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Waterborne Acute Gastroenteritis in Rural Kazakhstan: Insights from a Matched control-Case Study

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Abstract

In northern Kazakhstan, a rural village experienced a surge in acute gastroenteritis cases in mid-2021. Between May 14 and June 15, residents presenting with diarrhea, fever above 37.5 °C, vomiting, or generalized weakness were considered cases. For each case, two age-matched controls (±2 years) from the same village were selected. Information was gathered through structured interviews, and medical records were reviewed for clinical details. Case locations were plotted, and conditional multivariable logistic regression was used to identify factors associated with illness. A total of 154 residents were affected, yielding an attack rate of roughly 26 per 1,000. The most frequently reported symptoms were fever, diarrhea, weakness, vomiting, and reduced appetite. Among those interviewed, 74% of cases reported drinking unboiled tap water, compared with 18% of controls. Statistical analysis identified consumption of unboiled tap water as the primary risk factor (adjusted odds ratio: 18; 95% CI: 9–35), while drinking water from dispensers or carbonated beverages appeared to reduce risk. Cases were concentrated in a single water supply network, involving 79 households. The outbreak investigation revealed that water quality monitoring had been neglected since 2018, violating national regulations. No deaths occurred, and no additional cases were reported following intervention. Untreated tap water was determined to be the most likely source. The affected water supply had been disinfected twice two days prior to the investigation. Authorities were advised to implement regular water quality assessments and timely public alerts to prevent similar outbreaks in the future.

Keywords: Gastroenteritis, Diarrhea, Enteric diseases, Vomiting

Introduction

Despite global efforts to reduce the impact of enteric diseases, these infections continue to contribute substantially to illness and death worldwide, including in Kazakhstan and the broader Central Asia region [1]. Each year, over 1.6 million cases of intestinal infections are reported globally, with Kazakhstan alone documenting more than 11,000 cases in 2019. In North Kazakhstan, 384 cases were reported that year. Insufficient water, sanitation, and hygiene (WASH) infrastructure is a major factor driving the persistence of these diseases in Central Asia [2].

Between May 27 and June 1, 2021, health authorities in Kyzylzhar District observed a notable rise in cases of unspecified gastroenteritis within a village of approximately 12,000 residents in North Kazakhstan. To investigate, a joint team from the Practical and Scientific Center for Epidemiological Expertise and Sanitary and the Central Asia Field Epidemiology Training Program and Monitoring was deployed. Their mission was to characterize the outbreak's epidemiology and clinical presentation, identify associated risk factors, and determine the likely source to inform control measures.

Materials and Methods

Study design

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Between June 3 and 15, 2021, an outbreak investigation was carried out in the form of a case-control study. Individuals were classified as cases if they were residents of the rural village who received either inpatient or outpatient care for acute illness at any local healthcare facility from May 14 to June 15, 2021, and exhibited symptoms such as diarrhea, fever of 37.5 °C or higher, vomiting, or generalized weakness. Controls consisted of residents who had not experienced these symptoms during the same period. Controls were selected using simple random sampling from the village population registry maintained by the Kyzylzhar District Department of Epidemiological Control and Sanitary. Each case was matched to two controls based on age within a ±2-year range.

Ethics statement

The study protocol was evaluated and approved as a non-human research activity by the U.S. Centers for Prevention and Disease Control (under 45 CFR 46.102(l.2)) and by the Kazakhstan Ministry of Health (Committee No. 24-03-21/2703, dated June 3, 2021). Written consent was obtained from all adult participants. For minors under the age of 18, consent was provided by their legal guardians or parents, who also supplied all information regarding the child's health, as no direct interviews were conducted with the children themselves.

Data collection

The investigation began with a case list provided by the Kyzylzhar District Department of Epidemiological and Sanitary Control. To capture any additional cases, the team systematically reviewed medical records for all individuals who sought care for acute gastrointestinal illness between May 14 and June 15, 2021. For hospitalized children, laboratory culture results were also examined, though most cases in the region were treated based on clinical symptoms alone due to limited lab resources.

Data collection was performed using a standardized questionnaire that captured demographic information, clinical presentation, laboratory findings, and potential exposures. Investigators considered a broad range of possible risk factors, including recent visits to natural or recreational water sites (rivers, lakes, pools, water parks), dining at public food establishments, travel outside the village, contact with ill individuals, and consumption of different water sources (unboiled tap water, boiled tap water, water dispensers, wells, bottled water) or food items within the previous 14 days. For each case, exposure history focused on the two weeks preceding the onset of symptoms, while clinical and laboratory information was extracted directly from patient records.

Data analysis

Patient information was recorded and analyzed using EpiInfo version 7.2.3.1 (CDC, Atlanta). Initial univariate and bivariate analyses were conducted to explore potential associations with the illness. Variables demonstrating statistical significance ($p < 0.01$) were included in a conditional multivariate logistic regression to identify independent risk factors for gastroenteritis. Potential interactions and correlations between variables were also evaluated. Geographic clustering of cases was examined using QGIS version 2.28.

Laboratory testing

Stool samples were obtained from 12 cases who provided consent, and water samples were collected from two households with consent. Virological testing and molecular genetic analysis using PCR were performed at the Laboratory of the Practical and Scientific Center for Epidemiological Expertise and Sanitary and Monitoring in Almaty.

Results and Discussion

Descriptive characteristics

From May 27 to June 13, 2021, authorities identified 154 individuals with clinical signs of gastroenteritis as confirmed cases (**Figure 1).** This outbreak yielded an attack rate of 13 cases per 1,000 inhabitants across the entire village, which doubled to 26 per 1,000 in the village's older neighborhood. The highest number of symptom onsets was recorded on May 27, 2021, with only the normal low-level occurrence of intestinal infections noted beforehand in both the village and the broader district. The cases spanned all age groups and showed no specific temporal trends by age. Children accounted for the largest proportion of illnesses, comprising 44% of cases (68 out of 154) in those under 6 years of age, including 6% who were infants less than 1 year old. For children specifically, the attack rate stood at 27 per 1,000 village-wide and reached 53 per 1,000 in the older section.

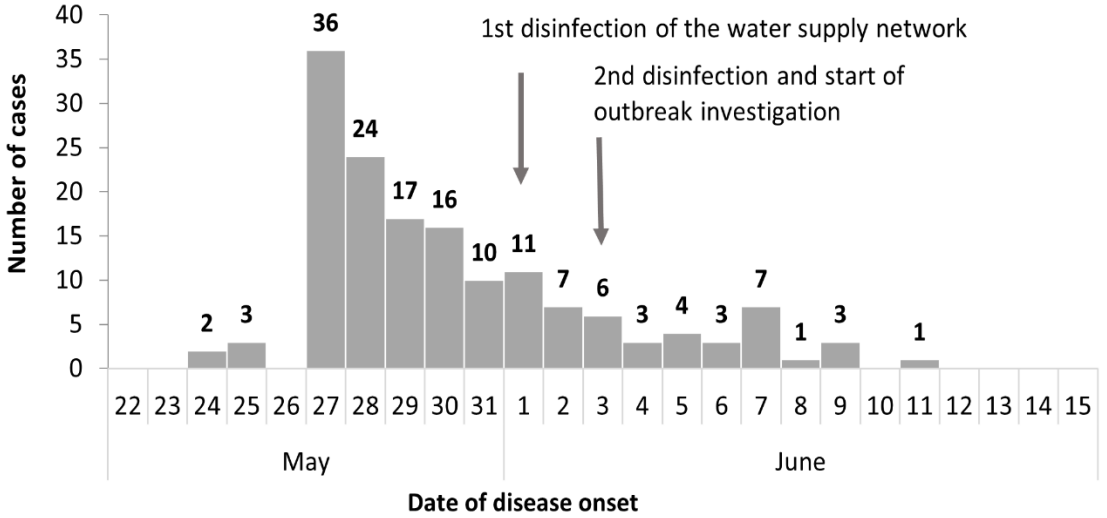

Figure 1. During May and June 2021, a bar graph displayed the timeline of gastroenteritis cases in a rural Kazakhstani village (total of 154 cases).

Case-control study result

Results from the case-control investigation From the 154 documented cases, 107 (about 70%) participated in the analysis, paired with 219 healthy controls. Exclusions happened because 12 people declined involvement and 35 were not at home during data collection. No one died from the illness. Severity was light in 13 instances and medium in 94. Common complaints involved loose stools (89%), throwing up (86%), stomach cramps (85%), feeling sick to the stomach (76%), and elevated temperature of 37.5°C or higher (65%) **(Table 1).**

Table 1. Profile of symptoms among gastroenteritis sufferers in a Kazakhstan, rural village, May 2021.

Feature	Case Group N (%)	Control Group N (%)	p-value
Overall Total	107 (100)	219 (100)	
Gender			0.8
Male	45 (42)	96 (44)	
Female	62 (58)	123 (56)	
Age Group (years)			0.9
Under 1	7 (7)	12 (5)	
1 to 6	42 (39)	80 (36)	
7 to 17	23 (22)	43 (20)	
18 to 40	17 (16)	39 (18)	
Over 40	18 (17)	45 (20)	
Reported Symptoms			NA
Diarrhea	95 (89)	0	
Vomiting	92 (86)	0	
Abdominal discomfort	91 (85)	0	
Nausea	81 (76)	0	
Fever (≥37.5°C)	69 (65)	0	
Headache	29 (27)	0	
Myalgia (muscle aches)	18 (17)	0	
Laryngitis	13 (12)	0	
Cough	11 (10)	0	
Runny nose (rhinitis)	5 (5)	0	
Skin rash	4 (4)	0	

No significant differences in age or sex were observed between cases and controls, with females comprising 42% of cases and 44% of controls (p = 0.8). Analysis identified two factors independently associated with gastroenteritis: consumption of unboiled tap water (OR: 12.5; 95% CI: 7.0–22.8) and having pets in the household courtyard (OR: 1.9; 95% CI: 1.2–3.2) **(Table 2).** Conversely, drinking water from dispensers, preboiled tap water, or carbonated beverages, as well as consuming kebabs, fish, berries, or canned foods, appeared to reduce the risk of illness. Other exposures—including water from pumps, attendance at public gatherings, contact with ill individuals, and swimming in natural or man-made water sources—were reported sporadically among both cases and controls and did not show a statistically significant association.

Table 2. Variables associated with gastroenteritis in a Kazakhstan, rural village, May–June 2021.

Characteristic	Controls n=219 (%)	Cases n=107 (%)	Crude OR (95% CI)	(95% CI)	Adjusted OR
Beverages consumed					
Carbonated drinks	74 (34%)	21 (20%)	0.5 (0.3–0.8)	(0.2–0.8)	0.4
Unboiled tap water	40 (18%)	79 (74%)	12.5 (7.0–22.8)	(9.4–35.3)	18.2
Filtered tap water	42 (19%)	18 (17%)	0.9 (0.4–1.6)		—
Boiled tap water	170 (78%)	74 (69%)	0.6 (0.4–1.1)		—
Bottled water	123 (56%)	48 (45%)	0.6 (0.4–1.0)		—
Water from a dispenser	100 (46%)	32 (30%)	0.5 (0.3–0.9)	(0.4–1.4)	0.8
Foods consumed					
Kebab	47 (21%)	10 (9%)	0.4 (0.2–0.8)	(0.1–0.9)	0.4
Ice cream	105 (48%)	41 (38%)	0.7 (0.4–1.1)		—
Fish	81 (37%)	13 (12%)	0.2 (0.1–0.5)	(0.5–1.5)	0.8
Fruit	194 (89%)	87 (81%)	0.6 (0.3–1.1)		—
Canned foods	28 (13%)	6 (6%)	0.4 (0.1–1.0)	(0.1–1.5)	0.4
Berries	45 (21%)	9 (8%)	0.4 (0.1–0.8)	(0.2–1.1)	0.4
Human contact					
Contact with a sick family member	19 (9%)	15 (14%)	1.7 (0.8–3.7)		—
Contact with a sick person	21 (10%)	16 (15%)	1.7 (0.9–3.4)		—
Animal contact					
Contact with pets in the courtyard	109 (50%)	70 (65%)	1.9 (1.2–3.2)	(0.9–2.9)	1.6
Places visited					
Visited a park	12 (5%)	8 (7%)	1.4 (0.5–3.8)		—
Visited a mall	23 (11%)	12 (11%)	1.1 (0.5–2.4)		—

CI: Confidence Interval; AOR: Adjusted odds ratio, OR: Odds ratio.

Multivariable analysis identified consumption of unboiled tap water as the sole significant risk factor for gastroenteritis (adjusted odds ratio [AOR]: 18.2; 95% CI: 9.4–35.3). Prior to falling ill, over half of the cases (54/107; 51%) reported perceiving abnormalities in the water's taste, color, or odor. Geographical mapping revealed that cases were concentrated in households located in the village's older section **(Figure 2)**. Among the 79 affected households, the majority (73%) had only one case, whereas 19 households reported two cases each, and two households reported three. A separate analysis restricted to the first symptomatic individual in each household reinforced the strong link between unboiled tap water and illness: 80% of cases versus 18% of controls reported drinking unboiled tap water (OR: 17.4; 95% CI: 9.2–34.0).

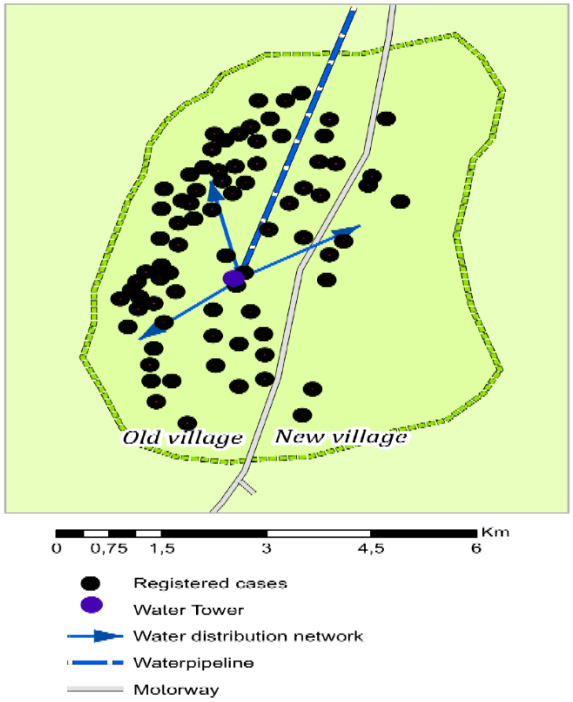

Figure 2. Distribution of gastroenteritis cases across households in a rural village, Kazakhstan, May–June 2021.

Laboratory analysis

Stool specimens were collected from 12 consenting patients, with pathogens detected in 11 samples. All positive cases involved viral infections; four patients were infected with a single virus, while seven had co-infections with two or more viruses. The viral agents identified included norovirus, astrovirus, rotavirus, and enteroviruses such as coxsackievirus **(Table 3).** Water samples from two affected households tested negative for pathogens; however, these samples were obtained following chlorination of the village water supply, which may have affected detection **(Figure 1)**.

Table 3. Stool pathogen detection among gastroenteritis cases (n = 12), rural village, Kazakhstan, May–June 2021.

Date	Virologic test results * PCR test results**	Detected Pathogens
25.05	negative	norovirus
27.05	negative	norovirus, astrovirus, rotavirus
27.05	negative	norovirus, astrovirus
28.05	negative	norovirus, astrovirus
28.05	negative	norovirus
28.05	negative	negative
30.05	negative	enterovirus, Campylobacter spp.
30.05	Coxsackievirus B3	rotavirus, enterovirus
30.05	negative	norovirus
31.05	negative	rotavirus
01.06	negative	enterovirus, astrovirus
02.06	Coxsackievirus B5	Enterovirus

*Virological testing performed to detect coxsackievirus and enterovirus.

Polymerase chain reaction (PCR) assays were performed to detect a range of viral and bacterial pathogens, including adenovirus group F,rotavirus group A, astrovirus, norovirus genotype 2, and enteroviruses such as coxsackievirus, as well as bacterial agents including Yersinia enterocolitica, Listeria monocytogenes, Yersinia pseudotuberculosis, Shigella species, enteroinvasive Escherichia coli (EIEC), Salmonella species, and Campylobacter species.

Water supply assessment findings

The village relies on a centralized water supply system. Sewage is partially managed through enclosed sewer pipes and is discharged into a storage pond located in the northwestern part of the village, approximately 3 km from the village center. Water is drawn from a nearby river and undergoes treatment—including filtration, coagulation, and chlorination—at treatment plants situated 22 km from the village, before being conveyed via main pipelines. Within the village, water is

distributed through separate networks serving the "old" and "new" sections. While the water network in the new section has been fully modernized, the old section has not undergone major renovation for over 30 years. In this older network, water from the main pipeline is first pumped into a 1,200 m³ water tower, then stored in clean water tanks, and finally delivered to households. The same company has been responsible for maintenance of the water supply system since 2017.

The investigation revealed that no records of water quality monitoring or safety inspections were available for the period 2018–2021. Documentation of routine chlorination, residual chlorine testing, microbiological analyses, or reports of technical malfunctions and repairs in the centralized network was also lacking in the 14 days preceding the first case.

District epidemiologists tested water samples from 15 households four days after the initial case was reported. These samples showed bacterial contamination levels exceeding 5,000 colony-forming units (CFU) per 100 mL. In response, the central water supply company undertook cleaning and disinfection of the network on June 1, 2021, and repeated the procedure the following day after testing revealed inadequate residual chlorine. By June 3, residual chlorine levels were within the recommended range.

Between May 27 and June 13, 2021, a gastroenteritis outbreak occurred in the old section of the village in Kyzylzhar district, North Kazakhstan, affecting an estimated 26 per 1,000 residents. Evidence strongly indicates that contaminated drinking water was the primary source. Individuals who consumed unboiled tap water had nearly a 20-fold higher odds of developing illness, whereas those who drank water from alternative sources such as dispensers or bottled beverages were less likely to become ill. Cases were geographically clustered within households served by the same water network. Laboratory testing revealed multiple viral pathogens in approximately half of the stool specimens collected. Local epidemiological findings further supported this conclusion, showing elevated microbial contamination in tap water during the early outbreak period and suboptimal residual chlorine levels even after disinfection of the water system.

No other common exposures were identified in the case-control study. Risk factors related to other water sources, such as visiting water parks, fountains, or open ponds, were rarely reported and did not differ between cases and controls. Similarly, attendance at communal events or dining activities was not linked to illness. The presence of multiple pathogens in stool samples supports the hypothesis of fecal contamination of the drinking water rather than a single-source infection. Comparable outbreaks in other countries have documented mixed etiologies, including norovirus, astrovirus, rotavirus, enterovirus, Coxsackievirus B3, and Campylobacter spp., associated with contaminated municipal water [3–6]. For instance, an outbreak in Greece found that six of eleven affected individuals had multiple pathogens detected in stool [6].

Deficiencies in maintenance and treatment of water distribution systems have been implicated in other waterborne outbreaks in the region [7–10], and inadequate water quality monitoring likely contributed to this outbreak as well [11]. Many rural water supply systems in post-Soviet countries have deteriorated due to prolonged neglect. A study from Uzbekistan, for example, found that rural areas face higher risks for waterborne illnesses [7]. In this investigation, no official water quality monitoring had been conducted since 2018, neither by the organization responsible for the water supply network nor by supervisory authorities. While technical failures were not formally documented, several residents reported concerns about water quality in the days leading up to the outbreak.

This investigation has several limitations. First, only a small number of stool samples were collected from cases, and no specimens were obtained from controls; local health facilities did not perform laboratory testing, and patients were treated empirically in a resource-limited setting. Second, the outbreak team arrived after the water system had been chlorinated, so household water samples may not reflect the quality at the onset of the outbreak. Third, a comprehensive inspection of the water supply system could not be conducted. Finally, active case finding was not performed, likely resulting in an underestimation of the outbreak's true magnitude.

Despite these limitations, the investigation demonstrates a clear, independent association between consumption of untreated tap water and illness while ruling out alternative explanations. When multiple intestinal pathogens are detected in cases and a strong epidemiological link with a specific water source exists, the outbreak can be attributed to contaminated water [12]. This approach aligns with WHO guidance, which defines a waterborne outbreak as an incident in which at least two individuals contract the same disease after consuming the same water source, with epidemiological

evidence implicating the water [13]. Regular maintenance, cleaning, and disinfection of water supply facilities in accordance with Kazakhstan's sanitary regulations can reduce the risk of similar outbreaks in the future [14].

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