

Foodborne Bacterial Pathogens Associated with the Risk of Gastroenteritis in the State of Qatar

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Abstract

Objective: To assess the risk of gastroenteritis associated with bacterial foodborne pathogens and identify associated factors in a highly diverse population.

Material and methods: A series of case-control studies were carried out to address the stated objective. The study population consisted of individuals who were admitted to the Hamad Medical Corporation hospitals and stool analysis indicated positive findings to *Campylobacter* spp., *Escherichia coli*, or *Salmonella* spp. between the period of August 2009 and December 2012. Cases were defined based on positive stool analysis to any of the previously mentioned organisms. Control group was similar to case group but negative in stool analysis to the particular pathogen under study. Association between demographic characteristics and likelihood of pathogen infection were investigated using logistic regression analysis.

Results: A total of 423 individuals diagnosed with these bacterial pathogens were randomly enrolled in the study. The majority of cases were infected by *E.coli*. Age was significantly associated with *E.coli* and *Salmonella* spp.

Conclusion: *E.coli* infection is common among young children. The risk of *Salmonella* increases with age. *Campylobacter* may affect any age. Further investigation of interaction between foodborne pathogen infection and environmental factors is necessary

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Introduction

Foodborne illness is major health burden worldwide. ⁽¹⁾ Although most of the infections are self-limited, different estimates of the cost of illnesses indicate high cost per an episode ranging from \$1,600 to \$3,000. ⁽²⁾ The World Health Organization (WHO) highlighted in 2005 report that 1.8 million people globally died from diarrheal diseases and emphasized the importance of epidemiological data in these estimates. ⁽³⁾ The global risk of the foodborne pathogens has been exacerbated by globalization of trade and ease of travel around the world. ^(4, 5) The state of Qatar is one of the places where these two factors intersect. The burden of foodborne infection in the State of Qatar had been indicated by report released by the Department of Epidemiology and Medical Statistics, Doha, Qatar in 2013. ⁽⁶⁾

Campylobacter spp., *Escherichia coli*, and *Salmonella* spp. are among the top-ranked foodborne pathogen that contributes to the burden of disease. ^(1, 2) Increased interest health promotion and emphasis on fresh food had exacerbated the risk of exposure to foodborne pathogens and the likelihood adverse consequences including gastroenteritis and associated sequelae. ⁽⁷⁾ Food consumption at restaurants and/ or public places exposes consumers to a greater risk for foodborne pathogen infections because of the potential post retail contamination. ^(2, 8, 9)

Non-typhoid *Salmonella* spp., is commonly associated with consumption of contaminated fruit and vegetables with animal waste in recent years. ^(10, 11) Clinical presentation of infection with this pathogen varies from enteric fever to gastroenteritis and bacteremia. ⁽¹⁰⁾ The most common source for *Salmonella* spp. in addition to fresh fruit and vegetables are egg, poultry, and dairy products. ⁽¹²⁾ The risk of infection and adverse consequences vary by age and individuals below the age of 12 months are at a greater risk and this risk has been speculatively attributed to lack of breast-feeding. ^(13, 14) Global annual estimates of the incidence of non-typhoid *Salmonella* gastroenteritis are about 93.8 million cases with case-fatality rate of 0.17%, however the estimates for the developing countries are much higher. ^(15, 16)

Consumption of undercooked meat increases the risk for *E.coli* infection and had attributed to several foodborne outbreaks. ⁽¹⁷⁾

E.coli outbreak was associated with consumption of ground beef and contaminated products and the infection may be transmit via interpersonal contact, contaminated water, contact with animal, and/ or laboratory acquisition. ⁽¹⁸⁾

Campylobacter spp., infection is the most prevalent foodborne pathogen infection in developing countries. ⁽¹⁹⁻²¹⁾ Among the species of this foodborne pathogens *C. jejuni* and *C. coli* are the most among human cases and transmitted through consumption of undercooked poultry and/ or contaminated products. ^(19, 20) Children below the age of 5 years of age are at a greatest risk for *Campylobacter* infection. ^(21, 22) Estimated annual incidence of *Campylobacter* infection the US is around 2.5 million cases and 60,000 cases in Germany. ^(22, 23) *Campylobacter* infection accounts for nearly 5% of food-related deaths, and 17% of food related hospitalization. ⁽²¹⁾ Although information of the occurrence of these pathogens and their role in the risk of gastroenteritis in other part of the world is available data their associated risk in the Middle East and Qatar are lacking.

The risk of illness associated with these foodborne pathogens is manageable if the factors that are associated their occurrence and perpetuation in different population are identified. We carried out a study to assess the risk of gastroenteritis associated with foodborne pathogens and identify associated factors in a highly diverse population, Qatar. The pathogens of interest were *Campylobacter* spp., *E. coli*, and *Salmonella* spp.

Material and method:

Study design and population:

Appropriate authorization was obtained to access subjects' health record at Hama Medical Corporation (HMC) hospitals, Doha, Qatar before commencement of the study.

A case-control design was adopted to address the stated objective. The study population consisted of a random sample of individuals admitted to HMC hospitals or clinics between the periods of August 2009 and December 2012. Individuals admitted to any of HMC hospitals or clinic with a complaint of gastroenteritis symptoms, fecal samples were collected and examined bacteriologically for any of the three foodborne pathogens of

interest, and confirmed with the diagnosis of one of the three pathogens targeted in the study. Cases were defined as individuals who tested positive to one foodborne pathogen but negative to the others. Negative individuals to a particular pathogen served as control. Any individual who did not meet the inclusion criteria or admitted but no confirmed bacterial isolation reported was excluded from the study.

Bacterial isolation and Identification:

Standard bacteriological methods for detection of enteric pathogens were employed. Briefly, 1 g of freshly collected diarrheal stool sample was diluted in 10 ml of phosphate-buffered saline (PBS, pH 7.2; Sigma, St Louis, MO, USA) and 500 µl of diluted sample were added to 5ml of Selenite broth (Oxoid, Basingstoke, Hampshire, UK) for enrichment and incubated at 37°C for 24-48 h. For *Salmonella* spp. enriched samples were then subcultured onto Hektoen Enteric agar/MacConkey agar at 37°C for 24 h. Suspicious colonies by their color were further screened using biochemical test such as Kligler's iron agar, motility indol-urea agar, Lysin iron agar and o-nitrophenyl-β-D-galactopyranoside. One presumptive colony from each sample chosen by this screen was identified with confirmatory biochemical tests using API 20E (bioMereux, Marcy l'Etoile, France) or VITEK II (bioMereux). Serotyping of *Salmonella* strains was performed by slide and tube agglutination according to the Kauffmann– White scheme (Popff, 2001). Somatic (O) antigen of each tentative *Salmonella* isolate was identified with antisera of O antigen (Difco, Becton, Dickinson and Company, Sparks, MD, USA) using slide agglutination test. Positively reacting strains were identified as *Salmonella* spp. Further serogrouping was carried out using polyvalent and monovalent O and flagella (H) antisera (Difco). The O- and H- reactions of each *Salmonella* isolate were combined and the specific serotype of the isolate was identified. For *E. coli* detection, the samples were inoculated on MacConkey agar.

For detection of *E. coli* the enriched samples were inoculated onto sorbitol_MacConkey agar (SMAC). From SMAC at least five non-sorbitol-fermenting (NSF) colonies, if any, were picked. All *E. coli* isolates were tested using the slide agglutination test using polyvalent and

appropriate monovalent EPEC O-specific antiserum (Bio-Rad Laboratories, Inc., UK).

All samples were also incubated on CAMP agar at 42 °C in microaerophilic conditions for the isolation of *Campylobacter* spp. Identification of presumptive pathogens was performed using biochemical tests and serum agglutination reactions according to standard methods.

Data Collection:

Individuals enrolled in the study medical record number (MRN) to ensure anonymity and confidentiality. Information on demographic characteristics, chief complaint at time of admission, and results of laboratory analysis were extracted from hospital records.

Statistical Analysis:

Descriptive analysis of demographic characteristics was performed using SPSS version 22 (IBM Inc., Chicago, IL, USA). Significance of association between demographic characteristics and likelihood of foodborne pathogen infection was evaluated by univariate logistic regression analysis. Factors that were significant in univariate analysis were further considered in multivariate analysis to assess the significance of each of the factors while simultaneously controlling for the significance of other putative factors. The significance of each of the factors was assessed by the significance of its respective regression coefficient and quantified by computing the odds ratio (OR). A comparison of the age distribution among the three groups infected by one of the pathogens was performed using Kruskal-Wallis test and Bonferroni-type adjustment multiple comparisons in SPSS. Statistical significance was considered at type I error protection level of 0.05.

Results:

General Description:

A total of 423 individuals who met the inclusion criteria were enrolled in the study and included 106 (25%) who were confirmed with the diagnosis of *Campylobacter* spp., 208 (49%) with *E.coli*, and 109 (26%) with *Salmonella* spp. (Table 1). Table 1 shows the distribution of the characteristics of the patients enrolled in the study by the pathogen

recovered. The age of the patients was not normally distributed and the median age varied by type of infection. *Campylobacter* spp. was isolated from patients with median age of 2 years but the range of ages extended from 0.1 to 86.0 years. *E. coli* was recovered mainly from younger patients with a median age of 0.9 years (approximately one year) however, the oldest patient with this pathogen was 83 years old. Patients infected with *Salmonella* spp. tended to be relatively older and had a median age of 5.3 year and a range of 85.8 years. There were significant differences in median ages among the three pathogen groups with the group infected with *E. coli* being the youngest and the one infected with *Salmonella* spp. being the oldest (Table 1).

Male were admitted at a slightly higher rate when compared to female (Table 1). There was no significant association between gender and each of the pathogens and appeared that the likelihood of infection with any of the three pathogens were equal (Table 1).

Because of the nature of the Qatar there are individuals from different countries around the globe. We grouped these individuals by country of origin and contentment assuming that there are different food practices among

these continents that predispose to infection with a particular foodborne pathogen. The risk of infection of each individual from each continent with a particular pathogen was compared to the risk of individuals from Qatar (Table 1). The risk for individuals from countries that were included in the category of others (western countries—America, United Kingdom, and East Europe) was associated with the likelihood of infection with *E. coli* and with *Salmonella* spp. Individuals from other countries were less likely to be detected with *E. coli* (Odds ratio (OR) was 0.3) while the same individuals had five-times more risk of infection with *Salmonella* spp. in comparison to the Qataris.

We also investigated the association between the season of the year and the likelihood of detecting these foodborne pathogens among the study population. Because of the weather conditions at Qatar two seasons were identified: hot (April to November) and cold (December to March). Only *E. coli* detection was associated with season—it was twice more likely to detect *E. coli* in patients admitted with gastroenteritis during the cold season in comparison to the hot season (Table 1).

Table 1: Distribution of demographic characteristics among individuals afflicted with bacterial gastroenteritis in the study population and within each pathogen

Variable	<i>Campylobacter</i> spp. N = 106	<i>E. coli</i> N = 208	<i>Salmonella</i> spp. N = 109
Age Median (Range in years)	2.0 (0.1, 86.0)	0.9 (0.02, 83.0)	5.3 (0.2, 86.0)
Gender			
Female (187) ^a	0.9 (0.5, 1.3) ^b [27%] ^c	1.0 (0.6, 1.3) ^b [50%] ^c	1.4 (0.9, 2.1) ^b [23%] ^c
Male (236) ^a	1.0 [24%] ^c	1.0 [48%] ^c	1.0 [28%] ^c
Country of origin			
Africa (21) ^a	1.0 (0.3, 2.8) ^b [5%] ^c	1.2 (0.5, 2.9) ^b [5%] ^c	0.9 (0.3, 2.5) ^b [5%] ^c
Middle East (109) ^a	1.2 (0.7, 2.0) [28%] ^c	1.4 (0.9, 2.2) ^b [30%] ^c	0.5 (0.3, 0.9) ^b [16%] ^c
Asia (84) ^a	1.1 (0.6, 2.1) ^b [22%] ^c	1.0 (0.6, 1.8) ^b [20%] ^c	0.8 (0.4, 1.5) ^b [17%] ^c
Others (35) ^a	0.5 (0.2, 1.4) ^b [5%] ^c	0.3 (0.1, 0.7) ^b [4%] ^c	4.7 (2.2, 10.1) ^b [20%] ^c
Qatar (174) ^a	1.0 [41%] ^c	1.0 [41%] ^c	1.0 [42%] ^c
Season			
Cold (Dec-March) (72) ^a	1.1 (0.6, 2.0) [24%] ^c	2.2 (1.3, 3.8) ^b [33%] ^c	0.4 (0.2, 2.9) ^b [43%] ^c
Hot (April-Nov) (351) ^a	1.0 [25%] ^c	1.0 [52%] ^c	1.0 [22%] ^c

^a: Number of study units within category; ^b: Odds ratio (95% Confidence interval); ^c: [Percentage within category]

Table 2 shows the results of the multivariate logistic regression analyses for the putative factors that were significantly associated with the likelihood of *E. coli* and *Salmonella* spp. The likelihood of detecting *E. coli* significantly decreased with the age of the individual. Figure 2 shows the plot of the probability of detecting *E. coli* in samples from patients with gastroenteritis. The probability of detecting *E. coli* approached zero after 15 years of age (Figure 2). Also it was also three-times more likely to detect *E. coli* in samples collected during the cold month of the years in comparison to the hot months (OR = 2.5) (Table 2).

Three factors were found significantly associated with the likelihood of detection of *Salmonella* spp.—age of the patient, country of origin, and season of the year. The probability of infection with this pathogen significantly increased with age of the patient when we

adjusted the season of the year and the country of origin of the patients (Table 2). Figure 3 shows the plot of probability of infection against age as computed from the logistic regression equation. The probability of infection with *Salmonella* spp. approached 100% after 60 years of age.

It was 3-times more likely to detect *Salmonella* spp. in gastroenteritis patient in the cold month of the year (December to March) in comparison to other time of the year when we adjust for the age of the patients and the country of origin (Table 2). Individuals from the Middle East were twice less likely to be infected with *Salmonella* spp. in comparison to Qataris when we controlled for the age of the patient and the month of the year (OR = 0.5) (Table 2). It was 4-times more likely to detect *Salmonella* spp. in individuals from western countries (others) in comparison to Qataris (Table 2).

Table 2: Association between each of the putative risk factor and the likelihood of each of the foodborne pathogens

Factor	Regression coefficient	Standard error of coefficient	Odds ratio (95% CI)
<i>E. coli</i>			
Age	-0.151	0.032	
Season			
Cold	0.931	0.286	2.5 (1.4, 4.4)
Hot	1.0		
Constant	-.258	0.266	
<i>Salmonella</i> spp.			
Age	0.050	0.009	
Season			
Cold	-1.377	3.04	0.3 (0.1, 0.5)
Hot	1.0		
Country of origin:			
Africa	-0.308	0.592	0.8 (0.2, 2.7)
Middle East	-0.614	0.332	0.5 (0.2, 0.9)
Asia	-0.309	0.849	0.7 (0.4, 1.3)
Others	1.246	0.413	4.4 (1.9, 10.2)
Qatar	0	0	1.0
Constant	-0.282	0.298	

*: significant in uni- and multi- variate regression analysis

Three serogroups of enteropathogenic *E. coli* (EPEC) were identified the study population: EPEC2, EPEC3, and EPEC4, at a proportions of 23, 27, and 50%, respectively. It was twice more likely to detect EPEC4 among the *E. coli* isolates in comparison to the other enteropathogenic group. There was no significant difference in the median age among the three enteropathogenic groups (Table 3). There was no significant association between each of the enteropathogenic groups and gender, season, or country of origin (Table 3).

Table 3: Association between *E. coli* verogroup expression and Demographic Parameters

Factor	EPEC-2	EPEC-3	EPEC-4
Age (years)	0.9 (0.1 – 49.0) ^a	1.0 (0.1 – 11.9) ^a	0.8 (0.1 – 83.0) ^a
Gender			
Female (95) ^b	1.6 (0.8, 3.0) ^c [26%] ^d	0.9 (0.5, 1.7) ^c [26%]	0.8 (0.4, 1.3) ^c [46%]
Male (113) ^b	1.0 [19%]	1.0 [28%]	1.0 [53%]
Season			
Cold (24) ^b	0.8 (0.3, 2.2) ^c [25%]	1.2 (0.4, 3.1) ^c [25%]	1.0 (0.4, 2.3) ^c [50%]
Hot (184) ^b	[22%]	[28%]	[5%]
Country of origin			
Africa (11) ^b	0.7 (0.1, 3.6) ^c [18%]	2.3 (0.6, 8.7) ^c [36%]	0.6 (0.2, 2.1) ^c [46%]
Middle East (62) ^b	0.9 (0.4, 2.1) ^c [23%]	1.9 (0.9, 4.0) ^c [32%]	0.5 (0.3, 1.0) ^c [44%]
Asia (42) ^b	0.8 (0.3, 1.9) ^c [19%]	2.0 (0.9, 4.6) ^c [33%]	0.5 (0.2, 1.1) ^c [43%]
Other (8) ^b	1.1 (0.2, 5.8) ^c [25%]	1.3 (0.2, 7.2) ^c [25%]	0.7 (0.2, 3.0) ^c [50%]
Qatar (85) ^b	1.0 [24%]	1.0 [20%]	1.0 [59%]

^a: Range values; ^b: Number of study units within category; ^c: Odds ratio (95% Confidence interval); ^d: [Percentage within category]

Table 4 shows the distribution of the putative risk factors among *C. jejuni* and *C. coli*. The majority (63%) of the isolates were identified as *C. jejuni*, while 7% were classified as *C. coli*. Only one strains of each of *C. fetus*, *C. lari*, and *C. upsula* were identified among the *Campylobacter* isolates. Twenty-nine of the isolates were not speciated. The median age for the patients detected with either *C. jejuni* or *C. coli* was the same. There was no significant association between gender, country of origin, season and whether the patient was infected with either *C. jejuni* or *C. coli* (Table 4—none of the odds ratios were significantly different than 1.0).

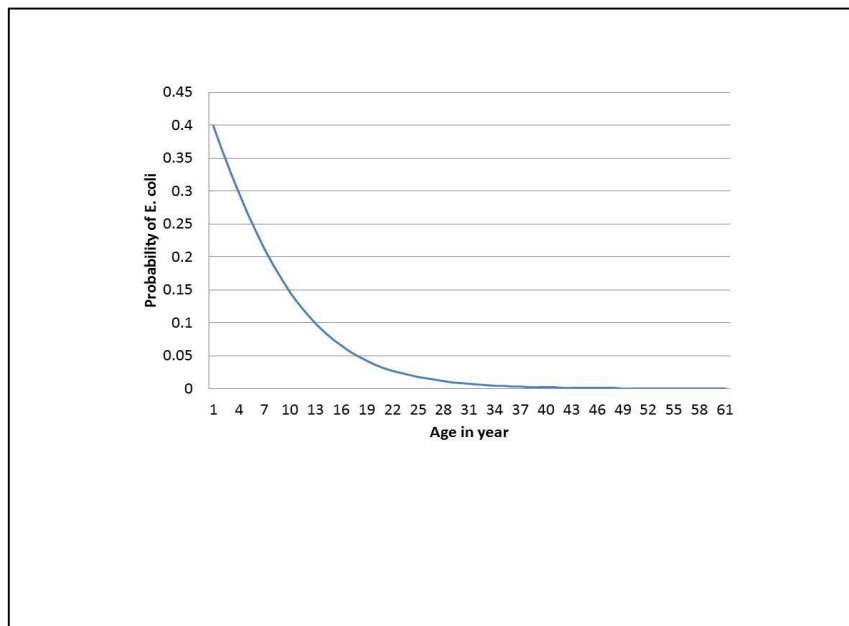
Four main serogroups were identified among the *Salmonella* spp. recovered from patients admitted during the study period (n = 109). Serogroups B (38%) and D (36%) were the most common among the isolates. Other serogroups identified in the study at a low presence were A, C1, C2, and E at proportions of 1, 13, 5, and 3% respectively (Table 4). Five isolates were not serogrouped. We evaluated the association between the putative factors and each of the serogroups. The analysis was performed by comparing the distribution of

each of the risk factors in one serogroups in comparison to the other serogroups combined (Table 4). For the country of origin, we compared the risk in non-Qataris to that of Qataris. It was three times more likely to detect serogroup in patients with gastroenteritis during the cold month of the year in comparison to other serogroups (OR = 3.4). It was less likely to isolate C1 from male patients in comparison to females (OR = 0.3). It was less likely to detect the risk serogroup D among non-Qataris in comparison to Qataris (OR = 0.3) (Table 4). There was no significant association between any of the other factors and the serogroups.

Patients diagnosed with *Salmonella* spp. serogroup D appeared to be older in comparison to patients diagnosed with any other serogroup (Table 4). For the purpose of hypothesis testing we only compared the ages of serogroup B to that of D because of the number of observations in each group. Patients detected with serogroup B were significantly older than patients detected with serogroup B (Table 4).

Table 4: Description of Campylobacter Species and Salmonella serogroups among the factors evaluated

	Age (Median) (Min, Max)	Gender		Ethnicity		Season	
		Male	Female	Qatari	Non-Qatari	Cold	Hot
Campylobacter:							
<i>C. jejuni</i> (67)	2.0 (0.1, 65.0)	35	32	33	34	48	19
<i>C. coli</i> (7)	2.0 (0.3, 86.0)	5	2	2	5	5	2
OR (95% CI)		0.4	(0.1, 2.4)	2.4	(0.4, 13.4)	1.0	(0.2, 5.7)
Salmonella serogroup:							
Salmonella B (41)	2.0 (0.2, 86.0)	63%	27%	51%	49%	41%	58%
OR (95% CI)		1.1	(0.5, 2.5)	1.7	(0.7, 3.9)	3.4*	(1.4, 8.7)
Salmonella C1 (14)	3.9 (0.8, 62.0)	36%	64%	43%	57%	7%	93%
		0.3*	(0.1, 0.9)	2.1	(0.7, 6.7)	0.2	(0.02, 1.4)
Salmonella C2 (6)	22.0 (9.0, 45.0)	67%	33%	33%	67%	17%	83%
OR (95% CI)		1.2	(0.2, 7.1)	3.1	(0.5, 17.6)	0.5	(0.1, 4.7)
Salmonella D (39)	15.0 (0.3, 52.0)	69%	21%	77%	23%	21%	79%
OR (95% CI)		1.7	(0.7, 3.4)	0.3*	(0.1, 0.7)	0.6	(0.2, 1.5)

Figure 1: The relationship between the age of individual enrolled in the study and the probability of *E.coli* infection among bacterial gastroenteritis cases as computed using the logistic regression model.

Discussion

To our knowledge this is the first study that investigated the role of top-ranked foodborne pathogens in the risk of bacterial gastroenteritis in the Middle East and in a population with diverse cultural background. Such knowledge is critical for development of cost-effective strategies for controlling the cost

of the burden of diseases associated with foodborne pathogens. ⁽²⁾ Findings from studies such as ours could be used to develop recommendations for setting priorities and implementing risk modification strategies. According to the report from the department of Epidemiology and Medical Statistics in Qatar that HMC received the largest number of cases

and most diverse patients between the years 2011 and 2012 when compared to other years. ⁽⁶⁾ During the study period a total of 926 patients were admitted to HMC hospitals with the complaint of food poisoning and we investigated approximately 50% of these cases. ⁽⁶⁾ The remainder of the admitted patients did not meet the inclusion criteria and therefore we excluded from the study. We attempted to select cases randomly and stratify them by season to ensure representation and increase validity of extrapolation of the results. ⁽²⁴⁾

The objectives of our study were to identify the pathogens that contribute to the risk of gastroenteritis and their associated factors. There are different epidemiologic approaches that could have been used to address such objectives. We opted to use the case-control study approach because it lends itself to addressing risk factors and using routinely collected data. ⁽²⁴⁾ The rationale for using the other two pathogens as controls in assessing the risk associated with each was based on the facts that when stools are collected from a patient they are automatically examined for the presence of all three pathogens. Therefore, we would increase the internal validity of the study and minimize the potential information bias by discriminating between cases and controls in each scenario. ⁽²⁴⁾ Furthermore, our inclusion criteria were intended to minimize the potential for information bias and increase the internal validity of the study. ⁽²⁴⁾

Among the three foodborne pathogens targeted in this study *E. coli* appeared to be the most common in our sample. It was twice more likely to detect *E. coli* from stools from patients in comparison to *Campylobacter* or *Salmonella* spp. Although no similar studies were carried out in Qatar, an earlier investigation on the common organism associated with bacteremia in a population of patients at HMC identified *E. coli* as the most common organism. ⁽²⁵⁾ Similar investigations in other part of the world found comparable proportions among gastroenteritis cases while others found that *Campylobacter* and *Salmonella* spp. were more common. ^(4, 26, 28) The difference in these findings between other studies and ours could be attributed to the difference in the populations investigated or the emphasis of the diagnostic laboratory at each site.

The ratio of enrollment of patients by gender in our study is similar to the one that had been reported previously on the epidemiology of bacteremia in the same population. ⁽²⁵⁾ We have not found any association between gender and any of the three foodborne pathogens. This finding is consistent with other findings in the region and around the world. ^(25, 27) However, the observed higher rate among males, though not significant, in comparison to female could be attributed to the outdoor lifestyle which may expose male to a greater risk for infection.

Patients diagnosed with *E. coli* infection appeared to be younger in comparison to patients diagnosed with either *Campylobacter* or *Salmonella* spp. This finding is consistent with the findings in other studies. ^(25, 27) Although the likelihood of detecting *E. coli* in stools of patients diagnosed with bacterial gastroenteritis dropped significantly after 1 year, the range included individuals who was 86 years old. Similar observation was reported among patients of bacteremia admitted to the same hospital. This finding implies that individuals with a potential immune compromised system (young and old) are more susceptible to infection with this pathogen. Lending credence to this observation was study investigated the etiology of primary immunodeficiency diseases (PID) in children in this population found that the most common condition was antibody deficiency. ⁽²⁸⁾

Salmonella spp. was recovered from 26% of the cases of bacterial gastroenteritis in our sample while other studies in other part of the world found higher proportions. ^(28, 29) We believe that the differences among these proportions could be attributed to the differences in the target population, in the pathogens focus among the diagnostic laboratory, or due to the prior request by the clinician at admission. One study estimated that 85.6% of the 93.8 million annual cases of gastroenteritis due to *Salmonella* spp. occur around the world are attributed to foodborne pathogens. ⁽¹⁵⁾ These estimates were based on mathematical models and population projections and are different than our actual calculations that were based on data from a particular population. The observed increased risk of infection with *Salmonella* spp. among gastroenteritis cases was consistent with the reported relationship in case control studies.

⁽¹⁰⁾ The difference between our study and Porter's et al., ⁽¹⁰⁾ could be attributed to the difference in target population which at the latter was enrolled from the Armed Services surveillance database in the U.S. The targeted populations in all other studies are different than the one in Qatar. Qatar had a much higher ethnic diversity among the population with a ratio of local to expatriates of 1:5 and majority of the expatriates eat at restaurants—which is known to be a risk factor. ⁽⁸⁾ This diversity contributes to the variability in the risk due to differences in cultural practices related to food preparation and travel to or from the country of origin. ^(4, 5, 30, 31) The travel association and cultural back ground speculation was supported by the finding that individuals from other countries were at increased risk of being diagnosed with *Salmonella* spp. in comparison to Qataris (Table 2). Furthermore, the increased risk of infection with *Salmonella* spp. observed in our study is consistent with what reported in the literature in countries with similar environmental conditions. ⁽³²⁾

As in our *Salmonella* spp. has been recovered from gastroenteritis cases of all ages around the globe and in the Middle East with slide tendency to be higher among older patients. ^(10, 11, 13, 16, 33) Most of the studies argued that the likelihood of infection with this pathogen is largely influenced by the immune status of the patients with high risk among immunocompromised. Also the likelihood of infection with *Salmonella* spp. among gastroenteritis patients is influenced by the season of the year with the risk being higher in the warm month of the year. ^(16, 32) This seasonal variation was observed among our study population. Among the *Salmonella* spp. isolates from gastroenteritis cases in our study the majority belong to serogroup B and D. This finding is consistent with findings many of the reports in the literature from the Middle East and around the world. ^(11, 16, 34) Many factors play role in the predominance of one serogroup in a particular population over the other including the cultural practices in food handling and preparation. Serogroup D was common in the Middle East as been observed in our study. ⁽¹¹⁾

Four species of *Campylobacter* were identified among cases of bacterial gastroenteritis in our study with majority being

C. jejuni. *Campylobacter* spp. has been identified among cases of gastroenteritis around the world at a different rate. ^(2, 3, 10, 22, 30) Data in the Middle East and the gulf region on this foodborne pathogen are scarce, however *C. jejuni* and *C. coli* are among the most reported. ^(35, 36) In Qatar, *Campylobacter* spp. has been associated with the risk of peritonitis. ⁽¹⁹⁾ The findings in our study regarding the lack of association between age or sex with the risk of infection with *Campylobacter* spp. among gastroenteritis cases was consistent with the reports literature in different part of the world. ^(10, 30) The inference is that this pathogen affects all age groups and there was gender predilection. Although we did not find any association between the country of origin and the likelihood of infection with *Campylobacter* spp. other studies that focus on travel and the risk of infection found that individuals that travel to West Europe and the North America were at higher risk of infection. ⁽³⁰⁾ The association in the previous study could be attributed to the fact that travelers to exotic countries take more precautions about the sanitary status of food while these measure are taken for granted or relaxed in the western hemisphere.

Conclusions:

Our data suggested that among the gastroenteritis cases that were enrolled in the study the major foodborne pathogen that was associated with the risk of bacterial gastroenteritis in this dynamic and diverse population was *E. coli* spp. However, this risk was varied with the age of the individuals where younger children were at increased risk and the season of the year where more cases are seen during the cold months. *Salmonella* and *Campylobacter* spp. were presents at equal rate but the risk of infection with *Salmonella* spp. among bacterial gastroenteritis cases was influenced by the age, season of the year, and country of origin. Our study was a retrospective study that focused only on bacterial foodborne pathogens and highlight the need for a more proactive approach, such as prospective study to identify additional factors that put individuals at risk of infection with these foodborne pathogens.

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