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Case Report

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Factors Associated with the Incidence of Cholera among Children Aged (0-18) Years: A Case Study of Kanyama Level 1 Hospital during the (2023-2024) Period, Lusaka, Zambia

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Abstract

Cholera remains a major global health threat, affecting millions of people annually, with children in Zambia facing significant challenges due to poor sanitation and limited access to safe water and sanitation services. Kanyama, a peri-urban settlement in Lusaka, experiences frequent cholera outbreaks, disproportionately affecting children. This study aimed to examine the incidence of cholera among children aged (0-18) years at Kanyama Level 1 Hospital from (2023-2024), while exploring contributing demographic, socioeconomic and environmental factors and providing evidence to inform interventions aimed at reducing the disease burden in this high-risk population.

The study utilized a retrospective descriptive-analytical design with a quantitative approach, involving 138 children who presented at the hospital with confirmed cholera. Data were collected from secondary sources, specifically records maintained by the hospital's Public Health Unit. Data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 20 and presented using descriptive and inferential statistics, including tables, pie charts and bar graphs. The findings revealed that younger children aged below 5 years were significantly more vulnerable to cholera, with 1.75 times higher odds of infection (95% CI: 1.10-2.85, p=0.02). Larger household size, particularly households with more than 8 members, was associated with more than twice the odds of cholera (OR=2.20; 95% CI: 1.30-3.75, p=0.01), while low parental education increased the odds of cholera by 1.95 times (95% CI: 1.15-3.20, p=0.03). Treatment delays were also strongly associated with cholera, increasing the odds nearly threefold (OR=2.80; 95% CI: 1.75-4.50, p=0.001).

Environmental factors were similarly significant. The use of unsafe water sources was associated with an increased risk of cholera (p=0.002), while failure to treat water further elevated the risk (p=0.002). Open defecation showed a strong association with cholera (p=0.001). In contrast, water chlorination was protective, reducing the odds of cholera by 50% (OR=0.50; 95% CI: 0.30-0.80, p=0.005). Correlation analysis demonstrated significant relationships between cholera incidence and household size (r=0.25), education (r=-0.28), treatment delay (r=0.35), water source (r=0.31) and sanitation (r=0.39).

Therefore, cholera incidence among children is significantly influenced by younger age, larger household size and lower parental education, highlighting the role of demographic and socioeconomic vulnerabilities. Delays in seeking treatment further exacerbate the risk, underscoring the need for improved healthcare accessibility and timely treatment. From an environmental perspective, reliance on unsafe water sources, inconsistent water treatment and inadequate sanitation facilities are major contributors to cholera outbreaks. Effective intervention strategies should therefore focus on health education, access to safe water, timely treatment and improved sanitation to reduce cholera incidence among vulnerable children in the community.

Keywords: Associated factors; Cholera incidence; Children (0-18 years); Kanyama Level 1 Hospital; Lusaka; Zambia

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Introduction

Cholera, caused by toxigenic strains of Vibrio cholerae, remains an important global public health problem, particularly in populations affected by inadequate access to safe Water, Sanitation and Hygiene (WASH), overcrowding, population displacement and limited access to timely healthcare. Although cholera is preventable and treatable, it continues to cause substantial morbidity and mortality, particularly in low and middle-income countries where environmental and socioeconomic conditions can facilitate transmission. Children represent an important proportion of the affected population and the consequences of diarrheal diseases during childhood may extend beyond acute illness to include impaired nutritional status, growth and longer-term health outcomes [1].

The global epidemiological burden illustrates the continuing magnitude of the problem. In 2023, the World Health Organization received reports of 535,321 cholera cases and 4,007 deaths from 45 countries, representing an increase in the reported global burden compared with the previous year. Age-disaggregated information was available for 99% of reported cases, with children aged five years or younger accounting for 38% of cases for which age was known [2].

Cholera transmission is closely associated with environmental and social determinants, particularly inadequate access to safe water and sanitation. Evidence from Africa demonstrates the substantial contribution of poor WASH conditions, population movement, rapid urbanization, overcrowding and limited health-system capacity to the persistence and spread of cholera. Between 1970 and 2011, African countries reported more than 3.2 million suspected cholera cases, representing approximately 46% of cases reported globally during that period. The burden was particularly pronounced during major epidemic periods, with Sub-Saharan Africa accounting for a substantial proportion of reported global cholera cases and deaths [3].

More recent epidemiological evidence confirms the continuing and widespread distribution of cholera across Sub-Saharan Africa. An analysis of outbreaks occurring between 2010 and 2019 identified 999 suspected outbreaks across 744 regions in 25 Sub-Saharan African countries. The median attack rate at the second administrative level was 0.8 cases per 1,000 population, while the median epidemic duration was 13 weeks. Larger attack rates were associated with longer epidemic durations, illustrating considerable variation in the magnitude and persistence of outbreaks across affected populations [4].

Zambia has experienced recurrent cholera outbreaks, reflecting continuing vulnerabilities in WASH infrastructure and the interaction of environmental, demographic and socioeconomic conditions. The (2023-2024) outbreak constituted a major national public health emergency, beginning in Lusaka Province in October 2023 before spreading to multiple provinces. By 17 January 2024, Zambia had reported 10,887 cumulative cholera cases and 432 deaths across nine of the country's ten provinces, corresponding to a national case-fatality rate of approximately 4.0%. Lusaka District was identified as the principal focus of transmission during the early phase of the outbreak, with densely populated communities experiencing substantial disease burden [5].

Children were substantially affected during the Zambian outbreak. In January 2024, UNICEF reported that children younger than 15 years accounted for approximately 52% of reported cholera cases in Zambia. Lusaka was identified as the most affected district at that stage of the epidemic, placing considerable pressure on health facilities and prompting the establishment and expansion of dedicated cholera treatment capacity. The substantial representation of children among reported cases highlights the importance of understanding the factors that influence exposure, infection and healthcare utilization among pediatric populations during cholera outbreaks [6].

The national response further demonstrated the importance of combining environmental interventions with targeted preventive measures. In Lusaka, outbreak-control activities included improving access to safe water, water-quality monitoring, chlorination, disinfection, hygiene promotion and reactive oral cholera vaccination. UNICEF and partners supported the delivery of approximately 1.7 million oral cholera vaccine doses in five high-burden districts of Lusaka Province, achieving approximately 99% coverage of the target population. During the same period, reported new cases declined by more than 50%, demonstrating the potential contribution of coordinated outbreak-control measures [7].

Kanyama is a densely populated peri-urban community in Lusaka that was affected by the 2023-2024 cholera outbreak. The area received WASH and outbreak-response interventions, including improved water supply, chlorination, disinfection and reactive oral cholera vaccination [7]. The occurrence of cholera in Kanyama shows the need to understand factors associated with the disease in the community.

Children aged 0-18 years may have different levels of exposure to cholera because of differences in age, dependence on caregivers and health-seeking behavior. Factors such as household size, socioeconomic conditions, access to safe water and sanitation, delays in seeking care and distance to health facilities may affect cholera occurrence and healthcare presentation. Despite the major cholera outbreak in Zambia during 2023-2024, there is limited facility-level evidence on factors associated with cholera among children in peri-urban Lusaka. National surveillance data describe the overall outbreak but provide less information about children presenting to individual health facilities. Local evidence can help identify

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vulnerable groups and guide prevention, health education and WASH interventions.

Therefore, this study aimed to determine the demographic, socioeconomic, environmental and treatment-related factors associated with cholera among children aged 0-18 years presenting at Kanyama Level 1 Hospital during the 2023-2024 outbreak period. The findings may support targeted cholera prevention and response in Kanyama and similar communities in Zambia.

Materials and Methods

Study design, time period and study setting

A retrospective descriptive-analytical study design with a quantitative approach was employed to assess the demographic, socioeconomic, environmental and treatment-related characteristics of children aged (0-18) years with documented cholera at Kanyama Level 1 Hospital during the (2023-2024) period. The retrospective design was appropriate because the study relied on previously recorded information contained in routinely collected hospital and public health records, rather than prospectively recruiting participants or collecting data directly from patients or their caregivers.

The descriptive component of the study was used to characterize the documented cholera cases according to variables such as age, household characteristics, parental education, water sources, water treatment practices, sanitation conditions and treatment-related factors. The analytical component was used to examine statistical relationships between selected demographic, socioeconomic, environmental and treatment-related variables and the outcomes recorded in the available health records. This approach enabled the study to identify patterns and factors associated with documented cholera cases while making use of routinely collected secondary data.

The study covered the period from (December 2023-December 2024). Records of children aged (0-18) years with confirmed cholera who were managed at Kanyama Level 1 Hospital during this period were reviewed. A total of 138 eligible records were included in the analysis. Data were extracted from existing hospital records and Public Health Unit records using a structured data extraction tool. No prospective participant recruitment or direct interaction with children or their caregivers was undertaken. Permission to access and use the relevant secondary health records was obtained from the responsible health authorities and institutional offices.

Confidentiality and data privacy were maintained throughout the study. Only information relevant to the approved research objectives was extracted from the records and direct personal identifiers were excluded from the research dataset. The extracted data were used solely for academic and research purposes and were not disclosed to unauthorized persons or third parties.

The study was conducted at Kanyama Level 1 Hospital, located in Kanyama, a peri-urban settlement within Lusaka Province, Zambia. Kanyama is situated approximately 7 km west of Lusaka's Central Business District (CBD), at approximately 15.3320° S latitude and 28.2799° E longitude. The settlement is bounded by Los Angeles Road and Mumbwa Road on its western and eastern sides, respectively. Kanyama is recognized as an area affected by waterborne diseases, particularly cholera, making it an appropriate setting for investigating factors associated with cholera among children.

The area experiences a seasonal climate, with temperatures ranging from approximately 15°C during cool-season nights to the low 30s°C during the hot months. Rainfall is strongly seasonal and is concentrated mainly between November and March **(Figure 1)** [8].

Study area

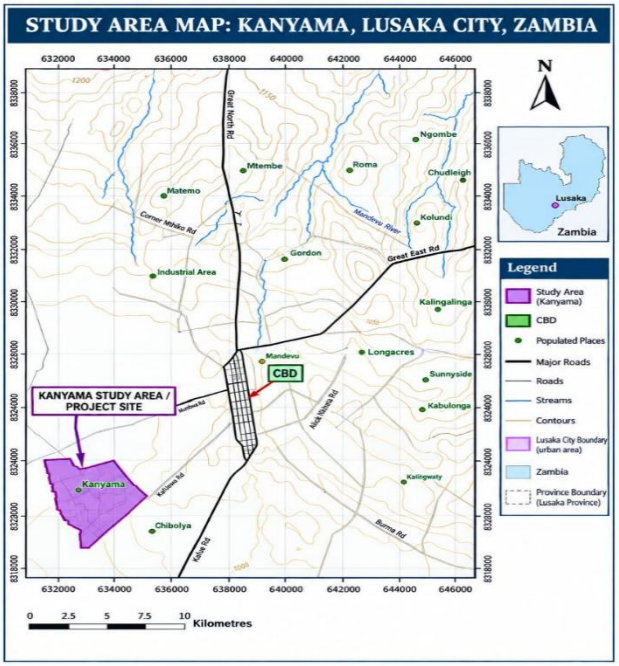


Figure 1: Location map of the Kanyama study area in Lusaka, capital city of Zambia.

Study population and eligibility criteria

The study population comprised children aged (0-18) years with confirmed cholera who were managed at Kanyama Level 1 Hospital during the study period. According to the Zambia Health Data System (ZHDS, 2024), a total of 5,253 confirmed cholera cases were recorded during the period from (December 2023-December 2024). From the available records, children aged (0-18) years who had a confirmed diagnosis of cholera and were managed at Kanyama Level 1 Hospital during the study period were considered eligible for inclusion.

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Records were included if they belonged to children aged 0-18 years and documented a confirmed diagnosis of cholera during the study period. Records without a confirmed cholera diagnosis, records outside the specified age range and cases managed at other health facilities were excluded from the study.

A sampling frame was developed from the hospital Public Health Unit records containing eligible cholera cases. Each eligible record was assigned a unique identification number and a random selection procedure was used to select records for inclusion in the study. This provided each eligible record with an equal probability of selection and helped minimize selection bias. The selection process continued until the predetermined sample size of 138 records was achieved.

Sampling technique and sample size determination

The sample size was determined using the Yamane formula for a known population size [9]:

$n=N/(1+N(e)^2)$

Where:

n: Required sample size

N: Population size

e: Margin of error expressed as a decimal

Using a population size of 5,253 confirmed cholera cases and a margin of error of 8.4% (0.084), the sample size was calculated as follows:

n: $5,253/(1+5,253(0.084)^2)$

n: 138

Therefore, a total sample size of 138 records of children aged (0-18) years with confirmed cholera was included in the study.

Data collection procedure

Secondary data were collected from hospital records and Public Health Unit records at Kanyama Level 1 Hospital using a structured data extraction tool. The tool was designed to capture information relevant to the study objectives. Only records relating to children aged (0-18) years who had a confirmed diagnosis of cholera during the December 2023 to December 2024 study period were reviewed.

The variables extracted included demographic characteristics such as age and sex; socioeconomic characteristics such as household size and parental education; environmental factors such as household water source, water treatment practices and sanitation conditions and treatment-related factors such as treatment delay and treatment outcomes. Clinical information, including underlying health conditions and other relevant clinical characteristics documented in the records, was also extracted.

The records were retrieved from the hospital database and physical files with assistance from authorized hospital staff. A systematic review of the records was undertaken to identify eligible cases and extract the required information. No direct interviews or prospective data collection involving children or their caregivers were conducted.

Data analysis

Data were entered, cleaned, coded and analyzed using the Statistical Package for the Social Sciences (SPSS) version 20. Descriptive statistics were used to summarize the characteristics of the study population. Frequencies and percentages were calculated for categorical variables, while appropriate summary measures were used for continuous variables. The findings were presented using tables, bar graphs and pie charts.

For the analytical component, associations between selected demographic, socioeconomic, environmental and treatment-related variables were assessed using appropriate statistical tests. The chi-square test was used to assess associations between categorical variables. Where applicable, correlation analysis was used to examine relationships between continuous or appropriately coded variables. Measures of association, including Odds Ratios (ORs) with corresponding 95% Confidence Intervals (CIs), were used where the structure of the available data permitted. Statistical significance was assessed at a 5% significance level ($p<0.05$).

The analytical approach was used to identify factors that showed statistically significant relationships with the documented cholera-related outcomes in the study population. The results were interpreted in relation to the study objectives and the available information contained in the secondary records.

Data quality assurance

Several measures were undertaken to ensure the quality, reliability and validity of the extracted data. Each selected record was reviewed for completeness and consistency before information was entered into the study database. Essential variables, including age, sex, diagnosis, environmental characteristics and treatment outcomes, were checked against the original records.

Records with missing or inconsistent information were flagged for further review. Where possible, discrepancies were verified against the original hospital or Public Health Unit records. Duplicate entries were identified and removed, while data inconsistencies were corrected before statistical analysis. Dates and other variables were standardized to ensure consistency across the dataset.

Following data entry, the dataset was cleaned and

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checked for errors, missing values, duplicate records and implausible values. These procedures helped minimize data-entry errors and improve the accuracy and reliability of the findings.

Data security and confidentiality

Confidentiality and data privacy were maintained throughout the study. Direct personal identifiers were excluded from the research dataset and each selected record was assigned a unique study identification number. The extracted information was used solely for the approved academic and research purposes.

Electronic data were stored in password-protected and encrypted files, with access restricted to authorized research personnel. Physical records were handled confidentially and maintained in secure storage. No identifiable patient information was disclosed to unauthorized persons or third parties.

Results

Demographic and socioeconomic characteristics of study participants

A total of 138 children aged (0-18) years with confirmed cholera were included in the analysis. The demographic and socioeconomic characteristics of the participants are presented in **Table 1**. Children aged under 5 years constituted the largest proportion of the study population, with 62 (45%) participants, followed by those aged 11-15 years with 52 (38%). Children aged 16-18 years accounted for 24 (17%) participants. The distribution therefore indicates that almost half of the documented cholera cases occurred among children below 5 years of age.

Males constituted a slightly higher proportion of the study population, with 72 (52%) participants, compared with 66 (48%) females. In relation to household size, households comprising 6-8 members represented the largest category, accounting for 55 (40%) participants, followed by households with 3-5 members at 48 (35%). Twenty-four (17%) participants were from households with more than 8 members, while 11 (8%) were from households with 1-2 members. Therefore, 79 (57%) of the children were from households with at least six members.

Parental education was predominantly at primary level, reported for 62 (45%) participants, while 52 (38%) had parents with secondary education and 24 (17%) had parents with tertiary education. Therefore, 114 (83%) of the participants had parents whose highest reported educational attainment was primary or secondary education.

Regarding treatment, 97 (70%) children received prompt treatment, whereas 41 (30%) experienced delayed treatment. Among the reported barriers to accessing treatment, distance to the healthcare facility was the most common, affecting 82 (60%) participants, followed by cost at 41 (30%) and other barriers at 15 (10%). With respect to preventive measures, water chlorination was reported most frequently at 69 (50%), followed by sanitation campaigns at 55 (40%), while 14 (10%) reported other preventive measures.

Table 1 demonstrates a marked concentration of documented cholera cases among younger children and participants living in relatively large households. The 62 cases among children under 5 years represented 45% of the total sample, meaning that nearly one in every two documented cases occurred in this age group. The predominance of younger children is epidemiologically important because young children may have greater vulnerability to dehydration and may depend more heavily on caregivers for safe water, sanitation and timely healthcare-seeking. The household distribution is also notable. A total of 79 participants (57%) came from households with six or more members, including 24 (17%) from households with more than eight members.

Table 1: Demographic, socioeconomic and treatment-related characteristics of study participants (n=138).

Variable	Category	Frequency (n)	Percentage (%)
Age group	Under 5 years	62	45
	11-15 years	52	38
	16-18 years	24	17
Gender	Male	72	52
	Female	66	48
Household size	1-2 members	11	8
	3-5 members	48	35
	6-8 members	55	40
	>8 members	24	17
Parental education	Primary	62	45
	Secondary	52	38
	Tertiary	24	17
Treatment	Prompt	97	70
	Delayed	41	30
Barrier to treatment	Distance	82	60
	Cost	41	30
	Other	15	10
Prevention measure	Water chlorination	69	50
	Sanitation campaign	55	40
	Other	14	10

The socioeconomic profile similarly indicates potential structural vulnerability. Although 24 (17%) participants had parents with tertiary education, the majority, 114 (83%), had parents with primary or secondary education. This distribution provides an important context for

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understanding household health literacy, sanitation practices and capacity to adopt preventive measures. Treatment-related findings show that although 97 (70%) children received prompt treatment, 41 (30%) experienced treatment delays. The fact that distance was reported by 82 (60%) participants as the principal barrier indicates that physical accessibility to healthcare may be an important challenge in the study population. The preventive profile further shows that water chlorination was reported by 69 (50%) households, leaving 69 (50%) reporting either sanitation campaigns or other preventive measures.

Correlation analysis of demographic, household and treatment-related variables

The relationships among demographic, household, socioeconomic and treatment-related variables are presented in **Table 2**. Age demonstrated a weak positive correlation with the study outcome (r=0.10), while gender demonstrated a weak negative correlation (r=-0.05). Household size showed a positive correlation of r=0.25, indicating a weak tendency for the outcome measure to increase as household size increased.

Parental education demonstrated a negative correlation with the outcome (r=-0.28), indicating that higher levels of parental education were associated with lower values of the outcome measure. Treatment delay demonstrated the strongest positive correlation with the outcome among the variables examined, with r=0.35. The correlations among the explanatory variables were generally weak to moderate. Education was negatively correlated with treatment delay (r=-0.30), while household size was negatively correlated with education (r=-0.20).

Table 2 indicates that treatment delay had the strongest observed correlation with the outcome (r=0.35), followed by household size (r=0.25) and parental education (r=-0.28). Although these correlations are not strong, they indicate potentially meaningful relationships that warrant further multivariable investigation.

Table 2: Correlation matrix of demographic, household and treatment-related variables (n=138).

Variable	Age	Gender	Household size	Education	Treatment delay	Outcome
Age	1	0.02	-0.11	-0.15	0.05	0.1
Gender	0.02	1	0.01	-0.03	0.07	-0.05
Household size	-0.11	0.01	1	-0.20	0.15	0.25
Education	-0.15	-0.03	-0.20	1	-0.30	-0.28
Treatment delay	0.05	0.07	0.15	-0.30	1	0.35
Outcome	0.1	-0.05	0.25	-0.28	0.35	1

The positive correlation between household size and the outcome (r=0.25) indicates that larger households may be associated with greater occurrence of the measured outcome. In a cholera-prone peri-urban setting, this may plausibly reflect increased exposure through shared water and sanitation facilities; however, the correlation itself does not establish causality. The negative correlation between education and the outcome (r=-0.28) indicates an inverse relationship, whereby higher parental education was associated with lower values of the outcome measure.

Treatment delay demonstrated the strongest correlation (r=0.35). Importantly, because treatment delay occurs after illness has developed. The correlation between education and treatment delay was -0.30, indicating that higher parental education was associated with less treatment delay.

Multivariable analysis of demographic, socioeconomic and treatment-related factors

The crude and adjusted estimates are presented in **Table 3**. The analysis demonstrated statistically significant associations for age under 5 years, household size greater than eight members, low parental education, treatment delay and water chlorination. Gender was not statistically significant.

Children under 5 years had a Crude Odds Ratio (COR) of 1.90 (95% CI: 1.20-3.00; p=0.01), which decreased to an Adjusted Odds Ratio (AOR) of 1.75 (95% CI: 1.10-2.85; p=0.02) after adjustment for the other variables in the model.

Participants from households with more than eight members had a COR of 2.50 (95% CI: 1.50-4.10; p=0.002), which decreased to an AOR of 2.20 (95% CI: 1.30-3.75; p=0.01). Low parental education had a COR of 2.10 (95% CI: 1.30-3.40; p=0.01) and an AOR of 1.95 (95% CI: 1.15-3.20; p=0.03).

Treatment delay demonstrated the largest effect estimate in the model. The COR was 3.00 (95% CI: 1.90-4.80; p<0.001), while the adjusted estimate was 2.80 (95% CI: 1.75-4.50; p=0.001). Water chlorination showed a protective association, with a COR of 0.45 (95% CI: 0.28-0.75; p=0.002), which changed to an AOR of 0.50 (95% CI: 0.30–0.80; p=0.005) following adjustment. In contrast, gender was not significantly associated with the outcome, with an AOR of 1.10 (95% CI: 0.85-1.40; p=0.45).

Table 3 identifies treatment delay as the factor with the largest adjusted association, with an AOR of 2.80 (95%

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CI: 1.75-4.50; p=0.001). The confidence interval excludes 1.00 and the p-value is substantially below 0.05, indicating a statistically significant association. The estimate remained relatively stable after adjustment, declining from 3.00-2.80, representing approximately a 6.7% reduction in the effect estimate.

Table 3: Crude and adjusted associations of selected factors with the study outcome (n=138).

Variable	COR	95% CI	p-value	AOR	95% CI	p-value
Under 5 years	1.9	1.20-3.00	0.01	1.75	1.10-2.85	0.02
Male gender	1.15	0.90-1.45	0.3	1.1	0.85-1.40	0.45
Household size >8	2.5	1.50-4.10	0.002	2.2	1.30-3.75	0.01
Low parental education	2.1	1.30-3.40	0.01	1.95	1.15-3.20	0.03
Treatment delay	3	1.90-4.80	<0.001	2.8	1.75-4.50	0.001
Water chlorination	0.45	0.28-0.75	0.002	0.5	0.30-0.80	0.005
Note: COR: Crude Odds Ratio; AOR: Adjusted Odds Ratio; CI: Confidence Interval. Statistical significance was considered at p<0.05.						

Household size greater than eight members was also significantly associated with the outcome. The adjusted estimate of 2.20 (95% CI: 1.30-3.75; p=0.01) indicates that the association remained statistically significant after adjustment. The reduction from a COR of 2.50 to an AOR of 2.20 suggests some confounding by other variables in the model, although the association remained substantial.

Low parental education demonstrated an AOR of 1.95 (95% CI: 1.15-3.20; p=0.03). The confidence interval remained above 1.00, indicating statistical significance. The approximately 7% reduction from the crude estimate of 2.10 to the adjusted estimate of 1.95 indicates relatively limited confounding. Children under 5 years had an AOR of 1.75 (95% CI: 1.10-2.85; p=0.02). The lower confidence limit remained above 1.00, indicating a statistically significant association after adjustment. The reduction from 1.90 to 1.75 suggests modest confounding by the other variables included in the model.

Water chlorination demonstrated an inverse association, with an AOR of 0.50 (95% CI: 0.30-0.80; p=0.005). The point estimates below 1.00 indicates that chlorination was associated with lower odds of the measured outcome. In epidemiological terms, an AOR of 0.50 corresponds to approximately 50% lower odds, assuming the exposure and outcome coding are correctly specified. This finding provides quantitative support for the importance of household water-treatment practices in cholera prevention. Gender was not statistically significant, with an AOR of 1.10 (95% CI: 0.85-1.40; p=0.45). The confidence interval included 1.00 and the p-value exceeded 0.05, indicating insufficient statistical evidence of an independent association between sex and the outcome in this sample.

Environmental factors

The environmental characteristics of the households represented in the study are presented in **Table 4**. Community boreholes and wells constituted the predominant drinking-water source, reported by 69 (50%) households, followed by council-provided piped water at 58 (42%). Streams were reported by 11 (8%) households. Regarding water-treatment practices, 69 (50%) households reported treating water occasionally or sometimes, 41 (30%) reported always treating their water and 28 (20%) reported never treating their water. Consequently, 97 (70%) households reported treating water either consistently or intermittently, while 28 (20%) reported no water treatment. Pit latrines were used by 97 (70%) households, whereas 41 (30%) reported open defecation.

Table 4 demonstrates substantial exposure to potentially important environmental conditions among the 138 documented cases. Half of the households (50%, n=69) depended on community boreholes or wells, while 8% (n=11) relied on streams. Thus, 80 (58%) households depended on these two potentially vulnerable water sources. Water-treatment practices were inconsistent. Although 41 (30%) households reported always treating their water, 69 (50%) treated it only occasionally or sometimes and 28 (20%) never treated it. Therefore, 97 (70%) households did not report consistent water treatment. This finding is particularly relevant in a cholera-prone environment because intermittent water treatment may provide less consistent protection against contamination. Sanitation conditions were also concerning. Although 97 (70%) households used pit latrines, 41 (30%) reported open defecation.

Table 4: Environmental characteristics of study households (n=138).

Environmental factor	Category	Frequency (n)	Percentage (%)
Main drinking-water source	Community boreholes/wells	69	50
	Council piped water	58	42
	Streams	11	8
Water treatment	Always treated	41	30
	Occasionally/sometimes treated	69	50
	Never treated	28	20
Toilet facilities	Pit latrine	97	70
	Open defecation	41	30

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Correlation analysis of environmental factors

The correlation between environmental characteristics and the study outcome is presented in **Table 5**. The main drinking-water source demonstrated a positive correlation of r=0.31, while water treatment demonstrated a correlation of r=0.25. Toilet facilities showed the strongest correlation with the outcome, at r=0.39. The correlation among environmental variables was generally weak. Drinking-water source was positively correlated with water treatment (r=0.23), while water treatment and toilet facilities had a weak positive correlation (r=0.12). Drinking-water source and toilet facilities demonstrated a weak negative correlation (r=-0.15).

Table 5 shows that toilet facilities had the strongest reported correlation with the outcome (r=0.39), followed by drinking-water source (r=0.31) and water treatment (r=0.25). The correlation of 0.39 represents a moderate positive relationship and suggests that sanitation conditions were more strongly related to the measured outcome than either water source or water-treatment practices. The correlation of 0.31 between drinking-water source and the outcome indicates a moderate positive relationship, indicating that differences in water sources were associated with differences in the measured outcome. Water treatment showed a weaker positive correlation of 0.25.

Table 5: Correlation matrix of environmental factors (n=138).

Variable	Drinking-water source	Water treatment	Toilet facilities	Outcome
Drinking-water source	1	0.23	−0.15	0.31
Water treatment	0.23	1	0.12	0.25
Toilet facilities	−0.15	0.12	1	0.39
Outcome	0.31	0.25	0.39	1

Multivariable analysis of environmental factors

The multivariable analysis of environmental factors is presented in **Table 6**. The main drinking-water source demonstrated an unadjusted coefficient of β=0.65 (SE=0.15; p<0.001), which decreased to β=0.58 (SE=0.12; p=0.002) after adjustment. Water treatment had an unadjusted coefficient of β=0.50 (SE=0.10; p=0.003), decreasing to an adjusted coefficient of β=0.43 (SE=0.08; p=0.01). Toilet facilities had an unadjusted coefficient of β=0.42 (SE=0.11; p<0.001), which decreased to β=0.35 (SE=0.09; p=0.001) after adjustment.

Table 6 demonstrates that all three environmental variables remained statistically significant after adjustment. The largest adjusted coefficient was observed for the main drinking-water source (β=0.58; SE=0.12; p=0.002), followed by water treatment (β=0.43; SE=0.08; p=0.010) and toilet facilities (β=0.35; SE=0.09; p=0.001).

Table 6: Multivariable regression analysis of environmental factors (n=138).

Environmental factor	Unadjusted β	SE	p-value	Adjusted β	SE	p-value
Main drinking-water source	0.65	0.15	<0.001	0.58	0.12	0.002
Water treatment	0.5	0.1	0.003	0.43	0.08	0.01
Toilet facilities	0.42	0.11	<0.001	0.35	0.09	0.001

The reduction in the drinking-water coefficient from 0.65 to 0.58 represents approximately a 10.8% attenuation after adjustment. Similarly, the coefficient for water treatment decreased from 0.50 to 0.43, representing a 14% attenuation, while the coefficient for toilet facilities decreased from 0.42 to 0.35, representing approximately a 16.7% attenuation. The persistence of statistical significance following adjustment indicate that the relationships were not completely explained by the other environmental variables included in the model. Among the environmental factors, drinking-water source therefore demonstrated the largest adjusted coefficient, while toilet facilities retained the strongest correlation with the outcome in the correlation analysis.

Discussion

The present study identified a combination of demographic, socioeconomic, healthcare-access and environmental characteristics among 138 children aged (0-18) years with confirmed cholera at Kanyama Level 1 Hospital during the 2023-2024 outbreak. The findings are consistent with the established multifactorial nature of cholera transmission, in which exposure to unsafe water and sanitation conditions interacts with household crowding, socioeconomic disadvantage and access to timely healthcare. Evidence from a systematic review and meta-analysis of 110 studies demonstrated that household and individual characteristics, including inadequate water,

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lower educational attainment, household exposure and inadequate water treatment, are important correlates of symptomatic cholera infection [10]. Similarly, a systematic review of case-control studies found that multiple WASH-related exposures were associated with increased or decreased odds of cholera, although the strength and consistency of individual associations varied across settings [11]. The present findings therefore fit within a broader epidemiological pattern while also demonstrating important local characteristics of the 2023-2024 outbreak in Kanyama.

Children below five years constituted the largest age group in the present study, accounting for 45% (62/138) of confirmed cases, compared with 38% among those aged 11-15 years and 17% among adolescents aged (16-18) years. The predominance of younger children is epidemiologically plausible because young children may have greater dependence on caregivers for safe water, hygiene and sanitation practices and may be more vulnerable to dehydration following acute diarrheal illness. Importantly, the association observed in the present analysis was not merely descriptive: Children below five years had 1.75 times higher adjusted odds of the study outcome (AOR=1.75, 95% CI: 1.10-2.85, p=0.020). This finding is broadly compatible with recent evidence from Lusaka. Kalima et al. in a study of 1,891 pediatric patients admitted to two referral cholera treatment centres during the same 2023-2024 outbreak, found that children represented a substantial proportion of the outbreak burden, although younger age was not independently associated with prolonged hospitalization or fatal outcome after adjustment [12]. This apparent difference is important because the two studies examined different outcomes: the present study examined characteristics associated with the specified cholera outcome among confirmed cases, whereas Kalima et al. examined severity-related outcomes among pediatric cholera patients [12]. Therefore, the findings should not be interpreted as contradictory; rather, they indicate that younger age may be important in the occurrence or presentation of pediatric cholera without necessarily being an independent determinant of severe clinical outcome.

The sex distribution was relatively balanced, with males accounting for 52% (72/138) and females for 48% (66/138). Neither the crude association (OR=1.15, 95% CI: 0.90-1.45, p=0.300) nor the adjusted association (AOR=1.10, 95% CI: 0.85-1.40, p=0.450) was statistically significant. This finding differs from the 2017 Lusaka case-control study by Nanzaluka et al. in which males had significantly higher odds of being cholera cases than matched controls (mOR=2.5, 95% CI: 1.4-5.0) [13]. However, the difference may reflect the different populations and study designs rather than a true epidemiological inconsistency. Nanzaluka et al. compared cholera cases with non-cases, whereas the present study analyzed confirmed pediatric cases without a non-case comparison group [13]. Furthermore, Kalima et al. studying the 2023-2024 Lusaka outbreak among children, found no significant association between sex and prolonged hospitalization, providing more recent local evidence that sex alone may not consistently explain differences in pediatric cholera outcomes [12]. The near-equal distribution of males and females in Kanyama therefore indicates that the outbreak affected both sexes substantially, with no evidence in this dataset that sex independently differentiated the study outcome.

Household crowding emerged as an important socioeconomic characteristic. Although households containing six to eight members represented the largest category, accounting for 40% (55/138), households with more than eight members had significantly higher adjusted odds of the study outcome (AOR=2.20, 95% CI: 1.30–3.75, p=0.010). This finding is consistent with the biological and social mechanisms of cholera transmission because increased household density can increase opportunities for contamination of shared water, food, sanitation facilities and household surfaces. Richterman et al. identified household-level exposures, including close contact with infected individuals, as important risk factors for symptomatic cholera [10]. However, evidence is not completely uniform. For example, an epidemiological investigation of the 2021-2022 cholera outbreak in southwest Cameroon did not find a statistically significant association between household overcrowding and cholera, although the estimated odds increased among households with more than five occupants [14]. The stronger association observed in Kanyama may therefore reflect the particularly dense peri-urban environment, household structure and WASH constraints characteristic of parts of Lusaka during the 2023-2024 outbreak rather than crowding having an identical effect across all cholera settings.

Parental or household educational attainment also demonstrated a significant association. Participants from households with lower educational attainment had approximately twice the adjusted odds of the study outcome (AOR=1.95, 95% CI: 1.15-3.20, p=0.030). This finding is consistent with the broader literature linking education with household capacity to understand and implement preventive WASH behaviors. Richterman et al. reported significantly greater odds of symptomatic cholera among individuals with less than secondary education (summary OR=2.64, 95% CI: 1.41-4.92) [10]. The present finding therefore supports the global evidence while demonstrating that educational disadvantage remained relevant within the specific context of the Kanyama outbreak. The observed negative correlation between education and treatment delay (r=-0.30) further suggests that education may influence not only preventive behaviour but also recognition of illness and decisions about seeking healthcare.

Treatment delay was another prominent finding. Thirty percent of participants (41/138) experienced delayed

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treatment, while 60% (82/138) identified distance as a barrier to accessing care, compared with 30% who identified cost and 10% who reported other barriers. Delayed treatment was strongly associated with the study outcome in the adjusted analysis (AOR=2.80, 95% CI: 1.75-4.50, p=0.001). This result is important from a clinical and public-health perspective because cholera can progress rapidly when effective rehydration is delayed. National evidence from Zambia's 2023-2024 outbreak similarly demonstrated rapid progression and early mortality, with Tembo et al. emphasizing the importance of prompt assessment and urgent fluid treatment following presentation [14]. However, the temporal interpretation of the present association requires particular caution. Treatment delay occurs after illness begins and therefore cannot logically be considered a determinant of acquiring cholera. In this study, it is more appropriately interpreted as an indicator of healthcare access and delayed management among affected children rather than as a causal risk factor for infection.

The importance of healthcare access is reinforced by recent evidence from Zambia. Tembo et al. analyzed national surveillance data from January 2023 to July 2024 and found that deaths could occur rapidly after presentation, highlighting the narrow window for effective management of severe cholera [14]. Similarly, Mweso et al. in their analysis of community cholera deaths during Zambia's 2023-2024 outbreak, documented substantial delays surrounding healthcare access and presentation [15]. These findings provide national support for the present observation that distance and delayed treatment were prominent characteristics among affected children.

Water-related characteristics were also important. Half of the children (50%; 69/138) came from households using boreholes or wells, while 42% used piped council water and 8% reported streams as their water source. Water source was positively correlated with the study outcome (r=0.31) and the environmental regression analysis demonstrated a significant association (β=0.58, SE=0.12, p=0.002). These findings are consistent with evidence from Lusaka, although the direction and magnitude of associations differ according to the specific water source and outbreak context. Nanzaluka et al. found that consumption of borehole water was associated with increased odds of cholera during the 2017 Lusaka outbreak (mOR=2.4, 95% CI: 1.1-5.6) [13]. More recent evidence from the 2023-2024 Lusaka outbreak also indicates that environmental conditions continued to structure the spatial distribution of cholera. Ngosa et al. using geospatial analysis of 4,591 suspected cases across Lusaka, reported concentration of cases in several unplanned residential areas and significant relationships between cholera occurrence and inadequate household handwashing resources [16]. The convergence of these findings indicates that access to a nominally improved water source does not necessarily guarantee microbiologically safe household water, particularly where source contamination, intermittent supply, unsafe collection or storage and inadequate household treatment remain possible.

The water-treatment findings provide particularly strong evidence for the importance of household-level prevention. In the present study, 30% of households reported always treating water, 50% treated water occasionally and 20% did not treat water. Chlorination was associated with substantially lower odds of the study outcome (AOR=0.50, 95% CI: 0.30-0.80, p=0.005), suggesting an important protective association. This result is strongly supported by the most recent systematic review and meta-analysis of water-quality exposures in cholera case-control studies. Nguyen et al. reported pooled protective associations for household water treatment (OR=0.42, 95% CI: 0.27-0.65), boiling (OR=0.38, 95% CI: 0.17-0.84) and chlorination (OR=0.37, 95% CI: 0.17-0.83) [19]. The direction and approximate magnitude of the present estimate are therefore highly consistent with the international evidence. Earlier meta-analytic evidence similarly identified household water treatment as protective against cholera [11]. Importantly, the present finding also has local relevance because Nanzaluka et al. documented the use of free-chlorine-residual monitoring and household chlorination as important components of the Lusaka outbreak response [13]. Taken together, these findings support sustained household water treatment and monitoring of residual chlorine as practical components of cholera prevention.

Sanitation characteristics showed a similar pattern. Seventy percent of participants reported access to pit latrines, whereas 30% reported open defecation. Toilet facilities demonstrated the strongest correlation with the study outcome among the environmental variables (r=0.39) and the environmental regression coefficient was significant (β=0.35, SE=0.09, p=0.001). The finding is compatible with the broader WASH literature, which identifies inadequate sanitation as an important pathway through which fecal contamination can reach water, food and household environments. Wolfe et al. found that several sanitation-related risk exposures were associated with higher odds of cholera across case-control studies, although the protective effect of improved sanitation was not uniform across all settings [11].

The pattern of correlations among WASH variables further supports the interpretation that cholera risk is multidimensional rather than attributable to a single environmental exposure. Water source was correlated with water treatment (r=0.23), while water treatment and toilet facilities showed a weaker positive correlation (r=0.12) and water source and toilet facilities demonstrated a weak negative correlation (r=-0.15). These relationships suggest that households may experience combinations of WASH advantages and disadvantages rather than uniformly favorable or unfavorable conditions. This is consistent with the systematic review by Wolfe et al. which found that WASH

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exposures do not operate as isolated determinants and that associations vary according to the specific exposure, setting and quality of the evidence [11]. More recent African evidence likewise demonstrates substantial heterogeneity in the relationship between WASH conditions and cholera across countries and subnational settings [17].

The findings also need to be understood within the wider epidemiological context of the 2023–2024 outbreak in Lusaka and Zambia. Koua et al. analyzing cholera data from 2000-2023 across the WHO African Region, demonstrated the persistent burden of cholera and its relationship with WASH and environmental conditions [17]. At the local level, Kateule et al. documented the scale and operational challenges of the 2023-2024 Lusaka outbreak and described a multisectoral response involving surveillance, sanitation, provision of safe water, health education and other control measures [18]. Ngosa et al. subsequently demonstrated substantial spatial heterogeneity during the same outbreak, with cases concentrated in particular townships and unplanned residential areas [16]. The present findings from Kanyama are therefore consistent with the broader observation that the 2023-2024 outbreak was shaped by interacting environmental and socioeconomic vulnerabilities rather than by a single exposure.

The preventive measures reported by households provide additional insight into this context. Chlorination accounted for 50% of reported prevention measures, sanitation campaigns for 40% and other measures for 10%. The prominence of chlorination is consistent with evidence that household water treatment can substantially reduce cholera risk [19]. However, the fact that only 30% of households reported always treating their water, while half did so only occasionally, indicates that access to preventive interventions does not necessarily translate into consistent use. This distinction is important because intermittent treatment may leave households exposed during periods of contamination. The findings therefore support an approach that combines reliable access to safe water with sustained household-level water treatment, sanitation, hygiene promotion and community engagement rather than relying on a single intervention.

The findings demonstrate substantial convergence with international and Zambian evidence concerning the importance of WASH conditions, household vulnerability and healthcare access in cholera epidemiology. The strongest consistencies are the protective association of water treatment, the importance of unsafe water-related exposures, the relevance of household-level vulnerability and the continuing influence of environmental inequalities in Lusaka. At the same time, several discrepancies are evident. The absence of a significant sex association in the present study contrasts with the male excess observed in the 2017 Lusaka case-control investigation by Nanzaluka et al. [13].

The study found that pediatric cholera in Kanyama was associated with several demographic, household, environmental and healthcare-related factors. Children below five years accounted for the largest proportion of cases (45%), followed by those aged 11-15 years (38%) and 16-18 years (17%). Children below five years had significantly higher adjusted odds of the study outcome (AOR=1.75, 95% CI: 1.10-2.85, p=0.020). This finding is consistent with the 2023-2024 Lusaka outbreak, in which children formed a substantial proportion of cholera patients [12]. However, Kalima et al. examined factors associated with severe outcomes among pediatric cholera patients, while the present study examined characteristics associated with the study outcome among confirmed cases. The findings are therefore not directly equivalent [12].

There was little difference between males and females, with males accounting for 52% and females 48% of cases. Sex was not significantly associated with the outcome (AOR=1.10, 95% CI: 0.85-1.40, p=0.450). This differs from the 2017 Lusaka case-control study, which reported higher odds of cholera among males (mOR=2.5, 95% CI: 1.4-5.0) [13]. The difference may be related to the different study designs and populations, since the earlier study compared cholera cases with controls, whereas the present study included only confirmed cases.

Household size was significantly associated with the study outcome. Children from households with more than eight members had higher adjusted odds (AOR=2.20, 95% CI: 1.30-3.75, p=0.010). This agrees with evidence from a systematic review showing that household-level factors and close contact can increase the likelihood of symptomatic cholera [10]. Larger households may increase exposure through shared water sources, sanitation facilities and household environments.

Educational attainment was also associated with the outcome. Lower parental education was associated with higher adjusted odds (AOR=1.95, 95% CI: 1.15-3.20, p=0.030). This is consistent with Richterman et al. who reported higher odds of symptomatic cholera among people with less than secondary education (summary OR=2.64, 95% CI: 1.41-4.92) [10]. Lower education may affect knowledge and adoption of appropriate water, sanitation and hygiene practices.

Treatment delay was reported by 30% of participants, while distance was the most commonly reported barrier to accessing care (60%). Delayed treatment was strongly associated with the study outcome (AOR=2.80, 95% CI: 1.75-4.50, p=0.001). This finding indicates the importance of timely access to cholera care. Evidence from the same Lusaka outbreak showed that clinical severity among children was associated with factors such as the level of dehydration and treatment required [12]. However, treatment delay should be interpreted as a healthcare-access factor rather than a cause of acquiring cholera because it occurs after illness begins.

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Water source was also associated with the study outcome. Boreholes or wells were used by 50% of households, piped council water by 42% and streams by 8%. Water source was positively correlated with the outcome (r=0.31), with a significant environmental regression coefficient (β=0.58, SE=0.12, p=0.002). This finding is consistent with the 2017 Lusaka outbreak, where borehole water was associated with increased odds of cholera (mOR=2.4, 95% CI: 1.1-5.6) [13]. More recent international evidence also found increased odds of cholera among people using unimproved and surface water sources [19].

Household water treatment showed a protective association. Although 30% of households always treated their water, 50% did so occasionally and 20% did not treat it. Chlorination was associated with lower adjusted odds of the study outcome (AOR=0.50, 95% CI: 0.30-0.80, p=0.005). This finding is supported by Nguyen et al. who reported a protective effect of water treatment (OR=0.42, 95% CI: 0.27-0.65) and chlorination specifically (OR=0.37, 95% CI: 0.17-0.83) [19]. The similarity between the findings supports the importance of consistent household water treatment in cholera prevention.

Sanitation was another important finding. Pit latrines were reported by 70% of households, while 30% reported open defecation. Toilet facilities had the strongest correlation among the environmental variables (r=0.39) and the environmental regression coefficient was significant (β=0.35, SE=0.09, p=0.001). This supports evidence that inadequate sanitation contributes to cholera transmission through fecal contamination of household and community environments [10].

Conclusion

This study identified a range of demographic, socioeconomic, healthcare-access and environmental characteristics associated with documented cholera cases among children aged 0-18 years at Kanyama Level 1 Hospital. Children under five years constituted 45% (n=62) of the study population and demonstrated an adjusted odds ratio of 1.75 (95% CI: 1.10-2.85; p=0.02). Household size greater than eight members was associated with an AOR of 2.20 (95% CI: 1.30-3.75; p=0.01), while low parental education had an AOR of 1.95 (95% CI: 1.15-3.20; p=0.03).

Treatment delay was an important healthcare-access characteristic, occurring in 30% (n=41) of the participants and demonstrating the largest reported adjusted odds ratio at 2.80 (95% CI: 1.75-4.50; p=0.001). Distance to healthcare was the most frequently reported barrier, affecting 60% (n=82) of participants. Water chlorination demonstrated an inverse association, with an AOR of 0.50 (95% CI: 0.30-0.80; p=0.005), indicating the potential importance of consistent household water treatment.

Environmental conditions were also prominent. Community boreholes and wells accounted for 50% (n=69) of reported drinking-water sources, 20% (n=28) of households reported never treating their water and 30% (n=41) reported open defecation. Drinking-water source, water treatment and toilet facilities were all statistically significant in the reported environmental analysis, with adjusted coefficients of β=0.58 (p=0.002), β=0.43 (p=0.010) and β=0.35 (p=0.001), respectively.

Therefore, the findings demonstrate that cholera in Kanyama occurs within a complex context of child vulnerability, household crowding, socioeconomic disadvantage, barriers to healthcare access, inadequate water treatment and sanitation deficiencies. The findings therefore support an integrated and multisectoral response combining improved WASH infrastructure, consistent household water treatment, strengthened sanitation, targeted health education, improved healthcare accessibility and early case management.

Given the retrospective hospital-based design, the findings should be interpreted as observed associations rather than definitive causal relationships. In particular, treatment delay should be understood as a healthcare-access and management characteristic rather than a cause of cholera acquisition. Nevertheless, the consistency of the demographic, household and environmental findings provides an important evidence base for strengthening cholera prevention and control strategies in Kanyama and comparable peri-urban communities.

Declarations

Ethics approval and consent to participate

This retrospective descriptive-analytical study was conducted in accordance with the ethical principles of the Declaration of Helsinki and applicable national and institutional requirements governing research involving human health information. Ethical approval was obtained from the University of Lusaka Ethics Committee (FWA00033228-518(08)/2024) on 25 February 2025. Regulatory approval was also obtained from the National Health Research Authority (NHRA Certificate No. NHRAR-R-2509/23/02/2025, dated 25 February 2025; NHRA Letter No. NHRA-2338/28/02/2025), while permission to conduct the study at the facility was obtained from the Lusaka District Health Office (Reference No. LDHO/101/2/2, dated 24 February 2025).

The study involved a retrospective review of routinely collected hospital records for children aged 0–18 years who presented with documented cholera at Kanyama Level 1 Hospital during the study period. No participants were recruited prospectively and no direct interaction with patients or their caregivers was undertaken for data collection. Individual written informed consent was therefore not obtained, as the study involved secondary analysis of existing routinely collected health records. The use of these records was conducted in accordance with the

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conditions and requirements stipulated by the relevant ethics and health research authorities.

To protect confidentiality and privacy, participants' names, telephone numbers, residential addresses, hospital identification numbers and other direct personal identifiers were not extracted. Data were accessed solely for the approved research purposes, stored securely and handled confidentially. Only authorized members of the research team had access to the study data. Findings are reported in aggregate form to minimize the possibility of identifying individual patients.

Consent for publication

Consent for publication was not applicable because the study used secondary hospital records and did not involve identifiable personal narratives, interviews, photographs, audio recordings or other individually identifiable information. No individual participant is identifiable in the manuscript and findings are presented only in aggregate form.

Clinical trial registration

Clinical trial number: Not applicable.

This study was not a clinical trial. It was a retrospective descriptive-analytical study based on secondary data obtained from routinely collected hospital records.

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Competing interests

The authors declare that they have no competing interests.

Authors' contributions

CLS conceptualized the study, contributed to the study design, data collection, data analysis and interpretation and drafted and revised the manuscript. LS contributed to the supervision of the research, interpretation of findings and critical revision of the manuscript. Both authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Data availability

The data generated and analyzed during this study are not publicly available because they were obtained retrospectively from routine hospital records and contain potentially sensitive health information relating to children. Public release of the underlying records could compromise patient confidentiality and privacy.

De-identified and appropriately aggregated data relevant to the findings may be made available from the corresponding author on reasonable request, subject to approval by the relevant institutional authorities and compliance with the conditions of the University of Lusaka Ethics Committee, the National Health Research Authority and the Lusaka District Health Office.

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