Outbreak Investigation Report

Investigation of a Cholera Outbreak in Monze District, Southern Province, Zambia, November 2025: A Case-Control Study

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Abstract

Background

Cholera remains a recurrent public health problem in Zambia, which recorded 29 outbreaks between 1977 and 2018. On 4 November 2025, Monze District in Southern Province reported a cluster of acute watery diarrhoea among residents and among travellers who had arrived by train for a funeral. We investigated to confirm the causative organism, describe the outbreak, measure the timeliness of the response against the 7-1-7 framework (7 days for detection, one day for notification and 7 days for early response actions) and identify factors associated with infection.

Methods

We conducted an unmatched case-control study with a ratio of four controls to each case in Monze District between 6 and 17 November 2025. We collected participant demographic, clinical and environmental exposure data using a structured questionnaire. We enrolled all cases; controls were residents of the same facility catchment areas without acute watery diarrhoea, drawn from neighbouring households and close contacts of cases. We collected stool samples for laboratory confirmation on 33 patients. Statistical analyses were performed using R version 4.3.3. Logistic regression was used to identify factors associated with cholera infection. The 7-1-7 framework was used to assess timeliness in detection, notification and response.

Results

We enrolled 166 participants (33 cases and 133 controls). Median age (Interquartile range) was 26 years (15, 47 years) among cases and 31 years (22, 42 years) among controls. Three community cases died (9.1% case fatality rate) out of 33 cases. All 33 cases had acute watery diarrhoea and 32 (97.0%) had dehydration. Onsets began on 2 November, peaked the same day with six cases, and formed a second cluster of four cases on 11 November. Vibrio cholerae O1 serotype Ogawa was confirmed by culture. Four exposures were independently associated with infection: travel in the 7 days before onset (adjusted odds ratio (aOR) 6.28, 95% CI 2.43–16.91), a household member with diarrhoea (aOR 5.54, 95% CI 1.65–20.18), untreated household drinking water (aOR 6.50, 95% CI 1.82–35.50) and no soap in the household (aOR 2.72, 95% CI 1.11–6.83). Detection took 2 days, notification 0 days and early response 0 days, within the targets of 7, 1 and 7 days, respectively.

Conclusion

The findings are consistent with travel-associated introduction followed by household and community transmission in areas with unsafe water and limited access to sanitation, although the precise source and transmission pathways could not be conclusively established. Strengthening household water treatment, reliable access to soap, prompt protection of households in

which a case occurs, and travel advice at transport hubs are the measures most likely to prevent similar events. All three deaths occurred in the community without the patient reaching care, highlighting the need to investigate barriers to timely care-seeking and access to emergency treatment.

Key words: cholera; case-control studies; drinking water; hand hygiene; 7-1-7; Zambia

Introduction

Cholera is an acute diarrhoeal illness caused by toxigenic strains of Vibrio cholerae serogroup O1 or O139 and is acquired by consuming contaminated water or food. Worldwide, it causes an estimated 2.8 million cases and 95,000 deaths each year, and most of that burden falls on Africa (1). Zambia has experienced repeated epidemics since the late 1970s, with 29 outbreaks documented between 1977 and 2018 (2). The epidemic of 2023 and 2024 produced 23,381 cases and 740 deaths across nine provinces and exposed continuing weaknesses in water supply, sanitation and outbreak preparedness (3).

A further nationwide outbreak was declared in 2025, and by mid-November 571 cases and 9 deaths had been reported. Monze District in Southern Province is a rapidly urbanising rural district with a population of 268,432 at the 2022 census, of whom 130,412 are male and 138,020 are female (4). The district lies about 180 kilometres south-west of Lusaka on the Lusaka to Livingstone road and on the main railway line, and it receives regular passenger traffic from Kabwe, Kapiri Mposhi and the Copperbelt. Settlement is concentrated in peri-urban townships along the road and rail corridors. Piped water is limited; roughly half of households draw water from boreholes or shallow wells, and sanitation in the denser townships is dominated by shared pit latrines. These conditions leave the district vulnerable to faecal-oral transmission once cholera is introduced.

On 4 November 2025 seven patients presented at Nampeyo Rural Health Centre, Monze Mission Hospital and Siatontola Rural Health Centre with acute watery diarrhoea, vomiting and dehydration, and rapid diagnostic tests were positive in four of them (5). Several of those first affected had travelled by train to attend a funeral at Chikuni. The Zambia National Public Health Institute, the Zambia Field Epidemiology Training Programme and district health authorities began an investigation on 6 November. The objectives were to confirm the outbreak and identify the causative serotype, describe the outbreak by time, place and person, measure the timeliness of detection, notification and response against the 7-1-7 framework, identify the likely source of infection and the factors associated with cholera infection.

Methods

Study design

We conducted an unmatched case-control study with four controls for each case. Individuals meeting the case definition "cases" were compared with contacts and neighbours from the same facility catchment areas who did not meet it "controls", in order to estimate crude and adjusted odds ratios for exposures of interest. The investigation combined case finding, laboratory confirmation, assessment of travel history, and inspection of water and sanitation conditions. Reporting follows the STROBE recommendations for observational studies.

Study setting

The investigation covered the affected communities of Nampeyo, Monze Urban, Manungu, St Mary's, Siatontola, Nteme, Keemba and Mulumbwa, together with cases managed at Monze Mission Hospital. These catchments have a combined population of 122,603. They lie along the road and rail corridors with limited piped water and a reliance on unprotected boreholes and inadequate toilet structures. Most areas depend on boreholes and have insufficient sanitation facilities. These conditions made the highlighted location a high-risk environment and the epicenter of the cholera outbreak.

Study population

Residents of the affected communities residing in of Monze District, Southern Province between 4 and 18 November 2025.

Case definitions

Suspected case: any person resident in or visiting Monze District presenting with acute watery diarrhoea, defined as three or more loose stools in 24 hours, with or without vomiting, detected at a health facility or in the community on or after 4 November 2025.

Probable case: a suspected case epidemiologically linked to a confirmed case, or occurring in an area with ongoing cholera transmission within Monze District, detected on or after 4 November 2025.

Confirmed case: a suspected case in whom Vibrio cholerae was isolated by culture or detected by polymerase chain reaction, in Monze District, detected on or after 4 November 2025.

Selection of cases and controls

Case selection: all cases meeting the case definitions and resident in Monze District, detected between 4 and 18 November 2025, were eligible, and all 33 identified cases were enrolled. These 33 cases were a total enumeration of every case identified during the investigation period, so no sample size was calculated for cases.

Control selection: controls were residents of the same facility catchment areas who had no episode of acute watery diarrhoea during the outbreak period. They were drawn from neighbouring households and from close contacts of cases so that they shared the general environment of cases. Selection was unmatched at the individual level, and a fixed ratio of four controls to each case was used to increase precision without imposing matching constraints. Of 140 people approached as controls, 7 were excluded because they reported diarrhoea during the period, leaving 133 who were interviewed. No one refused.

Data collection

Record review and surveillance data

Patient files and facility registers at all affected health facilities were reviewed retrospectively to establish the extent of the outbreak. The district line list, which held 33 cases, was the source for the epidemic curve, the description of clinical presentation, the distribution of cases by catchment, case classification and the 7-1-7 intervals. The interview dataset collected with KoBoToolbox, which held 166 participants, was the source for the comparison of cases with controls and for all regression analysis.

Variables

The outcome was case status, binary coded as case or control. The exposures of primary interest were travel in the seven days before symptom onset for cases or before interview for controls, the presence of a household member with diarrhoea in the preceding seven days, use of untreated household drinking water, and absence of soap in the household. Other variables recorded were age, sex, education, occupation, household size, facility catchment, HIV status, drinking-water source, toilet type, food source, attendance at gatherings, contact with a person who had diarrhoea, mode of transport used when travelling, clinical signs and symptoms, and laboratory results. Data were drawn from the questionnaire interviews, the district line list and daily situation reports.

Comparability of measurement

The same questionnaire, case definitions and exposure questions were applied to cases and to controls. Interviews were carried out by trained field teams working to a common procedure, so that measurement was comparable between the two groups.

Environmental assessment

Environmental health technologists inspected water and sanitation infrastructure in the hotspot areas and neighbouring communities. They mapped water points, assessed the condition and maintenance of boreholes and latrines, and looked for sources of faecal contamination. Sixteen water samples were collected and eight were processed.

Contact tracing

Cases were interviewed to identify close contacts, particularly household members and immediate neighbours. Contacts were followed for the development of symptoms.

Laboratory testing

Stool specimens were collected for rapid diagnostic testing and for culture. Water samples were submitted for bacteriological examination.

Bias

To limit recall bias, questions about exposure covered the seven days before symptom onset for cases and an equivalent period before interview for controls. These periods are anchored to different events and may not correspond to the same calendar dates, particularly in a rapidly evolving outbreak, so temporal misclassification of exposure is possible. A sensitivity analysis of the reference periods was not undertaken. Reported handwashing and water treatment are open to social desirability bias, so questions were worded neutrally and, where possible, answers were checked against direct observation of water containers and handwashing facilities. Interviewers were trained to question cases and controls in the same way in order to reduce differential misclassification. Handwashing results are reported for

controls only, because case responses were collected after illness and after health education and are not comparable with those of controls.

Data analysis

Data were cleaned and analysed in R version 4.3.3 (6). Categorical variables were summarised as counts and percentages and continuous variables as medians with interquartile range. Cases and controls were compared using Fisher's exact test for categorical variables and the Wilcoxon rank-sum test for continuous variables. Epidemic curves were drawn from date of symptom onset, and the geographical distribution of cases was mapped in QGIS.

With 33 cases available, ordinary maximum likelihood estimation would be prone to small-sample bias and to separation in sparse categories. All logistic models were therefore fitted by Firth penalised maximum likelihood with profile-likelihood confidence intervals (7,8). Crude odds ratios were estimated for each candidate exposure in a separate single-exposure model. The multivariable model was restricted before analysis to four exposures representing the transmission pathways under investigation: importation through travel, transmission within the household, the quality of household drinking water, and hand hygiene. Age, sex, education, HIV status, facility catchment and household size were compared descriptively (Table 1) but were not entered in the primary model, because the small number of cases limited the number of terms that could be estimated reliably. Some of these characteristics may be associated with both exposure and infection and could therefore act as confounders; a sensitivity model adding sex and age under 15 years is reported as supplementary material, and the primary and sensitivity analyses are distinguished accordingly. Holding the model to four terms kept the ratio of events to predictors at 8.25, which is below the conventional guide of ten events per variable (9). This ratio is only a rough guide and does not establish that the model is adequately powered: model stability also depends on the distribution of exposures, separation and the precision of estimates. Firth penalised regression was used to reduce small-sample bias and separation, but the small number of cases limits precision. No automated, stepwise or p-value-based procedure was used at any stage, and the four exposures were not chosen on the strength of their crude associations. Two further models are reported as supplementary material: one adding sex and age under 15 years, and one containing twelve exposures, the latter included to show how precision deteriorates when the number of terms exceeds what 33 events can support.

Age was analysed as a continuous variable and in bands of under 5, 5 to 14, 15 to 24, 25 to 44 and 45 years and above. Household size was kept continuous. Analyses were carried out on complete cases; observations with a missing value for a given exposure were omitted from the analysis of that exposure, and the number contributing to each estimate is given in the tables. Timeliness was assessed against the 7-1-7 targets, taking the earliest date of symptom onset as the date of emergence, the date on which the first patients presented at a health facility as the date of detection, the date of report to the next level as the date of notification, and the date by which the early response actions were completed as the end of the response interval (10).

Ethical considerations

The investigation was carried out under the umbrella protocol of the Zambia Field Epidemiology Training Programme as part of the national outbreak response. Before each interview, field staff explained the purpose of the investigation and obtained verbal informed consent from adult participants. For participants under 18 years of age, consent was given by a parent or guardian, and children aged 7 to 17 years also gave verbal assent. Where the case had died or was too young to answer, a parent, guardian or next of kin responded on their behalf. Participants were told that they could decline or stop the interview at any time without any effect on their care. Confidentiality was maintained and records were anonymised by assigning case identification numbers.

Results

Participants and laboratory confirmation

All 33 cases identified during the investigation period were enrolled. Of 140 people approached as potential controls, 7 reported diarrhoea during the outbreak period and were excluded, leaving 133 who were interviewed. There were no refusals. Of the 33 cases, 5 were confirmed, 10 probable and 18 suspected. Rapid diagnostic testing was positive in 17 cases overall, including 4 of the 7 patients who presented on 4 November. Vibrio cholerae O1 serotype Ogawa was isolated by culture on 7 November 2025 in five cases. Culture, as the reference standard, was the basis on which the outbreak was formally declared, three days after the first patients were seen and five days after the earliest symptom onset.

Characteristics of cases and controls

Median age was 26 years among cases and 31 years among controls, and ages ranged from 1 to 101 years among cases and from 3 to 85 years among controls. Cases were more often at the extremes of age: 8 of 33 cases (24%) were under 15 years and 11 (33%) were 45 years or older, against 12 (9.0%) and 28 (21%) respectively among controls. Cases had less formal education, were more often drawn from rural health post and hospital catchments, and were more often HIV positive (18% against 3.0%). Cases came from larger households, with a median of 6 members against 5. One control and no case reported having received oral cholera vaccine. Table 1 gives the full comparison, including the four exposures carried forward into the multivariable model.

Table 1. Characteristics and exposures of cholera cases and community controls, Monze District, 4 to 18 November 2025.

Characteristic	Cases (n = 33)	Controls (n = 133)	p-value
Sex			0.3
Female	18 (55%)	86 (65%)	
Male	15 (45%)	47 (35%)	
Age in years, median (Q1, Q3)	26 (15, 47)	31 (22, 42)	0.6
Age band in years			**0.010**
Under 5	2 (6.1%)	1 (0.8%)	
5 to 14	6 (18%)	11 (8.3%)	
15 to 24	7 (21%)	29 (22%)	
25 to 44	7 (21%)	63 (48%)	
45 and above	11 (33%)	28 (21%)	
Education level			**0.005**
No education	7 (21%)	6 (4.5%)	
Primary	20 (61%)	73 (55%)	
Secondary	6 (18%)	45 (34%)	
Tertiary	0 (0%)	9 (6.8%)	
Facility catchment type			**<0.001**
Health centre or clinic	9 (27%)	81 (61%)	
Hospital	4 (12%)	4 (3.0%)	
Rural health post or other	20 (61%)	48 (36%)	
HIV positive	6 (18%)	4 (3.0%)	**0.005**
Main drinking-water source			>0.9
Borehole	21 (64%)	87 (65%)	
Tap	5 (15%)	20 (15%)	
Well	7 (21%)	26 (20%)	
Toilet type			0.053
Flush	2 (6.3%)	15 (11%)	
Pit latrine	21 (66%)	104 (78%)	
Ventilated improved pit latrine	0 (0%)	1 (0.8%)	
No latrine	9 (28%)	13 (9.8%)	

Characteristic	Cases (n = 33)	Controls (n = 133)	p-value
Household size, median (Q1, Q3)	6 (5, 7)	5 (4, 6)	**0.005**
Exposures retained in the multivariable model			
Travel in the 7 days before onset	16 (48.5%)	16 (12.0%)	**<0.001**
Household member with diarrhoea	10 (30.3%)	9 (6.8%)	**<0.001**
Untreated household drinking water	31 (93.9%)	93 (69.9%)	**0.003**
No soap available in the household	21 (63.6%)	40 (30.1%)	**<0.001**
Other exposures assessed			
No toilet facility	10 (30.3%)	12 (9.0%)	**0.003**
Contact with a diarrhoea case	13 (39.4%)	53 (39.8%)	>0.9
Ate food outside the home	16 (48.5%)	43 (32.3%)	0.10
Attended a gathering	7 (21.9%)	26 (19.5%)	0.8
Received oral cholera vaccine	0 (0%)	1 (0.8%)	>0.9

Values are n (%) unless stated otherwise. Percentages for exposures are calculated on participants with a non-missing response for that item. p-values are from Fisher's exact test for categorical variables and the Wilcoxon rank sum test for continuous variables. HIV, human immunodeficiency virus; Q1, Q3, first and third quartiles.

Clinical presentation

The common symptoms and signs that the patients presented with are summarised in Figure 1. All 33 cases had acute watery diarrhoea. Dehydration was recorded in 32 (97.0%), mild in 30 and severe in 2. Body weakness was reported by 31 (93.9%) and vomiting by 30 (90.9%). Headache occurred in 23 (69.7%) and fever in 19 (57.6%). Signs of more advanced fluid loss were less frequent: sunken eyes in 7 (21.2%), poor skin turgor in 3 (9.1%), dry mouth or tongue in 2 (6.1%), and thirst, muscle cramps and reduced urine output in 1 case each. The combination of profuse watery stool, vomiting and dehydration in the great majority of cases is the expected presentation of cholera.

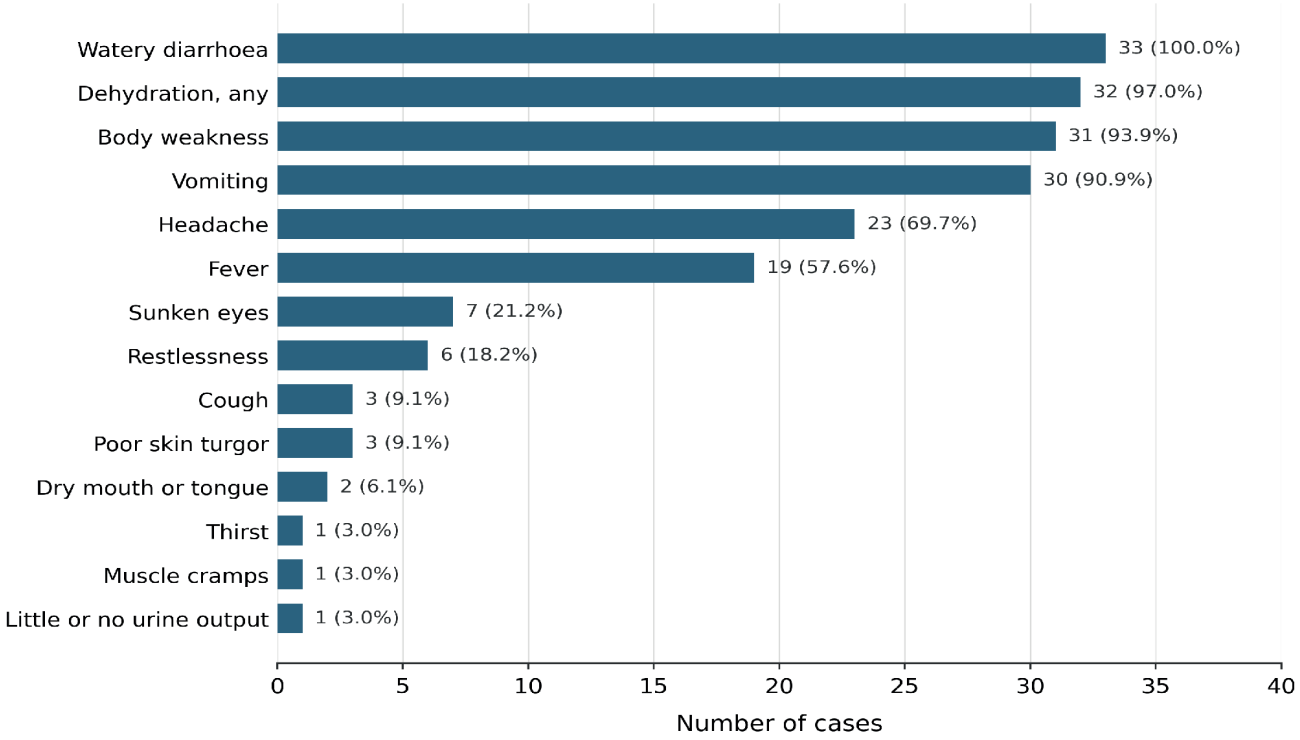


Figure 1. Signs and symptoms recorded among cholera cases, Monze District, November 2025 (N = 33). Percentages are of all 33 cases; cases reported more than one sign or symptom.

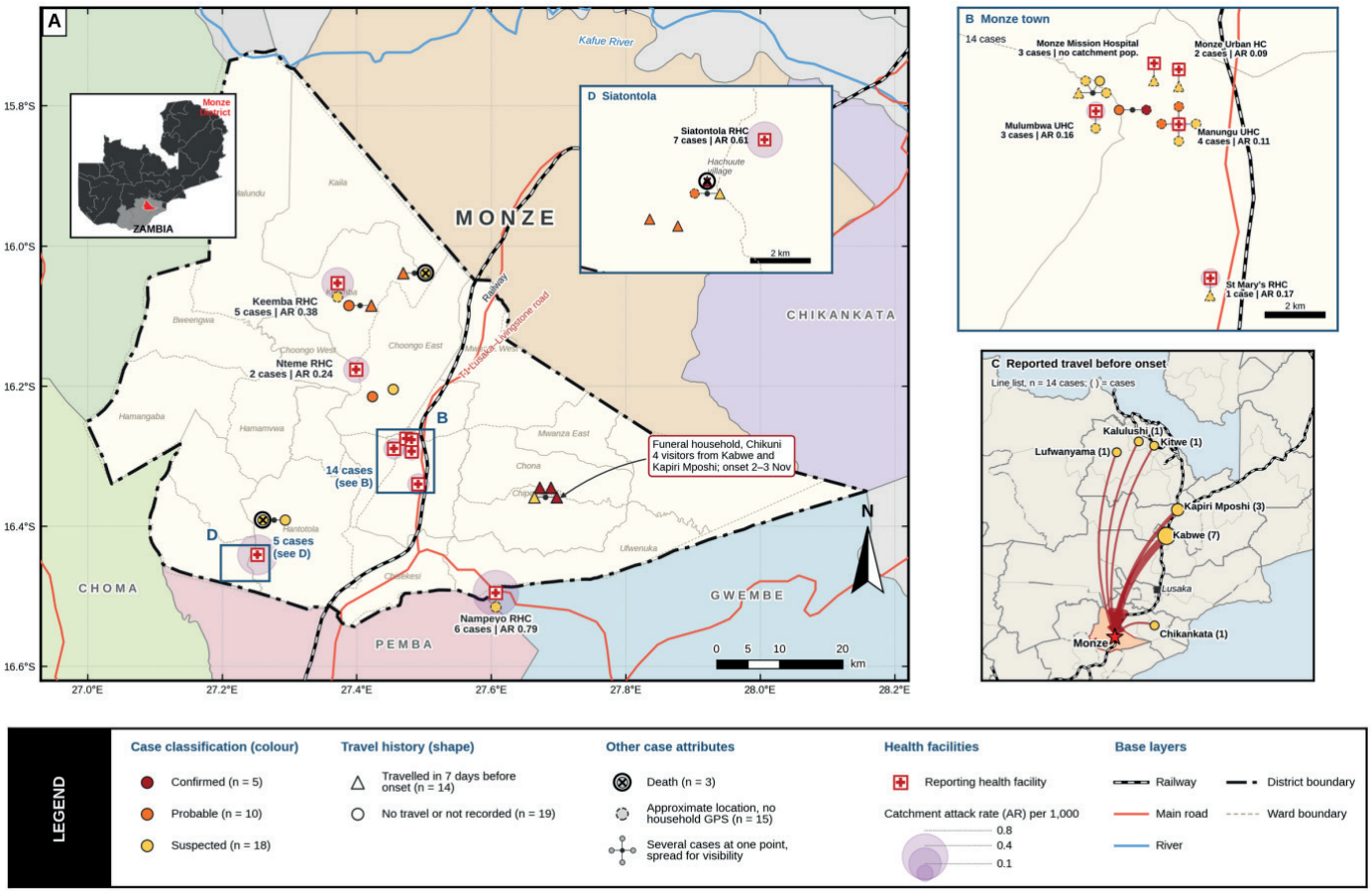
Distribution of cases by place

Cases occurred in nine facility catchments. Siatontola contributed the largest number with 7 cases (21.2%), followed by Nampeyo with 6 (18.2%) and Keemba with 5 (15.2%) (Table 2). Attack rates give a different ordering, because the catchments differ greatly in population. The highest attack rate was in Nampeyo at 0.791 per 1,000, followed by Siatontola at 0.609 and Keemba at 0.378. The pooled attack rate across the eight catchments with a defined population was 0.245 per 1,000 (30 cases among 122,603 people). Monze Mission Hospital is the district referral facility and has no catchment population of its own, so its 3 cases are counted in the total but excluded from the pooled attack rate. Hamapande reported no cases during the period and is not listed in Table 2. Cases were widely scattered, with clusters around the funeral household at Chikuni, in Siatontola and in Monze town (Figure 2).

Table 2. Cases and attack rates by facility catchment, Monze District, 4 to 18 November 2025 (N = 33)

Facility catchment	Cases (n)	Catchment population	Proportion of cases (%)	Attack rate per 1,000
Siatontola Rural Health Centre	7	11,485	21.2	0.609
Nampeyo Rural Health Centre	6	7,588	18.2	0.791
Keemba Rural Health Centre	5	13,229	15.2	0.378
Manungu Urban Health Centre	4	35,557	12.1	0.112
Monze Mission Hospital	3	Not applicable	9.1	Not applicable
Mulumbwa Urban Health Centre	3	18,725	9.1	0.160
Monze Urban Health Centre	2	21,981	6.1	0.091
Nteme Rural Health Centre	2	8,155	6.1	0.245
St Mary's Rural Health Centre	1	5,883	3.0	0.170
Subtotal, eight catchments with a defined population	**30**	**122,603**	**90.9**	**0.245**
Total	**33**	**–**	**100**	**–**

Monze Mission Hospital has no catchment population of its own. Its 3 cases are included in the total of 33 but not in the pooled attack rate, which is based on the 30 cases from the eight catchments with a defined population.



Data: Monze District Health Office cholera line list (November 2025). Boundaries: Zambia Statistics Agency (CSO) district and ward boundaries; roads, railway and rivers: Natural Earth. AR, attack rate per 1,000 catchment population. Projection: WGS 84 (EPSG:4326).

Figure 2. Distribution of cholera cases by household location and reporting health facility, Monze District, onset 2 to 16 November 2025 (N = 33). (A) District overview; shaded circles show the catchment attack rate per 1,000. (B) Monze town. (C) Reported travel in the 7 days before onset, from the line list (n = 14). (D) Siatontola. Households without GPS coordinates (n = 15) are placed at the reporting facility or at another case from the same village and are drawn with a dashed outline. Cases sharing one location are spread around it for visibility, with a line to the true point.

Distribution of cases by time

The first onset was on 2 November 2025 and the last on 16 November. The largest single day was 2 November with 6 cases, followed by 3 November with 5. Cases then fell away before a second cluster of 4 cases on 11 November, after which the outbreak declined and no onsets were recorded after 16 November during the study period. The three deaths had onset on 3, 12 and 16 November and were recorded on the line list on 9, 13 and 17 November. Two were residents of the Siatontola catchment and one of the Keemba catchment; they were aged 17 months, 12 years and 101 years. None of the three reached care alive: one child was never taken to a facility, one man was brought in dead and one boy died in the community. The shape of the curve in Figure 3, with a sharp initial peak among people who had recently travelled followed by a smaller second wave, is consistent with importation followed by local transmission over roughly one incubation interval (11).

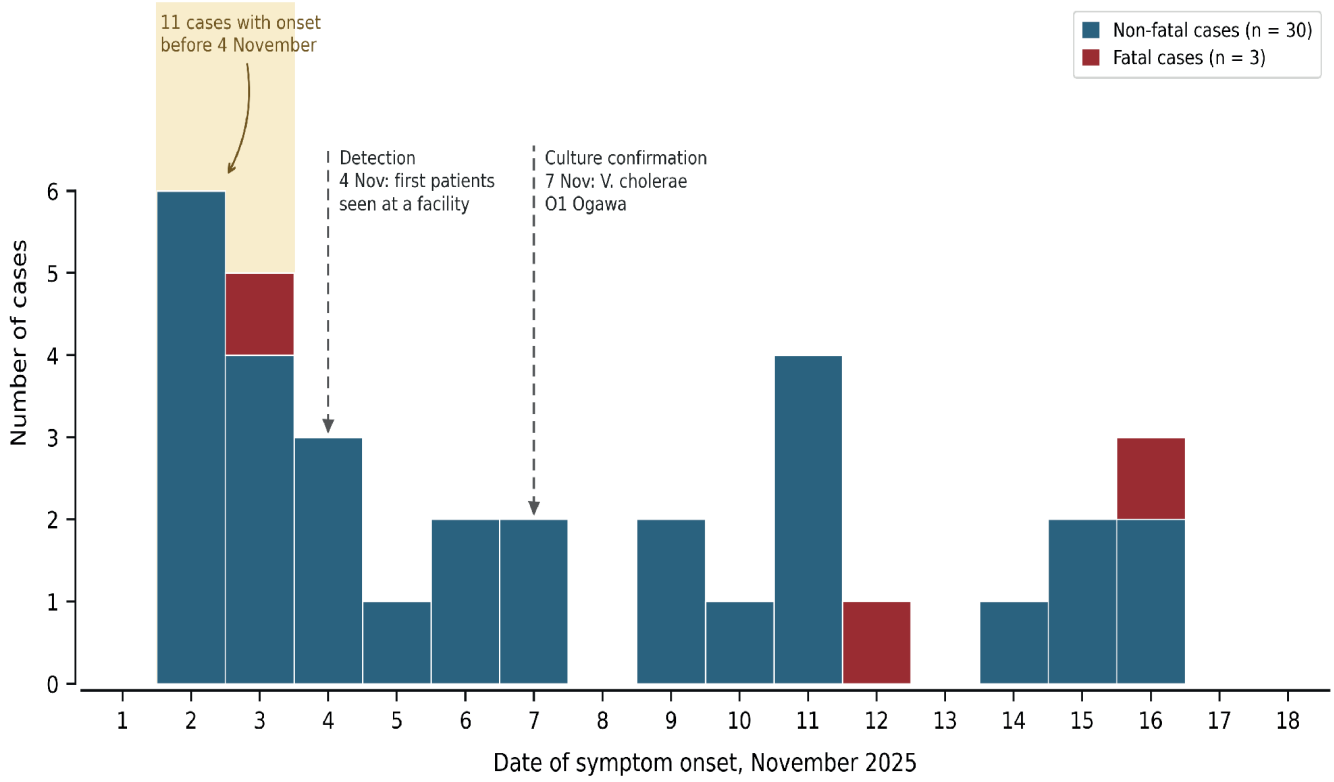


Figure 3. *Cholera cases by date of symptom onset and outcome, Monze District, 2 to 16 November 2025 (N = 33). Bars are contiguous; a break in the series means no case had onset on that day. The shaded red portion of a bar represents cases who subsequently died. The shaded yellow band covers the 11 cases whose symptoms began before the outbreak was detected. Broken lines mark detection on 4 November, when the first patients were seen at a health facility, and culture confirmation of Vibrio cholerae O1 serotype Ogawa on 7 November.*

Timeliness of detection, notification and response

The outbreak emerged on 2 November 2025, the earliest date of symptom onset recorded. Detection occurred on 4 November, when seven patients presented at Nampeyo Rural Health Centre, Monze Mission Hospital and Siatontola Rural Health Centre and rapid diagnostic tests were positive in four of them. Detection therefore took two days against a target of seven. The joint investigation by the district, the province and the

Zambia National Public Health Institute was launched on 6 November, two days after detection, and Vibrio cholerae was isolated by culture on 7 November. Notification to the next level was done within the 1 day target and completion of the seven early response actions within 7 days are set out as outlined in (Figure 4).

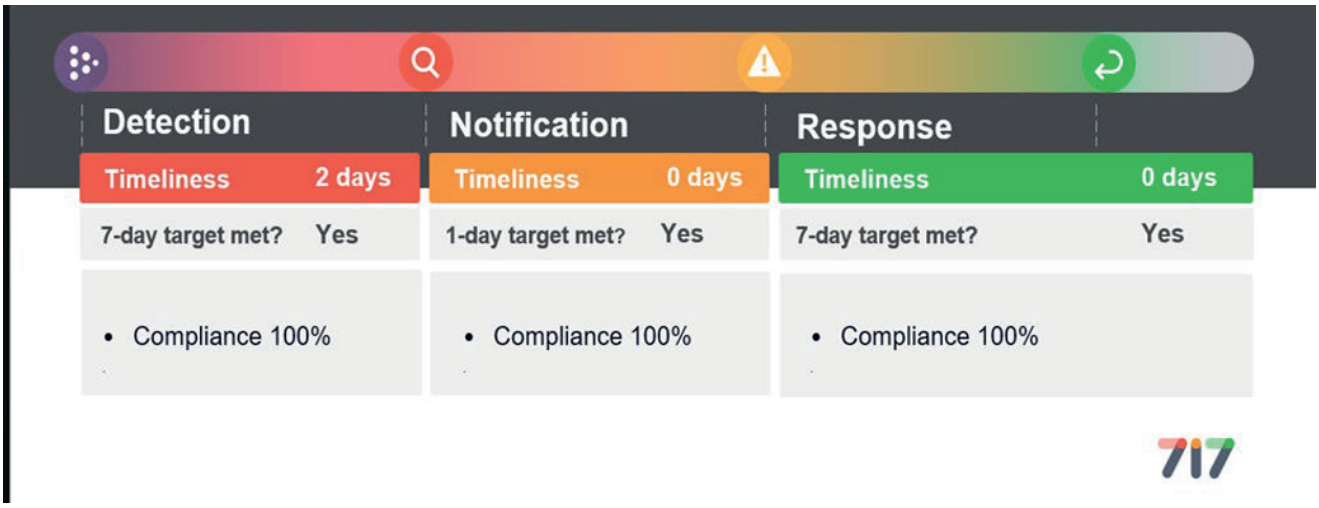


Figure 4. *Timeliness of detection, notification and early response against the 7-1-7 targets, Monze District, November 2025*

The outbreak response demonstrated strong compliance with the 7-1-7 strategy as evidenced above. Detection was enabled by the availability of clear cholera case definitions, Detection was helped by clear case definitions, a high index of suspicion among clinicians at the receiving facilities, and rapid diagnostic tests available at facility level, which gave a presumptive result on the day the first patients were seen. Notification performance benefited from dedicated surveillance staff and established electronic reporting channels, despite poor network connectivity at peripheral facilities such as Nampeyo and Siatontola. Response was supported by an active rapid response team, pre-positioned supplies and a functioning incident management structure. Against that, all three deaths occurred without the patient reaching care, which highlights the need to understand barriers to timely care-seeking and access to emergency treatment in the community.

Exposures, water, sanitation and hygiene

Cases were four times as likely as controls to have travelled in the 7 days before onset of symptoms (48.5% against 12.0%). Among those who travelled, the train was the dominant mode for cases: 10 of the 11 travellers who used the train were cases, against 1 control, whereas bus travel was reported by 4 cases and 10 controls and private vehicle by no case and 5 controls. Destinations named most often were Kabwe, Kitwe and Kapiri-Mposhi. Cases were more than four times as likely to report a household member with diarrhoea (30.3% against 6.8%). Nearly all cases drank untreated water (93.9% against 69.9% of controls), and cases were twice as likely to have no soap in the household (63.6% against 30.1%) and more than three times as likely to have no toilet facility (30.3% against 9.0%). Contact with a person who had diarrhoea was reported almost identically by the two groups (39.4% against 39.8%), and attendance at gatherings did not differ.

Among controls, reported handwashing was high at the two moments most often asked about in surveys: 132 of 133 (99.2%) said they washed their hands before eating and 130 (97.7%) after using the toilet. Reported handwashing was lower before cooking (94, 70.7%) and after cleaning a child's stool (87, 65.4%). These figures are self-reported and should be read against the finding that soap was absent from 30.1% of control households and 63.6% of case households, which suggests that the reported practice overstates what is possible in many homes (Supplementary table 4).

Comorbid conditions

HIV positive status was recorded in 6 cases (18.2%) and 4 controls (3.0%). Other conditions were uncommon in both groups, which is consistent with the age distribution of the outbreak population (Table 3).

Table 3. Comorbid conditions by case status, Monze District, November 2025.

Condition	Cases (n)	Cases (%)	Controls (n)	Controls (%)
HIV positive †	6	18.2	4	3.0
Diabetes	0	0	1	0.8
Tuberculosis	0	0	0	0
Hypertension	0	0	10	7.5
Pregnancy	1	3.0	3	2.3

†Human Immunodeficiency Virus.

Factors associated with cholera infection

In the multivariable model, all four pre-specified exposures were independently associated with infection: travel in the 7 days before onset (aOR 6.28, 95% CI 2.43–16.91), a household member with diarrhoea (aOR 5.54, 95% CI 1.65–20.18), untreated household drinking water (aOR 6.50, 95% CI 1.82–35.50) and absence of soap (aOR 2.72, 95% CI 1.11–6.83). The adjusted estimates were close to the crude ones for three of the four exposures, which indicates limited confounding among them. Table 4 presents both sets of estimates.

A sensitivity model that added sex and age under 15 years left the four estimates materially unchanged, and neither added term was associated with infection (Supplementary Table 3). An expanded model containing twelve exposures is reported as Supplementary Table 2. In that model the confidence interval for a household member with diarrhoea widened from a ratio of 12 between its upper and lower limits to a ratio of 54, and contact with a case appeared strongly protective. The same exposure analysed on its own gives a crude odds ratio of 0.99 (95% CI 0.45–2.12, p = 0.981), so that apparent protection is a product of fitting thirteen terms to 32 events rather than a finding about transmission. It is reported for completeness and is not interpreted.

Table 4. Crude and adjusted odds ratios for exposures associated with cholera infection, Monze District, 4 to 18 November 2025.

Exposure	n*	Crude OR‡ (95% CI §)	p-value	Adjusted OR (95% CI)	p-value
Travel in the 7 days before onset	166	6.71 (2.90–15.91)	<0.001	6.28 (2.43–16.91)	<0.001
Household member with diarrhoea	166	5.86 (2.19–15.95)	<0.001	5.54 (1.65–20.18)	0.006
Untreated household drinking water	166	5.46 (1.70–27.64)	0.003	6.50 (1.82–35.50)	0.003
No soap available in the household	166	3.97 (1.83–8.95)	<0.001	2.72 (1.11–6.83)	0.028

‡odds ratio; §confidence interval; *number of participants included in the analysis.

All estimates from logistic regression fitted by Firth penalised maximum likelihood with profile-likelihood confidence intervals. Crude estimates come from separate single-exposure models; adjusted estimates come from a single model containing all four exposures. The four exposures were fixed before analysis and no stepwise or p-value-based selection was used.

Discussion

This investigation identified four modifiable factors associated with cholera infection in Monze District: travel in the 7 days before onset, a household member with diarrhoea, use of untreated household drinking water, and absence of soap. The descriptive findings point in the same direction. The epidemic curve rose sharply

on 2 and 3 November among people who had recently travelled by train, fell, and rose again on 11 November, roughly one incubation interval later. Cases clustered in peri-urban catchments that depend on boreholes and shallow wells and where shared pit latrines are the norm. Taken together, the evidence is consistent with an outbreak seeded by movement along the transport corridor and sustained by household and community transmission rather than a single point-source contamination event, although the case-control design cannot establish the original source of infection or individual transmission chains. . The same sequence, importation followed by amplification in densely settled areas with limited services, has been described in Lusaka and in other Zambian hotspots (2,12).

The size and direction of the associations agree with evidence from other African epidemics. Household studies and transmission modelling show that living with a cholera patient raises the risk of infection substantially, with shared sanitation and shared food preparation as the main pathways (13). In Monze, a household member with diarrhoea remained associated with infection after adjustment, and cases came from larger households, both of which fit that mechanism. The association with untreated drinking water is consistent with reviews showing that household water treatment improves water quality and lowers cholera risk where piped supply is unreliable or absent (14). The finding for soap deserves particular attention. Reported handwashing among controls was almost universal at the moments people are usually asked about, yet soap was absent from a third of control households and from nearly two thirds of case households, and absence of soap remained associated with infection after adjustment. Observational work in cholera-affected communities has repeatedly found that reported handwashing exceeds observed practice and that soap is often unavailable at the point of use even when households say they wash (15,16). The pattern in Monze suggests that securing the physical means to wash matters more than further messaging about the importance of doing so.

Cases were more often drawn from hospital and rural health post catchments than from health centre catchments, and HIV positive status was more common among cases. Both differences were evident in the descriptive comparison (Table 1) but were not entered into the multivariable model, and neither should be read as an adjusted finding. The catchment association may reflect differences in population density, service coverage and care-seeking rather than any property of the facilities themselves; comparable urban to peri-urban gradients have been reported in inland African settings where cholera follows networks of informal settlement and market activity (17). The higher proportion of HIV positive cases is compatible with greater susceptibility or with more frequent presentation to care, and the numbers here are too small to separate the two.

The finding should not be interpreted as evidence of increased cholera risk: the comparison is unadjusted, the number of participants with HIV is small, and differences between cases and controls in how HIV status was ascertained, or in the completeness of that information, could have influenced it. Confounding and selection bias cannot be excluded.

Timeliness deserves comment because it is an element of the response the district can act on directly. Two days elapsed between the earliest symptom onset and the presentation of the first patients, well inside the seven-day detection target, and this reflects both a high index of suspicion at facility level and the availability of rapid diagnostic tests. The interval that mattered most here, however, is one the facility cannot influence. All three deaths occurred without the patient reaching care: one child was never taken to a facility, one man was brought in dead and one boy died in the community. Community awareness of when to seek help, and the availability of oral rehydration close to home, therefore deserve at least as much attention as reporting infrastructure. Barriers to timely care-seeking and access to emergency treatment, including delayed recognition of illness, transport difficulties and limited access to services, may have contributed to these three deaths and warrant further investigation.

Several limitations apply. The design depends on retrospective self-report of travel, water treatment and hand hygiene, so recall bias and social desirability bias are likely, particularly if cases were questioned more intensively or received health education before interview.

Because controls were drawn from neighbouring households and close contacts of cases, they may share environmental exposures with cases, which could bias the odds ratios towards the null and should be considered when interpreting them. The small number of cases limits precision, and the confidence intervals for untreated water in particular remain wide even in the restricted model. Restricting the model to four expo-

sures improved precision but means that other characteristics are described only in Table 1 and could not be adjusted. Residual confounding by these characteristics is therefore possible. Case ascertainment depended on presentation to a facility, so residents who were ill but did not seek care are likely to be under-represented. The initial cases were RDT positive before confirmation by culture on 7th November 2025 validating the diagnostic approach and supporting the accuracy of outbreak classification. Environmental sampling was limited: of 16 water samples collected, 8 were processed and one from the correctional facility showed Escherichia coli. No food samples were taken because the district has no capacity to process them. The investigation covered one district with a particular pattern of peri-urban settlement and transport links, and findings may not transfer directly to sparsely settled rural areas or to the large informal settlements of Lusaka and the Copperbelt.

Within those limits, the investigation produced evidence that shaped the response as it was happening. The measures identified here are consistent with national and World Health Organization guidance and are within the reach of a district health system: household water treatment, reliable access to soap, prompt protection of households in which a case has occurred, and health advice to travellers at transport hubs (18,19). The identified risks are likely to operate in the same way in districts that resemble Monze, that is, rapidly urbanising rural settings on major transport corridors with mixed dependence on boreholes and wells and incomplete access to safe sanitation.

Public health action

After confirmation of Vibrio cholerae O1 serotype Ogawa, the district rapid response team and partners used case area targeted intervention as the main delivery model. Teams reached affected households within 24 hours of case confirmation and carried out contact tracing, household disinfection, and point-of-use chlorination with demonstration of correct use. Other measures included waste management and clean-up campaigns, orientation of community volunteers to run oral rehydration points for mild community cases, health education for marketeers, travellers and mourners at funeral gatherings, systematic line listing of cases and contacts, and daily entry of data into the electronic Integrated Disease Surveillance and Response platform to allow the outbreak to be tracked in near real time. Clinical management followed World Health Organization guidance and cases were managed in designated cholera treatment centres.

Conclusion and recommendations

Cholera in Monze District in November 2025 was associated with travel in the 7 days before onset, transmission within households, untreated drinking water and absence of soap. Vibrio cholerae O1 serotype Ogawa was confirmed during the investigation period. The first cases were detected two days after the outbreak emerged, within the seven-day target, and culture confirmation followed three days later. Ensuring that households can treat their water and have soap to wash with, protecting the households of people who fall ill, and giving practical advice to travellers are the measures most likely to prevent reoccurrence.

We recommend four actions. The Senior Environmental Health Officer of the Monze District Health Office should facilitate distribution of household water treatment products and soap with a demonstration of correct use, beginning in the Nampeyo, Siatontola and Keemba catchments where attack rates were highest, and should continue case area targeted intervention around every confirmed case. The District Health Promotions Officer should provide health education on safe water and hygiene at the railway station, bus terminals and funeral gatherings, and should promote early care-seeking, since all three deaths occurred in the community. The District Surveillance Officer should maintain reporting from Nampeyo and Siatontola, where network access is poor, and strengthen surveillance along the rail and road corridors. In the longer term, the Southern Provincial Health Office and local government should invest in piped water and sanitation in peri-urban settlements and consider oral cholera vaccine for hotspots (18). Timelines are given in Supplementary Table 1.

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Conflicts of interest

The authors declare no conflicts of interest.

References

1. Ali M, Nelson AR, Lopez AL, Sack DA. Updated global burden of cholera in endemic countries. PLoS Negl Trop Dis. 2015;9(6):e0003832. doi:10.1371/journal.pntd.0003832

2. Mwaba J, Debes AK, Shea P, Mukonka V, Chewe O, Chisenga C, et al. Identification of cholera hotspots in Zambia: a spatiotemporal analysis of cholera data from 2008 to 2017. PLoS Negl Trop Dis. 2020;14(4):e0008227. doi:10.1371/journal.pntd.0008227

3. Hakayuwa CM, Sibomana O, Kalasa CS. Cholera resurges in Zambia: challenges and future directions. IJID Reg. 2025;15:100640. doi:10.1016/j.ijregi.2025.100640

4. Zambia Statistics Agency. 2022 Census of Population and Housing: Southern Province analytical report. Lusaka: Zambia Statistics Agency; 2023.

5. Monze District Health Office. Cholera situation report, 4 November 2025. Monze: District Health Office; 2025.

6. R Core Team. R: a language and environment for statistical computing. Vienna: R Foundation for Statistical Computing; 2024. Available from: https://www.R-project.org/

7. Firth D. Bias reduction of maximum likelihood estimates. Biometrika. 1993;80(1):27-38. doi:10.1093/biomet/80.1.27

8. Heinze G, Schemper M. A solution to the problem of separation in logistic regression. Stat Med. 2002;21(16):2409-19. doi:10.1002/sim.1047

9. Peduzzi P, Concato J, Kemper E, Holford TR, Feinstein AR. A simulation study of the number of events per variable in logistic regression analysis. J Clin Epidemiol. 1996;49(12):1373-9. doi:10.1016/S0895-4356(96)00236-3

10. Frieden TR, Lee CT, Bochner AF, Buissonnière M, McClelland A. 7-1-7: an organising principle, target, and accountability metric to make the world safer from pandemics. Lancet. 2021;398(10300):638-40. doi:10.1016/S0140-6736(21)01250-2

11. Azman AS, Rudolph KE, Cummings DAT, Lessler J. The incubation period of cholera: a systematic review. J Infect. 2013;66(5):432-8. doi:10.1016/j.jinf.2012.11.013

12. Sinyange N, Brunkard JM, Kapata N, Mazaba ML, Musonda KG, Hamoonga R, et al. Cholera epidemic - Lusaka, Zambia, October 2017-May 2018. MMWR Morb Mortal Wkly Rep. 2018;67(19):556-9. doi:10.15585/mmwr.mm6719a5

13. Meszaros VA, Miller-Dickson MD, Baffour-Awuah F Jr, Almagro-Moreno S, Ogbunugafor CB. Direct transmission via households informs models of disease and intervention dynamics in cholera. PLoS One. 2020;15(3):e0229837. doi:10.1371/journal.pone.0229837

14. Lantagne D, Yates T. Household water treatment and cholera control. J Infect Dis. 2018;218(Suppl 3):S147-53. doi:10.1093/infdis/jiy488

15. Zohura F, Bhuyian SI, Monira S, Begum F, Biswas SK, Parvin T, et al. Observed handwashing with soap practices among cholera patients and accompanying household members in a hospital setting (CHoBI7 trial). Am J Trop Med Hyg. 2016;95(6):1314-8. doi:10.4269/ajtmh.16-0379

16. White S, Mutula AC, Buroko MM, Heath T, Mazimwe FK, Blanchet K, et al. How does handwashing behaviour change in response to a cholera outbreak? A qualitative case study in the Democratic Republic of the Congo. PLoS One. 2022;17(4):e0266849. doi:10.1371/journal.pone.0266849

17. Rebaudet S, Sudre B, Faucher B, Piarroux R. Environmental determinants of cholera outbreaks in inland Africa: a systematic review of main transmission foci and propagation routes. J Infect Dis. 2013;208(Suppl 1):S46-54. doi:10.1093/infdis/jit195

18. Global Task Force on Cholera Control. Ending cholera: a global roadmap to 2030. Geneva: World Health Organization; 2017.

19. Bwembya J, Shempela DM, Chilengi R. Addressing cholera outbreaks in Zambia: a call for a social ecological approach. Health Press Zambia. 2025;9(3):4-6. doi:10.65715/thp.v9i3.40

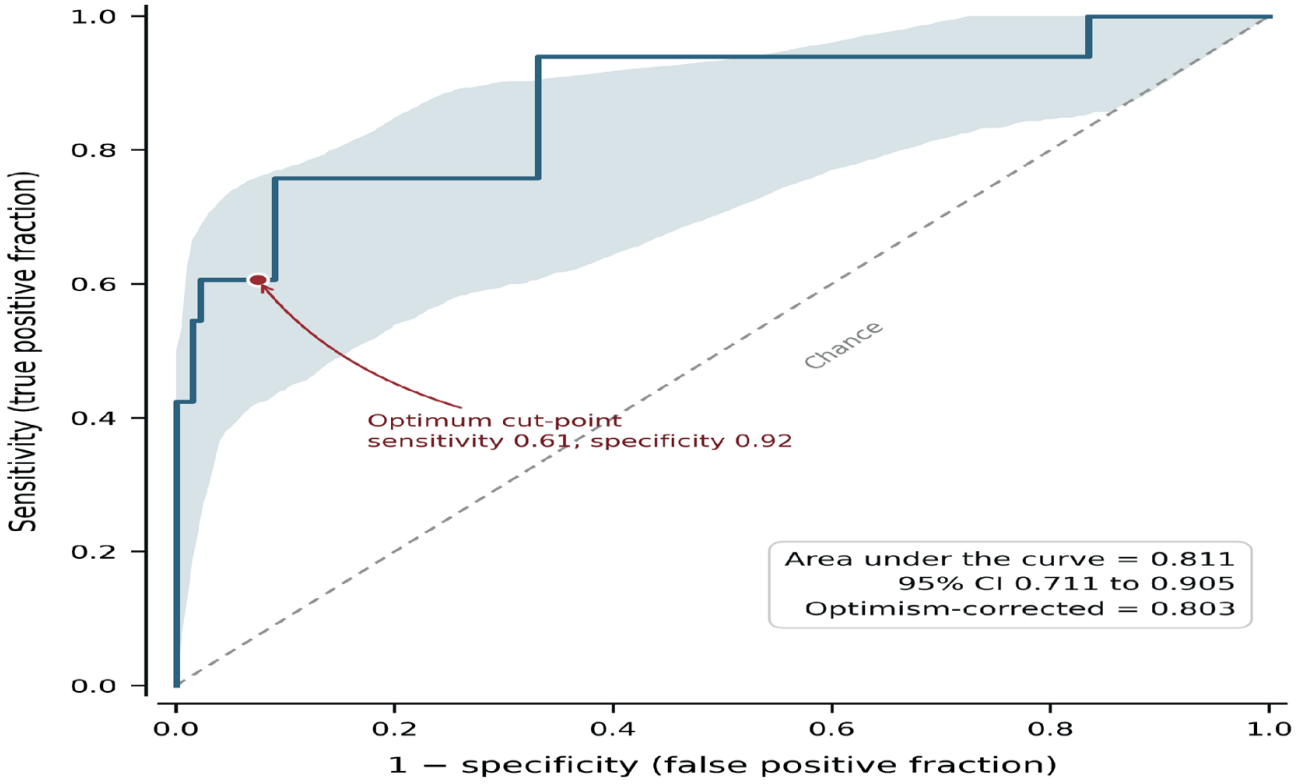
Supplementary files

The following files accompany this manuscript.

Supplementary Table 1. Gap analysis and action plan

Gap identified	Action	Responsible officer	Timeline
Low household water treatment	Distribute water treatment products with demonstration of correct use	Senior Environmental Health Officer	31/12/2025
Soap not available in many households	Include soap in household distribution alongside water treatment products	Senior Environmental Health Officer	31/12/2025
Travel-related importation	Health messaging at the railway station and bus terminals, and advisories for travel to affected areas	District Health Promotions Officer	31/12/2025
Household transmission	Case area targeted intervention with oral rehydration solution, disinfection and active case finding	Senior Environmental Health Officer	31/12/2025
Connectivity at peripheral reporting sites	Maintain network access or an offline reporting route at Nampeyo and Siatontola	District Surveillance Officer	31/03/2026
Deaths occurring in the community	Maintain oral rehydration points and community messaging on when to seek care	District Health Promotions Officer	31/03/2026

Supplementary Figure 1. Receiver operating characteristic curve for the primary multivariable model



The model shows good discriminatory performance with an AUC of 0.81 (95% CI: 0.71–0.91). At the optimum cut-point, it achieves 61% sensitivity and 92% specificity. The curve is a step function because all four predictors are binary, giving 14 distinct covariate patterns. The marked point maximises the Youden index and is shown to describe model behaviour.

Supplementary Table 2. Expanded multivariable model containing twelve exposures, shown to illustrate the loss of precision when the model is not restricted

Exposure	Adjusted OR (95% CI)	p-value	Width of CI (upper/lower)
Travel in the 7 days before onset	6.26 (1.97–21.21)	0.002	10.8
Household member with diarrhoea	12.98 (2.29–123.03)	0.003	53.8
Untreated household drinking water	4.35 (1.18–24.42)	0.025	20.6

No soap available in the household	2.11 (0.64–7.12)	0.216	11.1
No toilet facility	2.79 (0.58–13.94)	0.198	23.9
Contact with a diarrhoea case	0.15 (0.02–0.66)	0.009	32.7
Ate food outside the home	1.96 (0.58–6.74)	0.276	11.7
Attended a gathering	0.63 (0.15–2.24)	0.484	14.6
Male sex	1.46 (0.54–3.98)	0.449	7.3
Age under 15 years	3.35 (0.90–12.46)	0.071	13.9
Household size, per person	1.11 (0.88–1.41)	0.358	1.6
Water source: tap	2.30 (0.62–8.36)	0.209	13.6
Water source: well	0.86 (0.18–3.48)	0.840	18.9

Model fitted on 163 participants with complete data, 32 cases and 13 model terms, giving 2.46 events per variable. OR, odds ratio; CI, confidence interval.

Contact with a diarrhoea case appears protective in this model only. Analysed on its own the same exposure gives a crude odds ratio of 0.99 (95% CI 0.45–2.12, p = 0.981), so the apparent protective effect is an artefact of the expanded model and is not interpreted.

Supplementary Table 3. Sensitivity analysis of the primary multivariable model, Monze District, Zambia, 4-18 November 2025

Exposure	**Primary model adjusted OR (95% CI)**	**p-value**	**Sensitivity model adjusted OR (95% CI)**	**p-value**
Exposures common to both models				
Travel in the 7 days before onset	6.28 (2.43–16.91)	<0.001	7.35 (2.75–20.69)	<0.001
Household member with diarrhoea	5.54 (1.65–20.18)	0.006	4.09 (1.10–16.28)	0.036
Untreated household drinking water	6.50 (1.82–35.50)	0.003	5.96 (1.69–32.16)	0.004
No soap available in the household	2.72 (1.11–6.83)	0.028	2.56 (1.02–6.53)	0.044
Terms added in the sensitivity model				

Male sex	Not in model	-	1.93 (0.76–4.99)	0.166
Age under 15 years	Not in model	-	2.56 (0.69–9.03)	0.157
Model characteristics				
Participants	166		165	
Cases (events)	33		33	
Model degrees of freedom	4		6	
Events per variable	8.25		5.50	
Penalised AIC	122.68		120.16	

Both models fitted by Firth penalised maximum likelihood with profile-likelihood confidence intervals. p-values from profile penalised likelihood ratio tests. One participant had a missing age, so the sensitivity model was fitted on 165 participants. Both models contain all 33 cases. All four pre-specified exposures remain associated with infection and their odds ratios change little. Neither added term is associated on its own, although together they give a modest improvement in fit (chi-square 6.53 on 2 df, p = 0.038). OR, odds ratio; CI, confidence interval; AIC, Akaike information criterion.

The four-term model was retained because its exposures were fixed before analysis and because adding sex and age lowers the events-per-variable ratio from 8.25 to 5.50 without changing any conclusion.

Supplementary Table 4. Reported handwashing practices among community controls, Monze District, Zambia (n = 133)

Reported practice	N	Percent
After using the toilet	130	97.7
Before eating	132	99.2
Before cooking	94	70.7
After cleaning a child's stool	87	65.4
After handling children	3	2.3

Practices are self-reported and were collected from controls only, because case responses were recorded after illness and are not comparable.

Supplementary Figure 2. Case and control selection flow chart

