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An Investigation of a Bacillary Dysentery Outbreak in an Elementary School in Kuanmiao Township, Tainan County

Abstract

An epidemiological study was conducted to investigate the scope, the mode of transmission, and the likely risk factors of an outbreak of bacillary dysentery in Kuanmiao elementary school, Tainan County. A total of 28 students met the case definition of bacillary dysentery, giving an overall attack rate of 3.3%. The results of analysis of risk factors, inspection of school water supply, kitchen sanitary, and process of lunch food preparation showed that both contaminated water and school lunch were not associated with the outbreak of bacillary dysentery in Kuanmiao elementary school. Since all 28 cases could be linked in terms of person (schoolmates, relatives), time (sequences of dates of onset), and place (location of classrooms, residences), the route of transmission of the outbreak was believed to be the person-to-person contact.

Introduction

Generally speaking, bacillary dysentery (Shigellosis) is a highly

contagious disease of human involving the large and small intestines. The genus *Shigella* is comprised of four serogroups, Group A, *S. dysenteriae*, Group B, *S. flexneri*, Group C, *S. boydii*, and Group D, *S. sonnei*. Both *S. flexneri, S. boydii* and *S. dysenteriae* are more prevalent in developing countries; *S. sonnei* is most common and *S. dysenteriae* is least common in developed countries[1-3]. They usually induce major symptoms such as: diarrhea, fever, abdominal pain, nausea, vomiting, and tenesmus. These symptoms last for 3-5 days, sometimes a week[4]. The incubation period of shigellosis is 1-3 days. Bacillary dysentery is characterized by its transmission through person-to-person contact and infection caused by relatively small amount of pathogens. In young children and persons of poorer hygiene, infection is easily caused by fecal-mouth transmission. Symptoms in most cases are mild and transmission continues[5]. In Taiwan, most bacillary dysentery outbreaks are caused primarily by *S. flexneri* and *S. sonnei*[6-10].

The Center for Disease Control (CDC) received a report from the Tainan County Health Bureau for two suspected cases of bacillary dysentery on October 3, 2002. One of the cases was reported by a hospital in Taoyuan County showing symptoms such as abdominal pain, watery and mucous diarrhea, and fever. The other case was reported by a hospital in Tainan City showing symptoms such as vomiting, diarrhea and fever. Since both cases were the first grade students of the Kuanmiao elementary school, occurrence of a school outbreak of bacillary dysentery was then suspected.

To control and prevent further infection of bacillary dysentery, the Tainan County Health Bureau, the Kuanmiao Health Station, and the Fourth Branch Bureau of the Center for Disease Control dispatched a team of disease control workers on October 3 to the Kuanmiao elementary school for specimen

collection, disinfection, and health education. On October 6, the laboratory testing confirmed that the first reported case was *S. sonnei* positive. Subsequently, eight more *S. sonnei* positive cases were identified on October 8. Because the outbreak had never been happened at this school in the past years, members of the Field Epidemiology Training Program (FETP) of the Center for Disease Control started a field investigation for the purpose of searching possible cases, route of transmission, and the likely risk factors. The presented paper reported the results of the field investigation.

Materials and Method

Study subjects and school environment

The school had 28 classes with 902 students, 50 teachers, 4 cooks, 4 janitors, 5 teachers under internship, and 1 guard. They were all included in this investigation. The school environment was clean and tidy, and was kept away from other buildings by fences. Both underground and tap water were used. The underground water was used for hand washing, flowers watering, and toilet flushing. Tap water was used mainly for cooking and drinking. The structure of the school is shown in Figure 1.

Study Period

The field investigation began on September 10 and finished by October 10, 2002.

Health and Leave Records

The number of students cared for at the health center of the school and the daily number of students who took sick leave for fever, abdominal pain, diarrhea, nausea, and vomiting were carefully reviewed.

Questionnaire Interview

A semi-structured questionnaire was administered to all teachers,

employees, and students of the school. It included questions on demographic background, onset date of illness, time of onset, symptoms, clinical history, health conditions of family members, attendance of after-school classes, and others.

Case Definition

During the month of September 10 and October 10, 2002, any students of the Kuanmiao elementary school who appeared two and more times of diarrhea daily, one of the following symptoms, fever, vomiting, abdominal pain, and tenesmus, and had the *S. sonnei* positive results of his or her rectal swab specimen was defined as a confirmed case.

Within the same period of time, any students of the Kuanmiao elementary school who showed above similar symptoms, but *S. sonnei* was not isolated from his or her rectal swab specimen, was defined as a suspected case.

Specimen Collection

Rectal swab specimens were collected from suspected cases and whoever contacted with confirmed cases in the school, or in the after-school classes, or at the family. In addition, specimens of both tap water and underground water were collected from hand washing stands, water towers, underground water pools, and after-schools. Drinking water from school, students' home, and the after-school classes were also collected. Furthermore, environment specimens were collected from faucets of hand washing stands and doorknobs of toilet rooms.

Laboratory Testing

All rectal swab specimens were contained in the Cary-Blair culture media or buffered glycerol saline and sent to the CDC laboratory.

According to the standard operational procedures of the laboratory testing for *S. sonnei*, the specimens were placed on the HE, SS, DHL, or XLD media under 37℃ for 18-24 hours. At least five suspected colonies (dark green colonies on the HE plate media or red transparent colonies on the XLD media) were picked up and inoculated on assessment media TSI, SIM, LIM, Urea, Citrate, and VP under 37℃ for 18-24 hours. Biochemical reactions of typical bacillary dysentery bacilli are Alk/A (TSI), Gas (-), H2S (-), VP (-), Citrate (-), Motility (-), Lysine (-), and Urea (-). Serotypes and subtypes were determined by serological methods. Same testing procedures for rectal swab specimens were applied to environment specimens.

Each 1,000 ml of water specimen was divided into three parts of 400 ml, 400 ml, and 200 ml. The two 400 ml specimens were first filtered through a 0.2 μm filter membrane. The filtrate was then placed in HE, SS, DHL, or XLD media for isolation of pathogens. The 200 ml specimen was used for the testing of *E. coli*[11].

Data Processing and Analysis

Data collected by the questionnaire were processed, verified, described, and analyzed with Epi-info 2000 software. In order to identify sources of infection and routes of transmission, the EXCEL® software was used to draw a dot map showing cases' distribution and an epidemiological curve indicating onset dates of bacillary dysentery.

Control Measures

Health education: Talks on bacillary dysentery, its route of transmission, and control measures were offered to the teachers, employees, and students of the school. School teachers were asked to supervise students to wash hands with soap. Posters and other educational materials

were distributed to the school, the after-school classes, and medical care institutions.

Disease surveillance and reporting: The school nurse was asked to watch for the health conditions of each teacher and student of the school. The Kuanmiao Health Station also conducted surveillance of bacillary dysentery in the ten neighbor medical institutions. Any suspected cases were reported and their specimens were collected for laboratory testing.

Disinfection of environment: Lysol and bleaching powder were distributed to the school, the after-school classes, and families of suspected cases for the disinfection of environment. The janitors regularly disinfected toilets and doorknobs with bleaching powder to interrupt the transmission of infection.

Medical care of cases and follow-up: *S. sonnei* positive cases were referred to hospitals for medical care. They were followed up for their treatment and laboratory testing.

Results

Analysis of Questionnaire Data

A total of 876 copies of the questionnaire had been collected from all students, giving a collection rate of 97.1% (876/902). Of them, 34 copies were found invalid. Analysis was made according to the 842 valid copies (Table 1). Sixteen male and 12 female students met the case definition of bacillary dysentery, giving an attack rate of 3.3% (28/842). Grade-specific attack rates were estimated as following: 7.6% for the first grade, 2.3% for the second grade, 4.2% for the third grade, 1.9% for the fourth grade, 0.0% for the fifth grade, and 3.9% for the sixth grade (Table 1). The first grade had the highest attack rate and the fifth grade found no cases. Sex was not found significantly associated with the infection ($p > 0.05$). Major

symptoms of the 28 cases included diarrhea (96.4%), vomiting (53.6%), fever (50.0%), abdominal pain (50.0%), tenesmus (21.4%), cramps (7.1%), and weakness (7.1%). Cases were distributed in 13 classes, indicating a possible route of person-to-person transmission. The epidemiological curve of onset dates of bacillary dysentery showed an initial slow upward and later slow downward trend, also suggesting a chain of contact infection. In addition, this curve demonstrated that the first case appeared on September 15; the infection reached a peak on September 28; and the last case appeared on October 6.

The results of risk factors analysis (Table 2) showed that drinking from water fountains, drinking from washing stands, brushing teeth or mouth rinsing with water from the washing stands were not significantly related to infection of *S. sonnei* respectively (all 95% confidence limits included 1.0). Washing face with water from the washing stands, washing hands after toilet use, using water from the washing stands for cleaning up the environment, and watering flowers were also not significantly associated with the infection of *S. Sonnei* individually (all 95% confidence limits included 1.0). In addition, eating at night market, eating at food stands around the school or houses, and eating in restaurants after September 10 had no significant relationship with infection of *S. Sonnei* separately (all 95% confidence limits included 1.0). Attending after-school classes was also found no significant association with the infection of *S. Sonnei* (1.0 was included in the 95% confidence limit).

Environment Inspection

The underground water was pumped up from 45 meter deep well by a generator to a water pool. The well water was treated with an osmosis process before use. Water towers of both the tap and underground water were located on top of the school buildings. Pipes had been repaired several times. Each washing stand had one faucet for tap water and

several faucets for underground water.

Tap water of six faucets was tested on October 7 and residual chlorine was ranged 0.2 – 0.4 ppm. Water from the washing stands (only tap water was in use) was retested on October 8, the residual chlorine in one faucet was 0.05 ppm and in all other faucets 0.3 ppm. The water coming out of this particular faucet was underground water. The water pool was disinfected with the blench power. The residual chlorine of water coming out from all faucets was found 0.3 ppm on the test of October 9.

Records of the monthly consumption of tap water showed an average consumption of 200 degrees (range: 34 to 232 degrees). This consumption was considered unreasonable for a school population of 900 persons. It was suspected that underground water was used more often. In addition, the school offers teachers and students lunch every day. The school kitchen has four cooks and was located on the left side of the building. No refrigerators found in the kitchen. The kitchen prepared all foods for the daily lunch consumption. Food materials needed to prepare for lunch were delivered to school around 7:30 and 8:00 in the morning, then washed and processed. Foods were, after cooking, distributed in containers to each class. The lunch served in September and October all hot meals. No cooks met the definition of cases.

Laboratory Testing

The findings of laboratory testing for collected specimens are shown in Table 3. Of the 1,076 rectal swabs collected, *S. sonnei* was isolated in 10 specimens (9 from school children and 1 from a family member). Of the 83 water specimens collected, *coli* form was isolated in 5 specimens (two from the underground water in the water pool, two from the drinking water of the kindergarten where the two *S. sonnei* positive students attended,

and one from the tap water of the house of a *S. sonnei* positive case), but no *S. sonnei* was isolated. Of the 14 environment specimens collected, none was isolated *S. sonnei*.

Discussion and conclusion

In the present outbreak of bacillary dysentery, 28 cases met the cases definition of bacillary dysentery, giving an attack rate of 3.3%. Of them, nine were *S. sonnei* positive cases. Both the class location of cases in the school (dot map, Figure 1) and the disease onset date of cases (epidemiology curve, Figure 2) indicated a likely person-to-person transmission route. The bacillary dysentery can be transmitted mainly by contaminated food[12]; by flies[6]; by hands[2, 5, 8, 14]; and by water[5, 8-10, 12-16]. Direct or indirect fecal-mouth transmission occurs more often. An intake of a mere 10-100 *S. sonnei* is enough to cause the bacillary dysentery[17].

In the present investigation, both the kitchen and the dining room were found clean and tidy. Cooks wore hats, gauze masks and gloves when preparing foods. The foods supplied were well cooked. Foods were distributed to classes in covered containers. Each school member had his/her own eating chopsticks or spoons. No fruit was supplied. No flies were detected. In addition, the results of risk factors analysis showed that eating at night market, eating at food stands around the school or houses, and eating in restaurants after September 10 had no significant relationship with infection of *S. Sonnei*. Therefore, transmission of bacillary dysentery either by contaminated foods or flies was not likely to be happened.

Risk factors associated with water exposure such as drinking, or brushing teeth, or mouth rinsing, or washing face with water from water fountains, drinking from washing stands, washing hands after toilet use, using water from the washing stands for cleaning up the environment, and watering

flowers were also not significantly associated with the infection of *S. Sonnei*. If water was the source of infection, above water related activities would have increased the number of bacillary dysentery cases sharply, and the attack rate would have been higher. The attack rate found in the present outbreak was relatively low, about 3.3%. Hence, water can not be thought as the source and route of transmission.

Since both contaminated water and food were not associated with the incident of bacillary dysentery, we need to examine the evidence for supporting the route of person-to-person transmission. The outbreak lasted for 22 days from the first case on September 15 to the last case on October 6 (Figure 2). During this period, the epidemiological (person-time-location) link among 28 cases of bacillary dysentery, as shown in Figure 3, can be identified. Figure 3 showed that the classroom of the first case (3A) was next to the classrooms of 3D (with three cases) and 3C (with two cases). They shared the same washing stands and toilet facilities. The younger brother of the first case was in 2D. Classes of 2D, 2A and 1D shared the same washing stands and toilet facilities. Classrooms of 2A and 1D were next to each other. One case in 3D was sister of a case in 4D. Classes of 4D, 4A, 6C, 6B, and 6A shared the same washing stands and toilet facilities. One case in 4A attended the same after-school class A with one case in 1B. Another case in 6B attended the same after-school class B with one case in 1B. Classrooms of 1B and 1A were next to each other and shared the same washing stands and toilet facilities. Class 1B was one floor below Class 3A where cases were found earlier. A case mother was detected *S. sonnei* positive six days after her son became ill. These facts explained the person-time-location relationship in epidemiology. The mode of transmission of the present outbreak was therefore considered

to be a chain transmission of person-to-person contact.

The *coli* form was detected in two specimens collected from the underground water pool of the school out of 83 water specimens collected from all sources. Although water was not the cause of the outbreak, the use of underground water should have some negative impact on the health of the school children. The school was advised, by regulations, to use tap water for all purposes. The school has, ever since, re-installed water pipes and stopped using underground water.

Interviews of doctors attending to the cases in two hospitals and two clinics found that cases were initially diagnosed as common cold complicated with rotavirus infection and acute gastroenteritis. Their symptoms lasted for 2-3 days. Symptoms of infections caused by *S. sonnei* are the mildest in all dysentery infections, doctors often overlook them. Continuing education for doctors in this regard is considered necessary.

Of 1,076 rectal swab specimens collected, *S. sonnei* was only isolated in ten. This was not cost-effective. The reason that specimens were collected from all members of the school was that there had never been such outbreaks in this area in the past ten some years. The pressure of the mass media made the local education authorities and the school to request the health bureau to screen all likely contacts. Laboratory testing found, however, confirmed cases in only nine school children and one family member. This practice was considered not cost-effective in disease control.

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References

1. Nebraska Department of Health and Human Services. Shigella Fact Sheet. http://www.hhs.state.ne.us/epi/epishig.htm.
2. Rosenberg T, Kendall O, Blanchard J, et al., Shigellosis on Indian reserves in Manitoba, Canada: Its relationship to crowded housing, lack of running water and inadequate sewage disposal. Am J Pub H 1997; 87(9): 1547-1551.
3. CDC. *Shigella sonnei* outbreak associated with contaminated drinking water – Island Park, Idaho, August 1995. MMWR 1996; 45(11): 229-231.
4. Center for Disease Control, DOH. Bacillary Dysentery. Manual for the Control of Communicable Diseases 2001: 1-10.
5. Mohle-Boetani J, Stapleton M, Finger R, et al., Community with Shigellosis: Control of an outbreak and risk factors in child day-care centers. Am J Pub H 1995; 86(5): 812-816.
6. Pan TM. Epidemiologic trends of dysentery and its prevention. Epidemiology Bulletin 1996; 12: 212-219.
7. Pan TM. Wang TK, Lai MH, et al., Bacillary dysentery infections in

Taiwan, 1995-1996. Epidemiology Bulletin 1997; 13: 267-278.
8. Chiu JP, Wei HF, Chen KT, et al., A preliminary report of a dysentery outbreak in a primary school in Taichung City. Epidemiology Bulletin 1994; 10: 75-88.
9. Kao ST, Chao TY, Chen KT, et al., Investigation of risk factors of a bacillary dysentery outbreak in a primary school in Taoyuan County. Epidemiology Bulletin 1997; 13: 1-15.
10. Lu KL, Chiang TH, Pan TM, et al., A bacillary dysentery outbreak in a primary school in Kuanhsi Township, Hsinchu County. Epidemiology Bulletin 1998; 14: 147-157.
11. Center for Disease Control, DOH. Isolation and Assessment of Dysentery Bacilli. Manual of the Standard Operational Procedures of Laboratory Testing for Disease Control 2001: 27-30.
12. CDC. Outbreaks of Shigella sonnei infections associated with eating fresh parsley – United States and Canada, 1998. MMWR 1999; 48(14): 285-288.
13. Chen KT, Chen CJ, Chiu JP. A school waterborne outbreak involving both Shigella sonnei and Entamoeba histolytica. J Environ Health 2001; 64(4): 9-13.
14. Klausner JD, Aragon T, Enanoria WTA, et al., Shigella sonnei outbreak among men who have sex with men – San Francisco, California, 2000-2001. JAMA 2002; 287(1): 37-38.
15. CDC. Outbreak of gastroenteritis associated with an interactive water fountain at a beachside park – Florida, 1999. MMWR 2000; 49(25): 565-568.
16. Keene William E, McAnulty Jeremy M, Hoesly Frederick C, et al., A swimming-associated outbreak of hemorrhagic colitis caused by Escherichia coli O157:H7 and Shigella sonnei. N Engl J Med 1994; 331(9): 579-584.
17. Ko CH, Chang SC, et al., Bacillary dysentery. Contemporary Medicine 1999; 26(2): 134-135.

Table 1. Frequency and Attack Rates of Bacillary Dysentery Cases by Grade and Class

Grade	Class	No. of Students	No. of Valid Questionnaire	No. of Cases	Attack Rate (%)
1st	A	34	34	4	11.8
	B	33	32	5	15.6
	C	37	31	0	0.0
	D	37	34	1	2.9
	Subtotal	141	131	10	7.6
2nd	A	29	26	1	3.8
	B	29	25	0	0.0
	C	29	29	2	6.9
	D	29	24	0	0.0
	E	30	24	0	0.0
	Subtotal	146	128	3	2.3
3rd	A	33	30	1	3.3
	B	30	24	0	0.0
	C	31	29	2	6.9
	D	29	31	3	9.7
	E	30	29	0	0.0
	Subtotal	153	143	6	4.2
4th	A	34	33	1	3.0
	B	34	33	0	0.0
	C	34	30	0	0.0
	D	32	31	2	6.5
	E	35	31	0	0.0
	Subtotal	169	158	3	1.9

Table 1. Frequency and Attack Rates of Bacillary Dysentery Cases by Grade and Class（Continued）

Grade	Class	No. of Students	No. of Valid Questionnaire	No. of Cases	Attack Rate (%)
5th	A	33	32	0	0.0
	B	32	29	0	0.0
	C	34	31	0	0.0
	D	34	34	0	0.0
	Subtotal	133	126	0	0.0
6th	A	33	32	1	3.1
	B	29	29	1	3.4
	C	35	34	4	11.8
	D	32	32	0	0.0
	E	31	29	0	0.0
	Subtotal	160	156	6	3.8
Total		902	842	28	3.3

Table 2. Results of Risk Factors Analysis for Bacillary Dysentery Outbreak in Kuanmiao Elementary School

Risk Factors	Cases (N=28)		Controls (N=814)		Odds Ratios	95% CL
Drinking water in school						
a. water fountain	4	14.3%	200	24.6%	0.59	0.25-1.33
b. washing stands	0	0.0%	2	0.2%	0.00	0.00-160.94
c. brought from home	19	67.8%	560	68.8%	1.00	
d.others	1	3.6%	38	4.7%		
No answer *	4	14.3%	14	1.7%		
Tooth brushing and mouth rinsing						
a. regularly	11	39.3%	256	31.4%	2.32	0.73-8.63
b.sometimes	6	21.4%	155	19.0%	2.09	0.52-8.79
c.rarely	3	10.7%	126	15.5%	1.29	0.20-6.72
d.never	5	17.9%	270	33.2%	1.00	
No answer *	3	10.7%	7	0.9%		
Washing face with water from washing stands						
a. regularly	6	21.3%	190	23.3%	1.64	0.41-6.87
b.sometimes	7	25.0%	202	24.8%	1.80	0.48-7.27
c.rarely	5	17.9%	146	17.9%	1.77	0.40-7.83
d.never	5	17.9%	259	31.8%	1.00	
No answer *	5	17.9%	17	2.2%		
Washing hands after toilet use						
a. regularly	18	64.3%	735	90.3%	0.07	0.01-4.07
b.sometimes	5	17.8%	47	5.8%	0.32	0.02-20.07
c.rarely	0	0.0%	15	1.8%	0.00	0.00-10.40
d.never	1	3.6%	3	0.5%	1.00	
No answer *	4	14.3%	14	1.6%		

Table 2. Results of Risk Factors Analysis for Bacillary Dysentery Outbreak in Kuanmiao Elementary School（Continued）

Risk Factors	Cases (N=28)		Controls (N=814)		Odds Ratios	95% CL
Cleaning up environment with water from washing stands						
a.yes	11	39.3%	271	33.3%	1.46	0.59-3.52
b.no	14	50.0%	505	62.0%	1.00	
No answer *	3	10.7%	38	4.7%		
Watering flowers with water from washing stands						
a.yes	17	60.7%	485	59.6%	1.64	0.61-5.12
b.no	6	21.4%	280	34.4%	1.00	
No answer *	5	17.9%	49	6.0%		
Attending after-school classes						
a.yes	6	21.4%	210	25.8%	0.84	0.34-2.06
b.no	20	71.4%	584	71.7%	1.00	
No answer *	2	7.2%	20	2.5%		
Eating at night markets after Sept. 10						
a.yes	9	32.1%	283	34.8%	0.88	0.35-2.07
b.no	19	67.9%	525	64.5%	1.00	
No answer *	0	0.0%	6	0.7%		
Eating at food stands around school after Sept. 10						
a.yes	27	96.4%	715	87.8%	3.51	0.00-145.31
b.no	1	3.6%	93	11.4%	1.00	
No answer *	0	0.0%	6	0.9%		
Eating at food stands around house after Sept. 10						
a.yes	22	78.6%	600	73.7%	1.27	0.49-3.88
b.no	6	21.4%	208	25.6%	1.00	
No answer *	0	0.0%	6	0.7%		

Table 2. Results of Risk Factors Analysis for Bacillary Dysentery Outbreak in Kuanmiao Elementary School（Continued）

Risk Factors	Cases (N=28)		Controls (N=814)		Odds Ratios	95% CL
Eating in restaurant after Sept. 10						
a.yes	25	89.3%	655	80.5%	1.95	0.58-10.19
b.no	3	10.7%	153	18.8%	1.00	
No answer *	0	0.0%	6	0.7%		

Note：CL; confidence limit; sometimes: less than three days a week; rarely: several times a month.

* not included in analysis

Table 3. Findings of Laboratory Testing for Bacillary Dysentery Outbreak in Kuanmiao Elementary School

Collection Date	Humans Specimens			Water Specimens				Total
	No.	No. in After-school Class	No. of Contacts (families)	Tap Water	Under-ground Water	Drink-ing Water	Enviro nment Speci-mens	
91/10/4	73(9)	2	11(1)	9	3	3	6	107(10)
91/10/7	1	185	43	10	4	8		251
91/10/8	40		36	6	2	6	8	98
91/10/9	99		35	2				136
91/10/11	535		16	20		10		581
Total	748(9)	187	141(1)	47	9	27	14	1,173(10)

Note: a figure in parentheses indicates the number of *S. sonnei* positive.