

## Original Article

# Trends in Isolation and Antimicrobial Susceptibility of Enteropathogenic Bacteria in 2011-2019 at a Korean Tertiary Care Hospital Compared with Data in the Preceding Reports

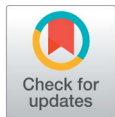
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## 2011년부터 2019년에 국내 한 대학병원에서 분리된 위장관 병원균의 균종 및 항균제 내성 변화 비교연구

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## ABSTRACT

**Background:** Environmental sanitation plays a significant role on the prevalence of enteropathogenic bacteria. This study aimed to determine the trends in the prevalence and antimicrobial resistance profiles of enteropathogenic bacteria from 2011 to 2019.

**Methods:** A retrospective analysis was performed using data from stool cultures of *Salmonella* spp., *Shigella* spp., *Plesiomonas shigelloides*, *Yersinia* spp., *Vibrio* spp., and *Campylobacter* spp. Samples were obtained between 2011 and 2019 from Severance Hospital. Antimicrobial susceptibility profile was determined using the disk diffusion method for nontyphoidal *Salmonella* (NTS) and *Campylobacter* spp., following the Clinical and Laboratory Standards Institute (CLSI) guidelines.

**Results:** The number of specimens obtained for stool culture increased significantly from 13,412 during the period of 1969–1978, to 48,476 over the past nine years (2011–2019), whereas the ratio of positive specimens decreased significantly from 1,732 (12.9%) to 449 (0.9%). The proportion of samples positive for *Salmonella* Typhi decreased from 472 (93.6%, 1969–1978) to 4 (1.5%, 2011–2019), whereas the proportion of NTS increased from 14 (2.8%, 1969–1978) to 261 (96.7%, 2011–2019). Among all the enteropathogenic bacteria isolated, *Shigella* spp. accounted for 60.0% (1,039) isolates from 1969 to 1978, but only 1.6% (7) from 2011 to 2019. *Campylobacter* was the second most prevalent enteropathogenic bacteria, accounting for 29.4% isolates (132). Among the NTS strains isolated from 2016 to 2019, their susceptibility rates to ampicillin and sulfamethoxazole-trimethoprim were 51.1% and 85.2%, respectively. Additionally, the susceptibility rate of *Campylobacter* to ciprofloxacin was 15.8%.

**Conclusion:** The prevalence of *Salmonella* Typhi and *Shigella* spp. significantly decreased, whereas those of NTS and *Campylobacter* spp. increased. Therefore, continuous monitoring of ciprofloxacin-resistant *Campylobacter* spp. is of vital importance.

**Keywords:** *Campylobacter* species, Enteropathogenic bacteria, *Salmonella* species

## INTRODUCTION

Gastroenteritis refers to stomach and intestinal infections, and most forms of acute gastroenteritis are known as acute diarrhea. Diarrhea in gastroenteritis is commonly characterized as the movement of an increased quantity and frequency of abnormally liquid or formless stools. It is classified as infectious diarrhea when diarrhea is caused by a source of infection and is followed by nausea, vomiting, and abdominal pain. However, in the clinic, microorganisms causing the infection are seldom confirmed [1].

Diarrheal disease is the second leading cause of morbidity and mortality, and mainly occurred in children under 5 years of age, which is one of the global public health issues, especially in developing countries, including Asia, Africa and Latin America [1-3]. According to the World Health Organization (WHO), 1.6 million deaths due to infectious diarrhea were recorded in 2010 [4,5]. The most frequent pathogens causing acute gastroenteritis worldwide are *Salmonella* spp., *Shigella* spp., *Campylobacter* spp., *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Yersinia enterocolitica*, *Vibrio cholerae*, Rotavirus, *Entamoeba histolytica*, *Cryptosporidium* spp., and *Giardia lamblia* [1,6]. Moreover, the diarrhea-causing pathogens depend on various factors such as atmosphere, climate, season, and region. Therefore, the prevalence of pathogen separation in each region must be considered [7]. In developing countries such as Cambodia, Kenya, and Burkina Faso, where diarrhea rates are high due to low income and undernutrition, the most frequently isolated pathogens were enteroaggregative *E. coli* [8-10], but the most prevalent in Tehran was *Shigella* spp. [11]. However, many developed countries have a high standard of health and hygiene, so enteritis is less likely to develop, but infectious diarrhea can also occur in developed countries, as was the case with more than 3,000 infections of the *E. coli* O104: H4 in Germany in May 2011 [3]. In addition, *Salmonella* spp. (56%) and *Shigella* spp. (21%) were the most commonly detected pathogens in Europe and Latin America, as examined by the 2003 global SENTRY Antimicrobial Surveillance Program [12].

Bacteria have been found not to account for a high percentage of cases [1]. In most cases acute gastroenteritis is a self-limiting condition that does not require antibiotic treatment. Inappropriate use of antibiotics may cause antibiotic-associated diarrhea or other complications and may also lead to antibiotic resistance in the long term [1]. With the continuous improvement of health and hygiene, the incidence of infectious enteritis is decreasing, but the resistance rate of infectious enteritis is increasing. In addition, the increase in overseas travel has increased the likelihood of the introduction or epidemic of infectious enteritis caused by contaminated food or water [6,7].

In Korea, 14.7% of enteropathogenic bacteria were isolated based on acute infectious diarrhea surveillance in 2017 [6]. However, studies in South Korea over the past 10 years have primarily focused on advanced genotypic and phenotypic characteristics of enteropathogenic bacterial strains and as a result very few studies have been done on conventional surveillance of these pathogens leading to a gap in data for monitoring the trends in isolation and resistance patterns. Conventional method, however, remains as a gold standard for the confirmation of bacteria to monitor the trend and resistance patterns of enteropathogenic bacteria. This

study aims to determine the trends in the isolation and antimicrobial resistance patterns of enteropathogenic bacteria between 2011 and 2019 at Severance Hospital. Also, to compare the current pattern and trends of enteropathogenic bacterial antimicrobial susceptibility with previous reports in Severance Hospital.

## MATERIALS AND METHODS

### Study design

A retrospective analysis was performed using existing data of stool culture from the patients hospitalized at Severance Hospital from 2011 to 2019.

### Specimen collection

The stool samples were collected and placed it in transport mini sputum container. Bacteria to be cultured belong to *Salmonella* spp., *Shigella* spp., *Plesiomonas shigelloides*, *Yersinia* spp., *Vibrio* spp., and *Campylobacter* spp..

### Bacterial culture media and condition

MacConkey agar base, *Salmonella Shigella* agar, selenite broth (BBL, Becton, Dickinson and Company, Sparks, MD, USA) were used for *Enterobacteriaceae*. Thiosulfate citrate bile sucrose agar base (BBL) was used for *Vibrio* species. *Campylobacter* selective supplement, *Campylobacter* growth supplement (Oxoid Ltd, Basingstoke, UK) and blood agar base (BBL) were used for *Campylobacter* species culture.

*Enterobacteriaceae* and *Vibrio* spp. cultures were incubated in aerobic condition at 35°C for 24 hours. For *Campylobacter* spp. specimen-inoculated plates were incubated in a microaerophilic atmosphere at 42°C for 48 hours [13].

### Species identifications and antimicrobial susceptibility testing (AST)

Colony shape, biochemical testing, matrix-assisted laser desorption/ionization time of flight mass spectrometry (MALDI-TOF MS) (Bruker Daltonics, Bremen, Germany), and VITEK 2 ID cards (bioMérieux, Inc., Durham, NC, USA) were used for bacteria identification. Moreover, serological identification of *Salmonella* or *Shigella* spp. was performed by using a slide aggregation reaction *Salmonella* and *Shigella* group diagnostic sera (National Health Research Institute, Osong, Korea). The AST was tested by VITEK 2 AST card, disc diffusion method and E-test following the Clinical Laboratory Standard Institute (CLSI) guideline [14]. A standardized 0.5 McFarland suspension was prepared, and VITEK 2 cards for AST were inoculated following the manufacturer recommendation. For AST testing of *Salmonella* or *Shigella* spp. were tested with N224 VITEK 2 card, and additionally ciprofloxacin disc susceptibility test. Erythromycin, ciprofloxacin, and tetracycline discs were tested at the same time for *Campylobacter* spp. Quality control of species identification and AST were performed according to CLSI guideline and manufacturer's instruction [14].

## Data registration and statistical analysis

Data stored in Severance Hospital information management system. Microsoft Excel 2010 (16.0.13328.20262) was used for statistical analysis.

## Ethical considerations

Ethical approval was granted from Yonsei Institutional Review Board at the Severance Hospital, Yonsei University, Seoul, Republic of Korea (IRB No. 4-2020-1031). Patients were identified with a unique hospital number. No other data besides those noted in the routine medical files were used for the clinical and epidemiological data.

## RESULTS

### Comparison of trends in isolation of enteropathogenic bacteria at a tertiary-care hospital

There were 48,476 specimens were requested for stool culture from 2011 to 2019. Among the total requested specimens, 449 specimens were positive accounted to 0.9%. The enteropathogenic bacteria isolated from the stool culture during 2011 to 2019 were distributed as 270 (60.1%) *Salmonella* spp., 7 (1.6%) *Shigella* spp., 132 (29.4%) *Campylobacter* spp., 7 (1.6%) *Vibrio parahaemolyticus*, 1 (0.2%) *Yersinia enterocolitica*, and 32 (7.1%) others isolates.

*Salmonella* spp. and *Campylobacter* spp. were the most common pathogen 60.1% and 29.4%, respectively. Followed by *Salmonella* spp., there were separated 4 (1.5%) *Salmonella* Typhi, 0 (0.0%) *Salmonella* Paratyphi A, 111 (41.1%) *Salmonella* serogroup B, 82 (30.4%) *Salmonella* serogroup C, 63 (23.3%) *Salmonella* serogroup D, 5 (1.9%) *Salmonella* serogroup E and 5 (1.9%) *Salmonella* another serogroup (Table 1).

### Number of patients with nontyphoidal *Salmonella* and *Campylobacter* spp. isolation by month in 2011-2019

The findings were figured out of the number of patients with nontyphoidal *Salmonella* (NTS) and *Campylobacter* spp. isolation by month in 2011-2019. Among 261 strains of NTS, most of them were isolated in summer-autumn season: August (16.5%), September (15.3%), October (15.3%) and July (10.0%). Moreover, 61 of 132 *Campylobacter* spp. were also isolated in the hot season, June (11.4%), July (13.6%) and August (21.2%) (Table 2).

### Number of patients with nontyphoidal *Salmonella* and *Campylobacter* spp. by age group

The patient under 5 years and older than 60 years of age were found highly infected by NTS and *Campylobacter* spp. However, *Campylobacter* was isolated, not only under the age of 5 and more than 60 but also found highly infected at 10-19 and 20-29 (Table 3).

**Table 1.** Comparison of trends in isolation of enteropathogenic bacteria at a tertiary-care hospital

Characteristic	Period of data acquisition*				
	1969-1978	1979-1988	1989-1998	2001-2010	2011-2019
No. of specimen cultured	13,412	37,846	51,441	60,714	48,476
No. of positive specimen	1,732	3,503	2,140	648	449
% of positive specimen	12.9	9.2	4.2	1.1	0.9
No. of positive patient	1,677	3,182	1,531	565	449
<i>Salmonella</i> Typhi	472	469	58	1	4
<i>Salmonella</i> Paratyphi A	18	101	3	2	0
<i>Salmonella</i> serogroup B	3	245	564	86	111
<i>Salmonella</i> serogroup C	4	108	126	89	82
<i>Salmonella</i> serogroup D	5	107	341	157	63
<i>Salmonella</i> serogroup E	2	32	55	22	5
<i>Salmonella</i> other serogroup	0	40	39	2	5
All <i>Salmonella</i> isolates	504	1,102	1,186	359	270
<i>Shigella</i> subgroup A	16	5	2	0	0
<i>Shigella</i> subgroup B	781	1,246	30	3	1
<i>Shigella</i> subgroup C	8	43	0	0	6
<i>Shigella</i> subgroup D	234	214	19	95	0
All <i>Shigella</i> isolates	1,039	1,508	51	98	7
<i>Campylobacter</i> spp.	NT	185	239	85	132
<i>Yersinia enterocolitica</i>	NT	29	18	1	1
<i>Vibrio parahaemolyticus</i>	45	96	42	27	7
<i>Plesiomonas shigelloides</i>	NT	4	11	0	0

\*The data from 1969-2010 were adapted from reference [7].

Abbreviation: NT, not tested.

**Table 2.** Number of patients with nontyphoidal *Salmonella* and *Campylobacter* spp. isolation by month in 2011-2019

Month	No. of patient with:	
	Nontyphoidal <i>Salmonella</i> (%)	<i>Campylobacter</i> spp. (%)
January	12 (4.6)	5 (3.8)
February	5 (1.9)	5 (3.8)
March	14 (5.4)	14 (10.6)
April	16 (6.1)	9 (8.6)
May	21 (8.0)	9 (8.6)
June	23 (8.8)	15 (11.4)
July	26 (10.0)	18 (13.6)
August	43 (16.5)	28 (21.2)
September	40 (15.3)	8 (6.1)
October	40 (15.3)	8 (6.1)
November	12 (4.6)	4 (3.0)
December	9 (3.4)	9 (6.8)
Total	261 (100.0)	132 (100.0)

**Table 3.** Number of patients with nontyphoidal *Salmonella* and *Campylobacter* spp. by age group

Organism	No. of patients by age group (yr)								Total
	≤ 5	6-9	10-19	20-29	30-39	40-49	50-59	≥ 60	
Nontyphoidal <i>Salmonella</i>	118	27	24	9	10	11	18	44	261
<i>Campylobacter</i> spp.	11	7	28	33	12	5	12	24	132

## Comparison of trends in antimicrobial susceptibility of nontyphoidal *Salmonella*

As shown in Table 4, the susceptibility rate of NTS between 2011 and 2015 was ampicillin (53%), sulfamethoxazole-trimethoprim (93%), cefotaxime (92%), ceftazidime (92%), and fluoroquinolone (84%). Similarly, the susceptibility rate of NTS between 2016 to 2019 was ampicillin (51%), sulfamethoxazole-trimethoprim (85%), cefotaxime (74%), ceftazidime (81%), and fluoroquinolone (73%).

**Table 4.** Comparison of trends in antimicrobial susceptibility of nontyphoidal *Salmonella*

Year	No. of patients	% of isolates susceptible to:					
		AMP	CHL	SXT	CTX	CAZ	FQN*
1979 - 1983	211	98	99	100	NT	NT	NT
1984 - 1988	337	54	64	98	NT	NT	NT
1989 - 1993	420	67	77	90	NT	NT	NT
1994 - 1998	865	76	NT	90	98	98	100
2001 - 2005	210	65	NT	93	99	100	100
2006 - 2010 <sup>†</sup>	141	61	NT	92	96	98	98
2011 - 2015	108	53	NT	93	92	92	84
2016 - 2019	153	51	NT	85	74	81	73

\*FQN: ofloxacin (1994-1996), levofloxacin (1997-1998), levofloxacin (2001-2010) and levofloxacin (2011-2019).

<sup>†</sup>The data from 1969-2010 were adapted from reference [7].

Abbreviation: AMP, ampicillin; CHL, chloramphenicol; SXT, sulfamethoxazole-trimethoprim; CTX, cefotaxime; CAZ, ceftazidime; FQN, fluoroquinolone; NT, not tested.

## Comparison of trends in antimicrobial susceptibility of *Campylobacter* spp.

As shown in Table 5, the rates of susceptibility to erythromycin and fluoroquinolone were 87.03% and 25.4%, respectively, for *Campylobacter* spp.; they were isolated from 2011 to 2015. On the other hand, the rates of susceptibility to erythromycin, fluoroquinolone and tetracycline were 98.2%, 15.8% and 51.4%, respectively, for *Campylobacter* spp.; they were isolated from 2016 to 2019.

**Table 5.** Comparison of trends in antimicrobial susceptibility of *Campylobacter* spp.

Antimicrobial agents	% of isolates susceptible						
	1981-1982 (n=29)	1986-1991 (n=127)	1994-1998 (n=138)	2001-2005 (n=41)	2006-2010* (n=39)	2011-2015 (n=72)	2016-2019 (n=60)
Erythromycin	100.0	NT	92.0	95.1	87.2	87.03	98.2
Fluoroquinolone <sup>†</sup>	NT	NT	74.2	53.8	79.5	25.4	15.8
Ampicillin	83.8	60.6	72.0	82.9	69.2	NT	NT
Cephalothin	0	7.9	8.8	4.9	7.7	0.0	NT
Amikacin	86.2	86.3	98.2	97.6	94.9	NT	NT
Gentamicin	86.2	85.6	98.2	90.2	92.3	NT	NT
Tobramycin	82.8	84.1	77.8	85.4	92.3	NT	NT
sulfamethoxazole-trimethoprim	64.3	19.2	22.1	4.9	7.7	NT	NT
Tetracycline	76.9	44.5	13.9	12.2	0	NT	51.4

\*The data from 1969-2010 were adapted from reference [7].

<sup>†</sup>Fluoroquinolones used: ofloxacin (1994-1996), levofloxacin (1997-1998), ciprofloxacin (2001-2010) and ciprofloxacin (2011-2019).

Abbreviation: NT, not tested.



## DISCUSSION

In this study, we compared the results of the isolation of enteropathogenic bacteria in 2011-2019 with the results of isolates in 1969-2010. Moreover, we analyzed the trend of enteropathogenic bacteria and examined the antibiotic resistance pattern. The number of requests for stool culture testing during this study period increased by 3.6 times compared to 13,412 samples from 1969-1978. However, the numbers of samples positive for culture decreased significantly from 1,732 (positive rate 12.9%) to 449 (positive rate 0.9%). These might be due to an increase in the number of patients with an increase in the number of beds, an increase in hospitalized infection monitoring culture, and improved health and hygiene [15]. *Shigella*, *Vibrio*, and *Salmonella* are mainly isolated among enterocolitis in developing countries, but *Shigella* and *Salmonella* Typhi are rare in developed countries [16]. In developed countries, *Campylobacter* and NTS became the major isolates. A USA study reported that 42% of the enteritis bacterial causative agents were *Campylobacter* 32%, NTS 32%, and *Shigella* 13%, supporting the changes in these isolates [16,17]. Another report regarding traveler diarrhea investigated tourists from South East Asia countries including Thailand where commonly identified *Campylobacter* and *Aeromonas* spp. [18].

Particularly, *Salmonella enteritidis* belonging to the *Salmonella* serotype D group, is one of the most common *Salmonella* serotypes prevalent all over the world and is known to be the main causative agent of foodborne salmonellosis [19]. During the study period, 2011-2019, NTS was detected in 261 patients, and it was the most isolated isolate, accounting for 58%. *Salmonella* isolated in 1969-1978, 472 (93.6%) were *Salmonella* Typhi, but in 2011-2019, there were only 4 (1.5%) isolated. The number of *Salmonella* Paratyphi A was 101 (9.2%) in 1979-1988, but it decreased significantly to 0 (0.0%) in 2001-2010. On the other hand, NTS's trend gradually increased and isolated from 14 cases in 1969-1978 to 261 cases in 2011-2019. In the past, there were many *Salmonella* serogroup B and D among NTS, but the isolates started to be decreased since 2010. Despite, compared to developing countries were remained highly infected as a massive typhoid fever outbreak in Pakistan resulted in 5,372 extensively drug-resistant (XDR) *Salmonella* Typhi cases stated during 2016-2018, and five travel-related cases in the United States [20].

*Shigella* spp. was the most common enteritis bacterium, accounting for more than 50% of the total number of isolates, separated from a total of 2,547 isolated in 1969-1988, but the trend decreased significantly after 1989. In this study, a total of 7 (1.6%) isolates were isolated from 2011-2019. In the developing countries, there were many *S. dysenteriae* and *S. flexneri* infections, but in developed countries, there were many *S. sonnei* infections [21]. In the recent years, *S. dysenteriae* infection has been rare in Korea [22], the number of *S. flexneri* was the most prevalent until the late 1980s, and *S. sonnei* has been the most prevalent since 1990 [23]. Nonetheless, even after the late 1990s, it was decreased, *Shigella* infections often occurred, it is requiring continuous culture [23]. On the other hand, Thailand reported that the most commonly isolated *Shigella* species over the past two decades have been *S. flexneri* (79%) and *S. sonnei* (15%) and the incidence of *S. sonnei* were predominated over 80% in children under 5 in their country [24]. Even though, Thailand is a developed country, *Shigella* ratio remains high, if compare to Korea's current situation.

*C. jejuni* is a major cause of bacterial diarrheal illness in the USA and in many other countries, with an estimated 845,000 foodborne cases per year in the USA alone, third in the number of estimated bacterial

foodborne disease cases after *Salmonella* spp. and *Clostridium perfringens* [21]. This hospital began to culture *Campylobacter* spp. from 1981 and identified 239 isolates in 1989-1998, 83 isolates in 2001-2010 and 132 isolates in 2011-2019. Among the 132 isolates of *Campylobacter* spp. in 2011-2019, *C. jejuni* was the most common pathogen. By the way, a study in Cambodia found in multiplex polymerase chain reaction (PCR) among 681 stool samples were 82 (12%) tested positive followed by *C. jejuni* in 66 samples and *C. coli* in 16 [25] with *Campylobacter* positive rates for Vietnam and Laos were below 5% [26]. Thus, it showed that the rate of *Campylobacter* spp. infection in developed country is higher than in developing countries.

*V. parahemolyticus* was isolated 7 (1.6%) during the investigation period. The number was small because patients with this enteritis recovered naturally after 2-3 days of infection without treatment, so there was little opportunity to isolate the bacteria from tertiary medical institutions. In Korea, it is projected that the number of infected patients is high because Korean coast often reproduce fish and shellfish [27]. In fact, with the food poisoning from 2003-2016 in 2017 Korea Ministry of Food and Drug Safety report, 225 cases and 4,256 patients were determined in the outbreaks by *V. parahemolyticus*, which was accounting for 5.8% of total outbreaks and 4.1% of total patients, respectively, based on all food-borne illnesses occurring in Korea [27].

Some studies have been reported on *Y. enterocolitica* distribution, mostly in Northern Europe and northern states of the USA, reflected its increased rate because of cold temperatures [28]. In Korea, have been reported 47 cases of *Y. enterocolitica* and 15 cases of *P. shigelloides* in 1979-1998 [15]. In this study, only one *Y. enterocolitica* was found.

NTS and *Campylobacter* spp. were mainly isolated in patients under five years of age, similar to those of other domestic and foreign researchers [16,29]. However, *Campylobacter* spp. was isolated, not only under the age of 5 but also at 10-19 and 20-29. While infection with *C. jejuni* or *C. coli* can occur in patients of all ages [30], a recent study from Denmark showed that infection is more common in children (1 to 4 years) and young adults (15 to 24 years) than in other age groups [31]. Also, slightly older patients (34.6 years versus 27.5 years) and those who traveled abroad were at a greater risk of being infected with *C. coli* than with *C. jejuni* [32]. Moreover, infections with *C. jejuni* and *C. coli* are more common during the summer [31,33]. Similarly, this study found that most of *Campylobacter* spp. was isolated in June, July, and August.

In this study, ampicillin and sulfamethoxazole-trimethoprim resistance in NTS was higher than in the previous period. Furthermore, in the last four years in 2016-2019, the susceptibility ratio of cefotaxime, ceftazidime and fluoroquinolone decreased significantly. The generation of extended-spectrum  $\beta$ -lactamase (ESBL) resistant to third-generation cephalosporin in Korea was first reported in 2003. It had been increasing since then, presumably due to CTX-M-type ESBL [34,35]. Even though, ciprofloxacin resistance rate has good activity against *Salmonella* spp.; continuous monitoring is still necessary because ciprofloxacin-resistant *Salmonella* has increased in foreign countries [36]. According to NTS analyzed by Korea Centers for Disease Control and Prevention (KCDC) from 2006 and 2008, the resistance ratios to ampicillin, nalidixic acid, ciprofloxacin, and trimethoprim-sulfamethoxazole (TMP/SMX) were at 49%, 50%, < 1%, and 8%, respectively [37].

Erythromycin and ciprofloxacin are recommended for the treatment of *C. enteritis*, and recently increased resistance to these drugs has been reported. Although, it is difficult to make a direct comparison according



to the change of the standard for analyzing the antimicrobial susceptibility test of *Campylobacter* spp., the ciprofloxacin susceptibilities were 79.5% in 2006-2010 [7], 25.4% in 2011-2015 and 15.8% in 2016-2019. Thus, we observed the resistance rapidly increased. On the other hand, the erythromycin and tetracycline susceptibility in 2016-2019 were gradually decreased to 98.2% and 51.4%, respectively, compared to the previous period. In other studies in Europe in 2012, ciprofloxacin resistance of *Campylobacter* spp. was reported to be as high as 44% in some European countries [38]. Fluoroquinolone resistance of *Campylobacter* spp. has also been reported to be high in Mexico (56%) and Thailand (> 92%) [39,40]. Despite, in Japan showed that macrolide resistance was in a low rate in *C. jejuni* and *C. coli* isolated, but quinolones-resistant *Campylobacter* spp. has emerged [41]. Considering these, macrolides including azithromycin may be considered for empirical antibiotic therapy in areas where *Campylobacter* spp. is common and has a high resistance to fluoroquinolone [42].

In summary, these results showed an increase in the incidence of enteropathogenic bacterial infection in Severance Hospital throughout the study. The pathogens with the most significant increase in incidence were nontyphoidal *Salmonella* and *Campylobacter* spp., even though there was a decrease in *Salmonella* Typhi and *Shigella*'s incidence. Enteropathogenic bacteria resistance to commonly prescribed antibiotics is steadily on the rise, as shown in this study. Nontyphoidal *Salmonella* resistance increased to ampicillin, sulfamethoxazole-trimethoprim, cefotaxime, ceftazidime, and fluoroquinolone.

*Campylobacter* resistance to fluoroquinolone increased significantly over the study period, but *Campylobacter* isolates remained susceptible to erythromycin. Continuous monitoring of resistant enteropathogenic bacteria is necessary.

## 요약

**배경:** 위생 환경의 변화에 따라서 위장관 병원균의 분리 추세는 바뀔 수 있다. 본 연구는 국내 한 대학병원에서 분리된 위장관 병원균의 균종 및 항균제 내성 양상을 과거에 보고된 자료와 비교하여 그 변화를 고찰하였다.

**방법:** 2011년부터 2019년에 *Salmonella* 균속, *Shigella* 균속, *Plesiomonas shigelloides*, *Yersinia* 균속, *Vibrio* 균속, 그리고 *Campylobacter* 균속을 분리하였던 세브란스병원 분변 배양 결과를 후향적으로 분석하였다. 항균제 감수성 시험은 상품화된 kit와 디스크 확산법으로 시행하였고 CLSI (Clinical and Laboratory Standards Institute) 기준에 따라서 해석하였다.

**결과:** 동일 병원에서 1969년-1978년 분리된 위장관 병원균의 수는 13,412 균주이었고, 본 연구 기간에는 48,476 균주이었다. 이들에서의 양성율은 동일 기간에 12.9%에서 0.9%로 변하였다. *Salmonella* Typhi 분리 균주 수(비율)은 472 (93.6%) 에서 4 (1.5%)로 변화하였으나, nontyphoidal *Salmonella* (NTS) 분리 균주수(비율)은 14 (2.8%)에서 261 (96.7%)로 증가하였다. 전체 분리 균주 중 *Shigella* 균주수(비율)은 1,039 (60.0%)에서 7 (1.6%)로 변화하였다. 본 연구기간 중 *Campylobacter* 균속의 균주수(비율)은 132 (29.4%)로 2번째로 흔하였다. NTS는 ampicillin과 sulfamethoxazole-trimethoprim에 각각 51.1%와 85.2% 감수성이었다. *Campylobacter* 균속은 ciprofloxacin에 15.8%의 감수성을 보였다.

**결론:** 1969년-1978년에 비교하여 본 연구기간인 2011년부터 2019년에는 *Salmonella* Typhi와 *Shigella* 균속의 분리는 현저하게 감소하였고, NTS와 *Campylobacter* 균속의 분리 빈도가 상대적으로 크게 증가하였다. *Campylobacter*에서 지속적인 ciprofloxacin 내성 감시와 관리가 필요하다.

## CONFLICTS OF INTEREST

No potential conflicts of interest relevant to this article were reported.

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