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BRIEF REPORT

Trends in Water- and Foodborne Disease Outbreaks in Korea, 2007—2009

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Abstract
Objectives
In Korea, every outbreak of acute gastroenteritis in two or more patients who are epidemiologically related is investigated by local public health centres to determine causative agents and control the outbreak with the support of the Korean Centers for Disease Control and Prevention. The findings and conclusions of each outbreak investigation have been summarized annually since 2007 to make reports and statistics of water- and foodborne disease outbreaks.
Methods
All outbreaks reported to Korean Centers for Disease Control and Prevention from 2007 to 2009 were included in the study. We analysed the trends and epidemiologic aspects of outbreaks by month, year, and location.
Results
The total number of outbreaks decreased steadily each year for the period the study covered, whereas the number of patients per outbreak continued to increase resulting from a dramatic increase in the number of patients per outbreak in food service establishments. The outbreaks occurred in the period of June to September, when temperature and humidity are relatively high, which accounted for 44.3% of total outbreaks. The monthly number of outbreaks decreased steadily until November after peaking in May 2009. The most common causative agent was norovirus (16.5%) followed by pathogenic *Escherichia coli*. The rate of causative agent identification was 60.1%, with higher identification rates in larger outbreaks.
Conclusions
Although a decreasing trend of outbreaks by year was observed in the study, the food services in schools and companies require more attention to hygiene and sanitation to prevent large outbreaks. The ability to establish the cause of an outbreak should be further improved.

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1. Introduction

Water- and foodborne disease is defined as any disease manifested mainly with gastrointestinal symptoms such as diarrhoea, abdominal pain, and vomiting caused by ingestion of water or food contaminated with pathogenic microorganisms or toxic materials.[1] In Korea, every outbreak of acute gastroenteritis with two or more epidemiologically related patients is investigated by local public health centres to identify causative agents and control the outbreak with the support of the Korean Centers for Disease Control and Prevention (KCDC). The findings and conclusions of each outbreak investigation have been summarized annually since 2007 to produce reports and statistics of water- and foodborne disease outbreaks. The aim of this study was to analyse the trends in water- and foodborne disease outbreaks in Korea from 2007 to 2009.

2. Methods

All of the water- and foodborne disease outbreaks reported to KCDC through the "Epitrace" on the Internet from 2007 to 2009 were included in the study. We analysed the trends and epidemiologic aspects of outbreaks by month, year, and location (food service establishments, public restaurants, and others). The outbreaks in which the final report of the investigation was not sent to the KCDC were excluded in the analysis for causative agent of outbreaks. The number of patients was counted by the case definition of each outbreak investigation.

3. Results

A total of 1026 outbreaks were reported resulting in 25,310 patients, whereas the reports of investigation for 913 outbreaks (89.0%) were sent to the KCDC. The total number of outbreaks for each year decreased steadily during the period the study covered, whereas the number of patients per outbreak continued to increase (Table 1). Outbreaks occurring in the period of June to September accounted for 44.3% of the total outbreaks. In 2009, unlike the previous years, the monthly number of outbreaks decreased steadily until November after it had peaked in May. The outbreaks in food service establishments of schools, student camps, and companies had two peaks in June and September and a relatively low incidence in July and August when the schools have summer vacation, whereas the outbreaks in public restaurants had peaks in May and August (data not shown).

More than half of the outbreaks occurred in public restaurants, and only a quarter occurred in food service establishments (Table 2). However, 54.9% of patients were from outbreaks at food service establishments and

Table 1 Water- and foodborne disease outbreaks by month in Korea, 2007–2009

Year	Total	January	February	March	April	May	June	July	August	September	October	November	December	Patients per outbreak
Total (no.)	1026	52	45	62	86	132	121	93	124	116	65	67	63	24.7
%	100.0	5.1	4.4	6.0	8.4	12.9	11.8	9.1	12.1	11.3	6.3	6.5	6.1	
2007	444	22	13	25	31	65	56	46	68	45	23	27	23	22.2
2008	355	14	16	19	31	29	34	25	27	53	34	35	28	24.3
2009	227	16	16	18	24	38	31	22	19	18	8	5	12	30.2

Table 2 Water- and foodborne disease outbreaks by location in Korea, 2007−2009 (no. of outbreaks (%)/patients per outbreak)

Year	Total	Food service establishments				Public restaurants	Others
		Schools	Camps	Others	Subtotal		
Total	1026 (100.0)/24.7	148 (14.4)/68.5	43 (4.2)/46.4	71 (6.9)/24.9	262 (25.5)/53.1	585 (57.0)/13.9	179 (17.5)/18.2
2007	444 (100.0)/22.2	64 (14.4)/50.6	24 (5.4)/37.8	36 (8.1)/26.6	124 (27.9)/41.2	262 (59.0)/14.4	58 (13.1)/16.7
2008	355 (100.0)/24.3	44 (12.4)/74.3	12 (3.4)/59.8	21 (5.9)/23.6	77 (21.7)/58.2	230 (64.8)/13.4	48 (13.5)/22.0
2009	227 (100.0)/30.2	40 (17.6)/90.7	7 (3.1)/53.4	14 (6.2)/22.5	61 (26.9)/70.8	93 (41.0)/14.0	73 (32.1)/16.8

32.2% were from outbreaks at public restaurants. Patients per outbreak were 3.8 times higher in food service establishments than in public restaurants. Only 1.3% of outbreaks in food service establishments were small outbreaks (less than 5 patients), whereas 37.6% of outbreaks in public restaurants were small (data not shown). Notably, the number of patients per outbreak in schools increased dramatically from 50.6 in 2007 to 90.7 in 2009, whereas that in other places did not change much.

The causative agents of outbreaks were identified in 60.1% of outbreaks (Table 3). The most common causative agent was norovirus (16.5%), followed by pathogenic *Escherichia coli* (13.9%), *Salmonella* spp. (7.7%), *Vibrio parahaemolyticus* (7.0%), and *Staphylococcus aureus* (5.5%). Enterohaemorrhagic *E coli* and *Salmonella typhi*, the pathogens of Group 1 notifiable communicable diseases in Korea, accounted for 0.7% and 0.4% of the outbreaks, respectively (included in pathogenic *E coli* and *Salmonella* spp. in Table 3, respectively). Outbreaks occurring by two or more pathogens accounted for 1.3% of the total outbreaks. Norovirus and pathogenic *E coli* were the major causes of outbreaks in food service establishments (54.9%), but, in public restaurants and other places, various pathogens caused outbreaks and the two major pathogens accounted for only 19.7% (data not shown).

Bacterial pathogens such as pathogenic *E coli*, *Salmonella* spp., and *S aureus* caused 65.3%, 55.7%, and 52.0% of the outbreaks between June and September, respectively. Outbreaks from *V parahaemolyticus* in August and September accounted for 65.6%. In contrast to bacterial pathogens, norovirus was common in outbreaks between November and May.

The pathogen identification rates varied across the location and size of the outbreak. The causative agents were identified in 79.0% of outbreaks in food service establishments, whereas investigators identified the pathogens in 51.5% of outbreaks in public restaurants. In the outbreaks with fewer than five patients, 40.9% of the pathogens were identified, whereas the pathogens of 90.7% of the outbreaks with 100 patients or more were identified. The identification rates increased as the size of the outbreak increased (data not shown).

4. Discussion

The trend in water- and foodborne disease outbreaks in Korea showed reciprocal aspects in the annual pattern. It is desirable that the number of outbreaks each year was decreasing, but the number of patients per outbreak increased continuously. It seems that this resulted from the growing size of outbreaks in school food service establishments. More efforts should be made to manage food services in schools and provide early reports and responses to outbreaks in schools.

When compared with past years, the annual number of water- and foodborne disease outbreaks was increasing in recent years, whereas the numbers fluctuated between years. In average, less than 100 outbreaks were reported each year in the 1980s and 1990s, whereas more than 100 outbreaks were reported yearly after 2000.[2,3] And in the long term, there was a peak in 2007 (510 outbreaks). This growing trend and its fluctuation might be influenced by the increase of food service establishments as well as increased reporting and notification of outbreaks. Kwun and Lee[3] suggested that this trend may reflect the change of the public's awareness about the reporting of water- and foodborne disease outbreaks, which could be affected by social issues. The peak in 2007 was caused by the change of the KCDC guideline for investigation, which expanded the subjects of reporting and investigation from outbreaks with five patients to outbreaks with two patients.

The monthly pattern of outbreaks, which had a high incidence between June and September, corresponded to the general tendency of pathogens to quickly proliferate in high temperature and high humidity. But the pattern in 2009 showed a different monthly outbreak incidence, which decreased continuously after May through November. It is possible that the national campaign to prevent the spread of the pandemic influenza H1N1 in 2009 elevated public awareness of the importance of personal hygiene and led to behavioural changes such as frequent hand washing and prevented the water- and foodborne disease outbreak unintentionally.

Norovirus was the most common causative agent of water- and foodborne disease outbreaks in Korea. This

Table 3 Water- and foodborne disease outbreaks by month and pathogen in Korea, 2007–2009

Pathogens	Total (no.)	%	January	February	March	April	May	June	July	August	September	October	November	December	Patients per outbreak
Total	913	100.0	46	41	54	81	115	98	89	112	111	56	56	54	25.8
Identified															
Norovirus	151	16.5	18	14	14	24	18	12	5	2	5	4	16	19	29.8
Pathogenic *Escherichia coli*	127	13.9	3	0	3	13	13	20	23	21	19	7	2	3	54.7
Salmonella spp.	70	7.7	0	1	5	6	15	12	8	7	12	2	1	1	28.2
Vibrio parahaemolyticus	64	7.0	0	0	1	0	2	3	7	24	18	7	2	0	15.7
Staphylococcus aureus	50	5.5	3	2	1	2	8	6	8	4	8	5	2	1	37.6
Campylobacter spp.	17	1.9	0	0	0	1	3	1	5	4	2	1	0	0	63.8
Shigella spp.	17	1.9	4	0	1	0	2	1	0	0	2	2	4	1	7.8
Bacillus cereus	14	1.5	0	1	2	2	2	2	0	2	1	0	1	1	21.3
Clostridium perfringens	10	1.1	0	1	4	2	1	0	0	0	1	0	0	1	94.6
Others	17	1.9	0	1	1	3	3	2	2	1	2	0	2	0	22.1
Multiple pathogens	12	1.3	0	2	1	0	3	1	0	1	0	1	0	3	28.8
Subtotal	549	60.1	28	22	33	53	70	60	58	66	70	29	30	30	35.5
Unidentified	364	39.9	18	19	21	28	45	38	31	46	41	27	26	24	11.1

is similar to the case of the United States.[4] The finding that bacterial pathogens were prominent in the period of June to September and norovirus was prominent in the period of November to May corresponded to the trends observed in the laboratory surveillance system of bacterial and viral pathogens for acute diarrhoeal disease in Korea.[5,6] The finding that the outbreaks caused by *V parahaemolyticus* were of high incidence in August and September was consistent with the observation that seawater temperature increases and plankton proliferate in summer so that *V parahaemolyticus* can easily grow in seawater.[7] However, it should be noted that no pathogen was identified in 39.9% of all outbreaks.

The composition of causative agent of outbreaks has been changed for the past two decades.

The outbreaks caused by *Salmonella* spp. accounted for 31.1% of the total in 1993–1998 and it had been the most common causative agent before 2005, but norovirus outbreak increased sharply in 2006 and it has ranked first since then.[2,3] The decreasing trend of bacterial pathogens such as *Salmonella* spp., *V parahaemolyticus*, and *S aureus* as causes of outbreaks except for pathogenic *E coli* was a characteristic aspect of water- and foodborne disease outbreaks in recent years. It might be another notable exception that *Campylobacter jejuni* outbreak, which is more common in developed countries, is steadily increasing in Korea (0.9% in 2003–2006, 1.9% in 2007–2009). Although its incidence remains low yet, we should pay attention to the large size of its outbreak (63.8 patients per outbreak), which is second only to *Clostridium perfringens* outbreak.

The increasing trend of norovirus outbreak might be because of improvement in identification method and surveillance system of viral pathogens. Acute infectious agent laboratory surveillance system for viral diarrhoeal disease has been operating by the KCDC and the Research Institutes of Public Health and Environment since 2000.[3] In 2006, when a large norovirus outbreak in multiple schools with food service establishment managed by one company occurred, the government reformed the regulations to operate laboratory surveillance system for 17 pathogens of diarrhoeal disease, so that the investigators can identify more viral pathogenic agents than before.

It seems that the discrepancy in the pathogen identification rates between food service establishments and public restaurants originated from the difference in the size of outbreaks between the two compartments. The outbreaks in food service establishments were 3.8 times larger than those in public restaurants. More than one-third of the outbreaks in public restaurants were small outbreaks (less than 5 patients). It is difficult to detect the causative agents in laboratory studies without a sufficient number of specimens from the patients or the environment.

The present study has several limitations. First, the subject of study includes only reported outbreaks of water- and foodborne disease. The notification of outbreaks relies on the reports from doctors or patients. There could be unidentified outbreaks, although the extent is difficult to assume, and these might lowered the completeness of data. Second, the sources of data for comparing the past and present features of outbreaks are different from each other. The articles showing the trend of outbreaks in Korea before 2006, which were mentioned above, used the data from the Korea Food & Drug Administration (KFDA). Although each of the water- and foodborne disease outbreaks is reported to the KCDC and the KFDA at the same time, there might be some differences in organizing the data and producing statistics. The outbreaks caused by natural or chemical toxin, which accounted for 1.4% of total, were included in the statistics from the KFDA but not in those from the KCDC.[8] There may exist more differences between the two sources of data, but it has not yet been examined systematically.

The recent trend in water- and foodborne disease outbreaks in Korea was briefly outlined. We found a decreasing trend in water- and foodborne disease outbreaks in Korea during 2007−2009 along with an increasing trend in the number of cases per outbreak in school food service establishments. More hygiene and sanitation effort to food and water is needed to prevent large outbreaks in school food services and public restaurants, which are the most common places for outbreaks.

The pathogen identification rate is an important index representing the quality of epidemiologic investigation for outbreaks. It is largely influenced by the number of specimens collected as well as by the testing procedures and the technical level of field investigation. Improving the ability to establish the cause of an outbreak in terms of the pathogens is a challenge faced by investigators in Korea.

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