Journal of
Infectious Diseases and Epidemiology

RESEARCH ARTICLE

An Acute Gastroenteritis Outbreak Caused by Astrovirus Serotype 4 in a School of Shenzhen City, China, 2017

Luo Li[1#], Li Yuan[2#], Gao Zhiyong[3], Zeng Jinshui[4], Lian Yiyao[1], Song Wentao[5], Lv Bin[6], Chen Qi[7], Liu Na[8], Jin Miao[8], Liao Qiaohong[1], Wu Shuyu[9], Li Zhongjie[1], Shi Guoqing[10] and Ran Lu[1*]

[1]Division of Infectious Disease, Key Laboratory of Surveillance and Early-warning on Infectious Disease, Chinese Centre for Disease Control and Prevention, Beijing, China

[2]Shenzhen Bao'an Center for Disease Control and Prevention, Shenzhen, China

[3]Beijing Centre for Disease Control and Prevention, Beijing, China

[4]Maoming Centre for Disease Control and Prevention, Maoming, Guangdong Province, China

[5]Nanchang Centre for Disease Control and Prevention, Nanchang, Jiangxi Province, China

[6]Xiaogan Centre for Disease Control and Prevention, Xiaogan, Hubei Province, China

[7]Hubei Provincial Center for Disease Control and Prevention, Wuhan, Hubei Province, China

[8]Institute of Viral Disease Control and Prevention, Chinese Centre for Disease Control and Prevention, Beijing, China

[9]Division of Global Health Protection, United States Centers for Disease Control and Prevention, Beijing, China

[10]Office for Emergence Response, Chinese Centre for Disease Control and Prevention, Beijing, China

[#]These authors contributed equally to this work.

*Corresponding author: Ran Lu, Division of Infectious Disease, Key Laboratory of Surveillance and Early-warning on Infectious Disease, Chinese Center for Disease Control and Prevention, Beijing, China

Abstract

Background: In November of 2017, a school outbreak of acute gastroenteritis was reported from Shenzhen City.

Methods: A cohort study was conducted to describe the epidemiological characteristics of the outbreak. Data on demographic details, onset of clinical symptoms, food and water intake history, contact with ill person prior to illness were obtained.

Results: 98 student-cases were identified. The main symptoms included vomiting (69%), abdominal pain (59%), nausea (47%), diarrhea (43%) and cough (38%) with the median duration of illness of 2 days (range: 1-8 days). The AR was 3.2% and involved 63% of the classes with the median age of 10 years (range 6-15 years). Based on epidemiological investigation, multivariate analysis showed that touching with ill students (RR = 3.95, 95% CI = 2.18-5.58) and touching the handles of faucet (RR = 4.18, 95% CI = 1.50-8.37) were associated with illness. Astrovirus serotype 4 was detected in 6 ill students and 1 asymptomatic cleaning staff.

Conclusions: This outbreak was caused by astrovirus. The main exposure mode was likely person to person and touching a contaminated water faucet. Recommendations included immediate isolation of cases and daily disinfecting the drinking water faucet. In the future, surveillance for astrovirus should be strengthened by laboratory testing after other common pathogens are ruled out.

Keywords

Astrovirus, Outbreak, Person-person, Environment exposure

Introduction

Human astrovirus (HAstV) was first detected by Appleton and Higgins in 1975 in association with an outbreak of acute gastroenteritis in a maternity ward in England, and the same year named by Madeley and Cosgrove because of its star-like appearance [1]. Astrovirus along with rotavirus, norovirus and sapovirus,

Li et al. J Infect Dis Epidemiol 2020, 6:108

• Page 1 of 7 •

is recognized as a common cause of viral acute gastroenteritis in adults and children. Similarly, with other enteric pathogens, the main clinical symptoms of astrovirus are vomiting, diarrhea, abdominal cramps and nausea [2]. However, incubation period varies within those common enteric viruses and astrovirus is longest among them, for example, the median incubation period for astrovirus is 4.5 days, 1.2 days for norovirus genogroups I and II, 1.7 days for sapovirus, and 2.0 days for rotavirus [3]. Direct contact with vomits or feces of infected persons, sharing food, water, utensils, and contact with a contaminated environment are all possible routes of astrovirus transmission [4]. Among the 8 serotypes of astrovirus identified, serotype 1 is the predominant strain worldwide. In addition, the detection rate of astrovirus types 2 to 8 has increased by using newly developed assays [5].

Shenzhen is a coastal city in Guangdong province, southern China. As a fast-developing city, many migrant populations and their kids are living in Shenzhen. Since October 23, 2017, more than 20 students developed a sudden onset of vomiting and diarrhea from a private school. In order to identify the source of contamination and infection route, Shenzhen Bao'an Center for Disease Control and Prevention (CDC), jointly with Chinese field epidemiology training program (CFETP) conducted a retrospective cohort study to investigate the risk factors and implement control measures associated with this acute gastroenteritis outbreak.

Methods

Study setting

The school, located at Bao'an district of Shenzhen city, was a private school from the 1st to 9th grades with a total of 49 classes, 3053 students and 151 staff, including teachers, kitchen staff and cleaning staff. The school supplied meals and bottled drinking water for every staff that lived on the school campus. All the students lived nearby so no accommodation offered for them. The school had only 1 cafeteria in which 84 students had breakfast and 1292 students had lunch, and all staff had 3 meals. Epidemiologists visited the premises after the outbreak to review the kitchen facilities and preparation procedures. All the meals were cooked in the kitchen of the school cafeteria. The cafeteria provided freshly prepared and completely cooked meals every day for part of students and all teachers. The Shenzhen Food and Drug Administration (Shenzhen FDA) requires that school cafeterias keep a food sample for 48 hours in one fixed refrigerator for each meal and that raw foods be stored in another refrigerator in a separate room. Students and all staff had breakfast in the cafeteria, while lunch for students were delivered to their own classrooms. All foods were served as usual from October 23 to November 17. The school provided direct drinking water for all students, which located at the playground. A total of 13 classes consumed commercial bottled water manufactured by 7 commercial brands, while teachers consumed bottled water offered by school.

Epidemiological investigation

We designed a retrospective cohort study to investigate and analyze the potential transmission mode. In this outbreak, cases were classified as probable cases and laboratory-confirmed cases. Probable case was defined as the person who had ≥ 1 vomits or ≥ 3 loose stools within 24 hours in this school between October 23 and November 17, 2017 without laboratory confirmation of astrovirus infection. Confirmed case was defined as the persons with identified astrovirus in his or her stool or rectal swabs among probable cases. Carriers are those who have astrovirus in their stool or rectal swab specimen without presenting any symptoms during the study period. We searched for cases among all students and school staff based on gastrointestinal symptoms. A questionnaire was used to collect information for cases on demographic characteristics, symptoms, meals in the school cafeteria, sources of drinking water, history of contact with persons who had diarrhea and/or vomiting, exposure to environmental fomite and personal hygiene habits. The study was conducted according to the principles and guidelines of the Declaration of Helsinki.

Specimen collection

Stool specimens were collected from 25 patients within 3 days post symptoms onset, because stool shed more virus load than other specimen. Due to the potential role of cleaning staff in transmitting the intestinal virus, we collected 2 rectal swabs of cleaning staff who were mainly engaged in sweeping the toilet and environment during the field investigation, even though none of them had reported any similar symptoms. All samples were placed on ice and transported to Beijing CDC laboratory via bio-safety cycle boxes and transfer vehicles.

Laboratory examination

The common intestinal bacteria including *Escherichia coli*, *Salmonella*, *Shigella*, *Yersinia enterocolitica*, *Cholerae*, *Vibrio parahaemolyticus*, *Aeromonas hydrophila* and *Plesiomonas shigelloides* were identified via bacterial culture according to the technical procedures of diarrheal pathogenic spectrum surveillance formulated by the China Center for Disease Control and Prevention. The intestinal viruses including Rotavirus, Enteric adenovirus, Norovirus, Saporovirus and Astrovirus were detected using the real time reverse transcription PCR detection kits (Bioperfectus Ltd., Taizhou, CHN) according to the manufacturer's protocol. The QIAGEN One-Step RT-PCR Kit (QIAGEN, Hilden, Germany) was used to amplify the partial ORF2 gene of HAstV with primers Mon269 and Mon270 [6]. The PCR products were purified and sequenced directly on an ABI 3730xl DNA Ana-

lyzer using a BigDye Terminator v3.1 Cycle Sequencing Kit (ABI, Austin, TX, USA). The sequence was compared with reference strains in GenBank to determine the genotype using BLAST.

Statistical analysis

The distribution of major symptoms in students was summarized by frequency and percent. A retrospective cohort study was conducted to investigate possible risk factors for acute gastroenteritis among five classes with highest Attack Rates (AR). Overall attack rate was calculated using the number of cases divided by the total number of students in the school. To evaluate the risk factor on the route of transmission, relative risks (RRs), with the corresponding 95% confidence intervals (CIs), and Fisher's exact test were calculated. A P-value of < 0.05 was considered statistically significant.

Results

Descriptive epidemiology

A total of 98 cases developed gastrointestinal symptoms during this outbreak, and the attack rate was 3.2%. All cases were students and distributed across 9 grades and 31 classes (Figure 1), including 61 boys and 37 girls (male-to-female ratio = 1.65:1). The attack rate in students from each grade (elementary and middle school) was not statistically different (P = 0.07). The average age was 10-years-old (range 6-15 years-old). The main symptoms were vomiting

(69%), abdominal cramps (59%), nausea (47%), diarrhea (43%) and cough (38%) (Table 1). Most of these infections are short-lived, mild and remain largely unnoticed. Few of them went to the hospital, and no hospitalizations or deaths were reported. The first case developed gastrointestinal symptoms on Oct 23, 2017, with the main symptoms of vomiting more than 3 times a day. 4 days later, the first laboratory-confirmed case presented vomiting and diarrhea, which was suspected as the outbreak source of the first cluster of outbreaks due to his widely spread of vomits on the playground, classroom and corridors. Since Nov 1, 2017, cases emerged rapidly among the school and one family member of first laboratory-confirmed case developed gastrointestinal symptoms simultaneously. The number of new cases reached peak on

Table 1: Clinical symptoms of 98 clinical cases.

Symptom/sign	No. of cases (n = 98)	Proportion (%)
Vomiting	68	69
1time	28	41
2times	25	37
≥ 3times	15	22
Diarrhea	41	43
Bellyache	58	59
Nausea	46	47
Cough	37	38
Fever	11	11
Ventosity	12	12
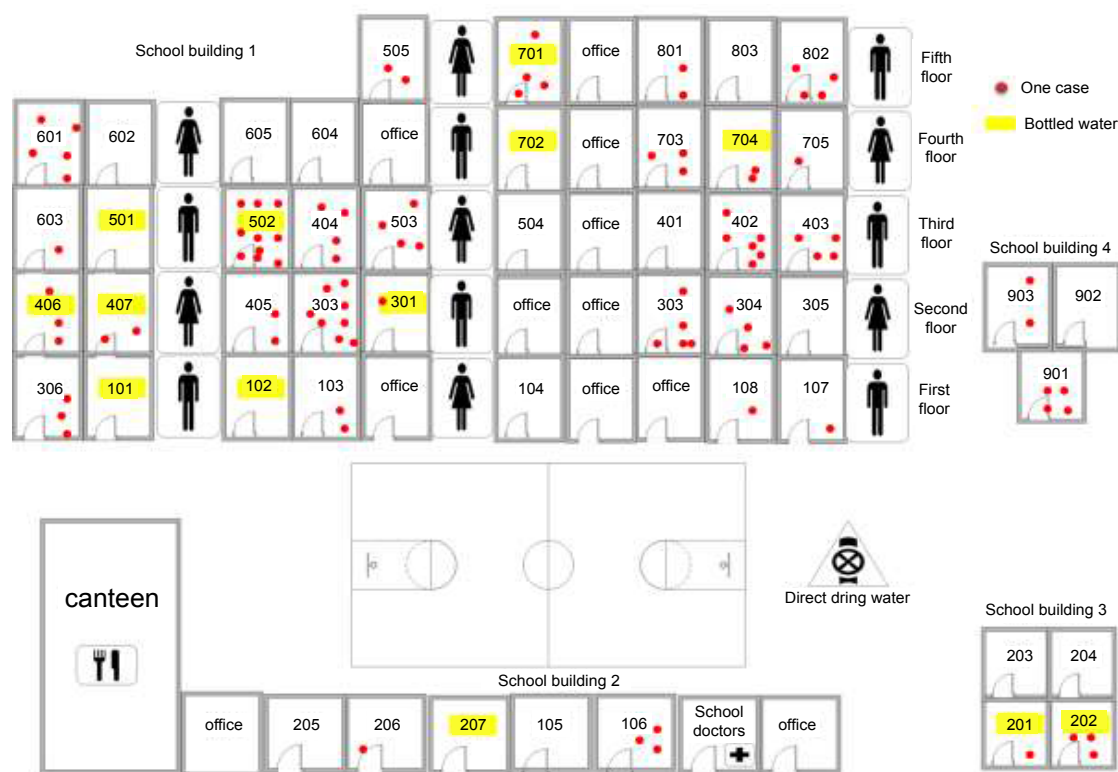
Note: The red dot represents for one case; the room number with yellow color means this classroom has commercial bottled drinking water.

Figure 1: Cases distribution among all classrooms in school compound.

Li et al. J Infect Dis Epidemiol 2020, 6:108
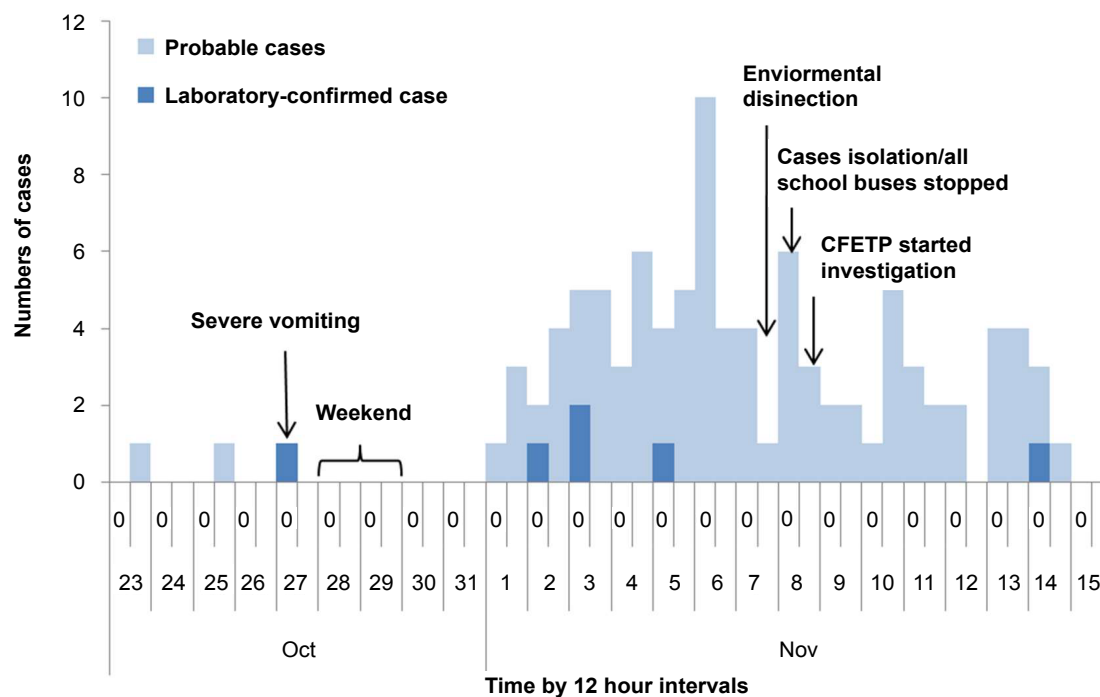
• Page 3 of 7 •

Figure 2: Cases of gastroenteritis by onset of illness during a school outbreak, 2017.

6-Nov (Figure 2). As of Nov 14, seven days after the control measures implementation, the last case appeared, and the outbreak terminated.

Cafeteria and drinking water investigation

We inspected the school's kitchen, pantry and dining hall and canteen. This school had 1 cafeteria providing various food for students and teachers, in which 13 employees working as kitchen staff. The environment at the canteen looked clean. The cafeteria was completely independent in both staff and food raw materials. No employee presented any symptom during this epidemic. The attack rate among those who took breakfast in the school canteen was not significantly different with those who took breakfast out of school (p = 0.3), while the pupils who took lunch in the school was less likely to get infected than those who took lunch out of school (p = 0.01).

We inspected their sources of cooking water and drinking water. Both were a public water source and were supplied as usual, during the epidemic, no community cases were reported. The mechanism of direct drinking water was adopting a physical filter which can exclude the macromolecule substance when water passed by. As we investigated, only 13% of cases consumed direct drinking water in this school. Moreover, student guardians from 13 classes invested separately to buy commercially-bottled water in the market for their kids; however, the brands were manufactured by as more as 7 companies. In conclusion, the attack rate among those classes who were supplied with barreled purified water had no difference with those who did not have in the classroom (p = 0.96).

Retrospective cohort study

Altogether, 5 classes with higher attack rate were selected for the retrospective cohort study. A total of 269 pupils have completed the questionnaire, among which there were 23 cases and 249 non-cases. Table 2 illustrated the univariate and multivariate analysis results. Astrovirus outbreak rates were found to differ: Drinking water from home was found to be related to decreased rates, while having breakfast outside of school, contacting with school cases, touching direct drinking water faucet were found to have an elevated astrovirus outbreak rate. Going to washroom more than 3 times per day was found to be marginally related to rates of outbreak. No difference was found in terms of seeing vomits nearby, having cleaned vomits before outbreak occurrence, washing hands thoroughly and commuting to school by school bus. In the multivariate analysis, contacting with school cases and touching direct drinking water faucet was still significantly related to increased astrovirus outbreak rates after adjusting for potential confounding factors (RR = 3.95, 95% CI: 2.18-5.58) (RR = 4.18, 95% CI: 1.50-8.37). And having Breakfast outside and drinking water from home were not statistically significant after adjusting for potential confounding factors.

Environmental survey

An environmental survey of the school compound was conducted to assess the general sanitation of the school. There were only 2 cleaning staff responsible for the sanitation and hygiene of school compound including the washrooms, corridors, playground, stairs, direct drinking water surfaces and waste bins. A total of 14 washrooms were provided for boys or

Table 2: Univariate and multivariate analysis of the relative risk of astrovirus during a school outbreak.

Risk factors	Exposed			Unexposed			Univariate analysis RR (95% CI)	Multivariate analysis RR (95% CI)
	total	cases	AR (%)	total	cases	AR (%)		
Contacting with school cases	32	9	28.1	237	14	5.9	6.23 (2.43-15.97)	3.95 (2.18-5.58)
Touching direct drinking water faucet	21	5	23.8	248	18	7.3	3.99 (1.31-12.15)	4.18 (1.50-8.37)
Having Breakfast from vendors	128	16	12.5	141	7	5.0	2.74 (1.09-6.89)	2.03 (0.81-4.58)
Water from home	189	12	6.3	80	11	13.8	0.43 (0.18-1.01)	0.43 (0.16-1.11)
Seeing vomits	36	5	13.9	233	18	7.7	1.92 (0.67-5.56)	
Cleaning vomits	4	1	25.0	264	21	8.0	3.86 (0.38-38.73)	
Went to toilet ≥ 3	74	10	13.5	192	13	6.8	2.15 (0.89-5.15)	
Washing hand thoroughly	116	9	7.8	150	14	9.3	0.82 (0.34-1.96)	
Catching school bus	47	3	6.4	221	20	9.0	0.69 (0.20-2.41)	

Table 3: Results of samples collection and detection.

No.	Type of samples	Samples origination	Date of onset	Date of resolution	Date of collecting sample	Duration of illness	Days between resolution to taking sample	Detection result
1	Stool	school cases	10/27	11/4	11/16	8	12	astrovirus
2	Stool	school cases	11/14	11/15	11/16	1	1	astrovirus
3	Stool	school cases	11/3	11/5	11/16	2	11	astrovirus
4	Stool	school cases	11/2	11/5	11/10	3	5	astrovirus
5	Stool	school cases	11/3	11/7	11/16	4	9	astrovirus
6	Rectal swab	school cases	11/5	11/8	11/10	3	2	astrovirus
7	Rectal swab	asymptomatic staff	-#	-	11/17	-	-	astrovirus
8	Stool	school cases	11/4	11/8	11/10	4	2	sapovirus

#Clean staff is asymptomatic, date of illness is not applicable.

girls on the school. Each washroom merely had one water faucet for washing hand, thus the lack of hand washing facilities and washrooms was a serious problem in this school. Based on the observation, cleaning staff used same towel and gloves to sweep and disinfect toilet surface, waste bin and direct drinking water faucets. Sometimes, the cleaning staff swept the toilet floor by using classroom floorcloth which was nearby, without washing and disinfection.

Laboratory tests

A total of 7 samples were tested positive for astrovirus using real time RT-PCR including 2 rectal swabs and 5 stool specimens. Of the 7 positive rectal swabs and stool specimens, 6 were from student cases and 1 from asymptomatic cleaning staff who did not report any clinical symptoms. In addition, another 1 stool sample from a school case was detected sapovirus positive as Table 3 shows. All specimens were tested negative for other bacterial and viral pathogens. In conclusion, the causing pathogen associated with this outbreak was found to be astrovirus type 4 strain which was rarely reported worldwide. Days between resolution to taking sample were ranged from 1 to 12 days, while the first laboratory-confirmed case was the person who shedding virus as long as 12 days since all the symptoms released.

Control measures

To control the outbreak, the Bao'an CDC used immediate control measures as soon as the epidemiological survey initiated on Nov 7, 2017, including environment disinfection, case isolation, school bus closure and hand hygiene enforcement. Since then, the classrooms and pubic areas were disinfected by local health department every day until outbreak suspended. Ill students were excluded at least 3 days since the date of onset, and chemical disinfection for hand hygiene were available in classrooms and washrooms, which was a central approach to interrupt the chain of astrovirus transmission. All those comprehensive control measures worked efficiently as no more case reported after Nov 14, 2017.

Discussion

Acute gastroenteritis is an important public health issue in children worldwide [7]. Recent studies have shown that among pathogens causing viral gastroenteritis, astrovirus was the third most common viral cause of acute gastroenteritis outbreaks in North Carolina from 2005-2007 and of sporadic cases in children in China through 1998 to 2005, following rotavirus and calicivirus [8]. 25% of children experienced astrovirus infections and the prevalence of

astrovirus in diarrheal stools was 5.6% according to a multiple-country study [9]. As previous research revealed, that the classic human astrovirus is highly diverse and consists of eight genotypes (genotype 1-8), while genotype 1 was the most prevalent genotype globally. But in China, astrovirus outbreak were rarely reported to date. According to published literature, only 2 kindergartens, 1 school and 1 hospital from 4 provinces have reported astrovirus outbreaks in China before 2017. Of those 4 outbreaks, 2 of them were caused by astrovirus genotype 1 based on further sequencing [10-13]. However, our study has detected genotype 4, the causative serotype, which has triggered this public health emergency. Our study added valuable understanding and knowledge for realizing astrovirus serotype 4.

This event found one case shed virus as long as 12 days since his symptoms free. According to a retrospective study conducted in USA, a subset of cases is associated with long-term virus shedding (range 17–183 days) [14]. Long shedding period of astrovirus is a big challenge for prevention and control of outbreaks. Based on epidemiological investigation, the transmission mode of this outbreak was multiple routes including environment contamination and person to person transmission, while foodborne and waterborne transmission were basically excluded. Previous studies have found that astrovirus can persist for approximately 2 months on contaminated surfaces and poor hygiene conditions, which contributed to the spread of astrovirus in the environment, therefore, in our study the asymptomatic cleaning staff may got infected when he touched the contaminated surfaces directly [15].

This outbreak setting was an elementary school, combined with middle school, which was one of the most frequent settings associated with astrovirus outbreaks [16,17]. After environment inspection, some factors were found by investigators: 1) this school did not provide enough hand washing facilities and direct drinking water vessels for students. Some students were observed to drink water by dirty hands. 2) It was not safe that the main waste bins were near the direct drinking water which is not accordance with the principle that waste bins should be in a secure area away from water and students' play areas. 3) limited labor source for cleaning staff and low level of environment hygiene requirements posed this school a big threat to enteric disease spreading. Only two cleaning staff dealt with their work roughly. Based on our observation, they used the same towels and gloves to sweep washroom and direct drinking water faucets, which was demonstrated by our epidemiological findings that touching the handles of faucet was a risk factor in infecting astrovirus.

Like other enteric virus, astrovirus mainly transmits through fecal to oral route. Under poor sanitation, astrovirus can be infected by person to person transmission and touching the contaminated environment surface. In China, astrovirus is belong to Other Infectious Diarrheal Diseases which is a type of syndrome surveillance. Other infectious diarrhea disease is defined as infectious diarrhea other than cholera, dysentery, typhoid and paratyphoid and belongs to category C notifiable disease. Due to low awareness and lack of laboratory testing, astrovirus is rarely reported to national surveillance system. In conclusion, our study recommends that surveillance for astrovirus should be strengthened by laboratory testing after other common pathogens are ruled out in the future. Continuous monitoring the circulating strains of astrovirus outbreak is also important.

Our study has several limitations. First, the outbreak characteristics were highly presumptive of contaminated environment transmission, but this was not confirmed through detection of astrovirus in implicated high-touch items, for example direct drinking water faucets, door handles, gloves or towels. Second, recall bias was difficult to avoid in this research since the young pupils were lack of communication and understanding ability, for example, they hardly remember the details about duration of onset, risk factors and behavior history when the investigator asked them questions.

Conclusions

This outbreak was caused by astrovirus serotype 4 which was rarely reported. The main exposure mode was likely person to person and touching a contaminated water faucet. Recommendations included immediate isolation of cases, disinfecting drinking water faucet daily, proper handling of vomits and training in good hand washing for students and teachers. Surveillance for astrovirus should be strengthened by laboratory testing after other common pathogens are ruled out. Continuous monitoring the circulating strains of astrovirus outbreak in China is also important.

Potential Conflicts of Interest

We declare that we have no conflicts of interest.

Ethical Approval

Ethical approval was not required for this study because the project involved data routinely collected for public health purpose. The research was carried out in compliance with the Helsinki Declaration.

References

1. Glass RI, Noel J, Mitchell D, Herrmann JE, Blacklow NR, et al. (1996) The changing epidemiology of astrovirus-associated gastroenteritis: A review. Arch Virol Suppl 12: 287-300.

2. Vu DL, Cordey S, Brito F, Kaiser L (2016) Novel human astroviruses: Novel human diseases? J Clin Virol 82: 56-63.

Li et al. J Infect Dis Epidemiol 2020, 6:108

• Page 6 of 7 •

3. Lee RM, Lessler J, Lee RA, Rudolph KE, Reich NG, et al. (2013) Incubation periods of viral gastroenteritis: A systematic review. BMC Infect Dis 13: 446.

4. Bosch A, Pinto RM, Guix S (2014) Human astroviruses. Clin Microbiol Rev 27: 1048-1074.

5. Vu DL, Bosch A, Pinto RM, Guix S (2017) Epidemiology of classic and novel human astrovirus: Gastroenteritis and beyond. Viruses 9: 33.

6. Noel JS, Lee TW, Kurtz JB, Glass RI, Monroe SS (1995) Typing of human astroviruses from clinical isolates by enzyme immunoassay and nucleotide sequencing. J Clin Microbiol 33: 797-801.

7. Walker CLF, Rudan I, Liu L, Nair H, Theodoratou E, et al. (2013) Global burden of childhood pneumonia and diarrhoea. Lancet 381: 1405-1416.

8. Fang ZY, Sun YP, Ye XH, Wang H, Zhang Q, et al. (2006) Astrovirus infection among hospitalized children with acute diarrhea in seven regions of China, 1998-2005. Zhonghua Liu Xing Bing Xue Za Zhi 27: 673-676.

9. Olortegui MP, Rouhani S, Yori PP, Salas MS, Trigoso DR, et al. (2018) Astrovirus infection and diarrhea in 8 Countries. Pediatrics 141.

10. Li CY, Liu N, Guo WD, Yu Q, Wang WR, et al. (2010) Outbreak of neonatal gastroenteritis associated with astrovirus serotype 1 at a hospital in Inner Mongolia, China. J Clin Microbiol 48: 4306-4309.

11. Wang X, Wang J, Zhou C, Yang S, Shen Q, et al. (2016) Viral metagenomics of fecal samples from non-human primates revealed human astrovirus in a chimpanzee, China. Gut Pathog 8: 53.

12. Zhou N, Lin X, Wang S, Wang H, Li W, et al. (2014) Environmental surveillance for human astrovirus in Shandong Province, China in 2013. Sci Rep 4: 7539.

13. Marshall JA, Bruggink LD, Sturge K, Subasinghe N, Tan A, et al. (2007) Molecular features of astrovirus associated with a gastroenteritis outbreak in an aged-care centre. Eur J Clin Microbiol Infect Dis 26: 67-71.

14. Cortez V, Freiden P, Gu Z, Adderson E, Hayden R, et al. (2017) Persistent infections with diverse co-circulating astroviruses in pediatric oncology patients, Memphis, Tennessee, USA. Emerg Infect Dis 23: 288-290.

15. Abad FX, Villena C, Guix S, Caballero S, Pinto RM, et al. (2001) Potential role of fomites in the vehicular transmission of human astroviruses. Appl Environ Microbiol 67: 3904-3907.

16. Gabbay YB, Chamone CB, Nakamura LS, Oliveira DS, Abreu SF, et al. (2006) Characterization of an astrovirus genotype 2 strain causing an extensive outbreak of gastroenteritis among Maxakali Indians, Southeast Brazil. J Clin Virol 37: 287-292.

17. Thongprachum A, Khamrin P, Maneekarn N, Hayakawa S, Ushijima H (2016) Epidemiology of gastroenteritis viruses in Japan: Prevalence, seasonality, and outbreak. J Med Virol 88: 551-570.

Li et al. J Infect Dis Epidemiol 2020, 6:108

• Page 7 of 7 •