

Determinants of Cholera Outbreak in Bati District and Bati Town, Oromo Special Zone, Amhara Region, Ethiopia (2024): An Unmatched Case-Control Study

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Abstract

Background: Cholera continues to pose a threat to public health and is frequently linked to injustice and a lack of social development. The study area has a history of recurrent cholera outbreaks. However, local risk factors remain unidentified, which challenges the targeted prevention and control measures. Therefore, this study identifies the potential risk factors and makes it easier to apply targeted interventions.

Methods: We conducted a 1:1 unmatched case-control study (117 cases and 117 controls). An interviewer-administered questionnaire was used to collect data. SPSS version 27 was used to calculate frequencies and odds ratios. We performed the enter method for binary logistic regression to determine the independent factors associated with cholera infection.

Results: Interviews with 234 study participants showed a 1.7% case fatality rate and an overall attack rate of 32 per 10,000. Males had a higher chance of being affected by cholera [AOR = 2.3, 95% CI: 1.1-5.1]. Attending a gathering increased the risk of cholera infection [AOR = 42.2, 95% CI: 13.6-55.1]. Those who didn't wash their hands before a meal were more likely to contract cholera than those who did [AOR = 4.2, 95% CI: 1.6-10.7]. Similarly, those who did not wash their hands with soap at key periods had an increased chance of contracting cholera [AOR = 4.2, 95% CI: 1.6-10.7]. Consumption of water from an unprotected source increased the risk of cholera infection (AOR = 2.9, 95% CI: 1.3-6.4).

Conclusions: In this study, the primary risk factors for the cholera outbreak were participating in social gatherings, using water from unprotected sources, and poor hygiene practices. Therefore, increasing access to safe drinking water sources, improving community awareness on good hygiene and sanitation practices, and promoting healthy social gatherings are priority interventions in the study area.

Introduction

Cholera is a serious disease that causes sudden and intense diarrhea, most often spread through dirty water or contaminated food. It mainly affects people living in places where clean water and sanitation are limited, and it affects the poorest communities the hardest. Without quick treatment, cholera can make people dangerously dehydrated and even lead to death, especially in areas where healthcare is hard to access. Even though there are vaccines to help prevent cholera, many people are still at risk, and new forms of the bacteria that resist antibiotics are making it harder to control (1, 2). This makes it crucial to find new ways to protect people and stop the spread of the disease.

Cholera outbreaks often happen where people live in crowded conditions, face poverty, or don't have reliable access to clean water and toilets. Since 1817, there have been seven major worldwide cholera outbreaks, and the disease still affects many poor communities today. The real number of people who get sick or die from cholera is probably much higher than what's reported, because many cases go uncounted, and some areas don't have the resources to test for the disease. Every year, cholera is believed to make between 1.3 and 4 million people sick, and it causes anywhere from 21,000 to 143,000 deaths. Tragically, about half of those who die are children under five. Cholera remains a serious and ongoing threat to public health in many parts of the world (3).

Prevention and control of cholera involve a combination of measures, including improving access to safe water and sanitation, promoting good hygiene practices, and providing vaccination in high-risk areas. The following are some of the strategies that have been used to prevent and control cholera: Provision of safe water and sanitation facilities. Access to safe water and sanitation facilities is essential in preventing cholera. This can be achieved through the

provision of clean water sources, such as wells and boreholes, and the construction of latrines and handwashing stations.

Promotion of good hygiene practices: good hygiene practices, such as handwashing with soap and water, can help prevent the spread of cholera. Health education campaigns can be used to promote these practices. Vaccination: Vaccination is an effective way to prevent cholera in high-risk areas. Oral cholera vaccines are available and are effective in reducing the incidence of cholera. Early detection and treatment: Early detection and treatment of cholera cases can help prevent the spread of the disease. Treatment involves rehydration with oral rehydration solution or intravenous fluids and the use of antibiotics in severe cases. Surveillance and outbreak response: Surveillance systems can help detect cholera outbreaks early, allowing for a rapid response to prevent further spread of the disease.

In summary, prevention and control of cholera require a combination of measures, including improving access to safe water and sanitation, promoting good hygiene practices, providing vaccination in high-risk areas, early detection and treatment, and surveillance and outbreak response (4, 5).

The global burden of cholera is largely unknown because the majority of cases are not reported. The low reporting can be attributed to the limited capacity of epidemiological surveillance and laboratories, as well as social, political, and economic disincentives for reporting. We previously estimated 2.8 million cases and 91,000 deaths annually due to cholera in 51 endemic countries. A major limitation in our previous estimate was that the endemic and non-endemic countries were defined based on the countries' reported cholera cases. We overcame the limitation with the use of a spatial modeling technique in defining endemic countries and accordingly updated the estimates of the global burden of cholera(6). This research aims to assess the situation of the outbreak, determine the cause and source, describe cases epidemiologically, and apply intervention measures to overcome the current outbreak and prevent similar events in the future.

Methods

Study Setting

Bati Town and Bati district are found in the Oromo Special Zone, Amhara region. Bati Woreda is one of the second largest districts in the Oromo Special Zone, which is administered by a total of 26 kebeles, and Bati town consists (4 urban and 2 rural). Both have a total population of 143,015 population of which females constituted 70,793 (49.5%) from the 2007 census estimate. These two districts have one primary hospital, 8 HC, and 28 health posts, which are currently in service. The physical health service coverage of the two districts was 100%.

Study Design and Period

An unmatched community-based case-control study was conducted between April 10 -30/2024 with a ratio of 1:1 case to controls.

Source Population

The study populations were all community members living in cholera-affected kebeles of Bati district and Bati town.

Study Population

The study population consisted of all cholera cases that met the standard case definition, as well as selected control individuals who were at risk of cholera exposure but did not develop any signs or symptoms of the disease in Bati Town and Bati District between April 4 and April 30, 2024.

Eligibility criteria

Inclusion Criteria

Cases: All individuals who were positive for cholera and epidemiologically linked to cholera cases in the outbreak period, and those who agreed to participate in the study were included.

Controls: Any resident of Bati District and Bati Town who lives with a cholera case, either as a household member or neighbor, and who does not exhibit signs or symptoms of cholera and agrees to participate, was included.

Exclusion criteria

Cases: Individuals not residing in the study area during and three weeks before the period of an outbreak were excluded.

Controls: Individuals who were not residing in the study area, such as temporary visitors and those who refused to participate, were excluded.

Data source

Medical records of cases (patient charts) at Bati Health Center, Bati Rural CTCs, and cholera patient line lists were reviewed as secondary data. A face-to-face interview, using a structured questionnaire, was conducted to obtain data from adult cases and controls. Data from children was obtained by interviewing caregivers.

Sample Size Determination

The sample size was computed using Epi Info version 7.2 statistical software, considering the following assumptions: 95% CI, power 85%, 1:1 ratio of controls to cases. The sample size was 117 cases and 117 controls.

Sampling process

We conducted an unmatched case-control study to identify determinants of the cholera outbreak in 15 kebeles of Bati Woreda and 6 kebeles of Bati Town. A total of 117 confirmed and epidemiologically linked cases were recruited from the official line list. Controls were randomly selected from the same source population among individuals who had not developed cholera.

For each case, a control was chosen using a lottery method. Whenever possible, neighbors were selected to ensure similar environmental exposures. If multiple eligible neighbors were available, one was randomly drawn. If no suitable neighbors were found, a non-affected family member was randomly selected.

Trained field data collectors facilitated the selection process and obtained informed consent. The random selection minimized selection bias and improved comparability by ensuring both cases and controls were exposed to similar community conditions.

Study Variables

Dependent variable

Cholera Case (Yes, No)

Independent variable

Socio-demographic factors: Such as Age, sex, educational level of the participant, occupational status of the participant, marital status, and family size.

Clinical Factors: Such as signs of diarrhea, vomiting, back pain, joint pain, date of onset of illness, date of seen health facility, contact history, treatment taken, travel history, awareness on prevention and control of cholera, and mode of transmission.

Exposure Information: Exposure to raw food (Yes/No); Eating outside the home (Yes/No); Attendance at gatherings (Yes/No); Travel history outside the village (Yes/No)

Sanitation and Hygiene Practices: Handwashing practices (Yes/No); Frequency of handwashing before meals (Sometimes/Always); Soap use for handwashing (Yes/No); Latrine availability (Yes/No); Latrine utilization (Used by all, some, or not used); Handwashing facility near the toilet (Yes/No)

Water-Related Practices: Water source (Pipe/Spring/River/Hand Dug); Water purification method (Yes/No, and method details); Treated water usage in the past week (Yes/No); Water storage container type (Jerry can/Bucket); Water fetching method (Deeping/Inclining with cup/Always inside); Water storage cleaning frequency (Every day/Every other day/Every week/Other)

Clinical Exposure: Family members with similar symptoms (Yes/No); Number of family members sick (Numerical); Contact with patients with similar symptoms (Yes/No)

Awareness: Awareness of transmission of AWD/cholera (Yes/No); Awareness of prevention methods (Yes/No)

Case definitions

Community case definition

Suspected cholera case: If any person 2 years or older with profuse acute watery diarrhea and vomiting.

Standard case definition

Suspected case:

In areas where a cholera outbreak has not been declared, any person aged 2 years or more presenting with acute watery diarrhea and severe dehydration or dying from acute watery diarrhea.

In areas where a cholera outbreak has been declared, any person aged 2 years or more presenting with or dying from acute watery diarrhea.

Confirmed case:

A suspected case in which *Vibrio cholera* O1 or O139 has been isolated from their stool. **Epidemiologically linked cases:** A case in which the patient has had contact with one or more individuals who have the disease, and where transmission of the agent through the usual modes of transmission is plausible.

A case may be considered epidemiologically linked to a laboratory-confirmed case if at least one case in the chain of transmission is laboratory-confirmed(14).

Operational definitions

Cholera contact: exposure to the bacterium *Vibrio cholera*, which can occur through various means such as consuming contaminated food or water, or being near an infected individual(15)

Cholera outbreak: a cholera outbreak involves the detection of confirmed cholera cases in a specific area.

Incubation period: The incubation period is usually 1 to 3 days, but can range from several hours to 5 days. Symptoms usually last 2 to 3 days, although in some patients they can continue up to 5 days.

Infectious period: Infected persons, whether they are symptomatic or not, can carry and transmit *Vibrio* for 1 to 4 weeks; a small number of individuals can remain healthy carriers for several months

Control: Any resident of Bati Town and Bati district during the study period who was living together with a case at home or a neighbor who did not develop signs and symptoms of cholera.

Exposure Information: Refers to data or details about factors that might have made individuals or populations vulnerable to contracting cholera.

Data collection method

Data was collected by trained health professionals through face-to-face interviews with cases and controls using structured and semi-structured questionnaires developed for this study. Additional data were gathered from the cholera line list. The WHO case definition was used to classify study participants as either cases or controls.

Data Processing and Analysis

The data were coded, entered, and cleaned into EPI Data version 4.6.6 and then exported to SPSS version 27 for analysis. The result was presented by words, tables, and figures. An epidemic curve was constructed to examine the development of epidemics over time.

We executed the enter method for simple and multivariable binary logistic regression to determine the independent factors associated with the development of Cholera. A variable with a p-value less than or equal to 0.25 in the bivariable analysis was considered to be a candidate variable for multivariable logistic regression to identify the independent predictors of Cholera. And then variables that are significant with a P- P-value of less than or equal to 0.05 at a 95% confidence interval in multivariable binary logistic regression were considered statistically significant. Both 95% CI and P-values were used to assess the associations between dependent and independent variables. In all cases, odds ratios were used to assess the strength of the association. The model goodness of fit was checked by the Hosmer and Lemeshow Test.

Data Quality Control

Before data collection, a half-day training was given for health workers who were assigned at Bati and Fura CTCs. Each question was asked clearly for cases and controls in a similar manner during the interview. Data was also cleaned for any missing and logically inconsistent values before analysis by running the frequency and cross-tabulation of each variable with the outcome variable.

Ethical consideration

A permission letter was written from the Oromo Special Zone Health Department to Bati Town and the Bati district health office. For those study participants aged 18 and above, written consent forms were taken and for children’s parents or caretakers took consent forms to take part in the study. Participants' right to withdraw from the study as they wish was also clearly stated before the interview started. The responses were confidential and analysis were as groups not for individual case or control.

Dissemination of the findings

The result of the study will be shared with the Bati district and Bati town health offices, Oromo Special Zone health department, and Amhara Public Health Institute. The findings will be presented at district and zonal level review meetings, and also it could also be prepared for publication.

Results

Descriptive Analysis

This study included a total of 234 study participants, 117 cholera cases, and 117 controls. Among the total cholera cases, 14 tested positive by rapid diagnostic test (RDT), and 11 of these were confirmed by culture. The remaining cases were classified based on the standard case definition and epidemiological linkage.

All cases were admitted to a Cholera Treatment Center (CTC) or an Oral Rehydration Point (ORP). A total of five cholera-related deaths were recorded, with four occurring at healthcare facilities and one in the community before admission to the CTC.

Sociodemographic Characteristics

A total of 264c individuals, 117 cases, and 117 controls were interviewed. The response rate of this study was 100%. Out of the 234 study participants, 119 (50.9%) were females, and the rest were males. Family size of the study participants: 129(55%) had less than five families per household, and the rest 105(45%) of the participants had greater than 5 families per household. The majority of study Participants, 194 (82.9%), were aged greater than 15 years. Among all 234 participants, 27 (29.3%) were unable to read or write, followed by 21 (22.8%) who could read and write. Nearly half of the participants, 116 (49.5%), were farmers (Table 1).

Table 1: Socio-demographic characteristics of Cholera cases and controls in Bati district and Bati town, Oromo zone, Amhara region, 2024

Variables		Cases(N=117)		Controls(N=117)		Total N=134
		Number	Percent	Number	Percent	Number (%)
Sex	Male	64	55%	51	44%	115(49.1%)
	Female	53	45%	66	56%	119(50.9%)
Age	Less than 5 years	15	13%	10	9%	15(6.4%)
	5-14 years	28	24%	11	9%	25(10.7%)
	>=15 years	74	63%	96	82%	192(82.9%)
Occupation	Student	13	11%	1	1%	14(6%)
	Farmer	52	44%	64	55%	116(49.5%)
	Merchant	2	2%	7	6%	9(3.8%)
	Teacher	2	2%	0	0%	2(1%)
	Housewife	14	12%	45	38%	59(25.2%)
	Other	34	29%	0	0%	34(14.5%)
Educational status	Not read and write	63	54%	92	79%	155(66.2%)
	Read and write	13	11%	5	4%	18(7.7%)
	Primary	18	15%	14	12%	32(13.7%)
	Secondary	6	5%	6	5%	12(5%)
	College and above	2	2%	0	0%	2(1%)
	NA	15	13%	0	0%	15(6.4%)
Number of family members	<=5	41	35%	64	55%	105(45%)
	>5	76	65%	53	45%	129(55%)
Marital status	Married	60	45%	89	70%	149(63.6%)
	Single	18	15%	4	3%	24(10.2%)
	Divorced	2	2%	5	4%	7(3%)
	Widowed	6	3%	9	5%	13(5.6%)
	NA	21	35%	20	17%	41(17.6%)

Clinical Presentation of Cases

Among all suspected cases, 116 (99%) had both diarrhea and vomiting, 99 (89%) had vomiting, and 19 cases (12.6%) had back pain, 17 cases (14.5%) had arthralgia, and 17 cases (14.5%) had muscle pain (myalgia).

Regarding dehydration status among suspected cholera cases, 22 patients (18.8%) had no dehydration, 42 (35.9%) had some dehydration, and 53 (45.3%) suffered from severe dehydration (Figure 2).

Of the total cholera cases, 105 (89.7%) received treatment after being admitted to a Cholera Treatment Center (CTC) or as inpatients. All patients diagnosed with severe dehydration received antibiotics and IV fluids, while the remaining cases were treated with oral rehydration solution (ORS).

Distribution of Cholera cases by place

This cholera outbreak has affected two districts within the Oromo Special Zone administration. As shown in Table 2 below, the highest number of cases was reported from Bati district, with 230 cases (78.2%) from 15 kebeles (57.7%) and 64 cases (21.8%) from 6 kebeles in Bati town (Table 2). Among the total cholera cases, five individuals died from four kebeles, resulting in a case fatality rate (CFR) of 1.7%. The overall Attack Rate (AR) was 32 per 10,000 people. A total of 302 people were affected between April 6 and May 17, 2024. Additionally, six cases were reported from the Dewe Harewa district, and two cases from the Afar region. Out of the total cases in Bati district, 19 were treated at the Bati town Cholera Treatment Center (CTC)(Figure 3).

Distribution of cholera cases by Person

Over 96,000 people were at risk for a cholera outbreak in Bati Town and Bati District, which has resulted in 294 cases and 5 fatalities (1.7% CFR). Bati district was more affected, as evidenced by 78.23% of cholera cases being reported from the district. Most cholera-affected kebeles were Chekorti (80 cases) and Cheleleka (52 cases). The greatest fatality rate was 10.5% for Teamelka.

Table 2. Distribution of Cholera Cases, Population at Risk, Attack Rate (AR), and Case Fatality Rate (CFR) in Bati District and Bati Town, Oromo Zone, Amhara Region, 2024.

Name of affected District	Kebele	Risk population	Number of Cholera cases	Attack rate per 10,000	Number of deaths	Case fatality rate (%)	Remark
Bati Town	Bati 01	6826	6	9	0	0.0	
	Bati 02	7471	20	27	1	5.0	
	Bati 03	7684	27	35	1	3.7	
	Bati 04	6315	3	5	0	0.0	
	Kame	4391	6	14	0	0.0	
	Salmene	9278	2	2	0	0.0	
	Bati Town	41965	64	15	2	3.1	
Bati District	Bira	5,942	11	19	0	0.0	
	Bofa	3,562	1	3	0	0.0	
	Burka	1,847	1	5	0	0.0	
	Chekorti	3,254	80	246	0	0.0	
	Cheleleka	2,376	52	219	1	1.9	
	Damto	3,966	2	5	0	0.0	
	Fura	4,080	48	118	0	0.0	
	Gerfa Urene	4,281	3	7	0	0.0	
	Gure	3,025	1	3	0	0.0	
	Hato	3,146	3	10	0	0.0	
	Kebele	3,697	4	11	0	0.0	
	Kurkura	3,914	2	5	0	0.0	
	Melka Lugo	4,993	1	2	0	0.0	
	Teamelka	3,776	19	50	2	10.5	
	Uungu	4,109	2	5	0	0.0	
	Bati District	54,124	230	42	3	1.3	
	Total	96,089	294	31	5	1.7	

Distribution of Cholera Cases by Time

Among all 117 cholera cases that were included in the study, 64 cases (54.7%) were male, and 53 cases (45.3%) were female. The age of the study participants, cholera patients, ranged from 1 to 90 years. In the two study areas, the overall case fatality rate (CFR) was 1.7%, with an Attack Rate (AR) of 32 per 10,000 population. Age-specific case

distributions were as follows: 15 cases (8.5%) were in children under five years old, 25 cases (21.4%) were in the 5-14-year age group, and 77 cases (65.8%) were in individuals aged 15 years and older.

After receiving reports from Genda Habure Gotte, on April 2, 2024, Hato Health Center admitted the first four cases of food poisoning. The identification of these four cases as the index cases was verified by the detection of 15 additional suspected cholera cases from the same outbreak, after four days. These 15 cases were reported on April 6, 2024. The highest number of cholera cases was reported on April 20, 2024, with 32 cases. The last date of the outbreak was on May 15, 2024, when 15 cholera cases were reported (Figure 4).

Risk factors for cholera outbreak: The presence of several predictive factors for a cholera outbreak posed significant challenges in containing and controlling it within a short period before it spread to other kebeles. Less than one-quarter of respondents had access to a latrine, and two-thirds were unaware of cholera prevention methods. The risk factor distribution among cholera cases and controls is presented in Table 3.

Table 3: Risk factors distribution among cholera cases and controls in Bati district and Bati town, Oromo zone, Amhara region, Ethiopia, May 2024

Risk factors	Category	Cases(n=117)		Controls(n=117)		Total(N=234)	
		Number	%	Number	%	Number	%
Eat anything outside the home in the past 5 days	Yes	17	15%	1	1%	18	8%
	No	100	85%	116	99%	216	92%
Attending gatherings	Yes	68	58%	5	4%	73	31%
	No	49	42%	112	96%	161	69%
History of travel outside of the village 5 days before the onset of illness	Yes	6	5%	3	3%	9	4%
	No	111	95%	114	97%	225	96%
Hand washing before a meal	Yes	65	56%	100	85%	165	71%
	No	52	44%	17	15%	69	29%
Use of soap for hand washing	Yes	20	17%	40	34%	60	26%
	No	97	83%	77	66%	174	74%
Latrine Ownership	Yes	23	20%	25	21%	48	21%
	No	94	80%	92	79%	186	79%
Hand washing practice after using the toilet (defecating)	Yes	8	7%	21	18%	29	12%
	No	109	93%	96	82%	205	88%
The water source for drinking	Pipe	11	9%	17	15%	28	12%
	Spring	7	6%	8	7%	15	6%
	River	51	44%	27	23%	78	33%
	Hand Dug	48	41%	65	56%	113	48%
The presence of a family member with the same illness	Yes	52	44%	11	9%	63	27%
	No	65	56%	106	91%	171	73%
History of patients having the same signs and symptoms	Yes	43	37%	12	10%	55	24%
	No	74	63%	105	90%	179	76%
Know the mode of transmission of AWD/cholera	Yes	37	32%	43	37%	80	34%
	No	80	68%	74	63%	154	66%
know the methods of prevention of AWD/cholera	Yes	37	32%	46	39%	83	35%
	No	80	68%	71	61%	151	65%

Factors associated with a cholera outbreak in Bati town and Bati woreda

Simple and multivariable binary logistic regression analyses were used to calculate odds ratios and 95% confidence intervals for the predictors of the Cholera outbreak. In the first step, bivariable analysis was used to select candidate variables for multivariable analysis at a P-value less than 0.25. The candidate variables analyzed in multivariable

analysis with a P-value less than 0.05 were considered significant. The final model was used to analyze variables related to sociodemographic factors, cholera exposure factors, Sanitation and Hygiene practices, Water utilization practices, Clinical exposure, and factors related to the knowledge of the study participants. In the final multivariable logistic regression analysis model, the following variables were associated using the enter method.

The odds of developing cholera were more than twice as high in males compared to females (AOR = 2.3, 95% CI: 1.1–5.1).

The likelihood of being infected with cholera was 42 times higher among individuals who attended gatherings compared to those who did not (e.g., those who did not attend gatherings like Sodeka) (AOR = 42.24, 95% CI: 13.615–55.1).

Study participants who did not wash their hands before meals were four times more likely to contract cholera compared to those who practiced handwashing (AOR = 4.2, 95% CI: 1.6–10.6).

The odds of contracting cholera were four times higher among study participants who did not wash their hands with soap compared to those who used soap for handwashing (AOR = 4.2, 95% CI: 1.6–10.6).

Participants with a family member who was ill with cholera were twelve times more likely to contract cholera than those without a sick family member (AOR = 12, 95% CI: 4.7–30.9).

The likelihood of becoming infected with cholera was three times higher among individuals who drank from unprotected water sources compared to those who drank from protected water sources (AOR = 2.9, 95% CI: 1.3–6.4) (Table 4).

Table 4: Bivariate and multivariable logistic regression analysis of factors associated with cholera outbreaks, Bati District and Bati town, Oromo special zone, Amhara region, Ethiopia, 2024.

Variables	Categories	Disease status		COR (95%CI)	AOR (95%CI)	P-value
		Case	Controls			
Sex	Male	64(54.7%)	51(43.6%)	1.56(0.93,2.62)	2.32(1.06,5.07)	0.036*
	Females	53(45.3%)	66(56.4%)	1	1	
Family Size	<=5	40(35%)	64(54.7%)	1	1	0.089
	>5	76(65%)	53(45.3%)	2.29(1.35,3.89)	0.5(0.229,1.11)	
Attending Gathering (Sodeka)	Yes	68(58%)	5(4.3%)	31.09(11.81,81.86)	42.24(13.62,55.07)	0.0001*
	No	49(42%)	112(95.7%)	1	1	
Hand washing before meals	Yes	65(55.6%)	100(85.5%)	1	1	0.003*
	No	52(44.4%)	17(14.5%)	4.71(2.51,8.84)	4.16(1.64,10.56)	
Hand washing with soaps	Yes	20(17%)	40(34.2%)	1	1	0.044*
	No	97(83%)	77(65.8%)	2.52(1.36-4.67)	4.16(1.64,10.56)	
Hand washing after toilet	Yes	8(6.8%)	21(18%)	1	1	0.26
	No	109(93.2%)	96(82%)	2.98(1.262,7.04)	2.55(0.50,12.97)	
Presence of an ill family member	Yes	52(44.4%)	11(9.4%)	1	1	0.0001*
	No	65(55.6%)	106(90.6%)	7.71(3.752,15.838)	12.04(4.69,30.89)	
Water sources	Protected	59(50.4%)	82(70%)	1	1	0,009*
	Un protected	58(49.6%)	35(30%)	2.30(1.47,3.94)	2.88(1.30,6.37)	
Contact history	Yes	43(36.8%)	12(10.3%)	1	1	0.725
	No	74(63.2%)	105(89.7%)	5.08(2.511,10.30)	0.7(0.096,5.12)	
Know prevention mechanisms	Yes	37(31.6%)	46(39.3%)	1	1	0.469
	No	80(68.4%)	71(60.7%)	1.40(0.818,2.39)	0.72(0.291,1.77)	

Discussion

This study revealed that the overall attack rate (AR) was found to be 31 per 10,000 population. This is lower than studies conducted in Uganda (32/10,000)(8), Western Kenya (9), Mile district of Afar region, (83/10,000) (16)and west Arsi, Oromia region, Ethiopia (230/10,000)(17), But it is higher than a study done in Kirkos sub city, Addis Ababa, Ethiopia (14.3/10,000)(13). This variation might be due to source of outbreak, early detection or surveillance system and response activities. The case fatality rate (CFR) was 1.7% which is lower than the WHO African region February 2024 report (1.9%)(18), Uganda (2.1%)(8), Mile district (7.8%)(16), and Werst Arsi (2.3%)(17). However, it is higher than a study conducted in Kirkos sub-city of Addis Ababa, Ethiopia, showed that there were no deaths reported due to a cholera outbreak. Possible explanations for this difference could be the strength of surveillance activity, the quality of case management, and the availability of supplies and drugs.

In this study, males were more attacked by cholera disease than females. This was supported by a study conducted in Kirkos Sub City, Addis Ababa(13). This might be justified by the fact that males most of the time, work, eat food, and drink water outside their home, which may expose them to cholera infection. Those who attended any gathering were 42 times more likely to be infected with cholera than those who didn't participate in gatherings. A possible explanation for this might be that any gathering increases the transmission of cholera because there will be a high probability of eating food and drinking water contaminated by *Vibrio cholera*.

In the current investigation, study participants who didn't use soap to wash their hands were four times become ill with cholera than their counterparts. This is in line with studies done in Addis Ababa, Ethiopia(13) and Yemen(7). This could be due lack of water, a lack of toilets, an increase in soap prices, or a lack of awareness.

This study found that using water from unprotected sources, such as rivers and spring water, was a significant predictor of the cholera outbreak. This aligns with findings from studies conducted in Yemen, Uganda (8), Benishangul Gumuz (12), and the Mile district of the Afar region (16). The higher risk associated with these sources may be due to their increased susceptibility to contamination compared to protected water sources, such as piped water and hand-dug wells.

These findings support the hypothesis proposed by healthcare workers, who identified unprotected river water as the source of the outbreak. This hypothesis was formed after observing that most cholera cases were among individuals who used river water for drinking and washing, due to limited access to safe water in the area. Furthermore, the geographic distribution of cholera cases closely followed the river basins. Collectively, this evidence suggests that the primary source of the outbreak in the study area was the consumption of river water.

The findings of this study indicate that the likelihood of contracting cholera was 42 times higher among individuals who attended gatherings compared to those who did not, such as those who avoided gatherings like Sodeka (AOR = 42.24, 95% CI: 13.615–55.1). This significant association suggests that social gatherings played a critical role in the transmission of cholera, likely due to close contact and the shared consumption of contaminated food or water.

These findings align with previous studies that have shown an increased risk of cholera transmission in crowded settings or during large gatherings. For instance, a study conducted in Yemen during a cholera outbreak found that attendees of public gatherings, including religious festivals and weddings, were at a higher risk of infection due to the lack of sanitation and safe drinking water [35]. Similarly, in a study in Bangladesh, it was observed that cholera outbreaks were frequently linked to mass gatherings, where limited access to safe water and poor hygiene practices contributed to the rapid spread of the disease [36].

The high risk associated with attending gatherings in this study could be attributed to several factors, including the sharing of food and drink in unsanitary conditions, overcrowding, and inadequate access to hygiene facilities. These factors likely facilitated the transmission of *Vibrio cholerae*, the bacteria responsible for cholera, among attendees. Furthermore, these results highlight the importance of public health interventions focused on improving hygiene practices and water and sanitation at mass gatherings to prevent future outbreaks.

This finding supports the second hypothesis proposed by healthcare workers, which suggests that the outbreak was waterborne and resulted from the consumption of unsafe water and food during a social gathering event, locally known as 'Sodeka.' The food served at this gathering was prepared with water fetched from a contaminated river on April 1, 2024, in Genda Habure Gotte of Fura Kebele, Bati District. Approximately 150 people from neighboring kebeles and districts attended the Sodeka program, and most of them contracted the disease.

In this study, participants with a family member affected by cholera were twelve times more likely to contract the disease than those without a sick family member. This finding is consistent with studies conducted in the Afar (16) and Oromia (17) regions of Ethiopia. This increased risk may be attributed to low awareness among family members regarding the modes of transmission and prevention methods for cholera.

Conclusion

The cholera outbreak was primarily caused by drinking contaminated water from unprotected sources, participating in social gatherings, and practicing poor hygiene, such as not washing hands with soap. The findings support the hypothesis that river water poisoning played a significant role in the outbreak due to the fact that a significant number of the illnesses were caused by drinking water consumed during a crowd.

Therefore, in order to prevent and early containment of future cholera outbreaks early, various governmental and non-governmental organizations, such as government health sectors, water and sanitation sectors, municipalities, district administrative bodies, local community administrations, and the affected community, have to work in collaboration. Increasing access to safe drinking water sources, improving community awareness on good hygiene and sanitation practices, and promoting healthy social gatherings might minimize the risk for cholera spread and hence prevent the occurrence of similar outbreaks in the future.

Declarations

Ethical Approval and Consent to Participate: Ethical approval and consent to participate were obtained from the Amhara Public Health Institute, Dessie Branch. Verbal or written informed consent was obtained from all participants data collection, in accordance with ethical guidelines.

Consent for Publication: Not applicable.

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Availability of Data and Materials: The datasets generated and/or analyzed during the current study are not publicly available due to government and institutional restrictions on data sharing related to outbreak surveillance data, but may be made available from the corresponding author upon reasonable request and subject to approval by the relevant authorities.

Author Contribution

****Tenaw Yibeltal Desalegn**** : Conceptualization, study design, data collection, data analysis, manuscript drafting. ****Melaku Girma**** : Conceptualization, study design, data collection, data analysis, manuscript drafting. ****Abtew Abera Abebe**** : Data collection, data analysis, manuscript review. ****Anteneh Demelash Abate**** : Data collection, interpretation, manuscript review. ****Melaku Girma Haile**** : Supervision, technical support, manuscript review. ****Mohamed Ahmed Seid**** : Data analysis support, interpretation, and manuscript review. ****Seid Mohamed Seid**** : Senior supervision, critical manuscript review, and approval. All authors reviewed and approved the final manuscript.

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Figures

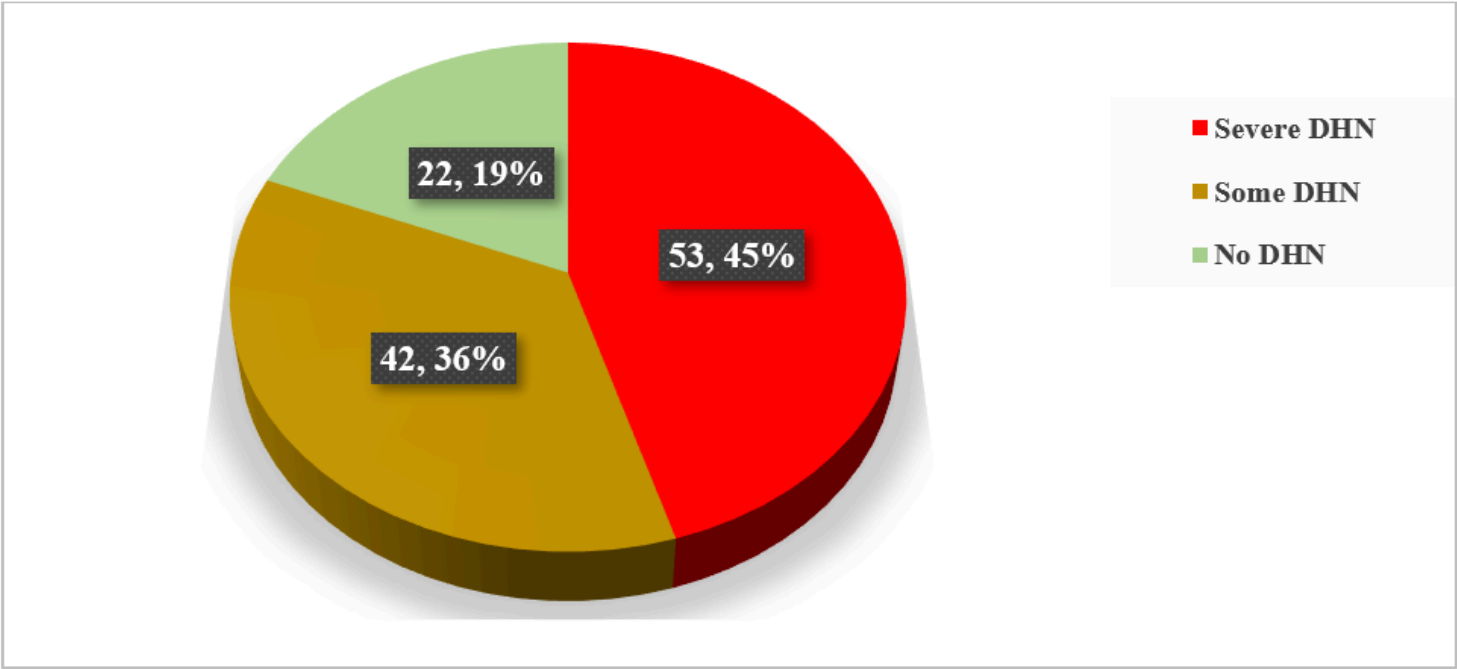


Figure 1

Figure 2: Dehydration status of cholera cases in Bati town and Bati districts in Oromia Zone, Amhara region 2024

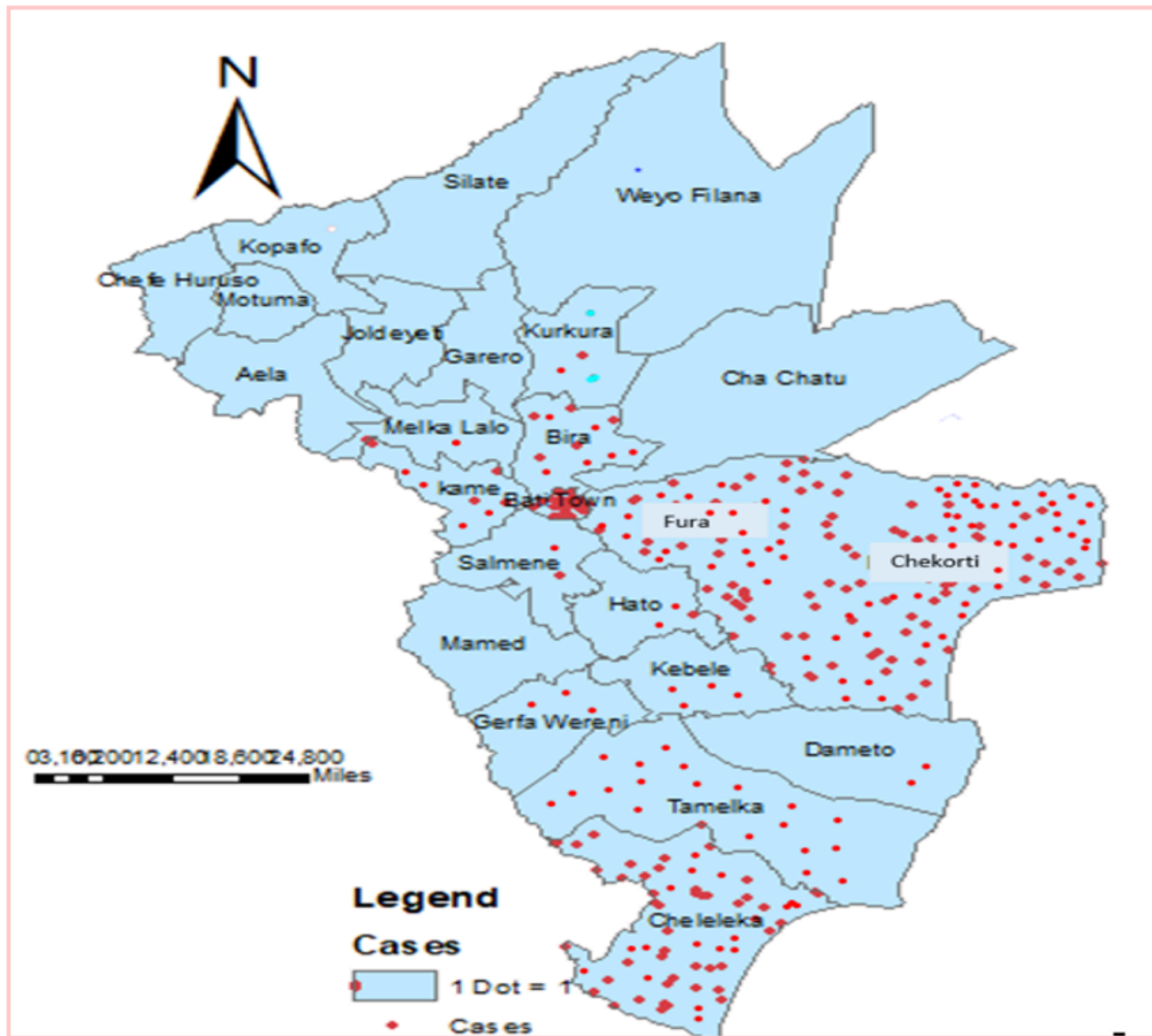


Figure 2

Figure 3: Spot map of cholera cases by kebeles in Bati district and Bati town, Oromo zone, Amhara region, Ethiopia, May 2024

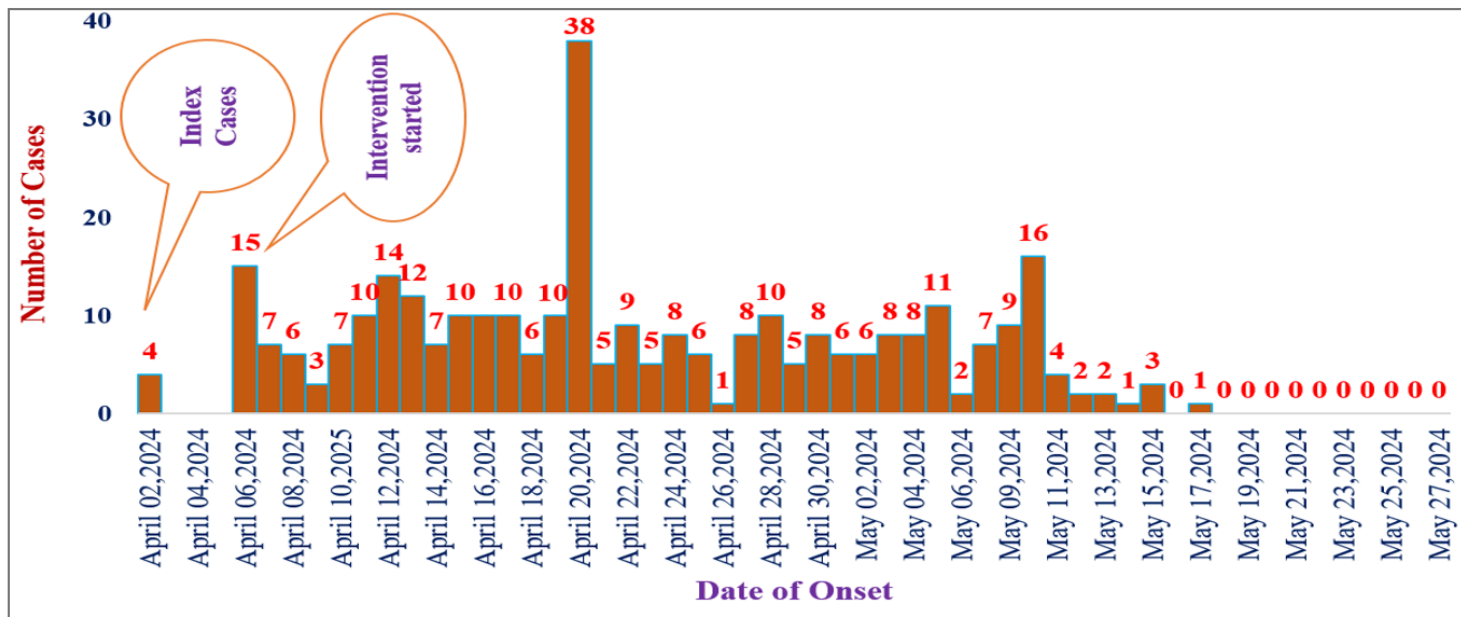


Figure 3

Figure 4: Distribution of cholera cases by date of onset at Bati district and Bati Town, Oromo Special Zone, Amhara, Ethiopia, 2024.

Supplementary Files

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