

Article One

Cholera Outbreak Investigation at a Secondary School in Kabwe, Zambia, April 2025: A Case-Control Study

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Abstract

Introduction: Cholera remains a significant public health threat in Zambia, with outbreaks commonly linked to inadequate water, sanitation, and hygiene (WASH) systems. In March 2025, a cholera outbreak was reported in Kabwe District, primarily affecting David Ramusho Secondary School and the surrounding Mine Compound. This investigation aimed to determine the source of infection, identify associated risk factors, and assess transmission dynamics to inform future interventions.

Methods: A case-control study was conducted involving 70 confirmed cholera cases and 70 matched community controls. Data were collected through structured interviews, environmental and sanitary assessments, and review of health facility records. Analysis was performed using R software, applying descriptive statistics to summarize participant characteristics and conditional logistic regression to identify factors independently associated with cholera infection.

Results: The median age of cases was 21 years (IQR: 6 - 20 years), and 50% were female. Most cases (35.7%) were aged 11 - 20 years, reflecting the school-based nature of the outbreak. The epidemic curve indicated a common point-source exposure followed by limited secondary transmission. Cases were significantly more likely than controls to rely on unsafe boreholes (57.1% vs. 28.6%, $p < 0.01$), use pit latrines (50.0% vs. 21.4%, $p < 0.01$), and consume untreated water (42.9% vs. 14.3%, $p < 0.01$). Multivariate analysis showed

that drinking untreated water (aOR = 4.00; 95% CI: 1.70–9.40), reliance on unsafe water sources (aOR = 3.20; 95% CI: 1.50–6.80), and poor sanitation (aOR = 2.80; 95% CI: 1.30–6.00) were the strongest predictors of infection.

Conclusion: The outbreak underscores the vulnerability of peri-urban populations due to unsafe water and poor sanitation. While the initial response was timely, challenges persisted in sustained control. Recommendations include strengthening household water treatment, improving sanitation infrastructure, enhancing health education, and instituting routine water quality monitoring. These measures are crucial for integrated WASH interventions and sustained preparedness to prevent future outbreaks in similar settings.

Keywords: Cholera, Outbreak investigation, Kabwe, Zambia, WASH, Case-control study, public health response

Introduction

Cholera is caused by toxigenic *Vibrio cholerae* serogroup O1 or O139 and is transmitted through the fecal-oral route. As such, infection is usually associated with drinking contaminated water, poor hygiene, and sanitation [1]. In endemic countries, cholera causes an estimated 2.86 million annual cases (uncertainty range: 1.3–4.0 million), resulting in approximately 95,000 deaths per year (uncertainty range: 21,000–143,000) (World Health Organization, 2022) [2]. Zambia's experience with cholera has been marked by fluctuating

cases and an increase in numbers since 1977. The most recent cholera outbreak in Zambia occurred in 2023, and by 21st February 2024, the country had reported over 19,719 confirmed cases with 682 deaths, the majority of which were recorded in Lusaka, the capital city [2].

The implementation of Zambia's Multi-Sectoral Cholera Elimination Plan after the 2017 outbreak led to a temporary pause in outbreaks until the year 2022[3]. A vaccination campaign spearheaded by WHO was carried out following the 2024 outbreak, targeting 1.5 million people, with priority given to children, health workers, and people at most risk of infection in the worst-affected areas [4].

One of the most recent cholera outbreaks in Zambia was recorded at David Ramusho Secondary in Kabwe District. The outbreak began on 27th March 2025, when a female teacher from David Ramusho Secondary School presented with diarrhoea at Kasanda Health Centre. The following day, a 13-year-old female pupil from the same school presented with diarrhoea and vomiting and was seen at Kabwe Women and Newborn Children's Hospital. The pupil, a resident of Makululu Compound, was referred from Makululu Mini Hospital and immediately isolated. Cholera rapid diagnostic test (RDT) confirmed infection, and samples were collected for culture and sensitivity testing.

On 28th March 2025, a 15-year-old male pupil from the same school presented with similar symptoms and was admitted to Kabwe General Hospital. On the same day, 14 additional cases were reported across various health facilities: Kasanda Health Centre (10 cases), Makululu Mini Hospital (2 cases), Makululu Health Centre (3 cases), and Magandanyama Health Post (1 case). In response, Ngungu Health Centre was opened to accommodate rising cases. By 29th March 2025, a total of 37 new cases were recorded, bringing the cumulative total to 51 cases. Among these, 44 were pupils from David Ramusho School, with 27 females and 24 males affected. As of 29th March 2025, 13 patients had been discharged, while 37 remained admitted.

The outbreak spread rapidly, with 111 cases reported between 27th March and 8th April 2025, most linked to David Ramusho Secondary School and affecting residents across six wards that included David Ramusho, Moomba, Zambezi, Makululu, Chililalila, and Justine Kabwe. This paper presents findings from the cholera outbreak investigation conducted at the school and surrounding communities in Kabwe District, aimed at

identifying the source of infection and assessing associated risk factors.

Methods

Design

A one-to-one case control study design was used. The study focused on case identification, environmental assessments to determine the source of infection and associated risk factors.

Study Setting

The study was conducted at David Ramusho Secondary School, with 1,200 pupils, and the surrounding high-density Mine Compound, home to over 35,000 residents in Kabwe. The area's WASH situation was poor, characterized by limited piped water and a reliance on unprotected boreholes and pit latrines. The school itself depended on a single, unprotected borehole and had insufficient sanitation facilities. These conditions made the location a high-risk environment and the epicenter of the cholera outbreak.

Sampling and Sample Size

The sample size of 70 cases and 70 controls was determined by including all confirmed cases identified in the outbreak up to the point of the investigation, constituting a census of known cases. An equal number of controls were then recruited to maximize the study's power to detect significant associations within the logistical constraints of the response.

Investigation team

The investigation team comprised of epidemiologists, environmental health officers, clinicians, and laboratory scientists. Clinicians and nurses from Kabwe District Health Office coordinated case management and patient follow-up, while two environmental health specialists conducted water and sanitation assessments in the school and the surrounding community.

Data Collection

Multiple data sources and collection methods were utilized to investigate the outbreak:

1. Record Review and Surveillance Data Analysis

A retrospective review of patient files and medical records from all affected health facilities was conducted to characterize the extent of the outbreak. This was complemented by an analysis of existing surveillance

data to determine the magnitude, describe case trends, and calculate epidemiological characteristics such as age, gender, and geographic distribution.

2. Case-Control Study and Structured Interviews

A 1:1 matched case-control study was implemented. Cases (individuals meeting the case definition for cholera) were compared with controls (healthy individuals of the same age group, sex, and residence from the same community or school) to minimize confounding. Data on potential exposures, including water sources, sanitation practices, and hygiene behaviors, were collected from both groups using structured interviews administered via KoboToolbox.

3. Environmental Assessment and Sanitary Inspection

Environmental health specialists conducted inspections of water and sanitation infrastructure at the school and in the surrounding community. This involved tracing water sources, assessing the safety and maintenance of boreholes and latrines, and identifying potential points of faecal contamination.

4. Contact Tracing and Response Evaluation

Contact tracing was performed by interviewing confirmed cases to identify their close contacts, particularly within households and the school. These contacts were then monitored for the development of symptoms.

Data Analysis

The datasets were exported from KoboToolbox and analyzed using R software [9]. Descriptive statistics for categorical variables were summarized as frequencies and proportions. The distribution of cholera cases was visualized through tables and graphs based on demographic and clinical characteristics. To identify risk factors associated with cholera infection, conditional logistic regression was employed to calculate unadjusted and adjusted odds ratios with 95% confidence intervals.

Case definition used

Cases and controls were those epidemiologically linked to David Ramusho Secondary School and the surrounding Mine Compound in Kabwe district. The case definition described a suspected cholera case as any person presenting with acute watery diarrhea (≥ 3 loose stools in 24 hours) with/without vomiting, and who is a resident of Mine Compound, Kabwe District, on or after 26th March 2025. A Probable cholera case was any suspected case with an epidemiological link to

a confirmed case or an area with ongoing cholera transmission within Mine Compound, Kabwe District, on or after 26th March 2025. A confirmed cholera case was a suspected case with *Vibrio cholerae*, confirmed by culture and/or PCR, from Mine Compound, Kabwe District, on or after 26th March 2025.

Ethical Considerations

This analysis was based on routine programmatic data collected during a public health emergency. It was covered by the umbrella protocol for the Field Epidemiology Training Program that was approved by the Zambian National Health Research Authority (NHRA) in 2023.

Results

Table 1 shows that cholera cases were predominantly aged 11–20 years, with no significant sex difference between groups. Cases were significantly more likely to rely on unsafe boreholes, use pit latrines, and drink untreated water compared to controls ($p < 0.01$). Education level was also associated with infection, with fewer cases having a tertiary education ($p = 0.04$). No difference was observed in oral cholera vaccine coverage between the two groups.

Table 1: Demographic Characteristics of Cholera Cases and Controls in Kabwe District, March 2025 (N=140)

Variable	Category/Value	Cases (N=70)	Controls (N=70)	Total (N=140)	p-value
Age Group	1–5 years	12 (17.1%)	8 (11.4%)	20 (14.3%)	0.34
	6–10 years	15 (21.4%)	10 (14.3%)	25 (17.9%)	
	11–20 years	25 (35.7%)	20 (28.6%)	45 (32.1%)	
	21–45 years	15 (21.4%)	25 (35.7%)	40 (28.6%)	
	46+ years	3 (4.3%)	7 (10.0%)	10 (7.1%)	
Sex	Male	35 (50.0%)	30 (42.9%)	65 (46.4%)	0.41
	Female	35 (50.0%)	40 (57.1%)	75 (53.6%)	
Education	No formal	10 (14.3%)	5 (7.1%)	15 (10.7%)	0.04
	Primary	15 (21.4%)	15 (21.4%)	30 (21.4%)	
	Secondary	30 (42.9%)	25 (35.7%)	55 (39.3%)	
	Tertiary	15 (21.4%)	25 (35.7%)	40 (28.6%)	
Water Source	Piped (Safe)	30 (42.9%)	50 (71.4%)	80 (57.1%)	<0.01
	Borehole/Unsafe	40 (57.1%)	20 (28.6%)	60 (42.9%)	
Toilet Type	Flush toilet	30 (42.9%)	50 (71.4%)	80 (57.1%)	<0.01
	Pit latrine	35 (50.0%)	15 (21.4%)	50 (35.7%)	
	No latrine	5 (7.1%)	5 (7.1%)	10 (7.1%)	
Water Treatment	Boiling/Chlorine	40 (57.1%)	60 (85.7%)	100 (71.4%)	<0.01
	Untreated	30 (42.9%)	10 (14.3%)	40 (28.6%)	
Received OCV*	Yes	50 (71.4%)	50 (71.4%)	100 (71.4%)	1.00
	No	20 (28.6%)	20 (28.6%)	40 (28.6%)	

*OCV - Oral Cholera Vaccine

Factors associated with cholera

The adjusted odds ratios (aOR) from the conditional logistic regression in figure 1 revealed that reliance on unsafe water was associated with more than a threefold increase in cholera risk (aOR = 3.20; 95% CI: 1.50–6.80), while poor sanitation, such as use of pit or no latrines, also increased the risk nearly three times (aOR = 2.80; 95% CI: 1.30–6.00). Failure to treat drinking

water was the strongest predictor, with affected individuals being four times more likely to develop cholera (aOR = 4.00; 95% CI: 1.70–9.40). In contrast, being aged 21–45 years (aOR = 0.50; 95% CI: 0.20–1.20) and having tertiary education (aOR = 0.60; 95% CI: 0.25–1.40) showed a trend toward being protective, though these were not statistically significant.

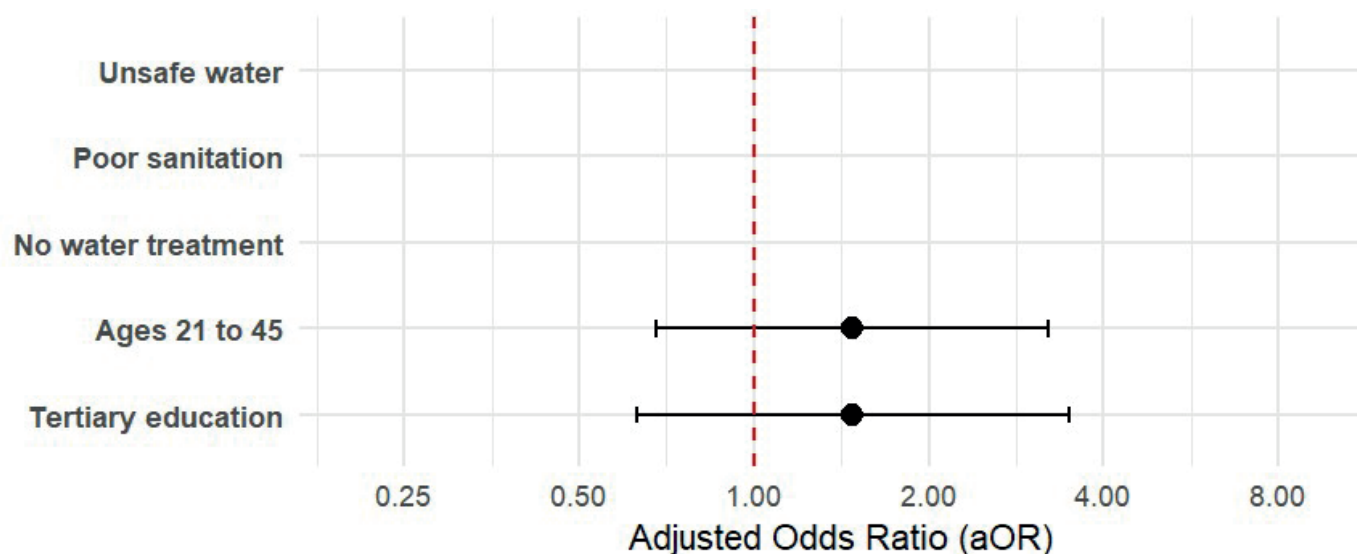


Fig 1: Factors Associated with Cholera at David Ramusho School in Kabwe District, 19th February to 13th May 2025 (N=140)

*aOR – Adjusted Odd Ratio

Epidemic curve for cholera cases recorded in Kabwe district from 19th February to 13th May 2025

The epidemic curve in Fig. 2 shows a sharp primary peak following the index case, indicative of a com-

mon point-source exposure. A subsequent plateau and smaller peaks suggest ongoing person-to-person transmission within the community. The curve illustrates the outbreak's rapid onset and prolonged tail, highlighting the challenge of containing secondary spread despite initial control measures.

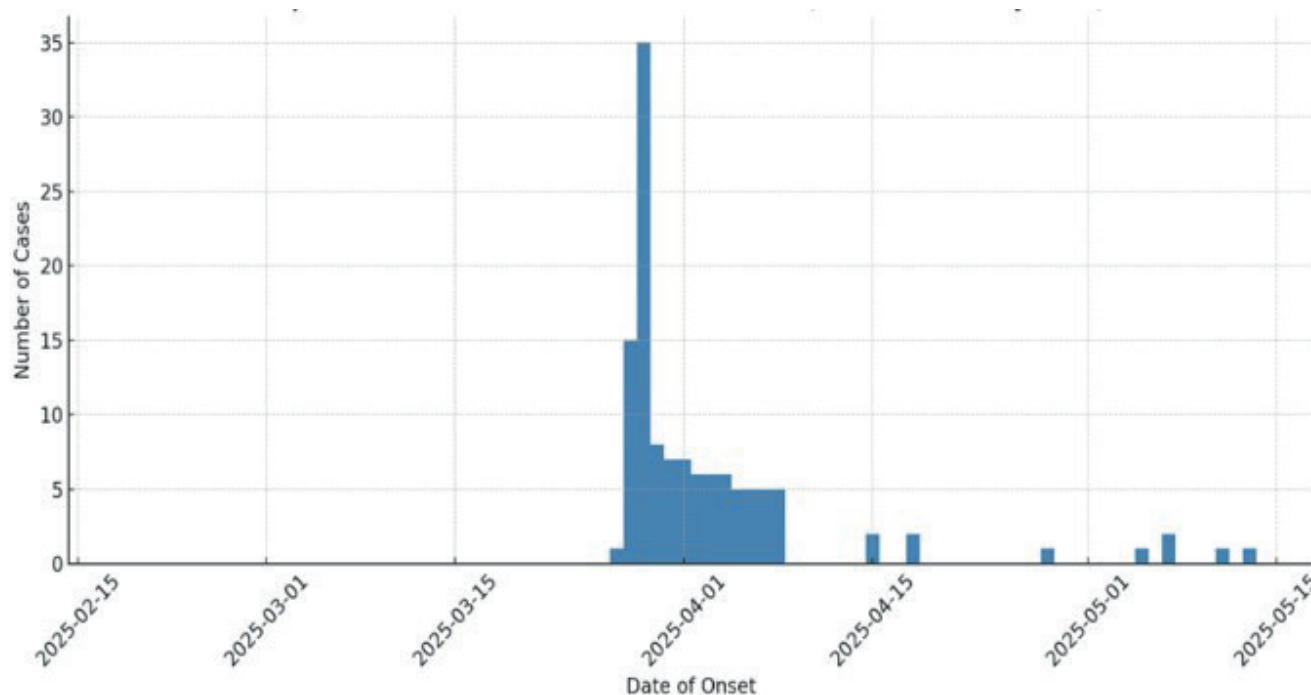


Fig 2: Epidemic curve for cholera cases recorded in Kabwe district from 19th February to 13th May 2025 (N=140)

Discussion

This study set out to investigate the cholera outbreak at David Ramusho Secondary School and the surrounding communities in Kabwe District in order to identify the source of infection, assess risk factors, and guide effective public health interventions. The investigation revealed that the primary risk factors were related to water safety and sanitation. Individuals relying on untreated and unsafe water sources were over three times more likely to develop cholera, a finding consistent with other studies in similar settings [5]. Similarly, poor sanitation, particularly the use of pit latrines or lack of latrines, was a significant contributor, underscoring the role of inadequate sanitation infrastructure in transmission [6]. These findings align with the known fecal-oral transmission pathways of *Vibrio cholerae* through contaminated water. Water treatment emerged as the most significant protective behavior, underscoring the importance of public health messaging on water boiling or chlorination [7]. Although OCV coverage was high, it did not show a protective effect, potentially due to reasons like strain mismatch, which has been noted in other outbreaks [8]. Demographic characteristics such as age and education initially appeared protective but lost significance in the multivariate model, indicating

they may act as proxies for underlying behavioral or environmental exposures.

These findings are similar to a study conducted in Lusaka during the 2017 cholera outbreak, where reliance on untreated water and poor sanitation facilities were also identified as major risk factors [5]. Comparable results were reported in Kenya, where the use of unsafe water sources increased cholera risk more than three-fold [6]. A study in Bangladesh equally demonstrated that untreated drinking water and inadequate sanitation infrastructure were the strongest drivers of cholera epidemics [7]. These consistencies across multiple contexts highlight that the Kabwe outbreak fits within a broader global pattern, reinforcing the need for sustainable WASH interventions as a cornerstone of cholera prevention and control.

Limitations

This investigation had several limitations that included recall bias, which could have affected the accuracy of data collected from case interviews, particularly concerning histories of food and water consumption. Second, contact tracing was incomplete, potentially leading to an undercount of secondary cases due to re-

luctance to report symptoms and losses to follow-up. Finally, the extensive environmental contamination, characterized by poor sanitation and multiple contaminated water sources, complicated efforts to pinpoint a single definitive source of infection.

Public health response and implications

The Kabwe cholera outbreak highlights critical implications for public health preparedness and response. Shortages of IV fluids and oral rehydration salts underscored the importance of pre-positioned medical supplies and resilient supply chains. Incomplete contact tracing and delayed water testing emphasized weaknesses in surveillance and laboratory systems, limiting timely corrective measures. The identification of schools as high-risk transmission sites points to the need for targeted WASH interventions, including borehole audits and provision of safe water points. Sustained investment in WASH infrastructure, coupled with intensified community engagement, is essential to break recurrent transmission cycles and strengthen future outbreak prevention and control.

Conclusion and Recommendations

The Kabwe cholera outbreak underscores the critical role of unsafe water, poor sanitation, and inadequate preparedness in sustaining transmission. To prevent future outbreaks, it is recommended that households adopt water treatment methods such as chlorine and boiling, while schools and communities establish adequate handwashing facilities with soap.

District health authorities should intensify health education campaigns to raise awareness about waterborne diseases and promote preventive behaviours. The Local Council should strengthen waste management systems, including safe sewage disposal in high-risk areas, and institutionalise routine water quality testing for early detection of contamination. Sustained investment in WASH infrastructure, community engagement, surge staffing, and pre-positioning of cholera supplies is essential to enhance outbreak preparedness and response.

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