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Prevalence of Cholera among Admitted Patients of Federal Medical Centre (FMC), Keffi, Nasarawa State, Nigeria: A Retrospective Observational Study

Akpan Collins Emmanuel[1]*, Atanyi Yusuf Emmanuel[1], Imam Akeyede[2], Orole Olukayode[3] & Peter Ogiri Agbo[4]
[1]Department of Mathematics, Federal University of Lafia, Nigeria
[2]Department of Statistics, Federal University of Lafia, Nigeria
[3]Department of Microbiology, Federal University of Lafia, Nigeria
[4]Department of Pharmacy, Federal Medical Centre Keffi, Nigeria

Abstract

This retrospective observational study assessed the prevalence, morbidity, and mortality patterns of cholera among admitted patients at Federal Medical Centre (FMC), Keffi, Nigeria, from 2021 to 2025. A total of 165 confirmed cholera cases were analyzed using descriptive statistics and logistic regression models. The overall case fatality rate (CFR) remained high, with a peak of 29.2 % observed in 2023 despite a decline in case incidence. Temporal trends revealed fluctuating morbidity with peaks in 2022 and 2025, suggesting persistent endemic transmission. Age-specific analysis demonstrated a U-shaped mortality pattern, with the highest risk observed among pediatric (0–20 years) and geriatric (>80 years) populations, while sex was not a significant predictor of mortality ($p > 0.05$). Multivariate analysis indicated no statistically significant independent predictors of mortality; however, predicted probability models showed increasing mortality risk with age. These findings highlight the sustained burden of cholera in Keffi and underscore the need for improved surveillance, early diagnosis, and targeted interventions focusing on high-risk populations. The study contributes to existing knowledge by providing localized epidemiological evidence to inform public health strategies in Nigeria.

Keywords: Cholera, Epidemiology, Case fatality rate, Morbidity, Mortality, Public health

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Correspondences
C. E. Akpan ✉
collins.eakpan@science.fulafia.edu.ng

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Introduction

Cholera remains a major public health concern in Nigeria, with recurrent outbreaks driven by inadequate water, sanitation, and hygiene (WASH) infrastructure. Recent national reports indicate persistent endemicity with periodic surges linked to environmental and socio-economic factors. Despite ongoing interventions, high case fatality rates continue to be reported, particularly in underserved regions.Cholera, an acute gastro-intestinal water-borne infection, is caused by the bacterium *Vibrio cholerae*, *V. cholerae* or O139. Some of the symptoms are vomiting and diarrhea. And if treatment is delayed, it can lead to severe dehydration and death within a few hours. The disease has two modes of transmission: direct and indirect transmission. Direct transmission (human-human) is very uncommon, while the indirect transmission (environment-human), which occurs through the ingestion of contaminated food or water, is more frequent. Known estimate of the incubation period for the cholera disease is (fourteen) 14 days. On the other hand, the *Salmonella typhi* bacterium is responsible for causing the life-threatening typhoid fever disease. Cholera have the same transmission modes. The reticuloendothelial system, the intestinal lymphoid, and the gall bladder are severe

Cholera is a waterborne infectious disease caused by *Vibrio cholerae* and remains a major public health problem in developing countries, including Nigeria. Recent outbreaks in Nigeria, including the 2024 resurgence, highlight the persistent burden of the disease, particularly in areas with inadequate sanitation and clean water supply. Studies have shown that cholera continues to affect vulnerable populations, especially children and those living in overcrowded environments. Cholera remains endemic in Nigeria with recurrent outbreaks driven by poor water, sanitation, and hygiene infrastructure.

Abubakar *et al.* [1], in their paper, described the two different stochastic differential equations representing cholera dynamics. The first stochastic differential equation is formulated by introducing the stochasticity to deterministic model by parametric perturbation technique which is a standard technique in stochastic modeling and the second stochastic differential

equation is formulated with the use of transition probabilities. They also went ahead to analyse a stochastic model using suitable Lyapunov function and its formula. Austin [2] tutorial explains how to analyze time-to-event data when subjects are clustered—like patients within hospitals, students within schools, or people within neighborhoods. Standard Cox or AFT models assume all observations are independent, but that breaks down with hierarchical data. Ehidiamhen *et al.* [3] also highlighted that contamination of water sources remains a primary transmission route. Recent reports indicate that cholera disproportionately affects children and younger populations, with significant mortality observed in these groups. Elimian [4] highlights that cholera control in Nigeria is not just technical but systemic. Lack of political will cascades into funding gaps, weak surveillance, and fragmented response.

Community trust emerges as central to resilience. Guerra-Silveira *et al.* [5] investigated the underlying mechanisms of sex differences in infectious disease burden, testing whether male-biased incidence reflects differential exposure due to behavior or intrinsic physiological susceptibility. Using national compulsory-notification data from Brazil (2006–2009) and 82 published exposure-prevalence surveys covering approximately 0.5 million cases across ten major pathogens, the authors compared two competing hypotheses: the Behavioral Hypothesis (BH), which attributes sex bias to gendered differences in risk behavior and exposure, and the Physiological Hypothesis (PH), which posits that sex steroids and immune function drive differential susceptibility. Godwin *et al.* [6] extend earlier SIR/SIVR-type cholera models by explicitly modeling asymptotic transmission, aligning with metapopulation work. Their results support using combined vaccination and water, sanitation, and hygiene (WASH) programs to control outbreaks and these findings align with the FMC Keffi results, which show high vulnerability among pediatric populations and persistent endemic transmission.

Hosmer *et al.* [7] provide the definitive applied text on logistic regression for modeling binary, multinomial, and ordinal outcomes. The 3rd edition updates the classic to address modern applications in health sciences, data mining, and machine learning, while retaining its hallmark accessibility for practitioners with limited mathematical background. Kelly *et al.* [8] address confusion around the case fatality ratio (CFR) as a measure of disease severity during outbreaks. Writing after the 2009 H1N1 pandemic, they note that widely varying CFR estimates caused public anxiety and policy uncertainty, yet the metric itself is often misunderstood and miscalculated. Klein *et al.* [9] establish that biological sex fundamentally shapes immunity via hormonal, genetic, and epigenetic mechanisms. Females generally have more robust immune responses than males, which improves pathogen clearance but increases risk of immunopathology and autoimmunity. The paper is a landmark call to integrate sex as a biological variable in immunology, vaccinology, and infectious disease research. The Lancet Nigeria Commission [10] shows Nigeria is underperforming on health despite economic size and increased spending. Poor outcomes reflect not just low investment, but inefficient, inequitable spending and weak systems. The report frames health as an investment in national prosperity, not a cost.

Mike-Ogburia *et al.* [11] show cholera remains endemic in Nigeria due to structural WASH deficits, conflict, and emerging drug resistance. While OCV and surveillance have helped, durable control depends on integrated investment in water, sanitation, health system resilience, and community-based prevention. Okolo *et al.* [12] frame hepatitis E virus (HEV) as a life-threatening infection in pregnancy, with 20–30 % mortality risk, especially in the third trimester. HEV causes preterm labour, vertical transmission, and poor feto-maternal outcomes, including fulminant hepatitis that can kill both mother and foetus. With no licensed treatment or vaccine and high maternal mortality in Nigeria, the authors stress the need to document HEV burden in vulnerable groups like pregnant women. Simonsen *et al*. [13] examined why influenza mortality patterns differ sharply between pandemics and subsequent epidemics. While almost all deaths in seasonal epidemics occur among the elderly, the 1918–1919 pandemic killed disproportionately many young adults. The study asked: Does age distribution of influenza deaths change systematically from pandemics to the epidemics that follow.

Sperandei [14] provides a didactic introduction to logistic regression for clinical and laboratory medicine readers. The paper explains when and how to use logistic regression to obtain odds ratios (OR) with multiple explanatory variables, using a fictional *Staphylococcus aureus* endocarditis dataset as a running example. Spychalski *et al.* [15] conclude that CFR is not an appropriate index to represent epidemic status in real time. It is highly sensitive to testing policy, age of tested cases, time lags, and healthcare burden. WHO [16] documents a worsening multi-country cholera crisis driven by conflict, climate, and displacement. Despite improved OCV production, supply gaps persist and deaths are rising. The agency stresses WASH, surveillance, and equitable vaccine access as priorities, and deems CFR an inadequate sole metric for epidemic status.

This study aligns with national epidemiological trends and focuses on the analysis of cholera cases at FMC Keffi. While several studies have examined cholera dynamics at national and regional levels, there is limited facility-based evidence describing clinical outcomes and epidemiological trends in specific healthcare settings such as FMC Keffi. This represents a critical knowledge gap, as localized data are essential for designing targeted interventions and improving patient outcomes.

This study aims to evaluate the prevalence, morbidity, and mortality patterns of cholera among admitted patients at FMC Keffi between 2021 and 2025. Specifically, the study seeks to: (1) Determine the

annual incidence of cholera cases; (2) Assess case fatality rates across the study period; (3) Analyze age-specific and sex-specific clinical outcomes; (4) Identify temporal trends in morbidity and mortality.
The study is justified by the need to provide empirical evidence to support improved clinical management and public health planning in Nigeria.

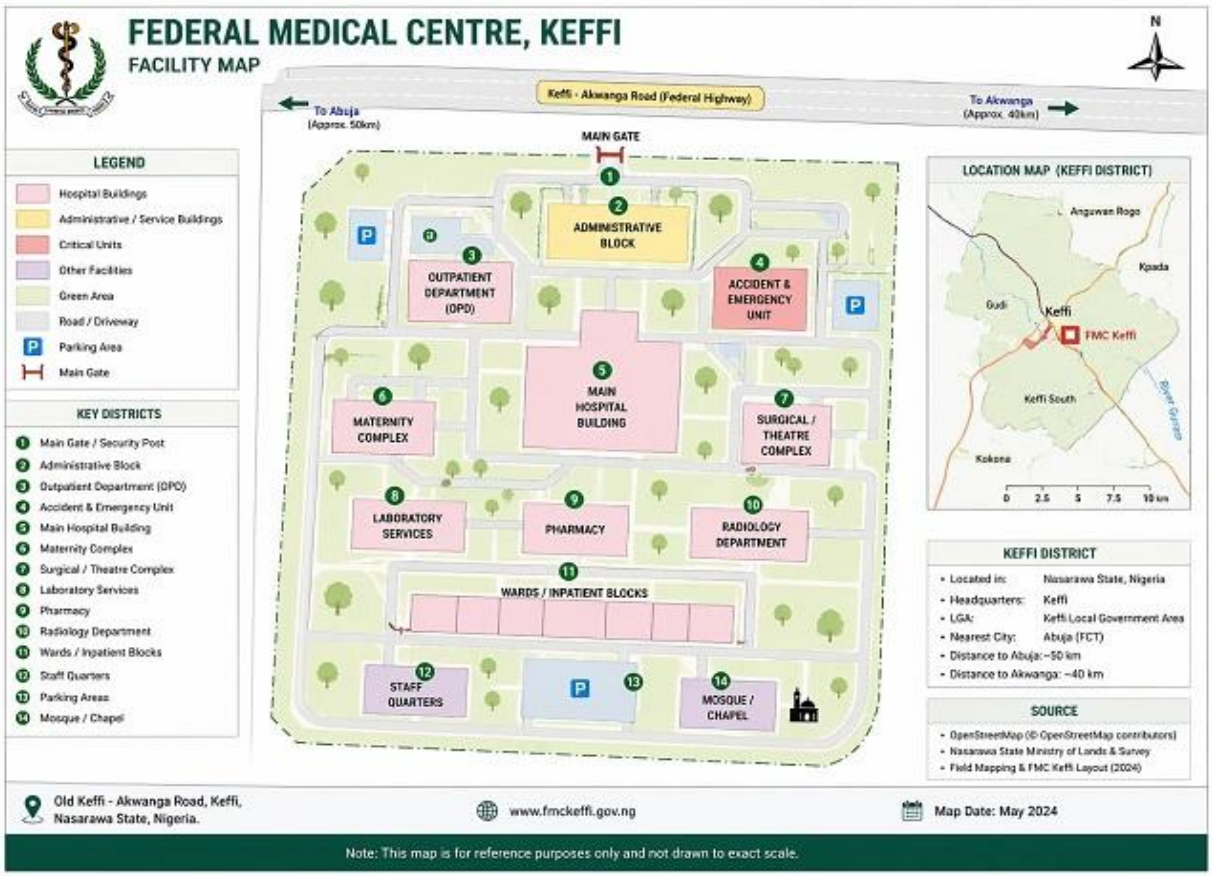
Materials and Methods

Research design

This study adopted a retrospective descriptive research design to assess the prevalence of typhoid fever among admitted patients at the Federal University of Lafia Teaching Hospital (FULAFIA TH). The design enabled the researcher to analyze already existing hospital records over a specified period (2021–2025) to determine patterns of morbidity, mortality, and case fatality rates.

Study area

The study was conducted at Federal Medical Centre (FMC) Keffi, Nigeria located at No. 1 Old, Keffi-Akwanga Rd, Keffi, Nasarawa State, Nigeria with coordinates 8.846251, 7.884901 in Keffi, Nasarawa State, Nigeria. The hospital serves as a major referral center providing healthcare services to residents within Keffi and surrounding communities including Abuja.



Source: Google Image
Figure 1: Map of Federal Medical Centre Keffi, Nasarawa State Nigeria

Study population

The study population included all patients admitted with laboratory-confirmed cholera during the study period.

Inclusion and exclusion criteria

The inclusion criteria include patients with laboratory confirmed cholera, complete demographic and clinical records. While the exclusion criteria include incomplete records and clinically suspected and clinical records.

Sample size and sampling technique

A total of 165 confirmed cases were included using a total sampling technique. The effective analytical sample of 72 cases used for regression analysis was determined based on completeness of data and eligibility criteria. This approach is consistent with retrospective studies where only complete records are analyzed.

Data collection method

Data were collected from hospital medical records, admission registers, and laboratory reports. Information extracted included age, number of confirmed cases, number of deaths, and yearly distribution of cases.

Variables of the study

The variables are independent variable which is the age group of patients and the dependent variables used are morbidity (number of cases), mortality (number of deaths), cases fatality rate and annual incidence of typhoid fever.

Method of data analysis

Data were analyzed using descriptive statistics and regression models. Frequencies and percentages were used to summarize the data. Case Fatality Rate (CFR) was calculated using the formula:

CFR (%) = (Number of deaths/Number of confirmed cases) × 100

Inferential statistics were applied using logistic regression to assess predictors of mortality. Statistical significance was set at $p < 0.05$.

Ethical consideration

Ethical approval was obtained from the hospital management with reference number (C.5187/76IT). Confidentiality of patient information was maintained by ensuring that no personal identifiers were included in the data collection process.

Results and Discussion

The results were analysed using both descriptive and inferential statistical methods. Logistic regression analysis showed that age, sex and test status were not statistical significant predictors of mortality ($p > 0.05$). However, descriptive trends indicate increased mortality among extreme age groups. Temporal analysis revealed fluctuation in incidence and CFR, with a notable spike in CFR in 20023 despite reduced case numbers. This suggests possible variations in disease severity or delays in treatment.

All results were derived from hospital records and analyzed systematically using statistical models to ensure reliability and validity.

Sex-based clinical outcomes

The analysis of clinical outcomes at FMC Keffi, stratified by sex, demonstrates a striking uniformity in patient recovery. As illustrated in Fig. 1, the proportional distribution of outcomes shows a negligible variance between the two cohorts. Females: 81.1 % recovery rate vs. 18.9 % mortality rate. Males: 81.3 % recovery rate vs. 18.7 % mortality rate.

The marginal difference of 0.2 % in recovery suggests that both sexes responded similarly to the clinical interventions provided during the study period.

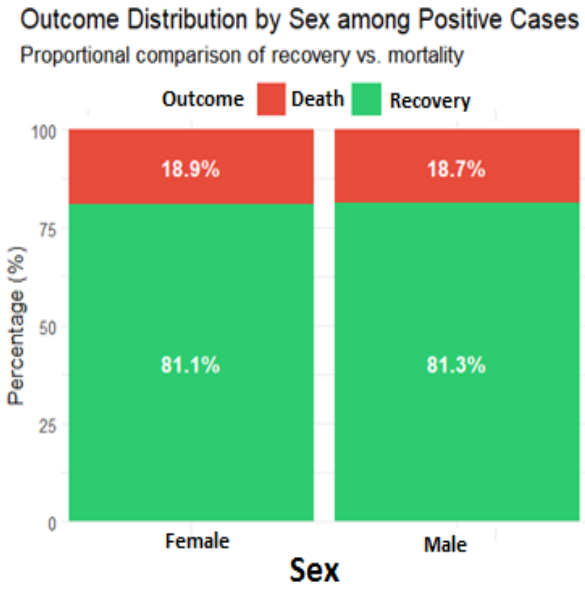


Figure 2: Proportional distribution of clinical outcomes by sex among positive cases at FMC Keffi

The observed parity in mortality (approx. 19 % for both groups) is a significant epidemiological finding, as many infectious diseases—including COVID-19 and certain respiratory pathogens—often exhibit a distinct male-biased mortality risk due to hormonal and immunological differences. The data from FMC Keffi suggests that biological sex was not a determinant factor in disease survival within this population.

This uniformity implies several clinical realities. Systemic Care Consistency: The clinical management and therapeutic protocols at FMC Keffi were applied with equitable efficacy across both sexes.Pathogen Neutrality: The specific condition analyzed does not appear to utilize sex-linked biological pathways to drive disease progression.Risk Factor Refinement: Since sex is not a significant predictor of death, clinical focus should shift toward age-based vulnerability and comorbidities as the primary drivers of the observed mortality rates.

While these percentages provide a clear high-level overview, they do not account for the absolute number of cases within each category. Future analysis should employ multivariate modeling to ensure that this sex-based parity remains consistent when adjusted for age and time-to-treatment.

Temporal trends in morbidity and mortality

The temporal analysis of CFR and Mortality Trends at FMC Keffi (2021–2025) reveals a critical lack of linear correlation between the volume of positive cases and the resulting lethality. While total positive cases showed high volatility—peaking initially in 2022 (n=43) and rising again toward a secondary peak in 2025 (n=39)—the Case Fatality Rate (CFR) followed a distinct, independent trajectory. The most significant epidemiological finding is the inverse relationship observed in 2023; despite a 44 % reduction in total positive cases from the previous year, the CFR

surged to its five-year maximum of 29.2 %. This "decoupling" suggests that during periods of lower transmission, the infected population encountered higher disease severity. This could be attributed to the emergence of more virulent strains in the Keffi region or delays in patient presentation at the facility during that specific period.

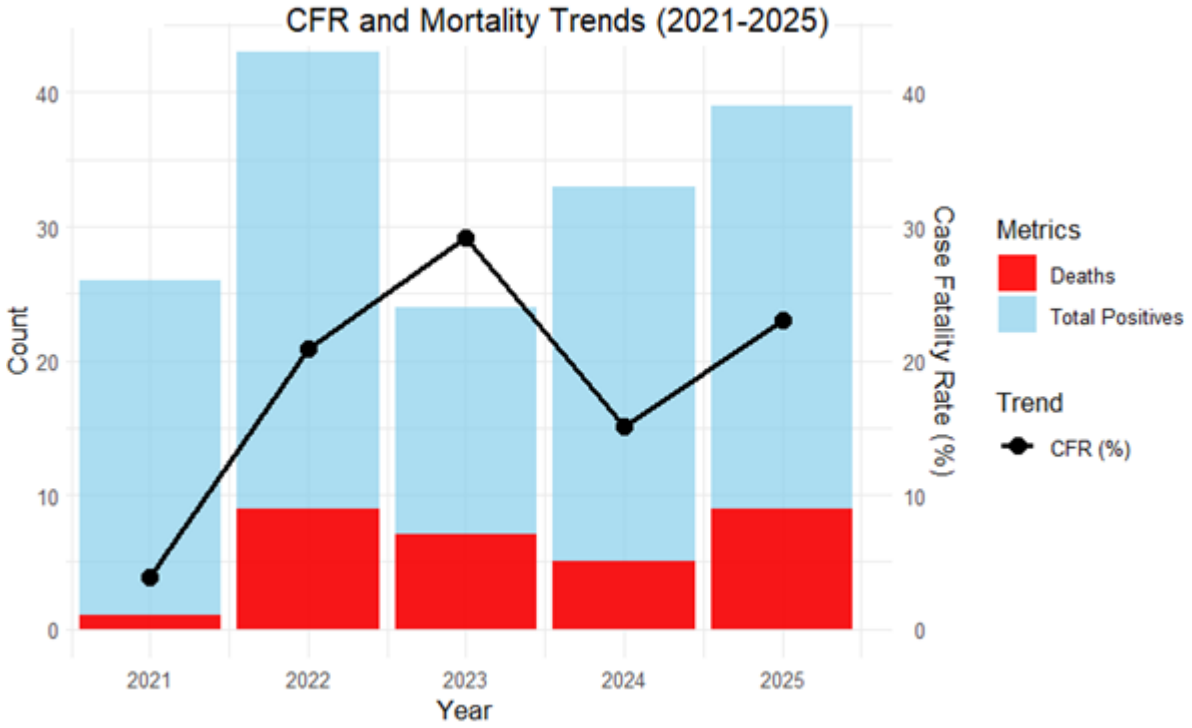


Figure 3: Temporal trends in morbidity and mortality at FMC Keffi. The dual-axis chart highlights the inverse relationship between total case volume (bars) and the fatality percentage (line) during the 2023 period

As the study progressed toward 2025, the data indicates a shift toward a high-prevalence endemic state. Although case numbers returned to near-peak levels in 2025, the CFR stabilized at 23.1 %, which is notably lower than the 2023 spike. This stabilization may reflect an improvement in local clinical management protocols at FMC Keffi or the gradual development of population-level resilience. However, the consistent maintenance of a CFR above 20 % from 2022 onwards highlights a persistent and high clinical burden. The primary limitation remains the low absolute count (N<50 annually), where single outcomes significantly influence percentage trends. Future strategies must focus on identifying the specific drivers of the 2023 fatality spike to prevent similar surges as community transmission fluctuates.

Table 1: Annual epidemiological summary (2021-2025)

Year	Total Positives	Total Deaths	CFR (%)	Positivity Rate (%)
2021	26	1	3.85	26.0
2022	43	9	20.93	36.8
2023	24	7	29.17	25.8
2024	33	5	15.15	31.2
2025	39	9	23.08	39.1

Table 2: Annual case morbidity (incidence) at FMC Keffi

Year	Number of New Positive Cases identified	Percentage Change (%)
2021	26	-- (Baseline)
2022	43	+ 65.4%
2023	24	- 44.2%
2024	33	+ 37.5%
2025	39	+ 18.2%

Annual case morbidity

The surveillance of annual incidence at FMC Keffi from 2021 to 2025 revealed a fluctuating trend in the identification of new positive cases. As detailed in Table 2, the study began with 26 cases in 2021, followed by a sharp 65.4 % increase to reach a five-year peak of 43 cases in 2022.

Following this peak, the facility recorded a significant decline in 2023, dropping to the study's lowest point of 24 cases—a 44.2% reduction from the previous year. However, the final two years of the study period showed a consistent resurgence, with cases climbing to 33 in 2024 and 39 in 2025 (Fig. 4). This steady upward trajectory in the latter half of the study suggests a persistent presence of the condition within the Keffi catchment area.

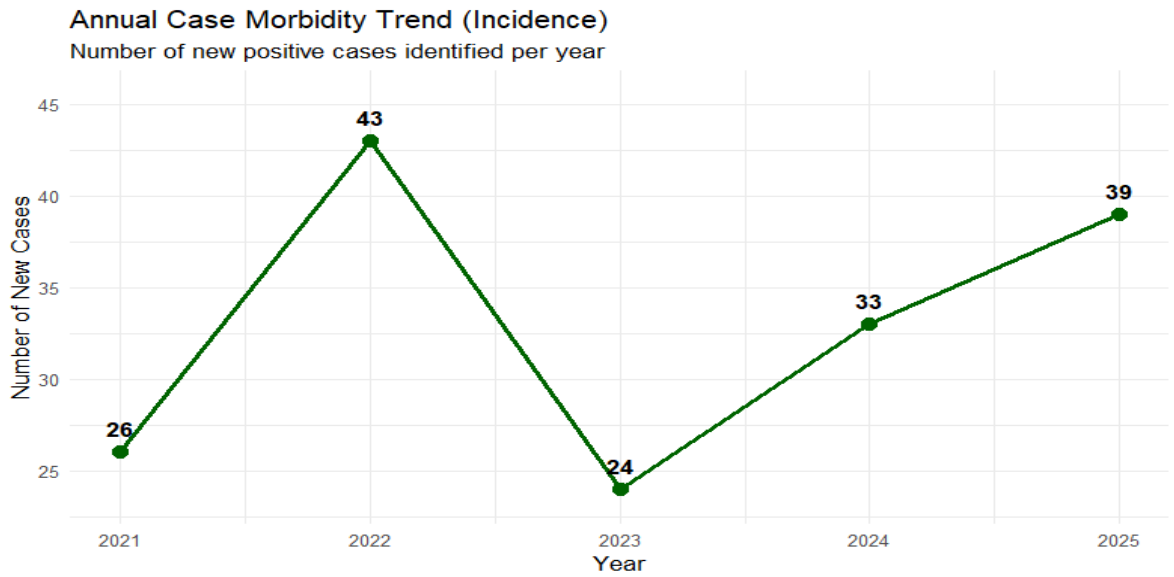


Figure 4: Annual case morbidity trend at FMC Keffi (2021–2025). The graph illustrates the fluctuation in new positive cases, highlighting the 2022 peak and the subsequent resurgence toward 2025

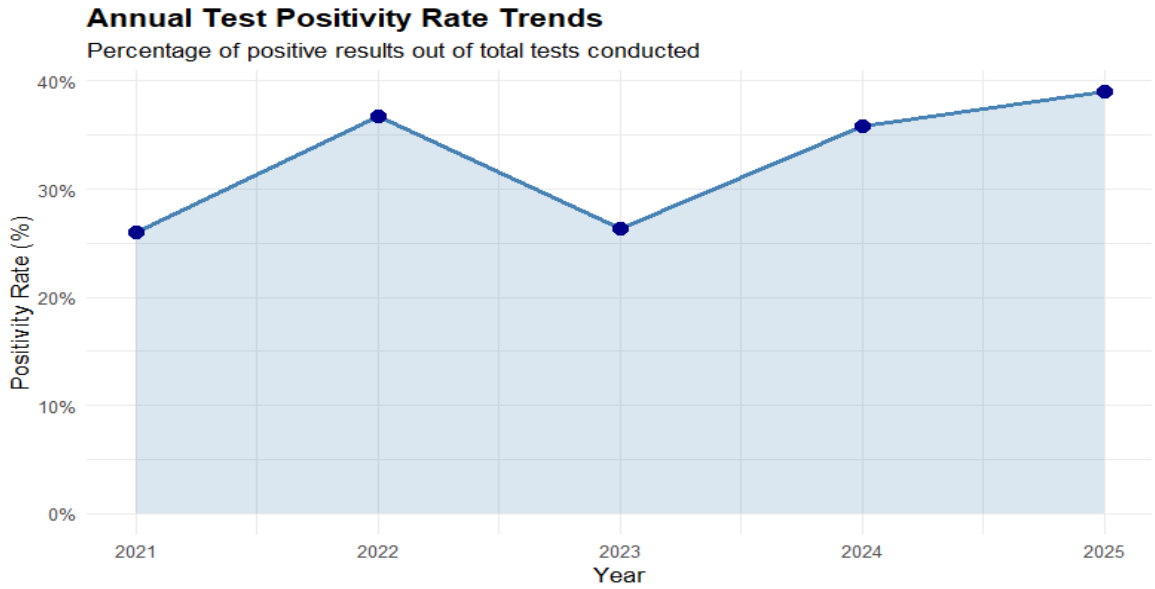


Figure 5: Trends in test positivity at FMC Keffi (2021–2025). The area chart illustrates the percentage of positive results relative to total tests, highlighting the sustained high prevalence and the peak observed in 2025

Annual test positivity rate trends

The Annual Test Positivity Rate Trends at FMC Keffi provide a nuanced understanding of disease prevalence by normalizing raw case counts against testing volume. This metric is critical for identifying whether fluctuations in morbidity are due to changes in diagnostic effort or actual transmission dynamics. The data reveals that the positivity rate remained significantly above the 5 % threshold often used by public health organizations to define controlled transmission, suggesting that the condition remained endemic and high-burden in the Keffi region.

The correlation between the positivity rate and total morbidity is striking. Both metrics peaked in 2022, dipped in 2023, and rose sharply through 2025. The surge to nearly 40 % positivity in 2025 is particularly concerning; because this rise occurred while absolute case numbers were also increasing, it confirms that the resurgence is driven by intensified community spread rather than an expansion of testing (Fig. 5). This high rate suggests that for every ten individuals tested at FMC Keffi in 2025, approximately four were positive, indicating a potential under-diagnosis of asymptomatic cases in the broader community. These findings necessitate more aggressive screening

protocols and community-based interventions to interrupt the transmission cycle.

Age-specific clinical outcomes at FMC Keffi

The analysis of clinical outcomes stratified by age group at Federal Medical Centre (FMC) Keffi reveals a complex, non-linear relationship between patient age and recovery. Unlike the typical "J-shaped" mortality curve often seen in viral infections—where risk increases strictly with age—the data from this cohort exhibits a "U-shaped" vulnerability profile, with significant mortality rates observed in both the youngest and oldest demographics.

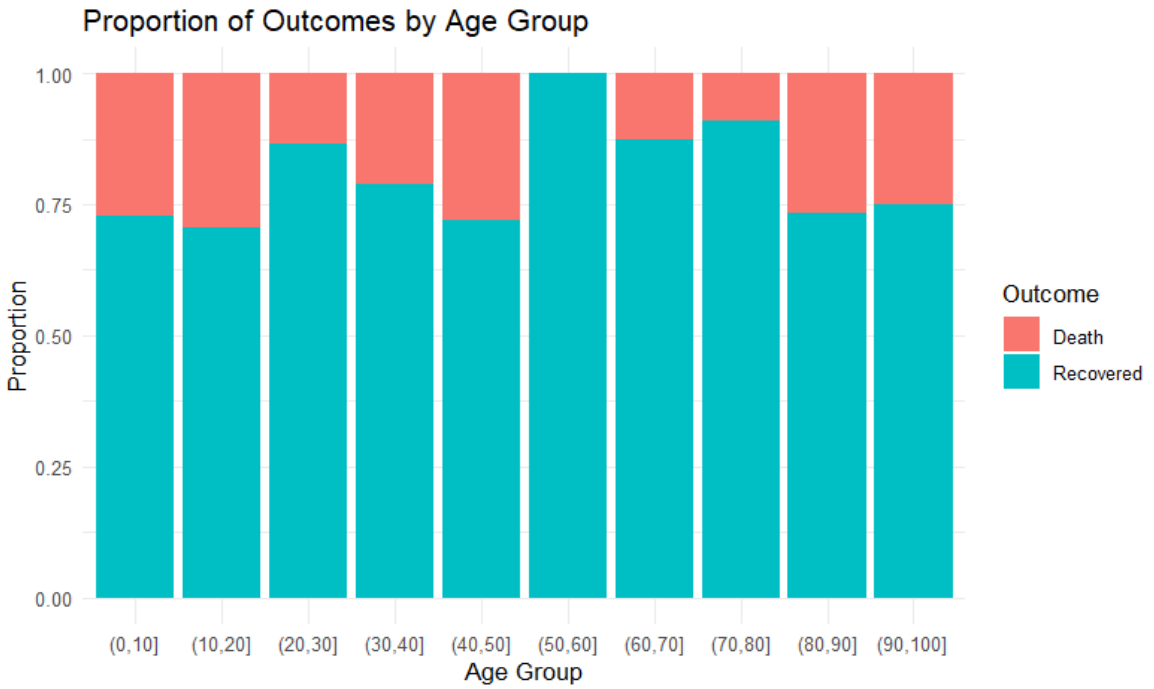


Figure 6: Distribution of clinical outcomes across age cohorts at FMC Keffi. The chart highlights the "U-shaped" mortality trend and the unique 100 % recovery rate in the 50–60 age group

Pediatric and adolescent mortality

A notable finding is the high proportion of deaths among the youngest patients. In the (0, 10] and (10, 20] age brackets, mortality rates are approximately 27 and 30 %, respectively. In many clinical settings, younger populations are expected to show higher physiological resilience. The high mortality at FMC Keffi for these groups may suggest late clinical presentation, the presence of pediatric-specific comorbidities (such as malnutrition or anemia), or a specific virulence of the pathogen toward developing immune systems.

Middle-age resilience: The 50–60 anomaly

The most striking feature of the age distribution is the (50, 60) age group, which achieved a 100% recovery rate. This represents a significant pocket of resilience, as this demographic usually begins to show increased risk due to the onset of chronic non-communicable diseases. This total recovery, alongside high recovery rates in the (60, 80) brackets, suggests that middle-aged and early-senior patients at FMC Keffi may have benefited from prior immunological exposure or more proactive health-seeking behaviors compared to other groups.

Geriatric trends

Consistent with global epidemiological trends, mortality rates rise again in the oldest age brackets. Patients in the (80, 100] range show a death proportion of approximately 25–27 %. While this is expected due to immunosenescence and frailty, it is statistically significant that their risk level is roughly equivalent to that of the adolescent group (10–20 years). This parity highlights that at FMC Keffi, being a teenager carried a similar clinical risk as being over 80 years old during the study period.

Table 4: Proportion of clinical outcomes by age group at FMC Keffi

Age Group (Years)	Recovered (%)	Death (%)	Clinical Observation
(0-10)	73	27	High pediatric mortality
(10-20)	70	30	Highest mortality bracket
(20-30)	86	14	Strong recovery
(30- 40)	78	22	Moderate risk
(40-50)	72	28	Increased vulnerability
(50-60)	100	0	Full recovery (Anomaly)
(60-70)	87	13	High resilience
(70-80)	91	9	High resilience
(80-90)	73	27	Geriatric risk increase
(90-100)	75	25	Geriatric risk increase

Multivariate risk modeling and mortality prediction at FMC Keffi

To evaluate the independent drivers of mortality, a multivariate logistic regression model was employed, integrating age, sex, and test status. This section reconciles the statistical significance of these predictors with the practical probability of patient survival at FMC Keffi.

Logistic regression and predictor significance

The Forest Plot (Fig. 6) visualizes the odds ratios (OR) for the primary risk factors. Despite clinical trends, the model indicates that none of the analyzed variables—Test Status, Sex, or Age—reached the threshold for statistical significance ($p > 0.05$), as evidenced by all 95 % confidence intervals crossing the null value of 1.0.

A positive test result shows a point estimate of OR ≈0.7, suggesting a lower risk compared to negatives, though the interval (0.4–1.1) remains non-significant.Males exhibited a higher point estimate (OR ≈1.3), but the wide confidence interval (0.8–2.1) confirms that sex is not an independent predictor of mortality in this cohort. The OR for age is centered at 1.0, suggesting that a linear increase in age does not significantly shift the odds of death when other factors are controlled.

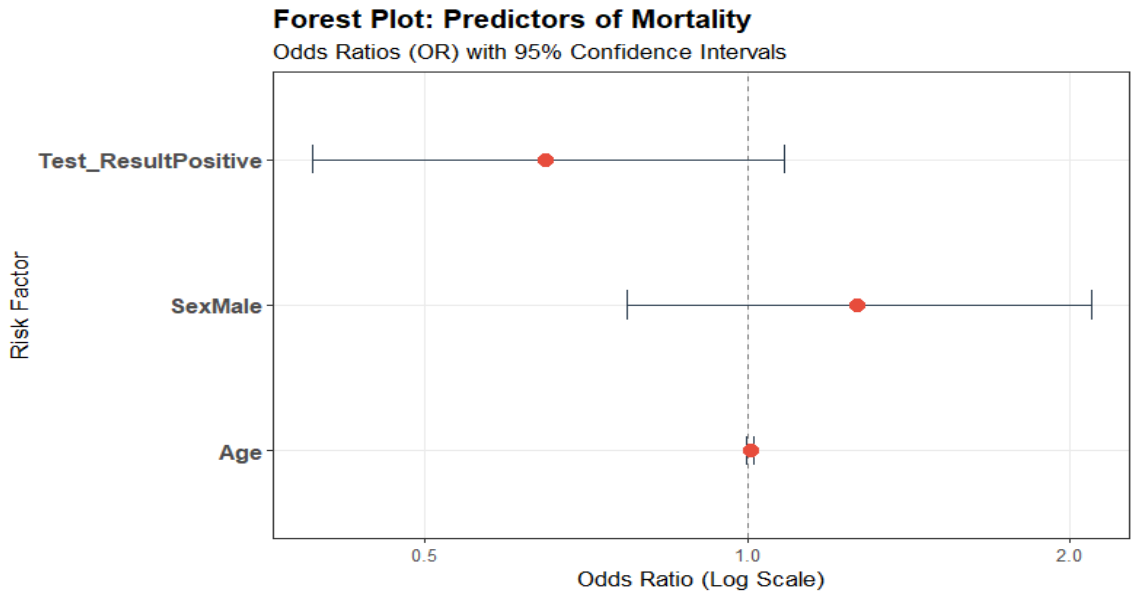


Figure 7: Forest plot of multivariate logistic regression analysis for mortality predictors at FMC Keffi

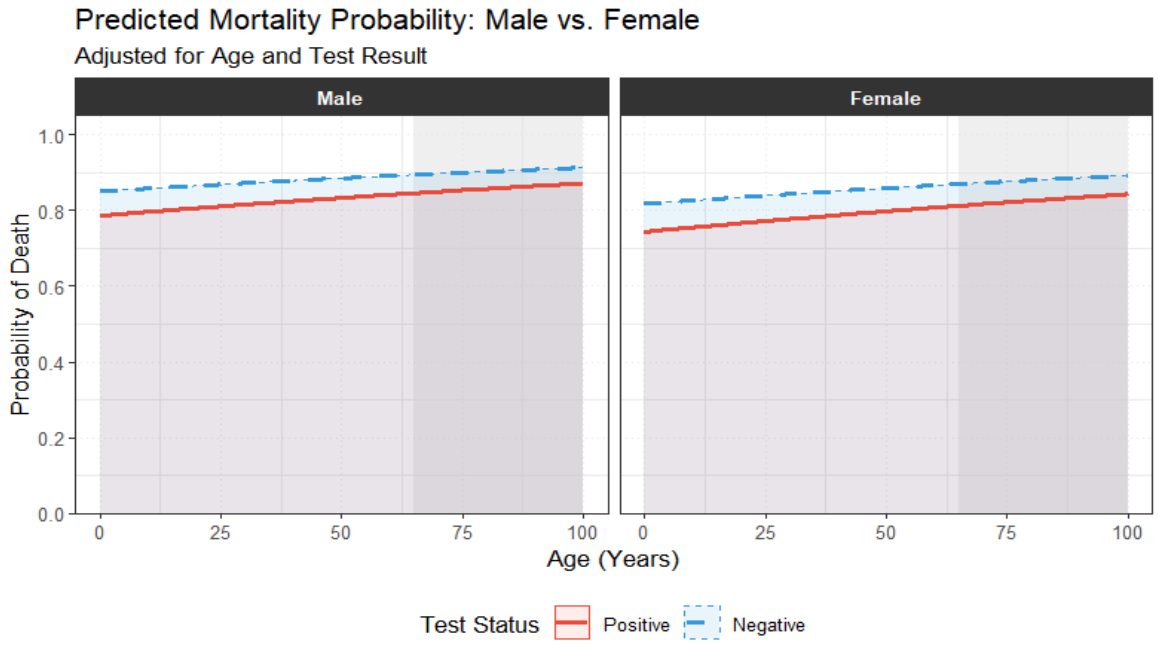


Figure 8: Predicted mortality probability at FMC Keffi adjusted for age, sex, and test status

Table 6: Summary of multivariate logistic regression at FMC Keffi

Variable	Odds Ratio (OR)	95 % Confidence Interval (CI)	Predicted Prob. (Age 75)
Test Status (Positive)	0.70	0.40 – 1.10	~0.81 (Female) / ~0.85 (Male)
Test Status (Negative)	Ref	--	~0.87 (Female) / ~0.89 (Male)
Sex (Male)	1.30	0.80 – 2.10	--
Age (per year)	1.00	0.99 – 1.01	--

Predicted mortality probabilities

While the regression identifies a lack of statistical significance for individual variables, the Predicted Mortality Probability graph (Fig. 7) reveals a paradoxical relationship between diagnostic status and survival. Across all age groups and both sexes, patients with a negative test status (dashed blue line) consistently demonstrated a higher predicted probability of mortality than those who tested positive (solid red line).

At FMC Keffi, this divergence suggests that patients presenting with severe clinical symptoms but testing negative may be suffering from more lethal underlying pathologies or co-morbidities. Furthermore, as age increases, the predicted probability of death climbs steadily for both groups, reaching its highest levels in geriatric patients (>80 years), where the probability exceeds 0.85. This highlights that while age was not a significant *linear* predictor in the regression, it remains a critical factor in the absolute probability of clinical failure.

The longitudinal study of clinical data at Federal Medical Centre (FMC) Keffi (2021–2025) provides a comprehensive overview of the epidemiological shifts and demographic vulnerabilities within the region. The findings confirm that the condition has moved toward a high-prevalence endemic state, with test positivity rates reaching a five-year zenith of 39.0 % and absolute morbidity climbing consistently through 2025. The key statistical milestone includes the following the 2023 Decoupling: A critical anomaly where the Case Fatality Rate (CFR) peaked at 29.2 % despite the lowest annual incidence ($n=24$), Sex Parity: Remarkable consistency in outcomes, with recovery rates for females (81.1 %) and males (81.3 %) showing no significant biological bias, age Vulnerability: A "U-shaped" risk profile identifying pediatric patients (0–20 years) and geriatric patients (80–100 years) as the highest-risk groups, while the 50–60 age bracket demonstrated an anomalous 100 % recovery rate and reductive Paradox which is multivariate modeling revealed that symptomatic patients who tested negative actually faced a higher predicted probability of mortality than those who tested positive, suggesting the impact of severe co-morbidities or potential diagnostic limitations.

Conclusion

The study concludes that at FMC Keffi, mortality is not driven by a single independent factor such as biological sex or age alone, as evidenced by the non-significant odds ratios in the multivariate regression. Instead, mortality appears to be a result of complex interactions between extreme age and underlying clinical severity.

The rising trend in test positivity toward 2025 indicates that the pathogen remains a significant public health threat in Keffi, with high community circulation. Furthermore, the high mortality observed in the 0–20 age group challenges the common clinical assumption of pediatric resilience and highlights a critical gap in early intervention for younger demographics.

This study confirms that cholera remains endemic in Keffi, Nigeria, with significant mortality among vulnerable populations. Although no single predictor of mortality was statistically significant, combined demographic and temporal factors influence outcomes.

The study contributes to existing knowledge by providing hospital-based epidemiological evidence and highlights the need for improved surveillance, early intervention, and targeted public health strategies.

Conflict of interest: The authors declare no conflict of interest.

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