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Cholera outbreak investigation report in Mille woreda, Afar region, Ethiopia, 2019

Abstract

Introduction: Cholera has remained as one of the important public health problems in Asia and Africa causing substantial morbidity and mortality. Although the burden is greatest in low-income populations with poor access to safe water, and sanitation, cholera is also an important health problem globally. Cholera occurs both as a short outbreak and protracted epidemic/pandemic and when uncontrolled; is devastating to communities and to their prospects for development. To respond quickly and control the outbreak, investigation is crucial; identify risk factors that cause the outbreak, and suggest prevention and control measures.

Objective: To identify risk factors and etiology of diarrheal disease outbreak and suggest prevention and control measures in Mille woreda, Afar region Ethiopia, May- June, 2018.

Method: Descriptive followed by unmatched case-control study with 1:2 ratio were conducted from May-June 2018. A total of 68 patients and 136 controls were enrolled. A structured interviewer-administered questionnaire was used and medical records and line lists review. Simple random sampling was used to select controls and the first 68 cases. Data were analyzed by SPSS and presented using odd ratio, and tables. Environmental and patient samples were collected for culture and rapid diagnostic test.

Result: The investigation identified 229 cholera patients, including 22 rapid diagnostic test confirmed patients and seven culture confirmed patients (attack rate: 8.31%, 229/27,562). Index patient were imported from epi-linked woreda. Diglena geraro kebele were the Epicenter of the outbreak. Epicure trend shows common source infection. Using bifurcation of Awash River for drinking, use untreated/ uncoiled water, poor hand washing practices, and close contact with cholera sick person were found to be associated with cholera.

Conclusion: This outbreak was caused by vibrio cholera 01 secondary to drinking water from a bifurcation of Awash River and using untreated water. Contact with diseased person, and use untreated/ uncoiled water was associated with being patients. In order to reduce the risk of cholera, safe drinking water or water treatment chemicals needs to be provided to communities.

Keywords: disease outbreak, cholera, Ethiopia

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Introduction

Cholera is an acute enteric disease caused by infection of the intestine (where they multiply and produce a very powerful entero-toxin) with Vibrio cholera (gram-negative bacteria), either type O1 or O139[1,2] characterized by the sudden onset of profuse painless watery diarrhea or rice-water like diarrhea, often accompanied by vomiting, which can rapidly lead to severe dehydration and cardiovascular collapse.[3] Vibrio does not cross the intestinal barrier and do not provoke septicemia.[3] There are over 100 vibrio species known but only the "cholera" species are responsible for cholera epidemics.[4] About 20% of those who are infected develop acute watery diarrhea and if these patients are not promptly and adequately treated, the loss of such large amounts of fluid and salts can lead to severe dehydration and death within hours.[5] The case-fatality rate in untreated cases may reach 30-50%. Treatment is straightforward (basically rehydration) and, if applied appropriately, should keep the case-fatality rate below 1%. Antibiotic therapy can decrease the duration of symptoms and the period of infectivity.[5]

Cholera is usually transmitted by the fecal-oral route through fecal contamination of water or food. As the incubation period of cholera is very short (2 hours to 5 days).[6] Infected persons whether they are symptomatic or not, can carry and transmit vibrio's during 1 to 4 weeks.[7] The infective dose depends upon individual susceptibility, but in general a 1000,000 dose is needed to cause the illness.[7] Moist grains, such as rice, millet, or sorghum, when served at room temperature or lightly warmed, are common vehicles for cholera transmission. Humans, water, fish, and aquatic plants are the main reservoir of Vibrio cholera.[8]

Cholera has remained as one of the important public health problems in Asia and Africa causing substantial morbidity and mortality.[4,9] But the overall global burden of cholera is poorly understood because only a small fraction of cases are reported to the World Health Organization (WHO).[9] Cholera case estimates officially reported to the World Health Organization (WHO) ranged between 190,000 -320,000 and 5,000 and 7,500 deaths for the years 2008, 2009 and 2010 were reported.[10] Although the burden is greatest in low-income populations with poor access to safe water, sanitation, and urgent medical care, Cholera is also an important health problem globally.[11]

Cholera is a disease of inequity, an ancient illness that today sickens and kills only the world's poorest and most vulnerable persons.[12] It affects communities already burdened by conflict, lack of infra- structure, poor health systems, and malnutrition. In fact, the map of cholera outbreaks is essentially the same as a map of poverty and marginalization.[13] It is one of the key indicators of social development and remains a challenge to countries where access to safe drinking water and adequate sanitation cannot be guaranteed.[14]

The risk factors for cholera incidence as revealed by various studies were lack of a piped water supply, poor water-handling practice, lack of water treatment at home, poor sanitation, lack of hand-washing facilities, living in rural areas, child age, and low socioeconomic status.[15] The greatest risk occurs in over-populated communities and refugee settings characterized by poor sanitation, unsafe drinking-water, and increased person-to-person transmission.[13,16] Climate change, urbanization, and population growth are all serving to increase the risk of severe cholera outbreaks.[11] Poor water access, sanitation, and hygiene (WASH) are responsible for approximately 58% of diarrheal-related deaths per year.[15] Underlying diseases such as malnutrition, chronic diseases and AIDS are thought to increase susceptibility to cholera, but this has not been proven.[17]

Cholera occurs both as a short outbreak and protracted epidemic/pandemic.[18] Cholera epidemics often start at the end of the dry season or at the beginning of the rainy season, when water sources are limited.[4] Uncontrolled cholera outbreaks, endemics, and repeated outbreaks are devastating to communities and to their prospects for development.[5,9] Forty-seven countries are affected by cholera in 2017, and among this 9 countries had large outbreaks.[9] Explosive outbreaks spread in Yemen, Democratic Republic of Congo, Ethiopia, Haiti, Nigeria Nigeria (Borno), Somalia, South Sudan, Sudan, and Zambia (Lusaka) during 2017.[19]

From December 2014 to September 2016, cholera outbreak has grasped 30 of the 47 counties of Kenya caused 16,840 cases and 256 deaths.[19] In Ethiopia, cholera was first reported in districts of Oromia and Ethiopian Somali close to the Ethio-Kenyan border in February 2016.[4] Thereafter, it continued spreading east and north reaching many parts of the country including the capital city and the northern parts of the country.[18] During 2006-2009 G.C, 8109 cases and 194 deaths of cholera were reported from three districts of Afar with a total case fatality rate of 2.4%.[4] The outbreak occurred in light of the El Niño floods which created favorable conditions for the spread of bacteria.[20] Global Task Force on Cholera Control (GTFCC) calls for focusing on the 47 countries affected by cholera, supporting countries to develop comprehensive, multi-sectoral cholera control plans.[6]

"Ending Cholera-A Global Roadmap to 2030" A Multi-sectoral Cholera Elimination plan operationalizes the new global strategy for cholera control at the country level and provides a concrete path in which cholera is no longer a threat to public health.[21] By implementing the strategy till 2030, the GTFCC partners will support countries to reduce cholera deaths by 90%.[19,22] This will become real based on three strategic axes; early detection and quick response to contain outbreaks at an early stage, a multi-sectoral approach to prevent cholera in hotspots in endemic countries and an effective mechanism of coordination for technical support, resource mobilization and partnership at the local and global level.[6,22]

Prevention and treatment of diarrhea is challenging because of pervasive infrastructural, political, and socioeconomic barriers, including access to safe water and sanitation, education, nutrition, and access to health care[5] and controlling cholera requires detailed, accurate data based on enhanced epidemiologic and laboratory surveillance systems that can identify hot spots and detect and confirm outbreaks early to facilitate a quick response and rely on rapid outbreak detection, access to clean water, safe sanitation, dedicated treatment centers, and the targeted use of oral cholera vaccines (OCV).[11,17,23]

It is known from previous studies that; improving water and sanitation services and general hygiene have proven effect in controlling and eliminating cholera and crucial in protecting people from cholera in many countries and the Global Task Force on Cholera Control considers water, sanitation and hygiene investments as the foundation to meeting the goal of reducing cholera deaths by 90% by 2030[22,24] and also known areas that lack basic infrastructure like potable water, poor environmental conditions and hygienic waste disposal facilities are ideal settings for cholera infection and transmission. In these settings, transmission occurs majorly by consumption of contaminated water or food.

In cholera outbreaks, water samples from the outbreak epi-center are always contaminated with Vibrio cholera fueling disease transmission via ingestion of food and water substances. In spite of the above studies; this study indicates that those factors alone are not adequate for disease transmission; an external factor is required to distort the epidemiological equilibrium for disease transmission to occur. The study indicated that importation of the etiology from an external source will responsible for the outbreak. This outbreak investigation demonstrated that water samples might remain uncontaminated during cholera outbreak. So addressing this gap in the rural community of the study area is reasonable to help policy makers and implementers in order to plan and design proper intervention strategies to prevent cholera and associated morbidity and mortality.

In May 26 2018, Mille Health Center saw five patients with acute diarrheal diseases from surrounding communities, which were suspected to be cases of cholera due to the presence of acute watery diarrhea among all cases. Ethiopian Public Health Institute staff (the investigator and one Graduate field epidemiologist already deployed for the same cases of Acute Watery Diarrhea happened in Dubti and Tendaho sugar factory) had received a rumor of AWD outbreak from Mille Public Health Emergency Management officer. Then the team notifies EPHI and was moved to Mille for verification of existence of outbreak. Specimens collected soon from all five patients and sent to Afar regional public health laboratory for analysis. In June 1st 2018 Vibrio cholera had been isolated in four samples collected from residents. Then outbreak of acute watery diarrhea (AWD) was approved by the ministry.

The team with health officials in the region immediately moved into protective response mode for the most vulnerable areas and has resolved to develop planned interventions to cope with the epidemic and to strengthen institutions and health networks. Suspected case definitions were established as "a suspected case is a patient aged 2 years or more develops severe acute watery diarrhea with or without vomiting". The Government of Federal Democratic Republic of Ethiopia was working with international partners to rapidly expand recommended cholera response actions, including increasing access to clean and safe water in the most affected communities. Partners were also intensifying health education to ensure that suspect cases seek care immediately and establishing cholera treatment centers closer to affected communities and withdrawing contaminated water supplies. A Cholera Response and Prevention Plan, seeking 474,856.5 thousand, has been developed to address the immediate needs of 117,960 people that could be affected by the outbreak.

Objectives

General objective:

To identify risk factors and etiology of diarrheal disease outbreak and suggest prevention and control measures in Mille woreda, Afar region Ethiopia, May- June, 2018.

Specific objective

a) To verify the existence of outbreak in Mille woreda, Afar region Ethiopia, May- June, 2018.

b) To identify the possible risk factors of outbreak in Mille woreda, Afar region Ethiopia, May- June, 2018.

c) To identify the etiology of outbreak in Mille woreda, Afar region Ethiopia, May- June, 2018.

d) To suggest control measures of outbreak in Mille woreda, Afar region Ethiopia, May- June, 2018.

e) To suggest prevention methods for occurrence of additional cases in Mille woreda, Afar region Ethiopia, May- June, 2018.

Methods

Study area:

Mille is one of the woreda as in the Afar Region of Ethiopia and Part of the Administrative Zone 1. The woreda is 534 KM far from the national capital Addis Ababa and 56 KM from regional capital Samara. It is named for the Mille River (a tributary of the Awash River, which drains parts of North and South Wollo Zones of the Amhara Region, and Administrative Zone 4 of the Afar Region and flows through Mille woreda). On 4 February 2007, the Afar Regional Cabinet approved the division of this woreda, creating a new woreda out of the western part, with its administrative center to be at Hadar. The highest point in this woreda is Mount Gabillema (1459 meters), a dormant volcano in the southeastern part. Important local landmarks include the Yangudi Rassa National Park, which covers the southeast corner of Mille. Mille is bordered on the south by the Administrative Zone 3, on the southwest by Administrative Zone 5, on the west by the Amhara Region, on the northwest by Chifra, on the northeast by Dubti, and on the southeast by the Somali Region.

Ninety-eight-point seventy two percent (98.72%) of the population were Muslim, and 1.22% was Orthodox Christians. Roads in this woreda include the road between Chifra and Mille, which is 105 kilometers in length. According to Ethiopian central statistics agency population projection from 2007 EFY, this woreda has a total population of 117,960, of whom 63,401 are men and 54,599 women and 15.67% are urban inhabitants, whereas 73.02% are pastoralists; with an area of 5,345.71 square kilometers. Mille has a population density of 16.96. A total of 14,515 households were counted in this woreda, which results in an average of 6.2 persons to a household. The woreda has five health centers and Eight Health posts that provide preventive and curative care.

Study design and period

Descriptive cross-sectional studies from line listing were conducted to describe the outbreak in terms of place, person and time followed by unmatched case-control study with one to two ratios from May-June 2018.

Study population

Cases: A 2 year or above year person residing in Mille Woreda who had three or more loose/watery stool in a day/24-hour's period with/without abdominal cramps, vomiting and nausea two weeks prior to the study (68 cases).

Controls: controls were all people who didn't fulfill the case definition during the study period (136 controls).

Sample size and sampling techniques

Sample size was computed by using statically function of Epi-info version 7.2.0.1 statistical software with the assumptions of proportion of contact with someone with diarrhea like disease 21.5%;[25] 95% confidence level, 80% power of the study, case to control ratio of 1:2 to detect an odds ratio of 2.75 and adding 10 % of non-response rate. A total of 68 cases and 136 controls were enrolled. Study subjects (both cases and controls) were identified and recruited at health center outpatient department. We identified study subjects (Both cases and controls) at health facilities at cholera treatment center (CTC) while seeking care and being an attendant of cases by using simple random sampling for 136 controls and the first 68 cases. When more than two eligible cases is found in one family, lottery method was used to select one and the other was excluded.

Data collection method

A structured interviewer-administered questionnaire were designed and used to collect data on possible exposures for acute watery diarrhea. Discussion with clinicians working at mille health center and at different Cholera Treatment Centers. Medical records and line lists containing 229 cases of cholera were assessed and reviewed for complementing the case control study. We evaluated information concerning any recent change in the case definitions, reporting situations and laboratory diagnosis tools and population size. Direct patient interview were conducted with some of the patients. After getting a written informed consent to participate in study, 68 cases and 136 controls were interviewed in addition to 229 cases from the line list for descriptive analysis. Water samples were taken for Microbial analysis; two water samples were collected from suspected river. The samples were collected using sterile 500ml container. Seven stool samples were collected from patients and shipped to regional bacteriology reference laboratory using Cary Blaire transport media with cold chain for bacterial culture investigations and twenty-two (22) samples for rapid diagnostic test at each CTC.

Data analysis and quality assurance

The collected data was entered into Epi-info version 7.2.0.1 software and checked for completeness and consistency. The data were then exported to Microsoft excel 2013 and descriptive analysis (description of the outbreak by time, place and person and calculation of attack rate by sex, age and place) were done. The data then exported to SPSS version 20 for statistical analysis. Descriptive statistics were used to determine the frequency of different variables. Bivariate and multivariate logistic regression analysis was applied. Results were displayed using tables and graphs and it was interpreted using Odd ratio, P value <0.05 and 95% confidence interval.

Variables

Socio-demographic variables like age, sex, residence and symptoms and sign for cases, source of drinking, adequate access to water, any travel to other areas, have a latrine and utilization of it was the independent variables. The dependent variable is either being a patient or a control.

Inclusion and Exclusion criteria

Inclusion criteria: Cases and controls residing in mille during the study period who give informed consent to participate in the study were included.

Exclusion criteria: Severely ill patients who can't provide information were also excluded. In addition, cases that are recently recovered from the disease can't be considered for controls.

Case definition

Suspected case of cholera: In an area where cholera outbreak has not been declared: a patient aged 5 years or more develops severe

dehydration or dies from acute watery diarrhea. In an area where there is a cholera epidemic: a patient aged 2 years or more develops acute watery diarrhea with or without vomiting.

Confirmed case of cholera: a case of cholera is confirmed when either vibrio cholera O1 or O139 is isolated from the patient stool.

Operational definitions

Diarrhea: The passage of three or more loose/watery stools per day or increased frequency of stool in the past 2 weeks prior to data collection, as perceived by the patient, mother/care- giver.

Hand washing at all 5 critical times: If a mother/caregiver practiced simple hand washing before eating, before food preparation, before child feeding, after child cleaning and after latrine visiting, if all five action were done, this were considered all practiced, If not, it were considered as "partially practiced".

Proper solid waste disposal: is a way of disposal of ordinary domestic waste which includes burning, buried in pit or stored in a container, compost was considered as proper disposal and whereas disposing in open field was considered as improper disposal.

Unimproved water source: when the people use water for drinking from a river, pond, well, unprotected spring or untreated with water treatment chemicals.

Basic water supply: access to safe drinking water sources including household connection, public standpipe, borehole, protected dug well, protected spring, or rainwater collection within a 30-minute round trip, plus household disinfection.

Basic sanitation: access to improved sanitation facilities, including connection to a public sewer or to a septic system, or a pour-flush, simple pit, or ventilated improved pit latrine.

Results

Section I: Descriptive part

In this study the whole study population consisted of 204 participants: 68 (33.33%) cases and 136 (66.67%) controls. Most of cases and controls are drawn from Diglena geraro kebele; which is the epicenter of the outbreak. But 229 cases from the line list also included as a complement (Table 1).

Table 1 Distribution of study participants by kebele in Mille woreda; June, 2018

Sl. No.	Kebeles	Cases	Controls	Total
1	Adaytu	15	30	45
2	Sanasna kusrtu	5	10	15
3	Diglena geraro	48	96	144
4	Total	68	136	204

The uncontained index case was imported from Dubti woreda; which had ongoing transmission during the time. Diglena Geraro kebele were the Epicenter of the outbreak. Cases that are linked to the epicenter in Mille have been propagated highly and confirmed in 3 additional kebeles. One hundred sixty one (70.31%) of cases were severely dehydrated and 65 (28.38%) cases were moderately dehydrated and only three (1.31%) cases were diagnosed with no dehydration. Despite the presence of favorable conditions for cholera transmission, Mille has never experienced any cholera outbreak in the past since 2009 G.C. 106 people use a bifurcation of Awash River as a source of drinking water; which is believed to be a source of infection. One hundred and sixty one cases were severely and fifty nine were moderately dehydrated yielding a bed occupancy rate of 5 days with min of 1 and max of 10 days of stay (Table 2).

Table 2 Sociodemographic characteristics of study population in in Mille woreda; June, 2018

Variables		Cases (N (%))	Controls (N (%))	Total (N (%))
Sex	male	31 (45.59)	68 (50)	105 (51.47)
	female	37 (54.41)	68 (50)	99 (48.53)
Age group	2-10	17 (25)	38 (27.94)	55 (26.96)
	11-20	24 (35.29)	41 (30.15)	65 (31.86)
	21-30	10 (14.71)	23 (16.91)	33 (16.18)
	31-40	7 (10.29)	15 (11.03)	22 (10.78)
	40+	10 (14.71)	19 (13.97)	29 (14.22)
HH member no	<5.7	26 (38.24)	56 (41.18)	82 (40.20)
	>5.7	42 (61.76)	80 (58.82)	122 (59.80)
Occupation	pastoralist	53 (77.94)	86 (63.24)	139 (68.14)
	student	13 (19.12)	48 (35.29)	61 (29.90)
	Gov't	2 (2.94)	2 (1.47)	4 (1.96)
Marital status	single	35 (51.47)	48 (35.29)	83 (40.69)
	married	33 (48.53)	88 (64.71)	121 (59.31)
Educational status	Not able to RW	53 (77.94)	82 (60.29)	135 (66.18)
	Primary	13 (19.12)	48 (35.29)	61 (29.90)
	Above pri	2 (2.94)	6 (1.47)	8 (3.92)
Head of HH	male	47 (69.12)	47 (34.56)	94 (46.08)
	female	21 (30.88)	89 (65.44)	110 (53.92)

Description by time

The declining trend observed since the peak of the outbreak in week 21 despite an upsurge in week 24 caused by the emergence of new cases in 05 village near to the epicenter (Figure 1).

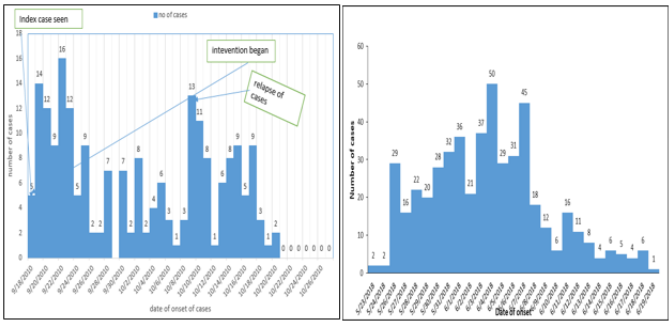

Figure 1 Trend of cholera cases by date of onset in mille woreda on the left and Afar region {four cumulative affected woredas} on the right May, 2018.

Place

Of the three kebeles affected in the woreda; Diglena geraro kebele (epicenter of the outbreak) takes the lead with 167 case and attack rate of 15.12/1000 and high case fatality reported in Adaytu kebele with CFR of 18.60 and yielding a total case fatality of 7.86. Galaha kebele in Mille was the latest area to report three suspected cases of cholera, of which one has been confirmed by culture. Mille had not reported new cases since 24 July 2018. (Table 3) Among the four woredas in Afar; mille were the second most affected woreda in the region second to Aysaita and shown on the top of the graph below (Figure 2).

Table 3 Distribution of cholera cases, case fatality rate and attack rate disaggregated by kebeles of Mille woreda, June 2018

Sl. No.	Kebeles/CTC site	Cases	Facility deaths	Community deaths	CFR (%)	Total Popn	AR/1,000
1	Adaytu/Mayremi	43	2	6	18.60	8450	5.08
2	Galaha/sanasna kusrtu	19	0	1	5.26	8067	2.36
3	Ferede/diglena geraro	167	5	4	5.39	11045	15.12
4	Total	229	7	11	7.86	27562	8.31

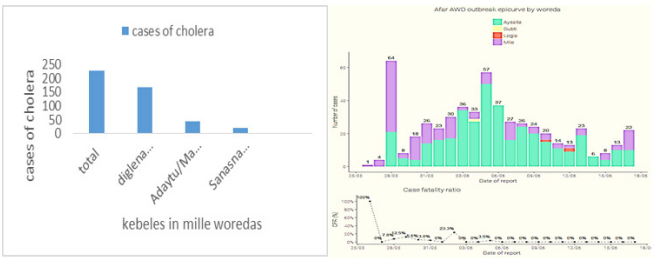

Figure 2 Distribution of cholera cases in Mille woreda on the left and afar region segregated by worded as showing mille woreda on the top of the graph and cumulative regional case fatality rate on the right bottom; June, 2018.

Person

From a total of 229 cases; 99 are females and the rest 130 are male but among the study participants; 31 (45.59%) were female and 37 (54.41%) were male. 11-20 age group were severely affected by cholera outbreak (65, 36.76%) followed by 2-10 age group (55, 26.96%). The mean age of cases were not very different from controls (21.80 yrs. control Vs 22.57 yrs. case); but there were less cases below 10 years than controls. Most sociodemographic status of cases and controls were equivalent. Educational status, occupation and marital status of cases and controls were slightly the same (Figure 3).

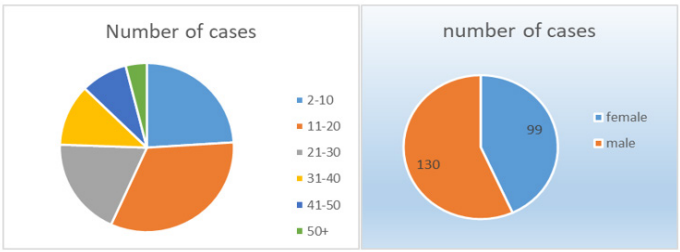

Figure 3 The distribution of cases of cholera by sex and age groups in Mille woreda, June, 2018.

Section II: Analytic part

In bivariate logistic regression; people who ate raw food, wash hand for Solat only; not at all critical times and didn't have latrine at home or in common were twice {OR, 2.37; 95%CI, 1.27-4.44}, eight times {OR, 8.30; 95% CI, 3.14-21.96} and eight times {OR, 8.36; 95% CI, 2.41-28.98} more likely to be a case respectively. Concerning people who had close contact with or attending a cholera patients over two weeks prior to disease onset; they were faced 6.69 times higher odds of having cholera {OR, 6.69; 95%CI, 2.14-20.94} and open field disposal of solid waste had increase the odds of being a cholera case by four {OR, 3.99; 95% CI, 2.08-7.69}.

From multiple variable analysis; the study found that drinking water from bifurcation of Awash River {OR,14.70; 95% CI,11.36-158.46} and spring water {OR, 3.95; 95% CI, 1.40-11.11} were significantly associated with being a case and even drinking a stored water for more than a day were significantly increases the odds of being a case {OR, 3.95; 95% CI, 1.40-11.11} but having adequate access to safe water two weeks prior to the diseases onset were significantly associated with being controls and haven't access to safe water were four time increase the odds of being a case {OR, 3.84; %CI, 1.27-11.65}. Moreover, using water treatment chemical or boil water before drinking over two weeks prior to disease onset were associated with being a control and using untreated/un-boiled water increases the odds of cholera cases eleven times {OR, 11.62; 95% CI, 3.97-33.97}. Concerning people who had close contact with or attending a cholera patients over two weeks prior to disease onset; they were faced 6.69 times higher odds of having cholera {OR, 6.69; 95%CI, 2.14-20.94} after controlling for other factors (Table 4).

Section III: Laboratory result

Of 229 about 22 are confirmed by RDT (three negative & Nineteen Positive) and 7 Culture (five positive & two negative) and the rest 200 were treated as suspected and probable case. There was no mop up oral vaccination for cholera. Two environmental (suspected river water) samples were collected for Microbial analysis; the samples were collected using sterile 500ml container. Coli form count, fecal coli form and E.coli was done. The water was full of coli forms and E. coli but vibrio cholera were not found. Vibrio cholera 01 was responsible for the acute watery diarrhea outbreak in Mille. The RDT was wrongly used as a confirmatory test for more than 10 cases which is not recommended by the cholera guideline and the reason is definitely due to the gap in linking epi with lab and working together in the area.

Table 4 Bivariate and multiple variable analyses of risk factors for cholera showing crude and adjusted odd ratio Mille, June, 2018

Variable		Cases (N=68)		Controls (N=136)		COR	AOR; P value	AOR
		No	%	No	%			
Source of drinking water	Bifurcation of awash river	48	70.6%	49	36.0%	4.50{2.33-8.68}	.02	14.7{11.36-158.46}*
	Spring	17	25%	78	57.4%	2.94{.75-11.52}	.029	3.51{1.13-10.83}*
	Tap	3	4.4%	9	6.6%	1	.019	1
Use stored water {for more than a day} for drinking	Yes	48	70.6%	39	28.7%	5.97{3.15-1.33}	.009	3.95{1.40-11.11}*
	No	20	29.4%	97	71.3%	1	.014	1
Use treated/boiled water in the last two weeks	Yes	19	27.9%	108	79.4%	1	.018	1
	No	49	72.1%	28	20.6%	9.95 {5.07-19.50}	.000	11.62{3.97-33.97}*

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Table Continued...

Variable		Cases (N=68)		Controls (N=136)		COR	AOR; P value	AOR
		No	%	No	%			
Adequate access to safe water in the last two week	Yes	56	82.4%	60	44.1%	1		1
	No	12	17.6%	76	55.9%	5.91{2.91-12.02}	.017	3.84{1.27-11.65}*
Ate row food	Yes	28	41.2%	105	77.2%	2.37{1.27-4.44}	.837	1.12{.38-3.29}
	No	40	58.8%	31	22.8%	1		1
Close contact with sick person	Yes	61	89.7%	68	50.0%	8.71{3.72-20.42}	.001	6.69{2.14-20.94}*
	No	7	10.3%	68	50.0%	1		1
Have latrine at home	Yes	5	7.4%	54	39.7%	1		1
	No	63	92.6%	82	60.3%	8.30{3.14-21.96}	.082	3.48{.85-14.18}
Wash hands at critical times	For solat only	47	69.1%	60	44.1%	8.36{2.41-28.98}	.059	5.11{.94-27.83}
	3-4 times/day	18	26.5%	44	32.4%	1.92{.98-3.74}	.099	2.74{.83-9.09}
	At all critical times	3	4.4%	32	23.5%	1		1
	Appropriate	16	23.5%	75	55.1%	1		1
Waste disposal	Open field	52	76.5%	61	44.9%	3.99{2.08-7.69}	.059	2.77{.96-7.99}

Intervention/response

The cholera outbreak in mille has markedly improved, following strong interventions by the local authorities and partners in each pillars of Cholera response. A team composed of different sectors (Agriculture office, health office, water office, women and children office, UN agencies and NGOs) at all level mobilized to Mille woreda and revitalized existing taskforce and engaged all cabinets. Properly prepared woreda response and contingency plan and submitted to RHB. Woreda level rapid response teams were set to have five jointed sub divisions for five pillars of cholera response activities. As part of coordination; >35 health professionals with different qualification were mobilized from different health centers in the woreda for cholera response. Technical person were assigned in all thematic areas (Surveillance, Wash, case management, social mobilization and logistics). There were Multi sectoral coordination mechanism set to ensure all thematic areas of response are addressed as planned. Daily AWD (former name for cholera) task force meeting were held at 1:30 pm which is chaired by woreda administrator and discussed on daily performed activities. Challenges in the coordination include; inaccurate supply ordering due to poor coordination between logistics and case management and surveillance pillars and difficult road conditions in remote areas challenge supply delivery.

Active case searching, contact tracing and house hold disinfection were conducted properly for each reported cases of cholera by HEW with assistance of health professionals, FETP residents and community volunteers. 493 household disinfected, 1,226 contacts traced and followed from different sites (Mille 01, Diglena geraro, san'asna kusrtu and Adaytu), and 108 active cases identified during active case searching. Reports and compiled line list from all CTC, CTU and ORPs were collected and reported to the next higher health department timely (within 30 minutes of case detection) containing most necessary variables but fail to generate information from line list data and prepare situation updates. For hard to reach areas to disinfect and trace contacts we use a well-trained community members to disinfect pre prepared chlorine and trace contacts on the way. Challenges faced during surveillance include; poor linking of epidemiology and lab data, incorrect use of RDTs; used as confirmatory testing and used in areas that already have confirmed cases and incorrect collection and transport of specimens.

Water supply coverage of the woreda was 39.5%. Furthermore, the hand washing practice for the community was so poor. As most of the affected communities are using the Awash River; water treatment chemical distribution to the affected kebele were enhanced and around 648,000 sachet of Water Pure were distributed for 6492 people (108,000 popx2L/dayx30 divide by 10). (Table 5)

Table 5 WaSH supplies distribution as part of response activities done in Mille woreda, June, 2018

Sites	Water service	Delivered by	Remark
Bele'ale	2 rotos & 1 bladder		
Amstegna	1 bladder	RWB car	Additional roto under maintenance
Mairemi	1 bladder, 1 roto & 1 em-watt kit	APDA	
Adaytu	roto	RWB	
Lahifage	1 Em-watt kit		
Ferede	1 roto	RWB car	
As m/d kudina keylu	1 roto	RWB car	
San'as	1 roto	APDA	
Lemele	1 roto	APDA	Needs additional roto

Safe water delivery to the affected community by water trucking car and refilling were conducted in line with Jerry can and baldi distribution. Three emergency water treatment kits (em-watt kit) are in place for most affected villages. Bladders and rotos are distributed in different sites of the woreda and water storage containers, tankers and rotos are washed and a chemist from RWB treating it.

Community engagement, social mobilization and health education were given by health care providers supported by montarbo with the assistance of HEWs. Health education was given for about 400 persons (professional estimate/ not counted each session) in different kebeles. Leaflets and brochures were distributed. Key messages includes; in case of acute watery diarrhea, come to the health care facility as soon as possible and start drinking ORS at home and during travel to the health care facility, wash your hands before cooking, before eating, and after using the toilet, cook food and drink safe water treated with water treatment chemicals, all treatment at CTCs are free of charge and disseminate the information for those who are not getting the information.

Site selection and establishment of proper CTC including were done based on the standard guideline in different kebeles of mille

woreda by local materials and case management according to management guideline and disinfection on arrival and discharge. Some health workers assigned on the CTC were trained onsite on proper case management of AWD (case definition, case management, CTC setup, contact tracing, criteria for admission and discharge and infection prevention precautions in the CTC and how to disinfect HH). Additionally, the chlorine solutions were properly prepared and utilized in the CTC.

Standby ambulance and mobile health team were serving for transporting patients and case management for hard to reach areas. The Woreda Health Office request logistic and supplies (IP materials, drugs, RDT kits, water treatment chemicals, CTC kits and other medical supplies) to mobilize as needed and provided by the RHB.

Discussion and conclusion

The onset date of the first cholera case in Mille was on May 26th 2018. The point source infection followed by propagation of cases from person to person is observed through epi week 21. The occurrence of sporadic cholera cases in Adaytu; that has been dragging on for several weeks could serve as a potential source of infection to other places. Cases have commonly drunken a bifurcation of Awash River (stream that branches off and flows away from a main stream channel); which is contaminated by the diarrheal patient coming from Dubti Woreda as witnessed by the community members and were believed that; the outbreak which was initially contained in Dubti woreda and Tendaho sugar factory has now expanded to relatively heavily populated woreda of Mille.

The ongoing outbreak control measures on the ground were not able to halt the propagation of the disease. Since the outbreak began in Epidemiological Week (EW) 21 and up to EW 30, 27 confirmed cases of cholera and 205 suspected cases have been identified in the woreda with 18 deaths (11 community and 7 facility deaths). The incidence rate/attack rates were 26 per 10,000. The cumulative case-fatality rate (CFR) has remained 7.76%, which were higher than the WHO's recommendation (below 1%). There were less cases below 10 years than controls comparable to the study in Yemen.[13] The attack rate was very high contrary to the study in Oromia, Ethiopia and Uganda.[2,26]

The results of the case-control study indicated that close contact with a person with cholera was a significant risk factor for contracting infection with a similar finding of the study in rural community of Nigeria.[27] Consumption of row foods and fruits were significantly associated with being a case of cholera in this study bivariate analysis and too in Iran.[28] Corresponding to this study, cases were less likely to have washed hands after using the toilet (at most critical hand washing times) compared to controls.[27] Hand washing after latrine usage was found to be protective of illness in a study in Afar (crude OR = 0.13, p= 0.03);[4] which is parallel to this study. The practice of drinking boiled water or Water treatment chemical (OR: 0.16, 95 % CI: 0.073-0.339) and regularly washing hands before eating (OR: 0.23, 95 % CI: 0.12-0.44) were associated with lower odds of developing cholera in the study done in India;[20] in parallel with this study. Lack of hand washing at critical times (AOR, 2.38; 95 % CI: 1.42-3.99) were predictors of diarrhea in the study done in Gojjam, Ethiopia;[29] which is also in line with the study done in Mille.

The reason why the water samples are negative for Vibrio cholera than being positive for E.coli and coliform was may be due the need to take samples at multiple sites (>10 samples) or miss-handling on transportation and processing procedures.

Even though oral cholera vaccine is perceived as an interim solution that can be deployed in advance,[21] in the study area no OCV were started for populations at risk due to lack of vaccines. Of the many successes of the response activities; the surveillance activities including active case, contact tracing and line listing takes the lead. Cholera response activities like surveillance, community mobilization and engagement accompanied by health education and community ownership and case management with safe water supplies has proven effect in controlling cholera as evidenced by many studies.[10,30–32]

Vibrio cholera 01 was responsible for the acute watery diarrhea outbreak in Mille. The cholera outbreak in Mille was imported from an area with ongoing cholera transmission. The outbreak affected nearly 7.28% of the woreda population and was due to contamination of the bifurcation of Awash River; which were the main drinking water source. Community propagation was facilitated by contact with cases. The key risk factor for contracting infection were use bifurcation of Awash River for drinking, use untreated/ uncoiled water, poor hand washing practices, drinking stored water for more than a day, close contact with cholera sick person and eating row food has remained an unresolved risk factor in cholera outbreaks in Mille.

Limitations of the study

We found difficulty to access most villages in the woreda during community mobilization and health education, active case search and household disinfection; which were inaccessible for vehicle transport. Most interventionists didn't support the investigation because they consider case management and health education will stop the spread and control infection; which is very far from the epidemiologic truth that without knowing the risk factors and source of infection, the outbreak couldn't be stopped. Considering results of the investigation for a personal consumption, interest and yield were another challenge faced during investigation.

Recommendations

a) Stop drinking water from a bifurcation of Awash River and close its link to the main Awash River to be dried up.

b) Sporadic cases that continue to occur in adaytu kebele need to continue an intense response measures, especially active surveillance, public health education/social mobilization as well as WASH interventions.

c) Opening oral rehydration points at all health centers and health posts in the kebeles.

d) Reduce close contact of attendants/caregivers to sick persons/ cholera patients and implement infection prevention and control measures to lessen the cross contamination.

e) Water for drinking from unsafe source need to be boiled or treated with water treatment chemical and hand washing practice at all five critical times should be well-thought out.

f) Identifying potential/suspected environmental risk factors by collecting environmental samples at multiple sites, points and at some interval for further laboratory analysis.

g) Supplies in high risk areas need to be prepositioned and contingency budget for emergencies needs to be allocated. If this is incredible, mobilizing finance for such cases needs to be made less bureaucratic and fast-tracking of ordinary procedures.

h) Health education and community mobilization needs to be based on outreach awareness campaigns and local language based with significant individuals (religious leaders, kebele leaders, village elders).

i) Oral cholera vaccines need to be procured and used; and helicopters to drop CTC kits, drugs, vaccines and WASH supplies.

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Investigators contribution

We know that doing outbreak investigation is a tricky and challenging work (requiring multiple risk exploring in line with plan development and response activities) especially when alone. Tesfahun Abye, Hana Mekonen, Kefyalew Amene, Dr. Samrawit Bisrat and Solomon Asfaw, investigated the outbreak with Tesfahun Abye taking the lead. Solomon Asfaw and Dr. Samrawit Bisrat supported the outbreak investigation with data collection for line list and case control study and Kefyalew with formatting of line list templates and cleaning of line lists. The other authors read, review and approve the finalized investigation.

Ethical clearance

Since the investigation is in-service investigation and too quick, formal procedures for ethical approval from institutional review board were not well-preserved. But detailed information about the study was provided to participants using a well written consent form that the study has no risk to any of respondents.

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Conflicts of interest

The authors declared that, there is no conflict of interest for this project.

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