11	9	81.82	[15]
The Democratic Republic of the Congo	Central Africa	Local	85	2021	*O. zairense*	12	6	50.00	[15]
Guinea	West Africa	Local	125	2021	*O. zairense*	23	12	52.17	[15]
Uganda	East Africa	Local	113	2022	*O. sudanense*	164	55	33.54	[15]
The Democratic Republic of the Congo	Central Africa	Local	36	2022	*O. zairense*	1	1	100.00	[15]
The Democratic Republic of the Congo	Central Africa	Local	72	2022	*O. zairense*	5	5	100.00	[15]
The Democratic Republic of the Congo	Central Africa	Local	88	2025	*O. zairense*	64	45	70.31	[15]
Uganda	East Africa	Local	86	2025	*O. sudanense*	12	4	33.33	[15]
The Democratic Republic of the Congo	Central Africa	Local	Ongoing	2026	*O. bundibugyoense*	Ongoing	Ongoing	Ongoing	[15]
Uganda	East Africa	Local	Ongoing	2026	*O. bundibugyoense*	Ongoing	Ongoing	Ongoing	[15]

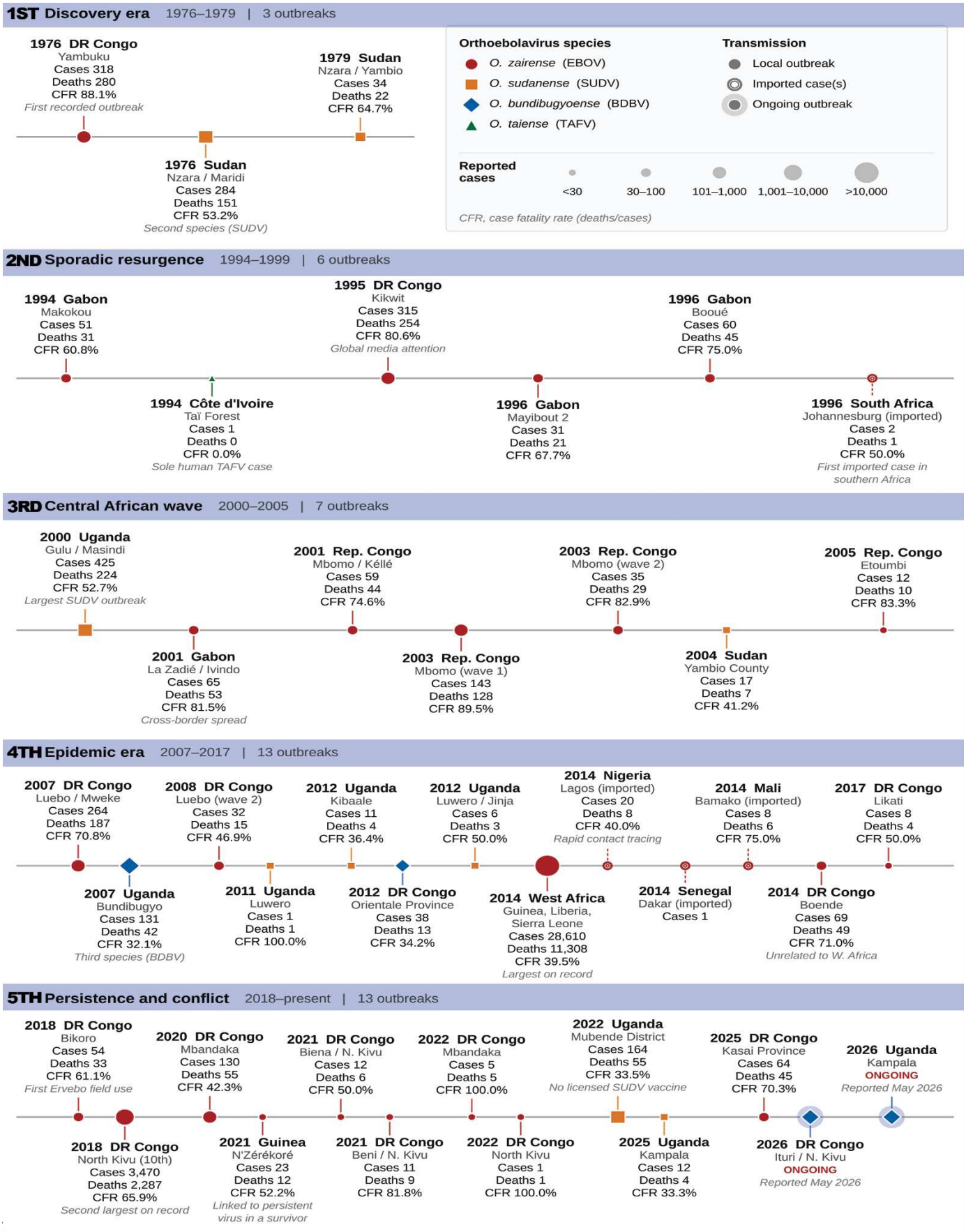
1ST Discovery era 1976–1979 | 3 outbreaks
1976 DR Congo
Yambuku
Cases 318
Deaths 280
CFR 88.1%
First recorded outbreak
1976 Sudan
Nzara / Maridi
Cases 284
Deaths 151
CFR 53.2%
Second species (SUDV)
1979 Sudan
Nzara / Yambio
Cases 34
Deaths 22
CFR 64.7%
Orthoebolavirus species
O. zairense (EBOV)
O. sudanense (SUDV)
O. bundibugyoense (BDBV)
O. taiense (TAFV)
Transmission
Local outbreak
Imported case(s)
Ongoing outbreak
Reported cases
<30
30–100
101–1,000
1,001–10,000
>10,000
CFR, case fatality rate (deaths/cases)
2ND Sporadic resurgence 1994–1999 | 6 outbreaks
1994 Gabon
Makokou
Cases 51
Deaths 31
CFR 60.8%
1994 Côte d'Ivoire
Taï Forest
Cases 1
Deaths 0
CFR 0.0%
Sole human TAFV case
1995 DR Congo
Kikwit
Cases 315
Deaths 254
CFR 80.6%
Global media attention
1996 Gabon
Mayibout 2
Cases 31
Deaths 21
CFR 67.7%
1996 Gabon
Booué
Cases 60
Deaths 45
CFR 75.0%
1996 South Africa
Johannesburg (imported)
Cases 2
Deaths 1
CFR 50.0%
First imported case in southern Africa
3RD Central African wave 2000–2005 | 7 outbreaks
2000 Uganda
Gulu / Masindi
Cases 425
Deaths 224
CFR 52.7%
Largest SUDV outbreak
2001 Gabon
La Zadié / Ivindo
Cases 65
Deaths 53
CFR 81.5%
Cross-border spread
2001 Rep. Congo
Mbomo / Kéllé
Cases 59
Deaths 44
CFR 74.6%
2003 Rep. Congo
Mbomo (wave 1)
Cases 143
Deaths 128
CFR 89.5%
2003 Rep. Congo
Mbomo (wave 2)
Cases 35
Deaths 29
CFR 82.9%
2004 Sudan
Yambio County
Cases 17
Deaths 7
CFR 41.2%
2005 Rep. Congo
Etoumbi
Cases 12
Deaths 10
CFR 83.3%
4TH Epidemic era 2007–2017 | 13 outbreaks
2007 DR Congo
Luebo / Mweke
Cases 264
Deaths 187
CFR 70.8%
2007 Uganda
Bundibugyo
Cases 131
Deaths 42
CFR 32.1%
Third species (BDBV)
2008 DR Congo
Luebo (wave 2)
Cases 32
Deaths 15
CFR 46.9%
2011 Uganda
Luwero
Cases 1
Deaths 1
CFR 100.0%
2012 Uganda
Kibaale
Cases 11
Deaths 4
CFR 36.4%
2012 DR Congo
Orientale Province
Cases 38
Deaths 13
CFR 34.2%
2012 Uganda
Luwero / Jinja
Cases 6
Deaths 3
CFR 50.0%
2014 West Africa
Guinea, Liberia, Sierra Leone
Cases 28,610
Deaths 11,308
CFR 39.5%
Largest on record
2014 Nigeria
Lagos (imported)
Cases 20
Deaths 8
CFR 40.0%
Rapid contact tracing
2014 Senegal
Dakar (imported)
Cases 1
2014 Mali
Bamako (imported)
Cases 8
Deaths 6
CFR 75.0%
2014 DR Congo
Boende
Cases 69
Deaths 49
CFR 71.0%
Unrelated to W. Africa
2017 DR Congo
Likati
Cases 8
Deaths 4
CFR 50.0%
5TH Persistence and conflict 2018–present | 13 outbreaks
2018 DR Congo
Bikoro
Cases 54
Deaths 33
CFR 61.1%
First Ervebo field use
2018 DR Congo
North Kivu (10th)
Cases 3,470
Deaths 2,287
CFR 65.9%
Second largest on record
2020 DR Congo
Mbandaka
Cases 130
Deaths 55
CFR 42.3%
2021 Guinea
N'Zérékoré
Cases 23
Deaths 12
CFR 52.2%
Linked to persistent virus in a survivor
2021 DR Congo
Biena / N. Kivu
Cases 12
Deaths 6
CFR 50.0%
2021 DR Congo
Beni / N. Kivu
Cases 11
Deaths 9
CFR 81.8%
2022 DR Congo
Mbandaka
Cases 5
Deaths 5
CFR 100.0%
2022 DR Congo
North Kivu
Cases 1
Deaths 1
CFR 100.0%
2022 Uganda
Mubende District
Cases 164
Deaths 55
CFR 33.5%
No licensed SUDV vaccine
2025 Uganda
Kampala
Cases 12
Deaths 4
CFR 33.3%
2025 DR Congo
Kasai Province
Cases 64
Deaths 45
CFR 70.3%
2026 DR Congo
Ituri / N. Kivu
ONGOING
Reported May 2026
2026 Uganda
Kampala
ONGOING
Reported May 2026

Figure 1. Chronological distribution Ebola virus disease outbreaks in Africa, 1976–present.

Chronological distribution of documented Ebola virus disease (EVD) outbreaks across Africa from the first recorded outbreak in 1976 to June 2026. Each event is represented by a circle positioned along a horizontal time axis, with circle area proportional to the total number of reported cases. Outbreaks are plotted above the axis for local transmission events and below the axis for imported or secondary cases. Colour denotes infecting species: red, *Orthoebolavirus zairense* (EBOV); orange, *Orthoebolavirus sudanense* (SUDV); blue, *Orthoebolavirus bundibugyoense* (BDBV); green *Orthoebolavirus taiense* (TAFV). Open circles with dashed stems indicate imported cases with no sustained local transmission. The orange pulsing marker denotes outbreaks active as of June 2026. Annotated boxes highlight epidemiologically significant events. Vertical dashed lines delineate five epidemiological eras: Discovery Era (1976–1989), Sporadic Resurgence (1990–1999), Central African Wave (2000–2009), Epidemic Era (2010–2016), and Persistence & Conflict (2017–present).

Geographic Distribution of Ebola Virus Disease Outbreaks

Ebola virus disease outbreaks were reported across eleven African countries and regions between 1976 and 2026 (**Figure 2**). The Democratic Republic of the Congo (DRC) recorded the highest number of outbreaks, accounting for 16 of the 41 outbreaks (39.0%). Uganda reported eight outbreaks (19.5%), while Gabon and the Republic of the Congo each experienced four outbreaks (9.8%). Sudan contributed three outbreaks (7.3%), Guinea contributed two (4.9%), whereas South Africa, Nigeria, Senegal, Mali, Liberia and Sierra Leone each accounted for one outbreak (**Figure 3**).

Central Africa represented the principal hotspot of Ebola virus disease activity throughout the study period, reflecting the concentration of outbreaks in the DRC, Gabon, and the Republic of the Congo. In contrast, East and North Africa experienced fewer but recurrent outbreaks, primarily involving Uganda and Sudan.

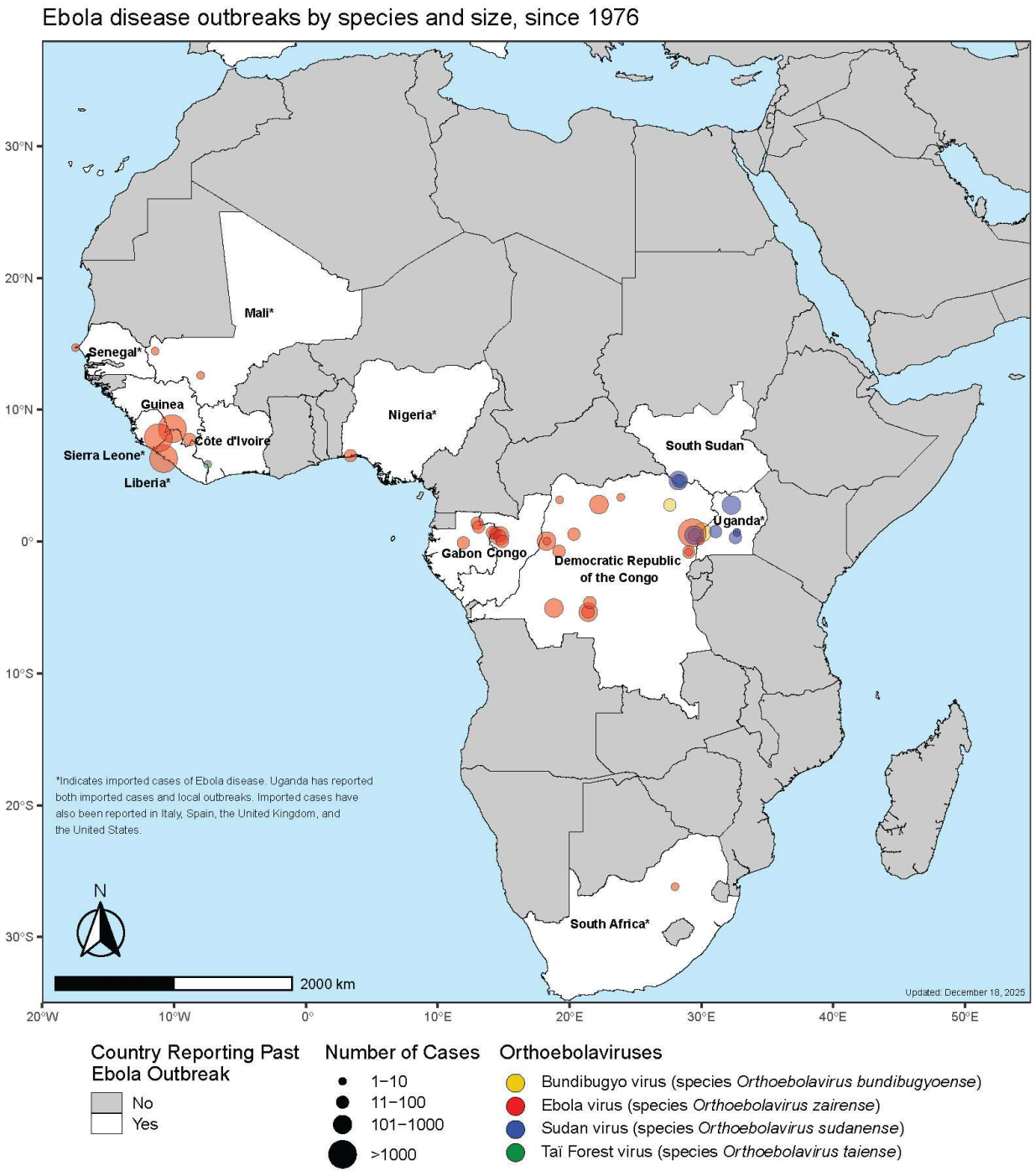

Figure 2. Geographic locations of Ebola outbreaks. Map of Africa showing the sites of all known ebolavirus outbreaks denoted by colored circles for *Bundibugyo virus* (yellow) *Zaire ebolavirus* (red), *Sudan ebolavirus* (blue), and *Tai Forest ebolavirus* (green). Image was adopted from CDC [15]

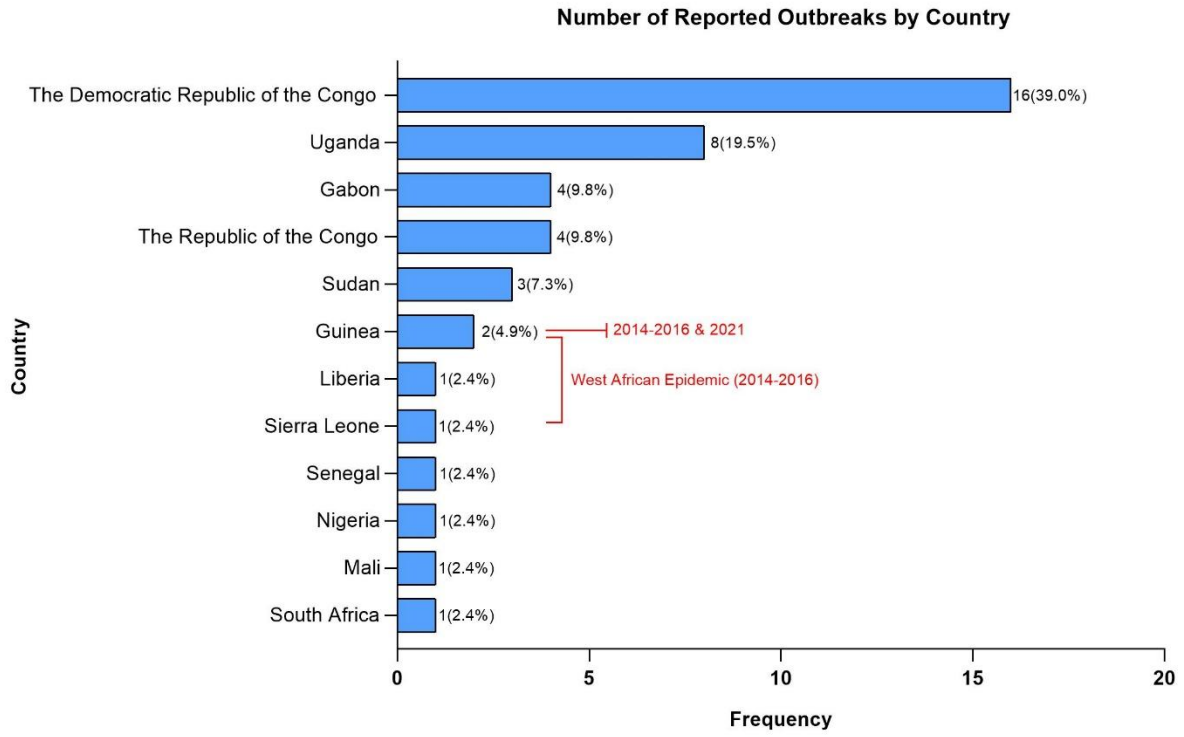

Figure 3. Distribution of Ebola virus disease outbreaks country, 1976–2026. Bars represent the number of outbreaks in each country. Percentages indicate the proportion of outbreaks attributable to a particular country. The Democratic Republic of the Congo predominated, followed by Uganda, all in Central Africa.

Species-Specific Epidemiological Characteristics

Of the three Ebolavirus species investigated in this study, *Orthoebolavirus zairense* was the predominant species, causing 28 outbreaks (68.3%) and accounting for 33,873 cases (96.8%) and 14,926 deaths (96.6%). The cumulative CFR associated with this species was 44.1% (**Figure 4**).

Orthoebolavirus sudanense was responsible for nine outbreaks (22.0%), resulting in 954 cases and 471 deaths, with a CFR of 49.4%. *Orthoebolavirus bundibugyoense* was the least frequently reported species, accounting for four outbreaks (9.8%), 169 cases, and 55 deaths, corresponding to the lowest CFR (32.5%) (**Figure 4**).

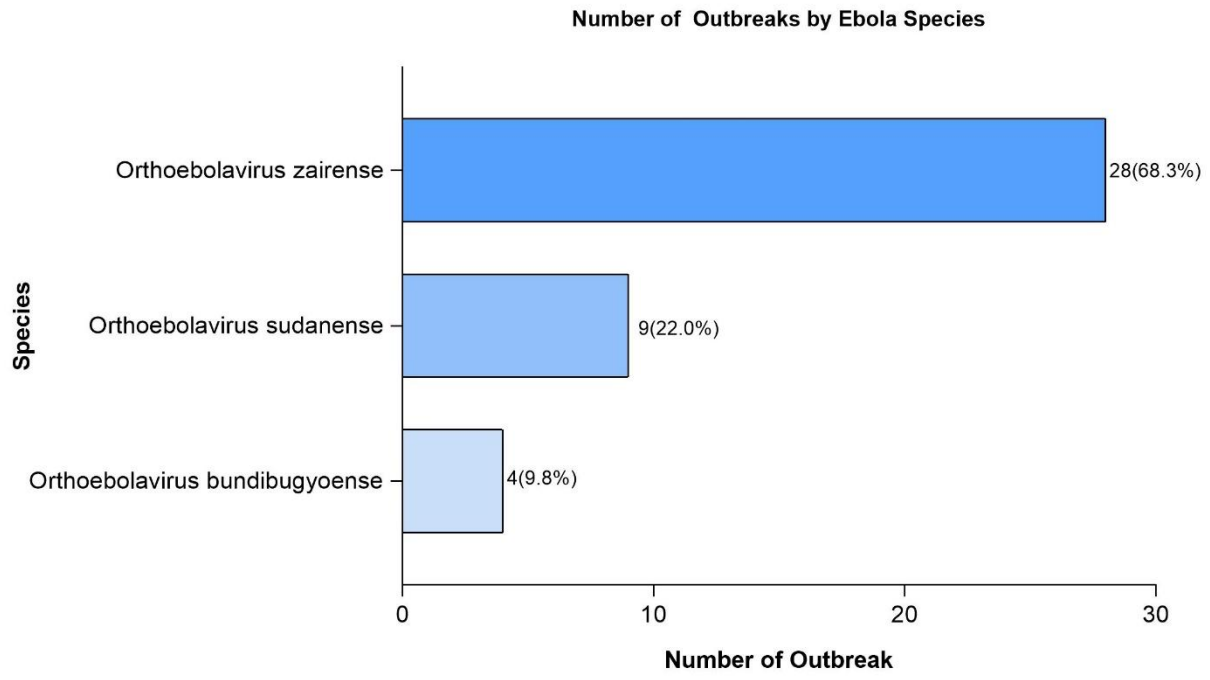

Figure 4. Number of Ebola virus disease outbreaks according to Ebola virus species in Africa, 1976–2026. Bars represent the number of outbreaks caused by each species. Percentages indicate the proportion of outbreaks attributable to a particular species. *O. zairense* predominated, followed by *O. sudanense* and *O. bundibugyoense*.

Regional Distribution of Ebola Virus Disease Outbreaks in Africa

Between 1976 and 2026, EVD outbreaks were reported in 13 countries across five African regions (**Figure 5**). Central Africa accounted for the highest number of outbreaks, recording 24 of the 41 outbreaks (58.5%) despite involving only three countries (23.1% of affected countries). East Africa reported eight outbreaks (19.5%) from a single country, while West Africa recorded five outbreaks (12.2%) across seven countries (53.8%).

North Africa contributed three outbreaks (7.3%) from one country, whereas Southern Africa recorded a single outbreak (2.4%) in one country (**Figure 5**). Although West Africa encompassed

the largest number of affected countries, outbreak frequency remained comparatively low. In contrast, Central Africa experienced repeated outbreak occurrences concentrated within a limited number of countries, reflecting sustained viral emergence and transmission within the region.

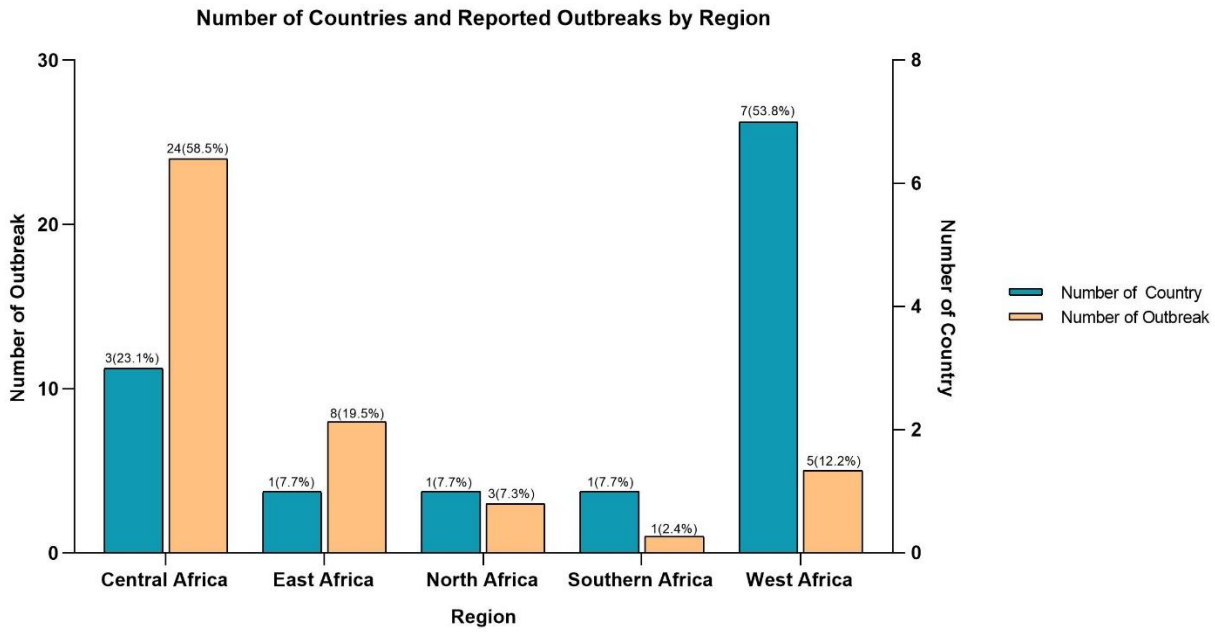

Figure 5. Regional distribution of Ebola virus disease outbreaks and affected countries in Africa between 1976 and 2026. Bars represent the number of reported outbreaks and the number of affected countries within each African region. Percentages indicate the proportion of total outbreaks (n = 41) and affected countries (n = 13) attributable to each region. Central Africa accounted for the majority of outbreaks (58.5%), whereas West Africa comprised the largest proportion of affected countries (53.8%).

Regional Distribution of Ebola Virus Species Across Africa

The distribution of Ebola virus species varied considerably across African regions (**Figure 6**). Of the 24 outbreaks reported in Central Africa, 22 (91.7%) were caused by *O. zairense*, while the remaining two outbreaks (8.3%) were attributed to *O. bundibugyoense*. No outbreaks caused by *O. sudanense* were recorded in this region.

In East Africa, six of the eight outbreaks (75.0%) were associated with *O. sudanense*, whereas two outbreaks (25.0%) were caused by *O. bundibugyoense*. *O. zairense* was not detected in East Africa.

All three outbreaks reported in North Africa were caused exclusively by *O. sudanense* (100.0%). Similarly, all five outbreaks documented in West Africa were attributed to *O. zairense* (100.0%). The single outbreak reported in Southern Africa was also caused by *O. zairense* (**Figure 6**).

Overall, *O. zairense* exhibited the broadest geographical distribution, occurring in Central, West, and Southern Africa and accounting for 28 of the 41 outbreaks (68.3%). In contrast, *O. sudanense* was restricted to East and North Africa, while *O. bundibugyoense* was confined to Central and East Africa. These findings suggest strong regional clustering of Ebola virus species across the African continent.

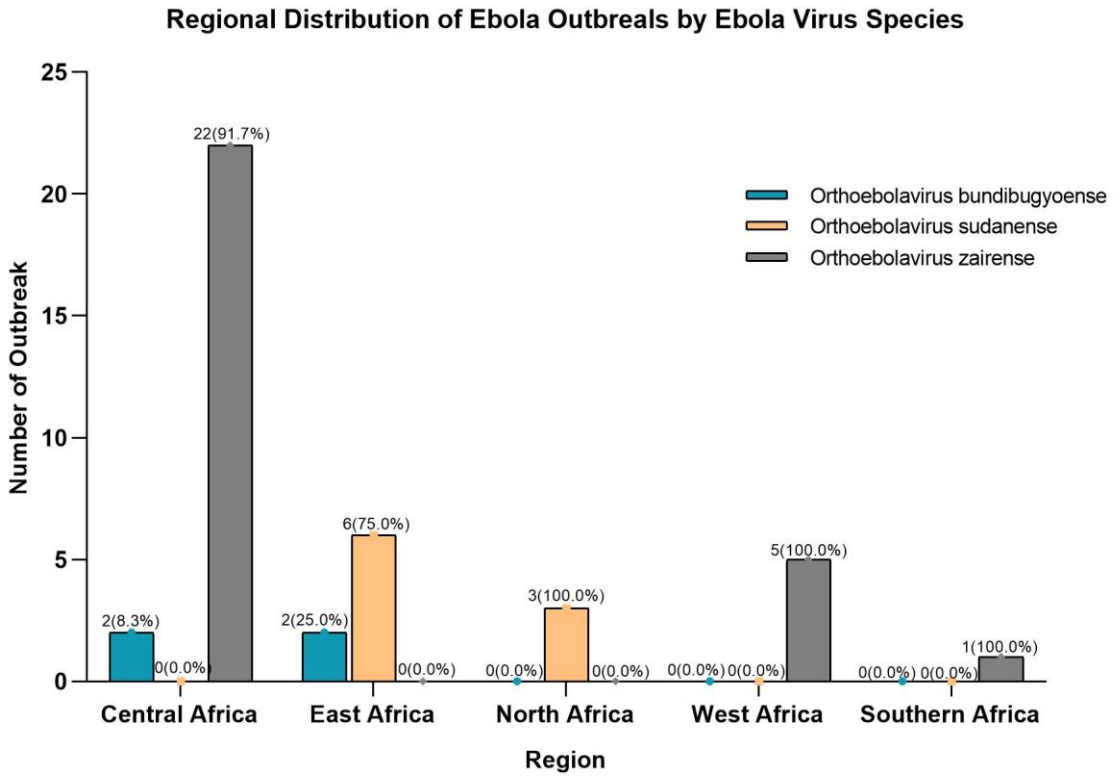

Figure 6. Regional distribution of Ebola virus disease outbreaks according to Ebola virus species in Africa, 1976–2026. Bars represent the number of outbreaks caused by each species within a region. Percentages indicate the proportion of outbreaks attributable to a particular species within each region. *Orthoebolavirus zairense* predominated in Central, West, and Southern Africa, whereas *Orthoebolavirus sudanense* was confined to East and North Africa. *Orthoebolavirus bundibugyoense* occurred exclusively in Central and East Africa

Temporal Distribution of Ebola Virus Species Across Five Decades

The distribution of Ebola virus species varied across the five decades of observation; however, these differences were not statistically significant ($p = 0.412$).

During the first decade (1976–1986), three outbreaks were reported, of which two (66.7%) were caused by *Orthoebolavirus sudanense* and one (33.3%) by *Orthoebolavirus zairense*. No outbreaks attributable to *Orthoebolavirus bundibugyoense* were recorded during this period (**Figure 7**).

In the second decade (1987–1996), all five documented outbreaks (100.0%) were caused by *Orthoebolavirus zairense*. During the third decade (1997–2006), *Orthoebolavirus zairense* remained the predominant species, accounting for five of seven outbreaks (71.4%), while *Orthoebolavirus sudanense* was responsible for the remaining two outbreaks (28.6%) (**Figure 7**).

The first occurrences of *Orthoebolavirus bundibugyoense* were observed during the fourth decade (2007–2016), where it accounted for two of twelve outbreaks (16.7%). In the same decade, *Orthoebolavirus zairense* and *Orthoebolavirus sudanense* contributed 58.3% and 25.0% of outbreaks, respectively. During the fifth decade (2017–2026), *Orthoebolavirus zairense* remained dominant, accounting for ten of fourteen outbreaks (71.4%), while *Orthoebolavirus bundibugyoense* and *Orthoebolavirus sudanense* each accounted for two outbreaks (14.3%).

Overall, *Orthoebolavirus zairense* was the predominant species throughout most of the study period, whereas *Orthoebolavirus bundibugyoense* emerged only in the latter two decades. Despite

these temporal fluctuations, the relative distribution of Ebola virus species did not change significantly over time.

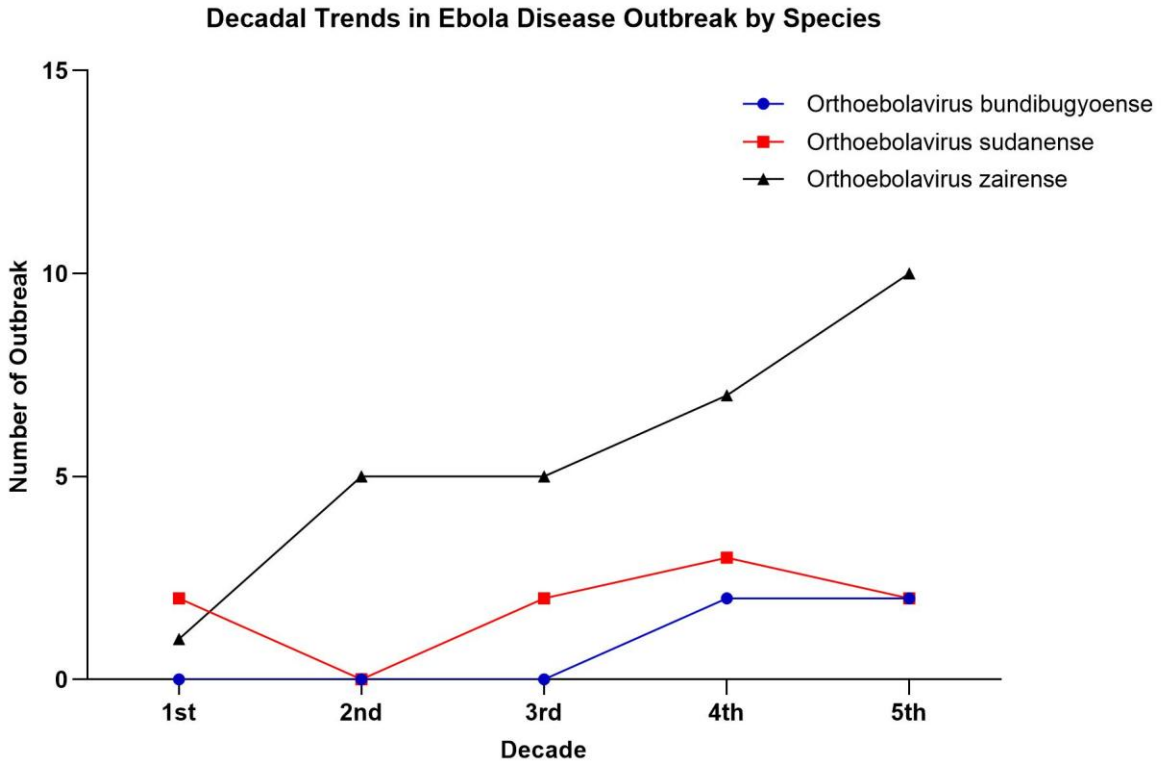

Figure 7: Distribution of Ebola virus species across five decades of Ebola virus disease outbreaks in Africa, 1976–2026. Plotted values are frequencies in a particular decade. The association between outbreak decade and Ebola virus species was assessed using Chi-square test, with no significant temporal variation observed ($p = 0.412$).

Regional Differences in Outbreak Duration, Size, Mortality, and Case Fatality Rate

Substantial variation was observed in outbreak duration, case burden, mortality, and case fatality rate (CFR) across African regions (**Figure 8**). However, statistically significant regional differences were identified only for CFR ($p = 0.027$).

Central Africa recorded the highest median CFR at 71.0% (IQR: 60.8–82.9%; range: 34.2–100.0%), followed by North Africa with a median CFR of 53.2% (range: 41.2–64.7%). West Africa exhibited a substantially lower median CFR of 40.0% (IQR: 19.8–63.6%; range: 0.0–75.0%), while East Africa recorded the lowest median CFR at 36.4% (IQR: 33.3–52.7%; range: 32.1–100.0%). The regional variation in CFR was statistically significant ($p = 0.027$) but it was not significant in a post hoc pairwise analysis.

Although not statistically significant, notable differences were observed in outbreak duration among regions ($p = 0.728$). North Africa experienced the longest outbreaks, with a median duration of 128 days (range: 67–152 days), whereas East Africa recorded the shortest median duration of 83 days (range: 37–190 days). Central and West Africa had comparable median outbreak durations of 89 days (range: 36-694 days) and 92 days (range:49-809 days), respectively.

Similarly, median outbreak size did not differ significantly across regions ($p = 0.701$). Central Africa reported the highest median number of cases (54 cases; IQR: 12–130; range: 1–3,470), followed by North Africa (34 cases; range: 17–284). West Africa showed the widest variation in outbreak size, ranging from 1 to 28,610 cases with median number of 20 cases, reflecting the influence of the 2014–2016 West African epidemic.

No statistically significant regional differences were observed in mortality burden ($p = 0.416$). Nevertheless, Central Africa recorded the highest median number of deaths (33 deaths; IQR: 10–55; range: 1–2,287), while East Africa reported the lowest median mortality (4 deaths; IQR: 3–55; range: 1–224). North and West Africa had median mortality of 22 deaths (range: 7-151 deaths) and 8 deaths (range:0-11,308 deaths), respectively.

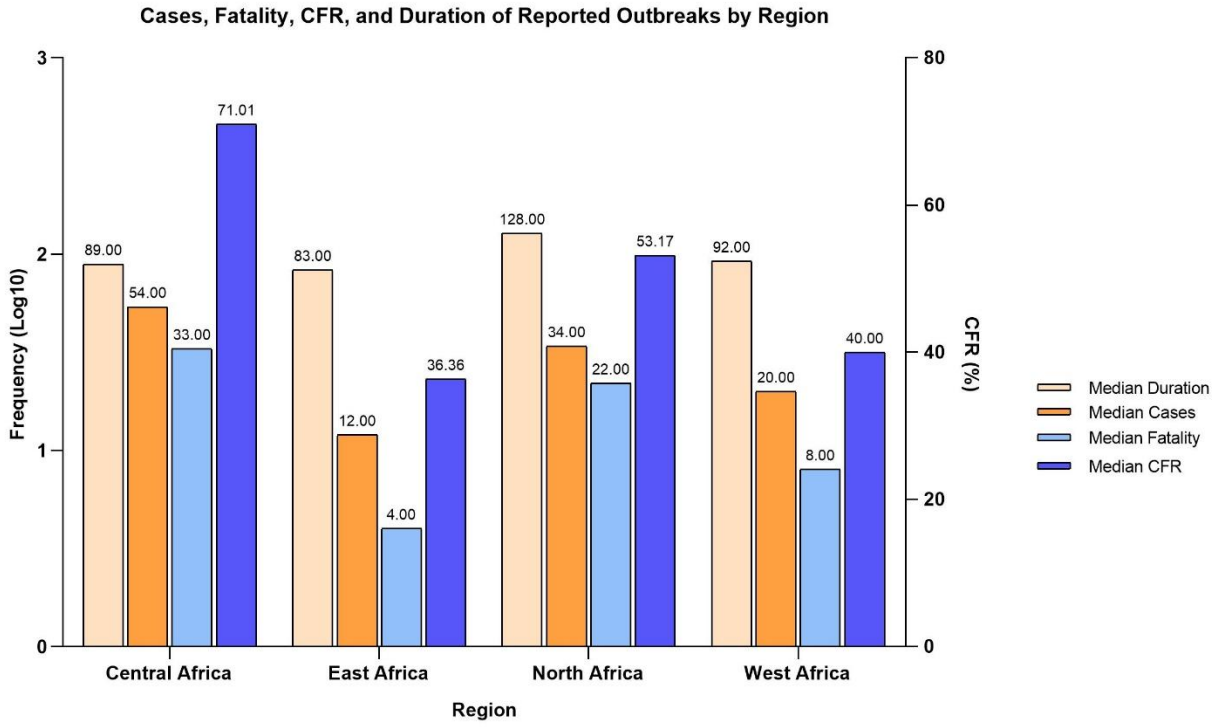

Figure 8. Comparison of outbreak duration, number of cases, deaths, and case fatality rates of Ebola virus disease outbreaks across African regions. Values are presented as median.

Decadal Trends in Outbreak Duration, Size, Mortality, and Case Fatality Rate

The number of EVD outbreaks increased progressively over time, rising from three outbreaks (7.3%) during the first decade (1976–1986) to fourteen outbreaks (34.1%) during the fifth decade (2017–2026) (**Figure 9B**). Despite this increase in outbreak frequency, no statistically significant differences were observed in outbreak duration ($p = 0.339$), number of cases ($p = 0.327$), number of fatalities ($p = 0.208$), or case fatality rate (CFR) ($p = 0.177$) across decades.

The median outbreak duration varied from 67.0 days (range: 53-152 days) during the first decade to 135.5 days (IQR: 387.00-196.00; range: 86-201 days) during the second decade, before declining to 85.5 days (IQR: 69.75-122.00; range: 36-694 days) in the fifth decade. However, these

366 temporal differences were not statistically significant. Similarly, median outbreak size decreased
367 over time, from 284 cases (range: 34-318 cases) in the first decade to 17.5 cases (range: 1-3,470)
368 in the fifth decade, although substantial variability was observed across outbreaks, particularly
369 during the fourth decade 26.0 cases (IQR: 6.50-115.50; range: 1-28610 cases), which included the
370 2014–2016 West African epidemic (**Figure 9A**).

371 Median fatalities also declined across successive decades, decreasing from 151 deaths (range:22-
372 280 deaths) in the first decade to 10.5 deaths in both the fourth (IQR: 3.25-47.25; range: 0-11308)
373 and fifth (IQR: 4.25-52.50; range: 1-2287) decades. Nevertheless, the variation in mortality burden
374 across decades was not statistically significant.

375 Case fatality rates exhibited temporal fluctuations. The highest median CFR was observed during
376 the third decade (81.5%; range: 41.2–89.5%), whereas the lowest median CFR occurred during the
377 fourth decade (43.4%; range: 0.0–100.0%). The fifth decade recorded a median CFR of 56.6%
378 (range: 33.3–100.0%). Despite these differences, no significant temporal trend in CFR was
379 detected ($p = 0.177$) (**Figure 9A**).

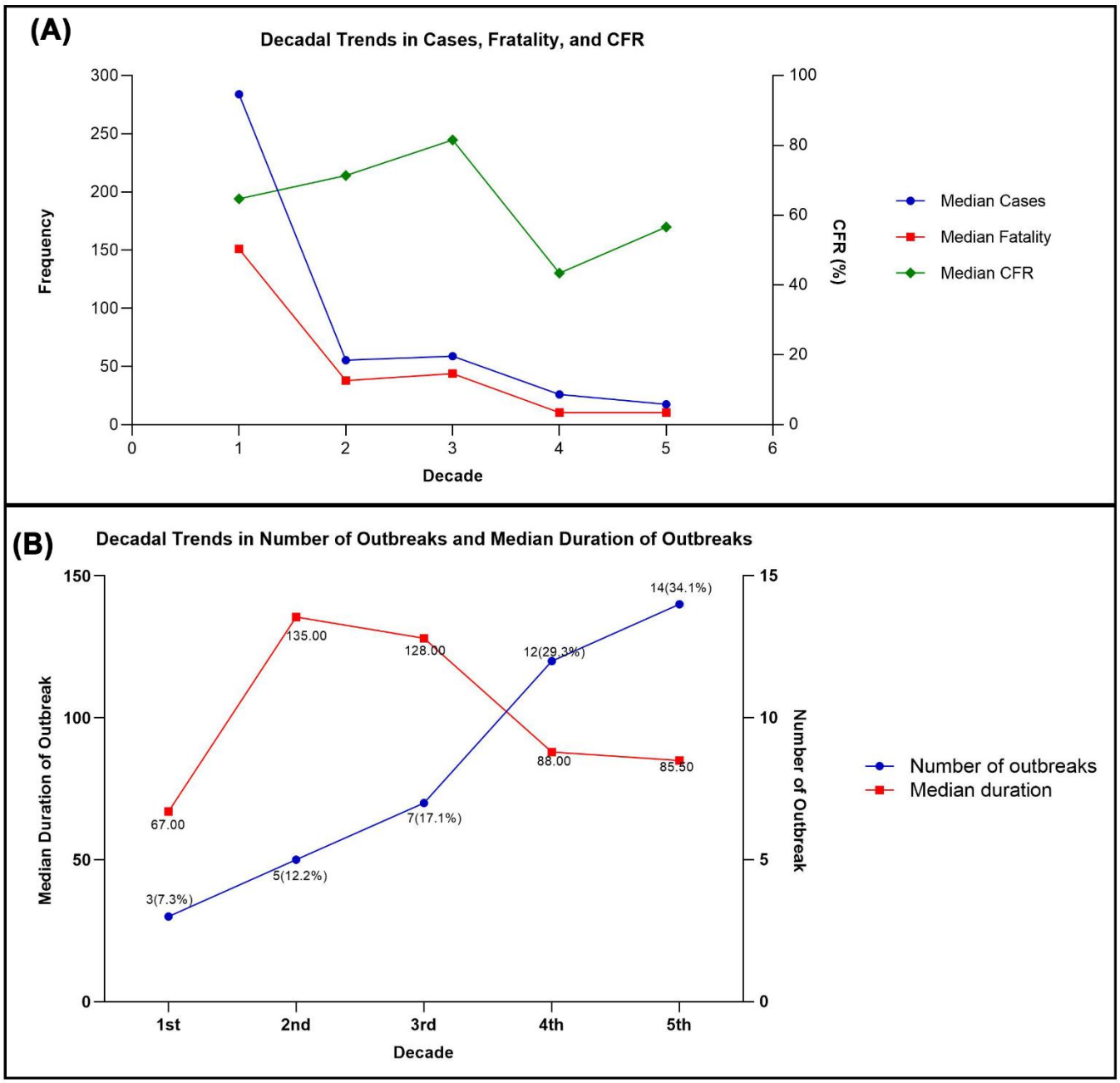

Figure 9: (A) Decadal trend in Ebola virus Disease outbreak case, Fatality, and CFR. **(B)** Decadal trend in Ebola virus Disease Number of outbreak and Median Duration of outbreak

Correlation Between Outbreak Characteristics

Spearman's rank correlation analysis was performed to evaluate associations among key Ebola virus disease outbreak characteristics (**Figure 10**).

A strong positive correlation was observed between outbreak duration and the number of reported cases ($\rho = 0.72$, $p < 0.001$), indicating that larger outbreaks tended to persist for longer periods (**Figure 10A**). Similarly, outbreak duration was strongly correlated with the number of deaths ($\rho = 0.71$, $p < 0.001$), suggesting that prolonged outbreaks were associated with greater mortality burdens (**Figure 10D**).

The strongest association was observed between the number of cases and fatalities ($\rho = 0.98$, $p < 0.001$), demonstrating a near-perfect positive relationship between outbreak size and the number of deaths recorded (**Figure 10B**). This finding indicates that outbreaks involving more cases consistently resulted in higher mortality counts.

In contrast, no significant correlation was identified between outbreak duration and case fatality rate (CFR) ($\rho = -0.13$, $p = 0.42$) (**Figure 10C**). Although a weak negative association was observed, the relationship was not statistically significant, suggesting that prolonged outbreaks were not necessarily associated with higher or lower lethality.

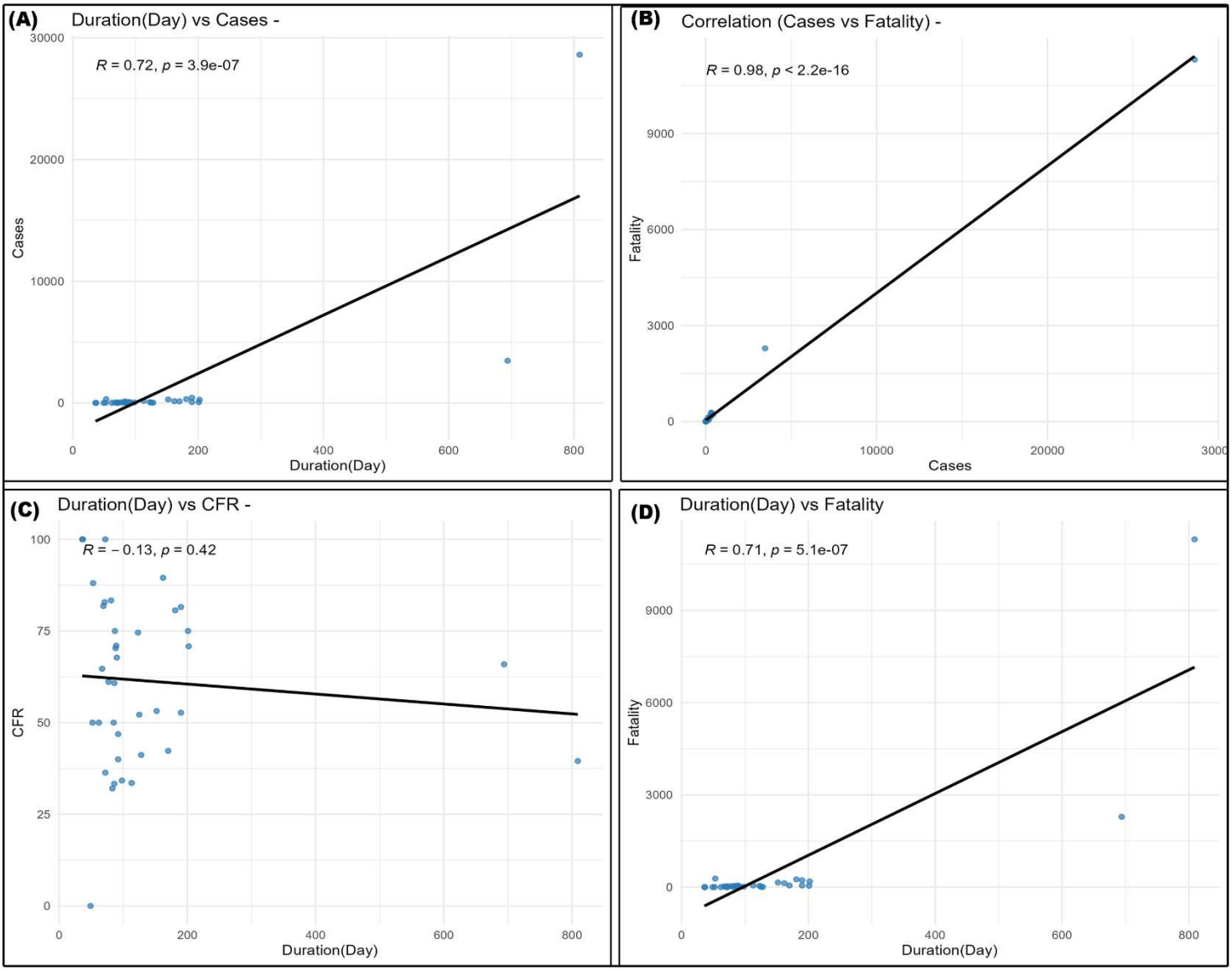

Figure 10. Spearman correlation analysis of Ebola virus disease outbreak characteristics in Africa, 1976–2026. **(A)** Relationship between outbreak duration and number of cases; **(B)** relationship between cases and fatalities; **(C)** relationship between outbreak duration and case fatality rate (CFR); and **(D)** relationship between outbreak duration and fatalities. Solid lines represent fitted regression lines. Spearman correlation coefficients (ρ) and corresponding p-values are displayed within each panel.

Comparison of Outbreak Characteristics Among Ebola Virus Species

Outbreak characteristics were compared across *Orthoebolavirus bundibugyoense*, *Orthoebolavirus sudanense*, and *Orthoebolavirus zairense* (**Table 2**). No statistically significant differences were observed in the number of cases ($p = 0.699$), fatalities ($p = 0.551$), or outbreak duration ($p = 0.817$) among the three species.

Median outbreak size was highest for *O. bundibugyoense* (84.5 cases), followed by *O. zairense* (51.0 cases) and *O. sudanense* (17.0 cases). Similarly, median fatalities were greatest among *O. zairense* outbreaks (31.0 deaths) and lowest among *O. sudanense* outbreaks (7.0 deaths). However, these differences were not statistically significant.

A significant overall difference was observed in case fatality rates (CFRs) among species ($p = 0.016$). *O. zairense* exhibited the highest median CFR (70.8%; IQR: 51.1–81.7%), followed by *O. sudanense* (50.0%; IQR: 36.4–53.2%) and *O. bundibugyoense* (33.1%; IQR: 32.1–34.2%). Nevertheless, post-hoc pairwise comparisons did not identify any statistically significant differences between individual species pairs after adjustment for multiple testing.

Table 2: Comparison of outbreak duration, cases, fatalities, and case fatality rates among Ebola virus species

	O. bundibugyoense	***O. sudanense***	***O. zairense***	***p-value***
Cases	84.50(38.00-31.00)	17.00(11.00-164.00)	51.00(12.00-99.50)	0.699
Fatality	27.50(13.00-42.00)	7.00(4.00-55.00)	31.00(8.50-54.00)	0.551
Duration	90.50(83.00-98.00)	86.00(67.00-128.00)	89.00(74.50-166.00)	0.817
CFR	33.14(32.06-34.21)	50.00(36.36-53.17)	70.83(51.09-81.68)	**0.016**[a]

Table 2. Comparison of outbreak duration, cases, fatalities, and case fatality rates among Ebola virus species causing Ebola virus disease outbreaks in Africa, 1976–2026. Values are presented as median (interquartile range). P-values were obtained using the Kruskal–Wallis' test. Pairwise post-hoc comparisons were performed for variables with significant overall differences. [a]; pairwise comparisons did not identify any statistically significant differences between individual species pairs after adjustment for multiple testing.

Temporal Trends in Ebola Virus Disease Outbreak Characteristics

Mann–Kendall trend analysis was performed to evaluate temporal changes in EVD outbreak characteristics between 1976 and 2026 (**Table 3**). A significant decreasing trend was observed in outbreak-related fatalities ($\tau = -0.242$, $p = 0.032$), with Sen's slope indicating an average reduction of approximately 0.8 deaths per outbreak over time (**Figure 11B**).

A declining trend was also observed in the number of reported cases ($\tau = -0.218$), although this association did not reach statistical significance ($p = 0.053$). Sen's slope estimate suggested a median decrease of approximately 1.3 cases per outbreak during the study period (**Figure 11A**). Similarly, outbreak duration exhibited a non-significant declining trend ($\tau = -0.124$, $p = 0.279$), corresponding to an estimated reduction of 0.7 days per outbreak over time (**Figure 11D**). No significant temporal trend was observed in CFR ($\tau = -0.132$, $p = 0.245$), although Sen's slope indicated a modest decline of approximately 0.4 percentage points per outbreak (**Figure 11C**).

To further assess temporal changes in outbreak occurrence, annual outbreak counts from 1976 to 2026, including years without reported outbreaks, were analyzed using Poisson regression. The analysis demonstrated a significant increase in outbreak frequency over time ($\beta = 0.039$, SE = 0.012, $z = 3.361$, $p < 0.001$). The incidence rate ratio (IRR) for calendar year was 1.04 (95% CI: 1.02–1.07), indicating that the expected number of Ebola outbreaks increased by approximately 4.0% per year. This corresponds to an estimated 48% increase in outbreak frequency per decade (**Figure 12**).

Table 3: Mann–Kendall trend analysis and Sen's slope estimates for Ebola virus disease outbreak characteristics in Africa, 1976–2026.

Variable	Tau	P-value	Sen's Slope	Interpretation
Outbreak Frequency	0.245	0.162	0.00	Increasing tendency, but not statistically significant
Cases	-0.218	0.053	-1.32	Borderline decline in outbreak size over time
Deaths	-0.242	0.032	-0.80	Significant decline in outbreak mortality over time
Duration	-0.124	0.279	-0.71	No significant temporal trend
CFR	-0.132	0.245	-0.40	No significant temporal trend

451

452

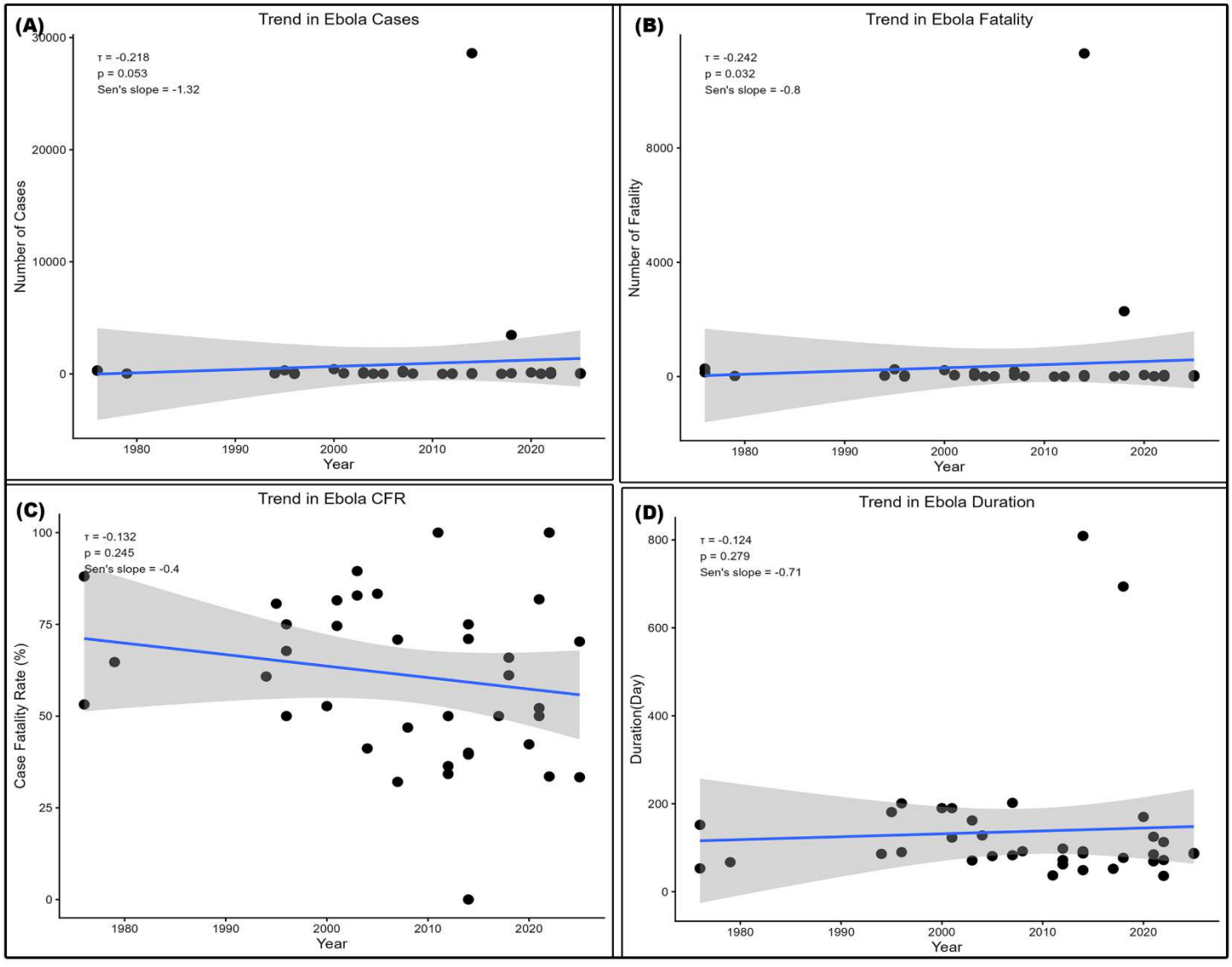

Figure 11: Temporal trends in Ebola virus disease outbreak characteristics in Africa, 1976–2026. (A) Number of reported cases per outbreak, **(B)** number of deaths per outbreak, **(C)** case fatality rate (CFR), and **(D)** outbreak duration. Points represent individual outbreaks, while solid lines indicate fitted trend lines with 95% confidence intervals. Mann–Kendall trend analysis and Sen's slope estimation were used to assess temporal trends. A significant decline was observed in outbreak-related fatalities ($\tau = -0.242$, $p = 0.032$), whereas trends in cases ($\tau = -0.218$, $p = 0.053$), CFR ($\tau = -0.132$, $p = 0.245$), and duration ($\tau = -0.124$, $p = 0.279$) were not statistically significant.

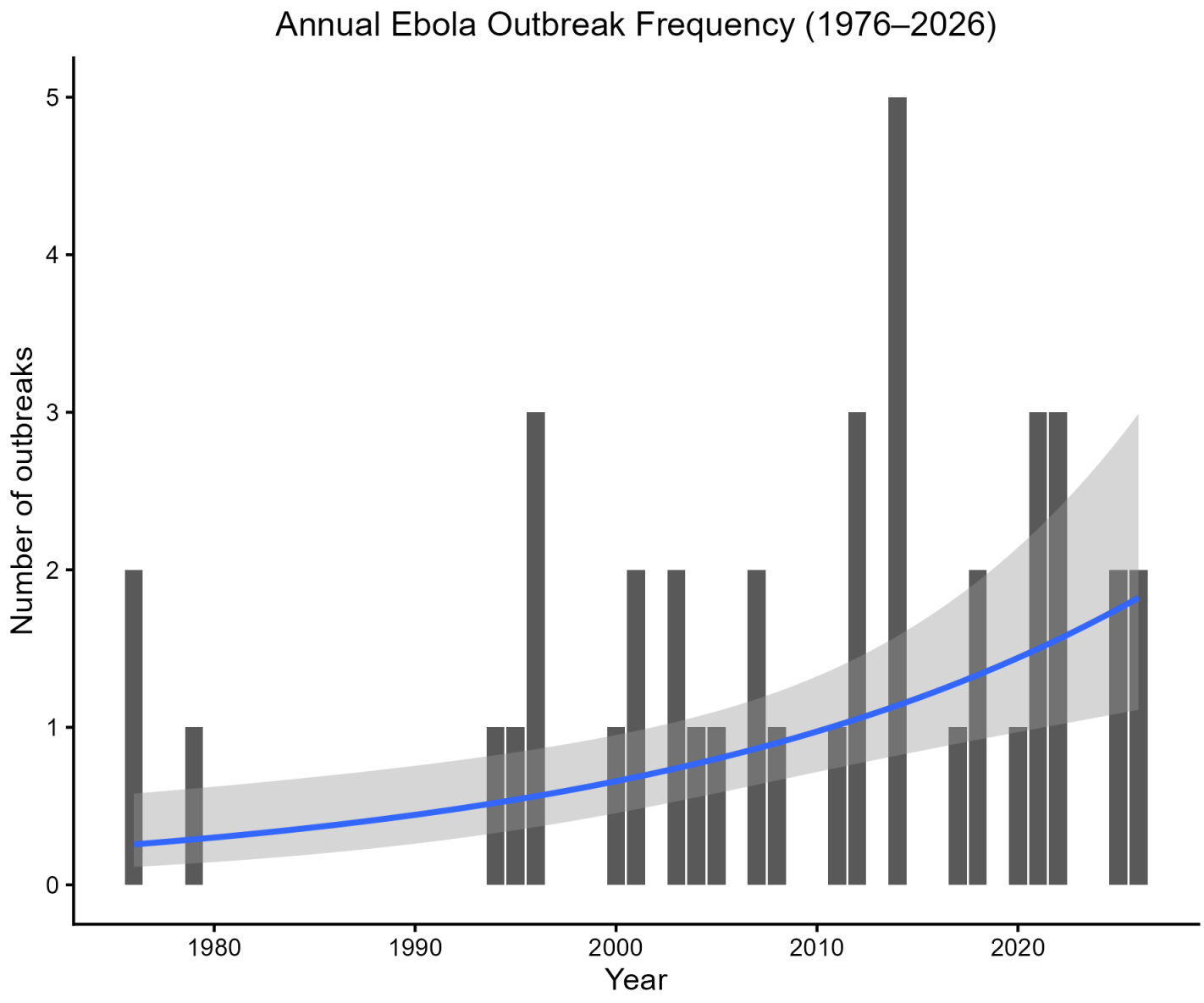

Figure 12: Temporal trend in annual Ebola virus disease outbreak frequency in Africa, 1976–2026.

Annual Ebola virus disease outbreak frequency in Africa from 1976 to 2026. The fitted Poisson regression model demonstrated a significant increase in outbreak occurrence over time (IRR = 1.04, 95% CI: 1.02–1.07, $p < 0.001$), corresponding to an estimated 4.0% increase in outbreak frequency per year.

Discussion

This study provides a continent-wide assessment of 41 human EVD outbreaks reported in Africa between 1976 and 2026. Three main findings emerged. Outbreaks became significantly more frequent over time, yet outbreak-related deaths declined. Central Africa and *Orthoebolavirus zairense* accounted for most outbreaks and the highest case fatality. Outbreak duration was strongly linked to the number of cases and deaths but not to case fatality rate (CFR).

The rise in outbreak frequency, estimated at about 4% per year, is unlikely to have a single cause. Forest fragmentation, recent loss of closed forest, mining, agricultural expansion, and growing human–wildlife contact have all been associated with Ebola spillover and may be increasing opportunities for emergence [39-41]. At the same time, better surveillance and laboratory capacity, particularly after the 2014–2016 West African epidemic, have probably improved detection of outbreaks that would once have gone unrecognized [42, 43]. The observed increase therefore likely reflects both a real rise in spillover risk and improved ascertainment, and the two cannot be separated with aggregate outbreak data.

Despite more frequent outbreaks, deaths per outbreak declined significantly, and the decline in cases approached significance. This is consistent with gains in preparedness and response, including rapid diagnostics [42], contact tracing [44], community engagement [45], and ring vaccination with rVSV-ZEBOV [12, 46]. Effective therapeutics may also have contributed [13]\. Earlier detection and isolation limit the number of transmission generations, which would reduce outbreak size and deaths without changing the lethality of infection. This fits our finding that CFR showed no significant temporal trend. Persistently high CFRs, particularly where timely diagnosis and advanced supportive care are limited [47], indicate that these gains rest on containing transmission rather than on a fall in the intrinsic severity of EVD. The trends should still be read

cautiously, because the series is small and heavily influenced by a few very large outbreaks, notably 2014–2016 and 2018–2020.

The strong correlations of duration with cases and deaths, and of cases with deaths, support this interpretation. Longer outbreaks allow more generations of transmission before control is achieved, and delayed recognition has been linked to longer and larger outbreaks [48]. Because deaths track outbreak size closely, whereas CFR is unrelated to duration, transmission intensity rather than lethality appears to be the main driver of outbreak burden [49]. Early detection and rapid containment are therefore likely to yield the greatest reductions in mortality, while clinical care and vaccination remain essential for reducing deaths among those infected [50].

Central Africa accounted for nearly 60% of outbreaks, confirming the Congo Basin as the principal hotspot for Ebola emergence [51, 52]. This is consistent with the ecology of the region, where forest habitats support the suspected fruit-bat reservoir [41] and hunting and handling of wildlife carcasses expose people to infection [53]. The high seroprevalence of Ebola IgG antibodies among Efé pygmies in the DRC's Watsa region provides direct serological evidence of Ebola virus exposure and supports the existence of sustained viral circulation among forest-dwelling populations within these ecosystems [54]. West Africa recorded only five outbreaks but the largest epidemic, showing that outbreak frequency does not predict outbreak magnitude. Delayed recognition, transmission in densely populated urban areas, fragile health systems, and cross-border movement allowed extensive spread before control measures took effect [48, 55, 56]. The emergence of *O. zairense* in Guinea, outside its historically recognized range [9], underlines the need for surveillance that extends beyond traditional high-risk areas, supported by One Health approaches and cross-border collaboration [57, 58].

O. zairense caused more than two-thirds of outbreaks and nearly all cases and deaths, in line with earlier reports [59, 60]. It also had the highest median CFR, and CFR differed significantly across regions, being highest in Central Africa [61]. However, neither the species nor the regional differences remained significant in pairwise post hoc comparisons. These differences should therefore be regarded as suggestive, and they are unlikely to be explained by viral factors alone. Delayed diagnosis, limited access to care, and the timeliness of the response probably also contributed [48, 59, 61]. The lower CFR in the West African epidemic may reflect expanded treatment capacity, laboratory support, and international response during the outbreak [62]. The clustering of species by region (*O. sudanense* in East and North Africa, *O. bundibugyoense* in Central and East Africa) is consistent with distinct ecological niches, although the underlying mechanisms remain unclear [63, 64].

This species pattern matters for preparedness. Licensed vaccines and most therapeutics target *O. zairense* [65, 66], whereas countermeasures for other orthoebolaviruses are far less developed. The ongoing 2026 *O. bundibugyoense* outbreaks in the DRC and Uganda illustrate this gap [67]. Accelerating broadly protective vaccines and antivirals, and strengthening genomic surveillance to identify the causative species early, should be priorities [68, 69].

The strengths of this study are its continental scope and 50-year observation window, which allow long-term patterns to be examined that shorter studies cannot capture, and its use of complementary trend, regression and correlation methods. This study has limitations. It relied on publicly reported outbreak data, which are subject to underreporting and to differences in surveillance capacity across countries and eras. Health-system capacity, access to care, and the timing and content of the response could not be included as covariates. Several comparisons rested on small numbers, and the analysis is ecological and observational, so causal inference is not

possible. Future work combining patient-level clinical data, genomic data, environmental variables, and health-system indicators would help clarify what drives emergence and outcomes.

Conclusion

Over the past five decades, EVD outbreaks in Africa have demonstrated a complex epidemiological pattern characterized by increasing outbreak frequency but improving capacity to limit outbreak size and mortality. Central Africa remains the primary hotspot for Ebola emergence, while *Orthoebolavirus zairense* continues to account for the majority of outbreaks and the highest observed CFR. The decline in outbreak-related deaths despite increasing outbreak frequency highlights the substantial progress achieved through strengthened surveillance, improved diagnostics, vaccination, and enhanced outbreak response systems. However, the continued occurrence of outbreaks and persistently high CFR demonstrate that Ebola remains a significant public health threat.

Future efforts should focus on sustaining and expanding One Health surveillance approaches, strengthening health system resilience in high-risk regions, improving preparedness for cross-border transmission, and developing broader therapeutic and preventive tools against diverse Ebola virus species. Maintaining these investments will be essential to reducing the future impact of EVD and preventing localized spillover events from developing into large-scale epidemics.

Declarations

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Ethical Approval

This study employed publicly available data. No primary data involving human participants or animals were collected for this work. Therefore, ethical approval was not required.

Consent to Participate

Not applicable, as this study did not involve human participants or primary data collection.

Consent to Publish

Not applicable. All data and information included in this manuscript are derived from publicly available sources or previously published studies. No individual-level personal data are presented.

Clinical Trial Number

Not applicable.

Authors' contributions

Conceptualization: R.O.A; Methodology: R.O.A, E.O, E.M.O, K.D.E.D, E.A.A, F.N, S.T, M.A.B and D.K.B; Formal analysis: R.O.A, E.O, D.K.B, F.N, and E.A.A; data curation: R.O.A, B.N, R.L, R.B.A; writing-original draft: R.O.A, E.O, E.M.O, K.D.E.D, E.A.A, F.N, and D.K.B; writing-review and editing: R.O.A, E.O, E.M.O, K.D.E.D, E.A.A, M.A.B, F.N, S.T, D.K.B, B.N, R.L, M.A.B, R.B.A, R.X.S, B.D.M, and D.B. All authors read and agreed to the published version of the manuscript.

Competing interests

The authors declare that they have no competing interests.

Dual Publication

This manuscript is original and is not under consideration elsewhere, nor has it been previously published in whole or in part elsewhere, in any language. All sources are appropriately cited.

Permission to Use Third-Party Material

All figures, tables, and text excerpts reproduced from other sources are accompanied by full citations. Where necessary, permission has been obtained from copyright holders and is available upon request.

Availability of data and materials

Data sharing is not applicable to this article as no datasets were generated or analyzed during the current study.

Acknowledgements

Not applicable.

REFERENCES

1. Feldmann H, Geisbert TW. Ebola haemorrhagic fever. The Lancet. 2011;377(9768):849-62.
2. Commission I. Ebola haemorrhagic fever in Zaire, 1976. Bull World Health Organ. 1978;56:271-93.
3. Malvy D, McElroy AK, de Clerck H, Günther S, van Griensven J. Ebola virus disease. The Lancet. 2019;393(10174):936-48.
4. Biedenkopf N, Bukreyev A, Chandran K, Di Paola N, Formenty PB, Griffiths A, et al. Renaming of genera Ebolavirus and Marburgvirus to Orthoebolavirus and Orthomarburgvirus, respectively, and introduction of binomial species names within family Filoviridae: N. Biedenkopf et al. Archives of virology. 2023;168(8):220.
5. Kuhn JH, Amarasinghe GK, Basler CF, Bavari S, Bukreyev A, Chandran K, et al. ICTV virus taxonomy profile: Filoviridae. Journal of General Virology. 2019;100(6):911-2.
6. Towner JS, Sealy TK, Khristova ML, Albariño CG, Conlan S, Reeder SA, et al. Newly discovered ebola virus associated with hemorrhagic fever outbreak in Uganda. PLoS pathogens. 2008;4(11):e1000212.
7. Leroy EM, Kumulungui B, Pourrut X, Rouquet P, Hassanin A, Yaba P, et al. Fruit bats as reservoirs of Ebola virus. Nature. 2005;438(7068):575-6.
8. Pigott DM, Golding N, Mylne A, Huang Z, Henry AJ, Weiss DJ, et al. Mapping the zoonotic niche of Ebola virus disease in Africa. elife. 2014;3:e04395.
9. Baize S, Pannetier D, Oestereich L, Rieger T, Koivogui L, Magassouba NF, et al. Emergence of Zaire Ebola virus disease in Guinea. New England Journal of Medicine. 2014;371(15):1418-25.
10. Team WER. Ebola virus disease in West Africa—the first 9 months of the epidemic and forward projections. New England Journal of Medicine. 2014;371(16):1481-95.
11. Sprecher A. Understanding the key to outbreak control—Sudan virus disease in Uganda. New England Journal of Medicine. 2022;387(26):2393-5.
12. Henao-Restrepo AM, Camacho A, Longini IM, Watson CH, Edmunds WJ, Egger M, et al. Efficacy and effectiveness of an rVSV-vectored vaccine in preventing Ebola virus disease: final

614 results from the Guinea ring vaccination, open-label, cluster-randomised trial (Ebola Ça Suffit!).
615 The Lancet. 2017;389(10068):505-18.
616 13. Mulangu S, Dodd LE, Davey Jr RT, Tshiani Mbaya O, Proschan M, Mukadi D, et al. A
617 randomized, controlled trial of Ebola virus disease therapeutics. New England journal of
618 medicine. 2019;381(24):2293-303.
619 14. Nations U. Standard country or area codes for statistical use (M49) [Available from:
620 https://unstats.un.org/unsd/methodology/m49/.
621 15. CDC. History of Ebola Outbreaks [Available from:
622 https://www.cdc.gov/ebola/outbreaks/index.html.
623 16. Team RoaWIS. Ebola haemorrhagic fever in Sudan, 1976. Bulletin of the World Health
624 Organization. 1978;56(2):247.
625 17. Baron RC, McCormick JB, Zubeir OA. Ebola virus disease in southern Sudan: hospital
626 dissemination and intrafamilial spread. Bulletin of the World Health Organization.
627 1983;61(6):997.
628 18. Georges A-J, Leroy EM, Renaut AA, Benissan CT, Nabias RJ, Ngoc MT, et al. Ebola
629 hemorrhagic fever outbreaks in Gabon, 1994–1997: epidemiologic and health control issues. The
630 Journal of infectious diseases. 1999;179(Supplement_1):S65-S75.
631 19. Khan AS, Tshioko FK, Heymann DL, Le Guenno B, Nabeth P, Kerstiëns B, et al. The
632 reemergence of Ebola hemorrhagic fever, Democratic Republic of the Congo, 1995. The Journal
633 of infectious diseases. 1999;179(Supplement_1):S76-S86.
634 20. WHO. Disease Outbreak News. 1996- Ebola haemorrhagic fever in Gabon. 1996.
635 21. WHO. Disease Outbreak News: 1996 - South Africa. 1996.
636 22. Francesconi P, Yoti Z, Declich S, Onek PA, Fabiani M, Olango J, et al. Ebola hemorrhagic
637 fever transmission and risk factors of contacts, Uganda. Emerging infectious diseases.
638 2003;9(11):1430.
639 23. Okware SI, Omaswa F, Zaramba S, Opio A, Lutwama J, Kamugisha J, et al. An outbreak of
640 Ebola in Uganda. Tropical Medicine & International Health. 2002;7(12):1068-75.
641 24. Organization WH. Outbreak (s) of Ebola haemorrhagic fever, Congo and Gabon, October
642 2001-July 2002= Flambée (s) de fièvre hémorragique à virus Ebola, Congo et Gabon, octobre
643 2001—juillet 2002. Weekly Epidemiological Record= Relevé épidémiologique hebdomadaire.
644 2003;78(26):223-8.
645 25. Formenty P, Libama F, Epelboin A, Allarangar Y, Leroy E, Moudzeo H, et al. Outbreak of
646 Ebola hemorrhagic fever in the Republic of the Congo, 2003: a new strategy? Médecine tropicale:
647 revue du Corps de sante colonial. 2003;63(3):291-5.
648 26. Nkoghe D, Kone ML, Yada A, Leroy E. A limited outbreak of Ebola haemorrhagic fever in
649 Etoumbi, Republic of Congo, 2005. Transactions of the Royal Society of Tropical Medicine and
650 Hygiene. 2011;105(8):466-72.
651 27. Onyango CO, Opoka ML, Ksiazek TG, Formenty P, Ahmed A, Tukei PM, et al. Laboratory
652 diagnosis of Ebola hemorrhagic fever during an outbreak in Yambio, Sudan, 2004. The Journal of
653 infectious diseases. 2007;196(Supplement_2):S193-S8.
654 28. Wamala JF, Lukwago L, Malimbo M, Nguku P, Yoti Z, Musenero M, et al. Ebola hemorrhagic
655 fever associated with novel virus strain, Uganda, 2007–2008. Emerging infectious diseases.
656 2010;16(7):1087.

29. Leroy EM, Epelboin A, Mondonge V, Pourrut X, Gonzalez J-P, Muyembe-Tamfum J-J, et al. Human Ebola outbreak resulting from direct exposure to fruit bats in Luebo, Democratic Republic of Congo, 2007. Vector-borne and zoonotic diseases. 2009;9(6):723-8.
30. Grard G, Biek R, Muyembe Tamfum J-J, Fair J, Wolfe N, Formenty P, et al. Emergence of divergent Zaire ebola virus strains in Democratic Republic of the Congo in 2007 and 2008. The Journal of infectious diseases. 2011;204(suppl_3):S776-S84.
31. Shoemaker T, MacNeil A, Balinandi S, Campbell S, Wamala JF, McMullan LK, et al. Reemerging Sudan ebola virus disease in Uganda, 2011. Emerging infectious diseases. 2012;18(9):1480.
32. reliefweb. Uganda: Ebola Outbreak - Jul 2012 2013 [Available from: https://reliefweb.int/disaster/ep-2012-000124-uga.
33. reliefweb. DR Congo: Ebola Outbreak - Aug 2012 2012 [Available from: https://reliefweb.int/disaster/ep-2012-000143-cod.
34. Maganga GD, Kapetshi J, Berthet N, Kebela Ilunga B, Kabange F, Mbala Kingebeni P, et al. Ebola virus disease in the Democratic Republic of Congo. New England Journal of Medicine. 2014;371(22):2083-91.
35. reliefweb. 2014-2016 Ebola Outbreak in West Africa 2016 [Available from: https://reliefweb.int/report/democratic-republic-congo/2014-2016-ebola-outbreak-west-africa.
36. reliefweb. Mali: Ebola Preparedness - Emergency Plan of Action Final Report, Fund n° MDRML011 2016 [Available from: https://reliefweb.int/report/mali/mali-ebola-preparedness-emergency-plan-action-final-report-fund-n-mdrml011.
37. PAHO. WHO declares end of Ebola outbreak in Nigeria 2014 [Available from: https://www.paho.org/en/news/20-10-2014-who-declares-end-ebola-outbreak-nigeria.
38. reliefweb. The outbreak of Ebola virus disease in Senegal is over 2014 [Available from: https://reliefweb.int/report/senegal/outbreak-ebola-virus-disease-senegal-over.
39. Rulli MC, Santini M, Hayman DT, D'Odorico P. The nexus between forest fragmentation in Africa and Ebola virus disease outbreaks. Scientific reports. 2017;7(1):41613.
40. Olivero J, Fa JE, Real R, Márquez AL, Farfán MA, Vargas JM, et al. Recent loss of closed forests is associated with Ebola virus disease outbreaks. Scientific reports. 2017;7(1):14291.
41. Olivero J, Fa JE, Farfán MÁ, Márquez AL, Real R, Juste FJ, et al. Human activities link fruit bat presence to Ebola virus disease outbreaks. Mammal Review. 2020;50(1):1-10.
42. Mukadi-Bamuleka D, Bulabula-Penge J, Jacobs BK, De Weggheleire A, Edidi-Atani F, Mambu-Mbika F, et al. Head-to-head comparison of diagnostic accuracy of four Ebola virus disease rapid diagnostic tests versus GeneXpert® in eastern Democratic Republic of the Congo outbreaks: a prospective observational study. EBioMedicine. 2023;91.
43. Keita M, Talisuna A, Chamla D, Burmen B, Cherif MS, Polonsky JA, et al. Investing in preparedness for rapid detection and control of epidemics: analysis of health system reforms and their effect on 2021 Ebola virus disease epidemic response in Guinea. BMJ Global Health. 2023;8(1):e010984.
44. Keita M, Cherif IS, Polonsky JA, Boland ST, Kandako Y, Cherif MS, et al. Factors associated with reliable contact tracing during the 2021 Ebola virus disease outbreak in Guinea. Journal of Epidemiology and Global Health. 2024;14(3):699-709.

45. Masumbuko Claude K, Underschultz J, Hawkes MT. Social resistance drives persistent transmission of Ebola virus disease in Eastern Democratic Republic of Congo: a mixed-methods study. PLoS One. 2019;14(9):e0223104.
46. Meakin S, Nsio J, Camacho A, Kitenge R, Coulborn RM, Gignoux E, et al. Effectiveness of rVSV-ZEBOV vaccination during the 2018–20 Ebola virus disease epidemic in the Democratic Republic of the Congo: a retrospective test-negative study. The Lancet Infectious Diseases. 2024;24(12):1357-65.
47. Muniroh M, Hermawati L, Fathurrohim F, Darifah S, Dewi LF, Putri NR, et al. Ebola virus disease: A persistent challenge in global health security. Open Veterinary Journal. 2026;16(2):768.
48. Matson MJ, Chertow DS, Munster VJ. Delayed recognition of Ebola virus disease is associated with longer and larger outbreaks. Emerging Microbes & Infections. 2020;9(1):291-301.
49. Chowell G, Nishiura H. Transmission dynamics and control of Ebola virus disease (EVD): a review. BMC medicine. 2014;12(1):196.
50. Abdul-Rahman T, Lawal L, Meale E, Ajetunmobi OA, Toluwalashe S, Alao UH, et al. Inequitable access to Ebola vaccines and the resurgence of Ebola in Africa: a state of arts review. Journal of Medical Virology. 2023;95(8):e28986.
51. Muyembe-Tamfum J-J, Mulangu S, Masumu J, Kayembe J, Kemp A, Paweska JT. Ebola virus outbreaks in Africa: past and present. Onderstepoort Journal of Veterinary Research. 2012;79(2):06-13.
52. Coltart CE, Lindsey B, Ghinai I, Johnson AM, Heymann DL. The Ebola outbreak, 2013–2016: old lessons for new epidemics. Philosophical Transactions of the Royal Society B: Biological Sciences. 2017;372(1721):20160297.
53. Ponce L, Kinoshita R, Nishiura H. Exploring the human-animal interface of Ebola virus disease outbreaks. Mathematical Biosciences and Engineering. 2019;16(4):3130-43.
54. Mulangu S, Borchert M, Paweska J, Tshomba A, Afounde A, Kulidri A, et al. High prevalence of IgG antibodies to Ebola virus in the Efé pygmy population in the Watsa region, Democratic Republic of the Congo. BMC infectious diseases. 2016;16(1):263.
55. Organization WH. Factors that contributed to undetected spread of the Ebola virus and impeded rapid containment 2015 [Available from: https://www.who.int/news-room/spotlight/one-year-into-the-ebola-epidemic/factors-that-contributed-to-undetected-spread-of-the-ebola-virus-and-impeded-rapid-containment.
56. Organization WH. Statement on the 1st meeting of the IHR Emergency Committee on the 2014 Ebola outbreak in West Africa 2014 [Available from: https://www.who.int/news/item/08-08-2014-statement-on-the-1st-meeting-of-the-ihr-emergency-committee-on-the-2014-ebola-outbreak-in-west-africa.
57. Hussein HA. Brief review on ebola virus disease and one health approach. Heliyon. 2023;9(8).
58. Adokiya MN, Awoonor-Williams JK. Ebola virus disease surveillance and response preparedness in northern Ghana. Global health action. 2016;9(1):29763.
59. Izudi J, Bajunirwe F. Case fatality rate for Ebola disease, 1976–2022: A meta-analysis of global data. Journal of infection and public health. 2024;17(1):25-34.
60. Rugarabamu S, Mboera L, Rweyemamu M, Mwanyika G, Lutwama J, Paweska J, et al. Forty-two years of responding to Ebola virus outbreaks in Sub-Saharan Africa: a review. BMJ Global Health. 2020;5(3).

61. Kawuki J, Musa T, Yu X. Impact of recurrent outbreaks of Ebola virus disease in Africa: a meta-analysis of case fatality rates. Public health. 2021;195:89-97.
62. Marston BJ, Dokubo EK, van Steelandt A, Martel L, Williams D, Hersey S, et al. Ebola response impact on public health programs, West Africa, 2014–2017. Emerging Infectious Diseases. 2017;23(Suppl 1):S25.
63. Judson SD, Fischer R, Judson A, Munster VJ. Ecological contexts of index cases and spillover events of different ebolaviruses. PLoS pathogens. 2016;12(8):e1005780.
64. Kock R, Begovoeva M, Ansumana R, Suluku R. Searching for the source of Ebola: the elusive factors driving its spillover into humans during the West African outbreak of 2013–2016. Rev Sci Tech. 2019;38(1):113-22.
65. Organization WH. Ebola vaccines 2026 [Available from: https://www.who.int/news-room/questions-and-answers/item/ebola-vaccines?
66. Nachega JB, Muyembe-Tamfum J-J, Zumla A. Therapeutic and prophylactic strategies for Ebola caused by Bundibugyo virus. Nature Reviews Drug Discovery. 2026.
67. Sullivan NJ. Bundibugyo virus disease in 2026—clinical and public health responses. New England Journal of Medicine. 2026;395(3):278-89.
68. Organization WH. Experts convened by WHO advise on candidate treatments and vaccines for Ebola disease caused by Bundibugyo virus 2026 [Available from: https://www.who.int/brunei/news/detail-global/28-05-2026-experts-convened-by-who-advise-on-candidate-treatments-and-vaccines-for-ebola-disease-caused-by-bundibugyo-virus.
69. Kinganda-Lusamaki E, Whitmer S, Lokilo-Lofiko E, Amuri-Aziza A, Muyembe-Mawete F, Makangara-Cigolo JC, et al. 2020 Ebola virus disease outbreak in Équateur Province, Democratic Republic of the Congo: a retrospective genomic characterisation. The Lancet Microbe. 2024;5(2):e109-e18.