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Antimicrobial prescribing practices for enteric bacterial infections in an integrated health care system, Wisconsin, 2004–2017

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Abstract

Background: Few studies have evaluated antibiotic prescribing practices for bacterial enteric infections. Unnecessary antibiotics can result in adverse events and contribute to the emergence of antimicrobial resistance. We assessed treatment practices among patients with laboratory-confirmed enteric infections in a regional healthcare system in Wisconsin, USA.

Methods: We used electronic health records to identify patients with laboratory-confirmed nontyphoidal *Salmonella*, *Shigella*, Shiga toxin-producing *Escherichia coli* (STEC), and *Campylobacter* infections during 2004–2017. Relevant clinical data, including diagnosis codes for chronic conditions and receipt of immunosuppressive medications and antibiotic prescriptions, were extracted. We defined appropriate treatment based on pathogen, patient characteristics, and practice guidelines for the study period.

Results: We identified 2064 patients infected with *Campylobacter* (1251; 61 %), *Salmonella* (564; 27 %), STEC (199; 10 %), or *Shigella* (50; 2 %). Overall, 425 (20 %) patients were immunocompromised, ranging from 17 % with *Salmonella* to 46 % with STEC. There were 220 (11 %) hospitalizations. Antibiotics were prescribed most frequently for *Campylobacter* (53 %), followed by *Shigella* (46 %) and *Salmonella* (44 %) infections. Among those prescribed antibiotics, prescriptions were appropriate for 71 % of *Campylobacter*, 100 % of *Shigella*, and 81 % of *Salmonella* infections. Antibiotics were prescribed for 24 % of STEC infections, despite recommendations against use. Guideline adherence generally decreased with age, except for *Shigella* infections, where adherence was highest for adults ≥ 50 years.

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Authors' contributions

All authors made substantial contributions to the conception of the study, interpreted the data, and read and approved this manuscript. SCO and HQN drafted the manuscript; HQN performed the analyses.

Conclusions: Antibiotic prescribing for laboratory-confirmed enteric infections was usually appropriate but did not follow practice guidelines in a substantial minority of cases, presenting opportunity for improvement. Antibiotic stewardship initiatives should address acute bacterial gastrointestinal infections in addition to other common infections.

Keywords

Anti-bacterial agents; Gastroenteritis

1. Introduction

Over 4800,000 bacterial enteric infections are estimated to occur in the United States, resulting in over 50,000 hospitalizations and 1000 deaths annually [1]. *Campylobacter*, *Salmonella*, Shiga toxin-producing *Escherichia coli* (STEC), and *Shigella* infections accounted for an estimated 3622,200 cases in 2014 [2]. The risk of infection with resistant strains of these bacteria has also increased — 2020 estimates suggest almost 30 % of *Campylobacter*, 50 % of *Shigella*, and 14 % of *Salmonella* infections are resistant to recommended empiric antibiotics [3].

While antibiotic treatment of some enteric pathogens such as *Shigella* and *Campylobacter* is recommended to shorten duration of illness and reduce duration of shedding in stool, most patients with nontyphoidal *Salmonella* infections can be managed without the use of antibiotics. Antibiotic treatment is recommended in patients with severe disease or in those with risk factors for invasive infection [4,5]. Inappropriate prescribing of antibiotics contributes to the development of antimicrobial resistance and is, therefore, a public health concern [6]. Furthermore, antibiotic use is associated with the development of adverse drug events and secondary infections such as *Clostridium difficile* colitis and may prolong shedding of nontyphoidal *Salmonella* in the stool [7,8].

Expert consensus management guidelines for diagnosis and management of bacterial gastroenteritis are available, such as those developed by the Infectious Disease Society of America (IDSA) and the American Academy of Pediatrics (AAP) [4,5,9,10]. While studies have evaluated the overall management of acute gastroenteritis in various clinical settings, few have specifically sought to examine adherence to antibiotic recommendations to assess prescribing practices [11–17]. A better understanding of prescribing practices and adherence to existing treatment guidelines could help to inform interventions to promote appropriate prescribing. We evaluated treatment practices of enteric bacterial infections in a large regional healthcare system from 2004 through 2017, using the 2001 IDSA treatment guidelines, as they were in effect during the study period.

2. Methods

We conducted a descriptive retrospective cohort study using electronic health records from the Marshfield Clinic Health System (MCHS). MCHS is a regional healthcare system serving a predominantly rural population in Western, Central, and Northern Wisconsin, USA. Diagnostic testing for all enteric pathogens at MCHS is performed by a central microbiology laboratory with results documented in the electronic health records.

The study population included patients with an inpatient or outpatient encounter with laboratory confirmed bacterial enteric infection from 2004 through 2017. The study period was determined based on data available at the time the study was proposed. Patients were included if they had a positive diagnostic test (e.g., culture or nucleic acid test) for *Campylobacter*, *Shigella*, nontyphoidal *Salmonella*, or STEC infection. For the majority of the study period, diagnostic testing was limited to stool culture, with nucleic acid testing being used primarily starting in 2013. Patients with dual enteric infections were excluded.

Data on patient demographics (age at the time of the visit, sex, race, ethnicity), insurance type (private, public, none/self-pay), and visit location (outpatient, inpatient) from the corresponding health care visit was extracted from the electronic health records. Data on medications (date, name, duration, dose) and healthcare visits (dates, ICD-9/ICD-10 diagnosis codes, and diagnostic tests) during the 60 days before through 60 days after the corresponding enteric infection encounter were extracted from the electronic health records to assess antibiotic receipt, treatment guideline adherence, and presence of high risk underlying chronic or immunosuppressive conditions.

We evaluated treatments in our cohort according to subjects' underlying health conditions, as guidance differs for immunocompetent and immunocompromised patients. Presence of a high risk underlying chronic or immunosuppressive condition was determined based on receipt of diagnosis codes for chronic obstructive pulmonary disease, chronic heart conditions, diabetes mellitus, malignancies, human immunodeficiency virus infection, cerebrovascular disease and renal disease, or receipt of immunosuppressive medications during the 60 days before through 60 days after the corresponding enteric infection encounter (Table 1) [6].

Antibiotic receipt was defined as an antibiotic prescription within 14 days following the visit associated with the confirmed infection; however, whether a prescription was filled could not be determined from the electronic health records. Though newer treatment guidelines have been published with updated recommendations [5], guideline adherence for our study was defined by infecting pathogen, patient characteristics, and antibiotic agent prescribed in accordance with the 2001 IDSA practice guidelines (Table 2) [4]. Guideline adherence was defined as receipt of erythromycin (or azithromycin, as it is within the same therapeutic class) or clarithromycin for *Campylobacter*, and receipt of trimethoprim-sulfamethoxazole (TMP-SMZ), a fluoroquinolone, ceftriaxone, or azithromycin for *Shigella*. For nontyphoidal *Salmonella*, guideline adherence was defined as receipt of TMP-SMZ, fluoroquinolone, or ceftriaxone among those at risk for severe disease, including those aged < 6 months or > 50 years, seen in the emergency department or hospital as a proxy for severity of disease, or with a high risk underlying chronic or immunosuppressive condition, and no antibiotics for immunocompetent patients (Table 2). In contrast, guidelines recommend avoidance of antibiotics for STEC due to the possible increased risk of hemolytic uremic syndrome (HUS). Thus, for STEC, guideline adherence was defined as those encounters without receipt of antibiotics or antimotility agents. To assess trends in guideline adherence over the course of the study, prescribing practices were compared for each pathogen between the first and second half of the study period. Multivariable logistic regression was used to identify patient characteristics that were independently associated with guideline adherence.

Characteristics with a $P < .2$ in univariate analysis were included in the initial model to assess associations. Backward elimination with a cutoff of $P = 0.05$ was conducted to determine inclusion in the final adjusted model. Patient characteristics assessed included the following: age group (< 6 months, 6 months - 17 years, 18–50 years, and > 50 years), sex, race/ethnicity (non-Hispanic White, Hispanic, other, unknown), insurance status (public, private, public and private, unknown), presence or absence of a high risk chronic or immune-suppressive condition, hospitalization within 2 weeks of diagnostic testing, and year of infection (2004–2010 and 2011–2017). Differences in proportions across groups were compared using chi-squared or Fisher's exact tests, where appropriate. P -values < 0.05 were considered statistically significant. Analyses were conducted using SAS Version 9.4 (Cary, NC).

This study was reviewed and approved by the Marshfield Clinic Health System Institutional Review Board (MCHS-IORG0000394, MCHS IRB#00000673, FWA00000873). Informed consent was waived by the Marshfield Clinic Health System Institutional Review Board.

3. Results

Over the 14-year study period, there were 2064 patients with one of the four bacterial enteric infections of interest: 1251 (61 %) had *Campylobacter*, 564 (27 %) nontyphoidal *Salmonella*, 199 (10 %) STEC, and 50 (2 %) *Shigella*. About half (51 %) were male and 82 % were non-Hispanic White, consistent with regional demographics in Western, Central, and Northern Wisconsin. The age of patients with enteric bacterial infections varied by pathogen. Median age was 25 years for patients with *Shigella*, 28 years for *Campylobacter*, 30 years for *Salmonella*, and 45 years for STEC. Overall, 18 % of patients had a high risk chronic or immunosuppressive condition but the percent varied by pathogen: 44 % among those with STEC, and 12–16 % for the other pathogens. There were 220 (11 %) hospitalizations (Table 3).

3.1. *Campylobacter*

Among the 1251 patients with *Campylobacter* infection, 658 (53 %) received an antibiotic prescription, of whom 471 (72 %) received recommended antibiotics, accounting for overall guideline adherence in 37 % of cases (Tables 4 and 5). Guideline adherence was highest in infants aged < 6 months (72 %) and decreased with increasing age, with lowest guideline adherence for patients > 50 years ($P < .0001$) (Table 5). Guideline adherence was lower for hospitalized patients (20 %) compared to ambulatory patients (39 %) ($P < .0001$) and for patients who were non-Hispanic White (38 %) compared with Hispanic (46 %) and other races (45 %) ($P = .002$). Guideline adherence improved during the second half of the study period (2011–2017; 43 %) compared with earlier years (2004–2010; 32 %) ($P < .0001$). Adherence to prescribing guidelines was similar by sex, insurance status, and immune status. In multivariable analyses, age, hospitalization status, and year of infection were independently associated with guideline adherence for *Campylobacter* infections (Table 5).

3.2. Shigella

Among 50 patients diagnosed with *Shigella*, 23 (46 %) received an antibiotic and all 23 (100 %) received a recommended antibiotic (Table 4). Guideline adherence was 30 % among encounters for children, 52 % among adults aged 18–50 years, and 67 % among adults > 50 years (Table 5). There was improved guideline adherence during the second half of the study period compared with the first half (61 % vs. 33 %; $P = 0.05$).

3.3. Nontyphoidal Salmonella

Among 564 patients with a *Salmonella* infection, 220 (39 %) received an antibiotic prescription, of whom 106 (48 %) received a recommended antibiotic. Among 287 patients with underlying health conditions or criteria associated with increased risk for severe illness (i.e., persons aged < 6 months or > 50 years, seen in the emergency department or hospital, or who have a high risk underlying chronic or immunosuppressive condition), 128 (45 %) received antibiotic prescriptions, and of those, 106 (83 %) were for recommended antibiotics (Table 4). Among the patients at risk for severe disease, adherence to guidelines was higher among adults than children (16 % among infants < 6 months to 44 % for adults > 50 years, $P = 0.005$), higher among non-Hispanic White patients than patients of other races/ethnicity (42 % versus 13 % among Hispanic patients, 24 % among those with other race, and 11 % among those with unknown race, $P = 0.003$), and higher among patients with private insurance than public or unknown insurance status (47 % vs 28 %–31 %, $P = 0.02$) (Table 5). There was no difference in guideline adherence by sex, presence or absence of an immunosuppressive condition, hospitalization status, or study period. In multivariable analyses, only age was independently associated with guideline adherence for *Salmonella* infections (Table 5).

3.4. STEC

Among 199 patients with STEC infections, 155 (78 %) subjects were not prescribed an antibiotic (Table 4), consistent with treatment guidelines. Guideline adherence to recommendations to withhold antibiotics and antimotility agents was 76 % overall and highest for encounters with children 6 months to 18 years old (89 %) compared to adults (64 %) ($P = .002$) (Table 5). There was no difference in prescribing guideline adherence by sex, race/ethnicity, immune status, insurance status, hospitalization status, or study period. In multivariable analyses, only age was independently associated with guideline adherence for STEC infections (Table 5).

4. Discussion

Across a 14-year period, prescribing practice for enteric bacterial infections in a regional healthcare system varied widely, despite the availability of expert consensus treatment guidelines. Guideline adherence to prescribing recommendations was highest for STEC infections (76 %) and lowest for *Campylobacter* infections (37 %). Among patients who did receive antibiotics, > 70 % received the recommended treatment. Increasing antibiotic resistance among common bacterial enteric pathogens remains a threat to public health. Our study of treatment practices for laboratory confirmed bacterial enteric infections within a large regional healthcare network suggest that there is room for improvement in

management of these bacterial enteric infections [18]. Adherence to consensus practice guidelines varied significantly by pathogen and patient characteristics. However, for all pathogens assessed, age was independently associated with guideline adherence. Health care networks and antimicrobial stewardship initiatives should include approaches for management of these common bacterial enteric infections, such as education initiatives for clinicians and encouragement of guideline use and target providers who care for patients in age groups with lower guideline adherence. Other methods of improving antimicrobial prescribing practices to consider include behavioral science-informed interventions, such as individualized audit and feedback, or financial incentives, such as pay-for-performance initiatives.

The variation in guideline adherence observed in this study of laboratory confirmed enteric infections has also been seen in studies of other common bacterial infections. For acute respiratory infections, multiple studies have reported wide variation in prescribing practices with relatively poor adherence to recommended guidelines for antibiotic prescribing and overuse use of broad-spectrum agents [19–26]. Within our study, variation in guideline adherence may have been due to multiple reasons. Treatment may have been withheld for mild disease or deemed unnecessary by the time microbiologic diagnosis was confirmed. Guidelines do not explicitly recommend against treatment with antibiotics for mild cases of *Campylobacter* and *Shigella*, and therefore was not considered in the guideline adherence definition in this study. Treatment may have been prescribed before the diagnosis was known, and consequently the empiric antibiotic prescribed was not consistent with treatment recommendations for the final isolated pathogen. For STEC infections, adherence to published guidelines may have been higher because of the risk of precipitating hemolytic uremic syndrome with antibiotic use. Additionally, allergies or previous adverse reactions may have precluded receipt of recommended antibiotics.

This study found rates of guideline adherence varied by patient age in multivariate analysis, however, the pattern of guideline adherence was discordant across enteric pathogens. Guideline adherence was lower for older patients when treating *Campylobacter* and STEC, but higher when treating *Salmonella*. Discrepancies in treatment based on patient age could be related to increased provider anxiety for progression to severe disease in elderly patients or increasing comorbidities with age not otherwise captured as high risk conditions. However, this would not explain our findings for *Salmonella*. A prior study of antibiotic prescribing found decreased rates of guideline adherence among patients older than 85 years old, but this study included only adult inpatients in a single French center and did not evaluate prescribing based on pathogen [27].

There are likely cases that were determined by this study to be non-adherent to guideline recommendations yet could be considered appropriate for the individual patient. More rapid microbiologic results due to use of culture-independent diagnostic tests (CIDT) later in the study period may have contributed to improved rates of adherence for infections for which antibiotics are indicated (*Campylobacter* and *Shigella*) but decreased rates for those in which antibiotics are not indicated (certain *Salmonella* infections and STEC) because some providers may feel inclined to treat when any pathogen is identified. Additionally, because stool culture susceptibility results were not included in our review, non-first line

recommended antibiotic treatment could still be appropriate due to resistant isolates in some patients. Nevertheless, qualitative studies to better understand provider perspectives in treating patients with enteric bacterial infections are needed.

Some limitations of this study should be noted. First, this study included only laboratory confirmed cases of bacterial enteric infection. Thus, cases that were not diagnosed by culture or CIDE were not included in our analysis. However, use of one shared microbiology laboratory for diagnosis of enteric infections ensured that, across the study period, testing was standard for all cases. Second, adherence to guidelines was based on prescribing data extracted from the electronic health record. Although the use of a shared electronic health record across all clinical sites allowed for automated access to all linked pertinent clinical, microbiology, and prescribing data, we were unable to determine whether prescribed medications were taken by patients. If antibiotics were prescribed but follow up guidance was provided based on subsequent laboratory results, such as stopping antibiotics if STEC was identified, that information was not accessible. Third, the list of high risk underlying chronic conditions and immunosuppressive medications is not comprehensive, and misclassification is possible. However, the list represents the most common conditions, and a more comprehensive list is unlikely to significantly change the results. Nonetheless, determination of high risk status is based on judgement by the treating provider taking account different factors, and can vary widely, especially when clear guidelines are not known or available. Finally, our study population was predominantly non-Hispanic White, and limited to a single region within Wisconsin, and therefore may not be representative of other populations or geographic regions.

Noteworthy strengths of this study include a stable population across a wide geographic area comprised primarily of rural patients, who may be underrepresented in similar studies. Additionally, the ability to link prescribing, clinical, and microbiologic data through the shared electronic health records within this study allowed a more specific assessment of guideline adherence than would be possible by use of other datasets.

5. Conclusions

This study demonstrates that despite the existence of published consensus guidelines for treatment of bacterial enteric infections, provider guideline adherence remained variable and suboptimal. Improving provider knowledge and use of consensus treatment guidelines for enteritis and other common infections could result in more targeted antibiotic treatment and fewer overall prescriptions when therapy is not warranted.

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Declaration of Competing Interest

Huong Nguyen receives research support unrelated to this work from CSL Seqirus, GSK, ModernaTX, and honorarium for participating in a consultancy group for ModernaTX outside the submitted work. All other authors declare no potential conflicts of interest.

Abbreviations:

AAP	American Academy of Pediatrics
HUS	hemolytic uremic syndrome
CIDT	culture-independent diagnostic tests
IDSA	Infectious Disease Society of America
MCHS	Marshfield Clinic Health System
STEC	Shiga toxin-producing <i>Escherichia coli</i>
TMP-SMZ	trimethoprim-sulfamethoxazole

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Table 1

Underlying health conditions with associated diagnosis codes and immunosuppressive medications used to determine immune status.

Conditions	ICD-9	ICD-10
chronic obstructive pulmonary disease	491 -492, 496	J44.0, J44.1, J44.9
congestive heart failure, ischemic or hypertensive heart disease	402, 404, 428, 410 -414	150, 125, 124, 111, 113
diabetes mellitus	250	E10, E11, E13, E9, E8
malignant neoplasms and neoplasms of uncertain or unspecified behavior	140 -208	C00-C96, C7A, C7B, D37-D49
human immunodeficiency virus infection	042, v08	Z21, B20
cerebrovascular disease	235 -239, 430 -438	160-169
acute or chronic renal disease	403, 580 -588	N17 - N19
Immunosuppressive medications		
methotrexate, etanercept, infliximab, adalimumab, tacrolimus, cyclosporine, mycophenolic acid, prednisone, methylprednisolone, prednisolone, dexamethasone		

Abbreviation: ICD, international classification of diseases

Summary of 2001 Infectious Diseases Society of America Practice guidelines for management of enteric infections [4].

Table 2

Pathogen	Patient Group	2001 Guideline Recommendation
<i>Campylobacter</i>	All	Erythromycin, clarithromycin
<i>Shigella</i>	All	TMP-SMZ (if susceptible), fluoroquinolone (e.g., ofloxacin, norfloxacin, ciprofloxacin), ceftriaxone, azithromycin, nalidixic acid
Nontyphoidal <i>Salmonella</i>	Age < 6 months or age > 50 years, Immunocompromised individuals (HIV infection, cancer chemotherapy recipients, persons receiving long-term oral steroids, or immunosuppressive agents) Other immunocompetent patients not meeting the above criteria	TMP-SMZ (if susceptible), fluoroquinolone, ceftriaxone
STEC	All	Antibiotics not recommended routinely No antibiotics; no antimotility agents

Abbreviations: STEC, Shiga toxin-producing *Escherichia coli*; TMP-SMZ, trimethoprim-sulfamethoxazole

Table 3

Characteristics of patients with *Campylobacter*, *Shigella*, nontyphoidal *Salmonella*, or STEC infection, 2004–2017.

	<i>Campylobacter</i> n = 1251	<i>Shigella</i> n = 50	Nontyphoidal <i>Salmonella</i> n = 564	STEC n = 199
Age				
< 6 months	24 (2)	0	25 (4)	3 (2)
6 months–17 years	451 (36)	20 (40)	177 (31)	56 (28)
18–50 years	451 (36)	21 (42)	217 (38)	49 (25)
> 50 years	325 (26)	9 (18)	145 (26)	91 (46)
Male sex	706 (56)	21 (42)	261 (46)	85 (43)
Race/ethnicity				
Non-Hispanic White	1040 (83)	38 (76)	445 (79)	173 (87)
Hispanic	67 (5)	3 (6)	19 (3)	0
Other	42 (3)	3 (6)	39 (7)	12 (6)
Unknown	102 (8)	6 (12)	61 (11)	14 (7)
Insurance status				
Public	444 (35)	12 (24)	201 (36)	77 (39)
Private	409 (33)	20 (40)	174 (31)	57 (29)
Public and private	191 (15)	5 (10)	79 (14)	42 (21)
Unknown	207 (17)	13 (26)	110 (20)	23 (12)
High risk chronic or immunosuppressive condition^a	202 (16)	6 (12)	85 (15)	88 (44)
Hospitalized^b	128 (10)	4 (8)	65 (12)	23 (12)
Year of infection				
2004–2010	662 (53)	27 (54)	287 (51)	66 (33)
2011–2017	589 (47)	23 (46)	277 (49)	133 (67)

Abbreviations: STEC, Shiga toxin-producing *Escherichia coli*

^a Presence of a high risk underlying chronic condition was determined based on receipt of diagnosis codes for chronic obstructive pulmonary disease, chronic heart conditions, diabetes mellitus, malignancies, human immunodeficiency virus infection, cerebrovascular disease and renal disease or receipt of immunosuppressive medications during the 60 days before through 60 days after the corresponding enteric infection encounter

^b Within two weeks of diagnostic testing

Table 4
Antibiotic receipt and guideline adherence among patients who received an antibiotic prescription, 2004–2017.

	No. who received antibiotics/total (%)	No. who received guideline adherent treatment (% of total who received antibiotics)
<i>Campylobacter</i>	658/1251 (53)	471 (72)
<i>Shigella</i>	23/50 (46)	23 (100)
Nontyphoidal <i>Salmonella</i> ^a	128/287 (45)	106 (83)
STEC	44/199 (22)	N/A ^b

Abbreviations: STEC, Shiga toxin-producing *Escherichia coli*

^a Among those aged < 6 months or > 50 years, seen in the emergency department or hospital, or have a high risk underlying chronic condition

^b Antibiotics for STEC are not recommended in any condition

Table 5

Guideline adherence among patients by patient characteristics for each infection, and patient characteristics independently associated with *Campylobacter*, *Shigella*, nontyphoidal *Salmonella*, or STEC infections.

	<i>Campylobacter</i>			<i>Shigella</i>			Nontyphoidal <i>Salmonella</i> patients at risk for severe disease ^a				Nontyphoidal <i>Salmonella</i>			STEC	
	n/N (%)	P	aOR ^b (95% CI)	n/N (%)	P	aOR ^{b,c} (95% CI)	n/N (%)	P	aOR ^b (95% CI)	n/N (%)	P	aOR ^b (95% CI)	n/N (%)	P	aOR ^b (95% CI)
All	471/1251 (37)			23/50 (46)			106/287 (37)			291/564 (52)			151/199 (76)		
Age		< .0001			.2			.005			< .0001			.001	
< 6 months	17/24 (72)		6.4 (2.6, 16.0)	0			4/25 (16)		0.3 (0.1, 0.9)	4/25 (16)		0.2 (0.1, 0.5)	2/3 (67)		0.4 (0.03, 4.8)
6 months-17 years	231/451 (51)		2.5 (1.9, 3.2)	6/20 (30)			12/53 (21)		0.4 (0.2, 1.0)	109/177 (62)		1.4 (1.0, 2.2)	50/56 (89)		1.6 (0.5, 5.1)
18-50 years	138/451 (31)		Ref	11/21 (52)			26/64 (41)		Ref	114/217 (53)		Ref	41/49 (84)		Ref
> 50 years	85/325 (26)		0.8 (0.6, 1.1)	6/9 (67)			64/145 (44)		1.2 (0.6, 2.1)	64/145 (44)		0.7 (0.5, 1.1)	58/91 (64)		0.3 (0.1, 0.8)
Sex		.7			.3			.6			1.0			.6	
Female	202/545 (37)			15/29 (52)			58/152 (38)			156/303 (51)			85/114 (75)		
Male	269/706 (38)			8/21 (38)			48/135 (36)			135/261 (52)			66/85 (78)		
Race/ethnicity		.002			.2			.003			.4			1.0	
Non-Hispanic White	399/1040 (38)			20/38 (53)			97/231 (42)			236/445 (53)			131/173 (76)		
Hispanic	31/67 (46)			0/3 (0)			1/8 (13)			7/19 (37)			0/0		
Other	19/42 (45)			0/3 (0)			5/21 (24)			17/39 (44)			9/12 (75)		
Unknown	22/102 (22)			3/6 (50)			3/27 (11)			31/61 (51)			11/14 (79)		
Insurance status		.005			.9			.02			.6			.4	
Public	176/444 (40)			6/12 (50)			32/114 (28)			100/201 (50)			54/77 (70)		
Private	164/409 (40)			9/20 (45)			37/79 (47)			92/174 (53)			45/57 (79)		
Public and private	76/191 (40)			3/5 (60)			23/49 (47)			37/79 (47)			32/42 (76)		

	<i>Campylobacter</i>			<i>Shigella</i>			Nontyphoidal <i>Salmonella</i> patients at risk for severe disease ^a				Nontyphoidal <i>Salmonella</i>		STEC		
	n/N (%)	P	aOR ^b (95 % CI)	n/N (%)	P	aOR ^{b,c} (95 % CI)	n/N (%)	P	aOR ^b (95 % CI)	n/N (%)	P	aOR ^b (95 % CI)	n/N (%)	P	aOR ^b (95 % CI)
Unknown	55/207 (27)			5/13 (38)			14/45 (31)			62/110 (56)			20/23 (87)		
High risk chronic or immune-suppressive condition ^d		.3			.4			.1			.1			.4	
Present	70/202 (34)			4/6 (67)			37/85 (44)			37/85 (44)			64/88 (73)		
Absent	401/1049 (38)			19/44 (43)			69/202 (34)			254/479 (53)			87/111 (78)		
Hospitalized ^e		< .0001			.6			.8			.02			.4	
Yes	27/128 (21)		0.5 (0.3, 0.8)	1/4 (25)			25/65 (38)			25/65 (38)			19/23 (83)		
No	444/1123 (40)		Ref	22/46 (48)			81/222 (36)			266/499 (53)			132/176 (75)		
Year of infection		< .0001			.05			.08			.03			.08	
2004–2010	214/662 (32)		Ref	9/27 (33)			42/133 (32)			161/287 (56)			55/66 (83)		
2011–2017	257/589 (44)		1.8 (1.4, 2.3)	14/23 (61)			64/154 (42)			130/277 (47)			96/133 (72)		

Abbreviations: STEC, Shiga toxin-producing *Escherichia coli*; n = number guideline adherent, N = total in stratum, %=percentage (row), aOR=adjusted odds ratio for guideline adherent, CI=confidence interval, ref=reference *P*-values from chi-square or Fisher's exact tests, *P*< .05 indicates statistical significance; 95 % CI that exclude 1 indicates statistical significance.

^aPatients aged < 6 months or > 50 years, seen in the emergency department or hospital, or have a high risk underlying chronic condition

^bAdjusted odds ratios were reported for patient characteristics that were independently associated with guideline adherence in logistic regression models. Characteristics with a *P*< .2 in univariate analysis were included in the initial model to assess associations. Backward elimination with a cutoff of *P*= 0.05 was conducted to determine inclusion in the final adjusted model.

^cMultivariable analyses was not conducted for *Shigella* infections due to the small sample size.

^dPresence of a high risk underlying chronic condition was determined based on receipt of diagnosis codes for chronic obstructive pulmonary disease, chronic heart conditions, diabetes mellitus, malignancies, human immunodeficiency virus infection, cerebrovascular disease and renal disease or receipt of immunosuppressive medications during the 60 days before through 60 days after the corresponding enteric infection encounter

^eWithin two weeks of diagnostic testing