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Acute Gastroenteritis Outbreak in a Rural Area in Perak, Malaysia, 2022

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Abstract

An outbreak of acute gastroenteritis was identified in a rural village in Perak, Malaysia, on 22 Jun 2022, following the detection of 20 cases. The Larut, Matang, and Selama District Health Office implemented public health measures to control the outbreak. We detected 25 cases during 22–24 Jun 2022, among private boarding school students and residents. Half (52%) of the cases were aged between 11 and 15 years, 68% were male, and 44% were students. Common symptoms included vomiting (88%), abdominal pain (76%), and diarrhoea (72%). No food was suspected based on food diaries, as there was no common food eaten by all cases. The epidemic curve showed a point-source pattern. Mapping of cases demonstrated that all cases used water for drinking, cooking, and other domestic usages that were supplied by the same gravity feed system. Several empty containers of carbofuran-containing insecticide and nematicide, used for agriculture, were found near the gravity feed system route at an altitude higher than its inlet. No known pathogen was isolated from the rectal swabs of cases. This acute gastroenteritis outbreak was suspected to have occurred from drinking water contaminated with chemicals such as carbofuran. After excluding other possible causes, health education to the villagers, particularly on the appropriate use of insecticides nearby the source of water supply with good cooperation from the local communities had helped successfully controlling the outbreak.

Keywords: acute gastroenteritis, insecticide, chemical, gravity feed system

Introduction

Acute gastroenteritis is a condition wherein inflammation occurs in the stomach as well as the small or large intestine. Presenting symptoms include abdominal pain, nausea, vomiting, and diarrhoea, which normally resolve within 14 days.[1] The main causes are infectious agents such as viruses, bacteria, and parasites. Larut, Matang, and Selama (LMS) is a district in Perak State, Malaysia. The LMS District Health Office monitors acute gastroenteritis cases in the district through a surveillance system whereby notifications are received from all public healthcare facilities in the district. On 22 Jun 2022, the LMS District Health Office received a notification of 11 acute gastroenteritis cases seeking treatment at a nearby health clinic on 21 Jun 2022. They were all male students aged between 11 and 15 years old who were staying in a private boarding school in a rural area within the LMS District. Further nine cases were detected on 22 Jun 2022. These involved people in the same locality where the school is located. Therefore, an outbreak of acute gastroenteritis was declared on 22 Jun 2022, and the district rapid response team was activated to investigate the event. The objectives of the investigation were to present descriptive epidemiological characteristics, identify possible sources for the outbreak, and implement public health measures to control the outbreak.

Material and Methods

The operation room of the LMS District Health Office was activated during the outbreak to synchronize all actions and commands.

Operational Case Definition

Anyone who lived in a rural village within LMS District and experienced at least one of the following symptoms including nausea, vomiting, abdominal pain or diarrhoea, between 19 and 24 Jun 2022, was defined as a case.

Active Case Detection

The detection of cases was conducted on 24 Jun 2022, based on the operational case definition. Due to limited resources, we visited 39 premises and met 189 (21.6%) of the 876 residents. We conducted face-to-face interviews using a standard investigation form [FWBD/KRM/ BG/001 (Pindaan 2006)] and a food diary form.

Epidemiological Analysis

We conducted a descriptive epidemiological analysis of all identified cases, including their close contacts. The variables included socio-demographic characteristics such as age, gender, and occupation, as well as date of onset of symptoms, clinical manifestation, food intake, and significant movement history. Data were coded, manually checked for any inconsistencies, duplication, and missing values, and analyzed using the Statistical Package for the Social Science (SPSS), version 21.0. Descriptive results were presented as follows: quantitative data were presented using the mean and standard deviation, whereas qualitative data were presented using frequency and percentage. An epidemic curve was constructed based on symptom onset dates. A map of cases in this outbreak was done to identify the possible source.

Environmental Assessment and Laboratory Study

The area around and above the gravity feed system (GFS) catchment, which was surrounded by a durian orchard at the peak of the hill, was inspected to detect any illegal activity at the river that supplied the GFS. This GFS is a system that was built to supply untreated water to a community from a river through a structure that water will directly flow using force of gravity to the consumers. Water samples were taken from the GFS at various points as listed below and sent to Malaysia Chemistry Department (Perak Branch) for chemical pesticides (Alpha-BHC, Beta-BHC, Lindane, Delta-BHC, Heptachlor, Heptachlor exo epoxide, Alpha Endosulfan, Beta Endosulfan, Endosulfan sulphate, 4,4-DDE, 4,4-DDD, 4,4-DDT, Aldrin, Dieldrin, Endrin, Methoxychlor, Endrin Aldehyde, Alpha Chlordane and Gamma Chlordane), light metal [NH_3-N, (NO_3+NO)N, Fluoride, Chloride, Ferum, Manganese and Aluminium), heavy metal (Arsenic, Mercury, Cadmium, Plumbum, Chromium, Argentum, Cuprum, Zinc, Magnesium, Natrium, Selenium, Sulphate, Chloroform, $CHCl_2Br$, $CHBr_2Cl$, $CHBr_3$) and bacteriological (total coliform and *Escherichia coli*) using Membrane Filtration Method analysis: a) two water samples from the river at the altitude above the water catchment area; b) one water sample from the GFS catchment area; c) two water samples from the GFS outlet in the private boarding school; and d) one water sample from the GFS outlet in a randomly selected case's house.

We randomly took eight rectal swab samples from eight cases and sent them to a public health laboratory in Ipoh, Perak, Malaysia, for culture and drug sensitivity tests for pathogenic enteric bacteria. Two water-selling dispenser machines in these villages were also identified and inspected for cleanliness, and the source of the water supply was determined. Water from the outlets of these machines was tested for pH, turbidity, and the presence of residual chlorine, coliform, *Bacillus cereus, Coagulase-positive Staphylococci, Escherichia coli, Salmonella spp.,* and total plate count.

Ethics

An ethical approval for this study was obtained from the Medical Research and Ethics Committee of the Ministry of Health, Malaysia on 26 Jan 2023 [Reference number: NMRR ID-22-02381-CBQ (IIR)].

Results

Descriptive Epidemiology

Socio-demographic characteristics

There were 25 cases detected in this outbreak through both passive and active case detection activities, with an attack rate of 2.85%. Most of them were male (68%), aged between 11 and 20 years (60%). Almost half of them were students who stayed in a private boarding school (44%), followed by housewives (20%), durian orchard farmers (16%), other students (8%), and the remaining three cases were a businessman, a private sector worker, and a government officer. Most of the students from the private boarding school consumed water that was supplied by the GFS only and underwent the same daily activity in the school. Meanwhile, 72% of cases consumed water from a low-cost water-selling dispenser machine for drinking and cooking in addition to GFS water (Table 1).

Table 1. Socio-demographic characteristics of cases linked to an acute gastroenteritis outbreak in a rural village in Perak, Malaysia, from 22 to 24 Jun 2022 (n=25)

Characteristics	Frequency	Percentage
Age group (years)		
0–10	0	0.0
11–20	15	60.0
21–30	4	16.0
31–40	3	12.0
41–50	2	8.0
51–60	0	0.0
More than 60	1	4.0
Age (years)		
Mean (SD)	23.0 (14.86)	
Minimum	11	
Maximum	73	
Gender		
Male	17	68.0
Female	8	32.0
Occupation		
Student (private boarding school)	11	44.0
Housewife	5	20.0
Durian orchard farmer	4	16.0
Other students	2	8.0
Businessperson	1	4.0
Private sector worker	1	4.0
Government officer	1	4.0
Water source		
GFS only	7	28.0
GFS and water-selling dispenser machines	18	72.0

GFS: gravity feed system. SD: standard deviation

Clinical manifestation

Most cases presented with vomiting (88%), abdominal pain (76%), and diarrhoea (72%). Other symptoms included nausea (24%), dizziness (8%), and myalgia (4%). None of the cases developed a fever (Table 2).

There were 18 cases (72%) who had received out-patient treatment, while seven did not seek treatment at any healthcare facility as they claimed to have very mild symptoms.

Epidemic curve

The first and last onset were on 21 Jun 2022, at 3:30 AM and 22 Jun 2022, at 2:50 AM, respectively. Most cases developed symptoms on 21 Jun 2022, between 4:00 PM and 8:00 PM. The outbreak was declared on 22 Jun 2022, and ended on 24 Jul 2022. The epidemic curve suggested a point-source outbreak with a single exposure (Figure 1).

Table 2. Clinical manifestation of cases linked to an acute gastroenteritis outbreak in a rural village in Perak, Malaysia, from 22 to 24 Jun 2022 (n=25)

Clinical Manifestation	Frequency	Percentage
Vomiting	22	88.0
Abdominal pain	19	76.0
Diarrhoea	18	72.0
Nausea	6	24.0
Dizziness	2	8.0
Myalgia	1	4.0

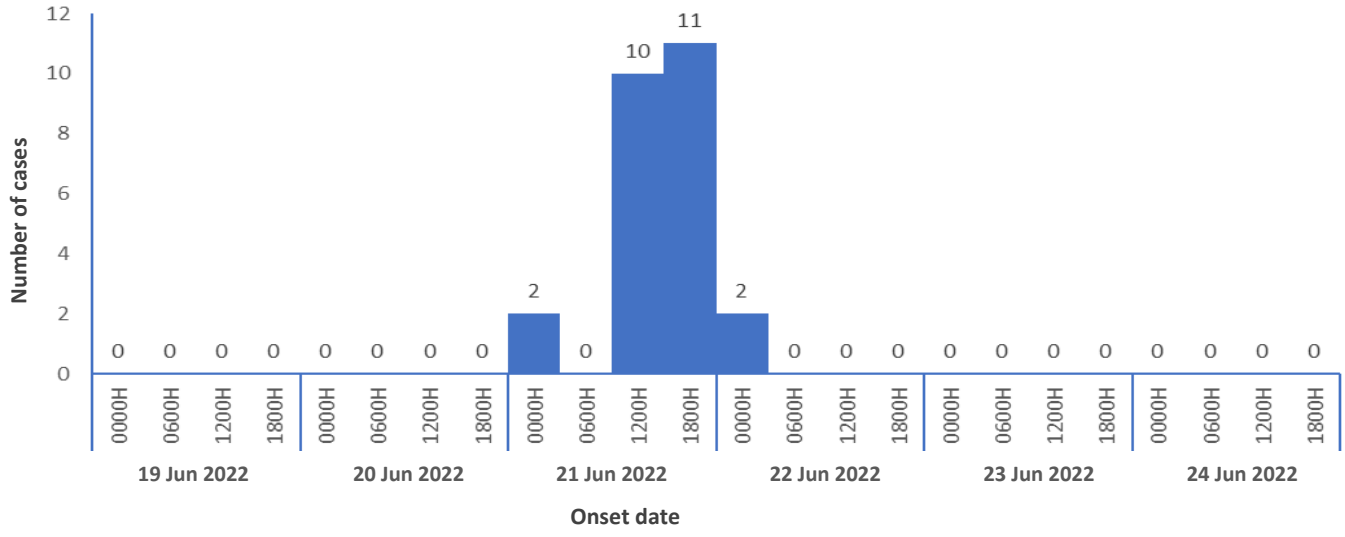

Figure 1. Epidemic curve of an acute gastroenteritis outbreak in a rural village in Larut, Matang, and Selama District, Perak, Malaysia, from 22 to 24 Jun 2022

Mapping of cases

The same GFS outlet supplied untreated water directly to all cases and other residents. Figure 2 shows the location of the cases' houses with respect to the water supply from the GFS outlet.

Food diary

There was no common food eaten by all cases, and none of them had any history of eating or drinking from the same restaurant or food stall except for students from the private boarding school who ate the same food provided by the school. Most residents of the villages also ate foods they cooked at home. In fact, none of the cases reported any abnormal appearance, taste, or smell of the food they consumed prior to the onset of symptoms. Thus, no specific food was identified as the possible cause of this outbreak.

Environmental Assessment and Laboratory Study

Gravity feed system

The GFS water catchment from the river as well as higher-altitude areas up to the peak of the hill were surrounded by a durian orchard. Chemical smells were detected nearby the GFS inlet, and several empty containers of insecticide and nematicide that contain carbofuran 3% w/w (anticholinesterase carbamate) as their active ingredient were also found near the inlet.

Analysis of all water samples taken from the GFS found that all chemical pesticides, namely Alpha-BHC, Beta-BHC, Lindane, Delta-BHC, Heptachlor, Heptachlor exo epoxide, Alpha Endosulfan, Beta Endosulfan, Endosulfan sulphate, 4,4-DDE, 4,4-DDD, 4,4-DDT, Aldrin, Dieldrin, Endrin, Methoxychlor, Endrin Aldehyde, Alpha Chlordane, and Gamma Chlordane, were found to be lower than the mandatory standard value. Furthermore, none of the light metal, namely NH_3-N, $(NO_3+NO)N$, Fluoride, Chloride, Ferum, Manganese, and Aluminium, as well as the heavy metal, namely Arsenic, Mercury, Cadmium, Plumbum, Chromium, Argentum, Cuprum, Zinc, Magnesium, Natrium, Selenium, Sulphate, $CHCl_2Br$, $CHBr_2Cl$, and $CHBr_3$, in the water samples exceeded the Malaysia Drinking Water Quality Standard. However, the level of chloroform ($CHCl_3$), a type of heavy metal, in a water sample was 0.204 mg/L, which exceeded the maximum acceptable value of 0.2 mg/L. Nevertheless, no test was done to identify the presence of carbofuran.

Bacteriological analysis of all water samples showed that the total coliform level at the GFS water catchment area and one of the houses with water supplied by the GFS exceeded 16,000/100 mL, based on the most probable number technique.

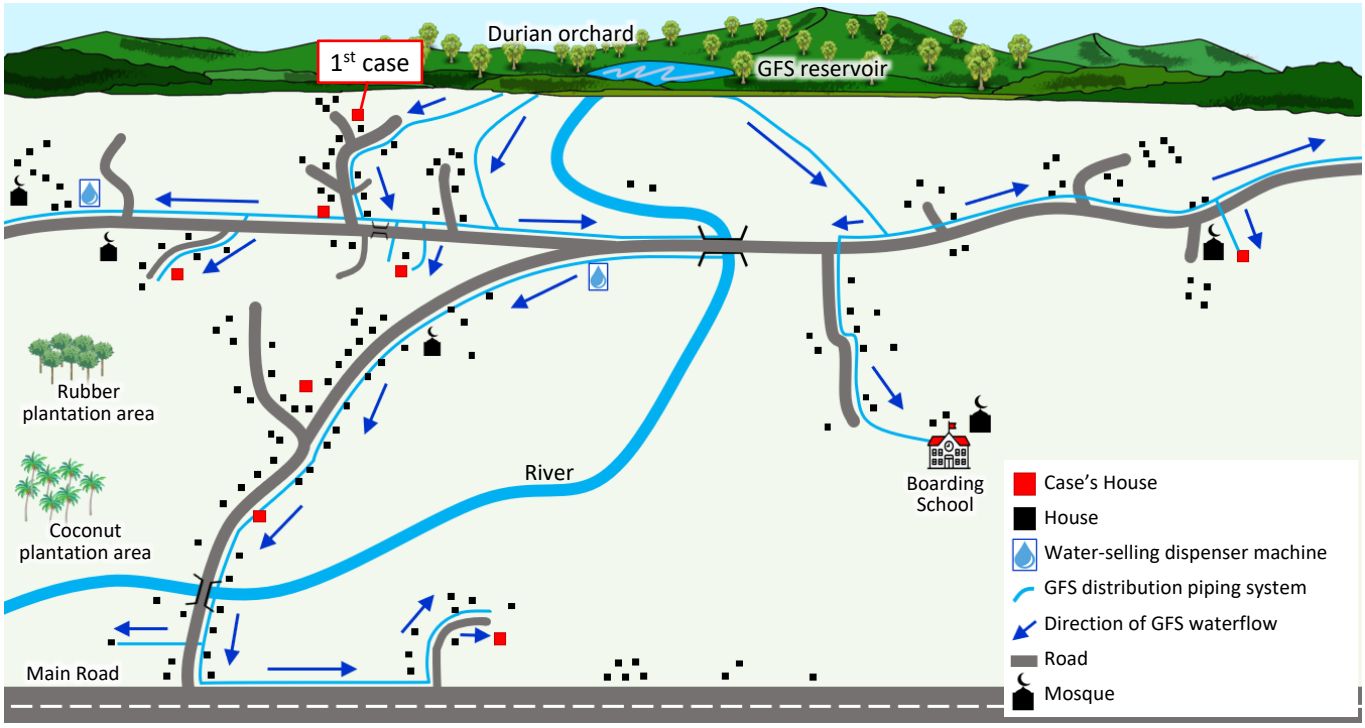

Figure 2. Mapping of cases of acute gastroenteritis outbreak in a rural village in Larut, Matang, and Selama District, Perak, Malaysia, from 22 to 24 Jun 2022

Inspection of water-selling dispenser machines

Two suspected dispensing machines received treated water supplies from the Perak Water Authority, and their outer surfaces were clean and well maintained. An analysis of the water from these machines showed low free residual chlorine (0.07 mg/L and 0.02 mg/L, respectively). Both the pH and turbidity levels of the water from these machines did not exceed the maximum acceptable value. Analysis to detect the presence of coliform, *Bacillus cereus, Coagulase-positive Staphylococci, Escherichia coli, and Salmonella spp.* was found to be negative except for the total plate count (7.5×10^1 CFU/mL and 1.1×10^2 CFU/mL, respectively).

Clinical Sample Analysis

Analysis of all rectal swab samples taken randomly from eight cases did not isolate any pathogenic enteric bacteria.

Health Education

Health education about the importance of consuming treated water for drinking and cooking was given to all cases and their household family members, other residents who were met during the active case detection activity, and teachers at the private boarding school. They were also advised to avoid consuming water from the GFS water supply for any activity if the water was turbid or had an abnormal smell. Pamphlets on food poisoning prevention were also distributed to all villagers, as was the proper usage of insecticides, especially near rivers that supplied water to the villagers.

Discussion

This acute gastrointestinal outbreak involved a group of community members in a rural area with an attack rate of 2.85%. A higher attack rate was previously reported in closed institutions, such as 55% among residents and 25% among employees at a geriatric convalescent facility in Los Angeles County in 1988 and 40% in a secondary school in Pathum Thani Province, Thailand, in 2022.[2,3]

The symptoms experienced by all cases were generally mild and did not require hospitalization. Most cases presented with vomiting, abdominal pain, and diarrhoea. However, none of them presented with fever, which is one of the main symptoms normally experienced by most food- and water-borne bacterial infectious disease cases.[4] Furthermore, no known pathogenic enteric bacteria were isolated from all rectal swab samples.

All cases consumed water from the same GFS. The presence of coliform in the GFS water that exceeded its maximum acceptable value may indicate the presence of pathogenic microorganisms such as viruses, bacteria, or protozoa.[5] They are commonly found in the environment, such as soil or vegetation, and inside mammals' intestines, including humans, particularly *Escherichia coli.*[6]

However, a systematic review and meta-analysis study by Gruber et al. found that fecal coliform had no significant association with diarrhoea.[7] Although those infected by *Escherichia coli* may present with abdominal cramps, fever, vomit, and diarrhoea, bacteriological analysis of all GFS water samples in this outbreak only found a high total coliform, and none of them isolated *Escherichia coli.*[8] Thus, the presence of total coliform in the water samples could not be significantly linked with this outbreak occurrence. Nevertheless, the source of infection from viruses and other microorganisms cannot be excluded because no test was conducted for virus analysis on both clinical and water samples in this outbreak, as water can be contaminated by bacteria, viruses, protozoa, and helminths, as well.[9]

Analysis of water samples from both water-selling dispenser machines discovered low free residual chlorine, which indicates the chlorine level for disinfecting waterborne microorganisms was low.[10] Moreover, the high total plate count in both water samples indicates a high level of microorganisms (mold, yeast, and bacteria) in the water samples.[11] However, clinical sample analysis did not support the epidemiological link between the water consumed by these machines and this outbreak.

Next, the analysis of water from the GFS at various points showed that none of the specific chemical pesticides nor light metal exceeded the mandatory standard value and Malaysia Drinking Water Quality Standard. The test for specific heavy metal also produced similar findings, except for chloroform in one sample. The presence of chloroform in raw water can be a result of contamination by pesticides. This is because chloroform has been used as an ingredient in pesticide production.[12] Although chloroform can also be produced naturally in the water by the chlorination process (mainly water and wastewater), there is no history of this river having been chlorinated previously.[13,14]

In fact, chloroform ingestion may adversely affect a human's health in ways that include central nervous system depression, respiratory depression, delayed

hepatotoxicity, severe gastrointestinal injury, and dermatitis.[15] However, all cases in this current outbreak merely presented with mild symptoms and signs and mostly involved the gastrointestinal tract.

Further investigation had discovered that the same source of GFS water is continuously consumed by villagers for domestic use, but the epidemic curve shows a point source with single exposure. Thus, it is more likely to have recent environmental contamination. In fact, carbofuran-containing insecticides and nematicides are normally used seasonally, especially near the durian season, to eliminate unwanted pests on the fruit.

Therefore, a chemical, namely carbofuran, is highly suspected as the source of this outbreak in comparison with an infectious cause. This is based on the symptoms presented by all the cases and is further supported by the fact that none of the rectal swab samples that were taken from more than 30% of the cases had isolated any known pathogenic enteric bacteria. According to the Centers for Disease Control and Prevention, those who consume carbofuran tend to present with vomiting, abdominal cramps, diarrhoea, nausea, headache, miosis, blurred vision, sweating, salivation, lassitude, muscle twitching, incoordination, and convulsions as a result of the inhibition of blood cholinesterase, which later affects the function of both the central nervous system and peripheral nervous system.[16,17] An exposure to chemical such as carbofuran is commonly immediate or shortly after exposure and the cases in this outbreak may had consumed the flowing contaminated water that resulted in different time of exposure with different time of onset.

Moreover, several empty containers of insecticides and nematicides containing carbofuran were found at higher altitudes in the GFS water catchment area, suggesting their use may possibly contaminate the water that is consumed by the villagers. Carbofuran is an anticholinesterase carbamate that is frequently used in agriculture.[18] It can contaminate food, water, and air, adversely affecting human health. Thus, all cases may have consumed river water through GFS that was contaminated by carbofuran, as it supplies water to all the affected premises, even though there was no supportive laboratory evidence due to no water analysis for carbofuran was conducted.

The exposure at every premises is transient as the water flows continuously through the GFS, where possibly carbofuran-contaminated water becomes diluted, resulting in the dose of exposure becoming lower as the distance from the GFS inlet increases. The high number of cases from the private boarding school can be explained by the similar time of exposure to the water from the GFS among them. Nevertheless, some residents who were not working in the villages may not have been exposed to the water at the time it flowed into their house.

During the outbreak, health education for the villagers was intensified, particularly on the proper usage of insecticides near the river that supplies water to the GFS. This was successfully conducted through strong efforts to build trust, respect, and a good relationship with the local communities. Subsequently, there were no additional cases reported with an epidemiological link to this outbreak.

Limitations

This outbreak involved a rural area with a large number of residents. Therefore, we were unable to visit all premises or interview all residents in this area due to limited resources. Furthermore, the results of the analysis should be interpreted with caution, as there was a possibility of non-response bias given that some residents who may have been affected by mild symptoms did not seek healthcare and were subsequently not detected as a case. Secondly, although levels of chemical pesticides in the water samples taken from GFS were found to be under the mandatory standard values, dilution of the chemicals may have occurred to some degree.

Conclusion

An acute gastroenteritis outbreak was detected in a rural area in Perak, Malaysia, that involved 25 cases with an attack rate of 2.85%. The possible source of this outbreak was water from a gravity feed system that was suspected to be contaminated by carbofuran. This hypothesis is based on epidemiological, clinical, and environmental findings, namely the mapping of cases, epidemic curve, and symptoms experienced by all cases, as well as the discovery of several empty containers of insecticide and nematicide containing carbofuran 3% w/w as its active ingredient nearby the river that supplies water to the GFS, although no laboratory analysis to detect the presence of carbofuran in the water was conducted. This acute gastrointestinal outbreak investigation shows the importance of not merely focusing on food but also on other possible sources of illness, including chemicals. This can help better understand these types of outbreaks and lead to a more proper intervention to control the outbreak and prevent its recurrence in the future.

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Conflicts of Interest

This research has no conflicts of interest.

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