

Antimicrobial Susceptibility of *Campylobacter jejuni* and *Campylobacter coli* Isolates Obtained in Montreal, Quebec, Canada, from 2002 to 2013

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From 2002 to 2013 in Montreal, Quebec, Canada, 38 *Campylobacter coli* isolates were more frequently erythromycin, tetracycline, and ciprofloxacin resistant than 440 *Campylobacter jejuni* subsp. *jejuni* isolates (18.4% versus 1.8%; $P = 0.00005$), of which the 148 isolates acquired abroad were more frequently erythromycin, tetracycline, and ciprofloxacin resistant than the 292 isolates acquired locally (5.4% versus 0%; $P = 0.0001$).

Campylobacter jejuni subsp. *jejuni* and *Campylobacter coli* are major human pathogens representing the first and second most frequent *Campylobacter* species, respectively, in most countries (1, 2). Macrolides and fluoroquinolones are first- and second-choice agents when antimicrobial treatment is indicated (1, 2). The objectives of this study were to ascertain and compare the erythromycin, tetracycline, and ciprofloxacin resistance rates of human *C. jejuni* subsp. *jejuni* and *C. coli* isolated in 2002 to 2013 in Montreal, Quebec, Canada. The resistance rates of *C. jejuni* subsp. *jejuni* and *C. coli* isolates acquired abroad were compared to the resistance rates of those acquired locally. The multidrug resistance rates of *C. jejuni* subsp. *jejuni* and *C. coli* isolates obtained from 2002 to 2013 to erythromycin and ciprofloxacin or to erythromycin, tetracycline, and ciprofloxacin were compared to one another.

C. jejuni subsp. *jejuni* and *C. coli* were isolated from 2002 to 2013 at the Centre Hospitalier de l'Université de Montréal (CHUM)–Hôpital Saint-Luc. The phenotypic identification (2) of 96 *C. jejuni* subsp. *jejuni* isolates, including all multidrug-resistant isolates, and all other *Campylobacter* spp., including *C. coli*, was confirmed at the genus and species levels by *cpn60* gene sequencing (3) at the Laboratoire de Santé Publique du Québec (LSPQ). Susceptibilities to erythromycin, tetracycline, and ciprofloxacin were assessed initially by disk diffusion and later confirmed by agar dilution, Etest (AB Biodisk, Solna, Sweden), or both (2, 4, 5). Clinical and Laboratory Standards Institute *Campylobacter* susceptibility and resistance breakpoints for erythromycin, tetracycline, and ciprofloxacin were implemented (4). Susceptibilities to amoxicillin-clavulanic acid, gentamicin, and imipenem were determined by the Etest method. The significance of differences was analyzed by the chi-square test, Fisher's exact 2-tailed test, or the chi-square test for linear trend with Epi Info software, version 6.0 (Centers for Disease Control and Prevention). P values of ≤ 0.05 were considered statistically significant.

Considering a single *Campylobacter* isolate per patient, 479 *C. jejuni* subsp. *jejuni* (86.6%), 38 *C. coli* (6.9%), and 36 other *Campylobacter* species (*C. fetus*, *C. lari*, *C. upsaliensis*, and *C. hyointestinalis*) (6.5%) isolates were obtained at CHUM–Hôpital Saint-Luc from 2002 to 2013. In previous studies, *C. coli* represented 7 to 15% of the *Campylobacter* spp. identified (6). Eight of the 479 (1.7%) *C. jejuni* subsp. *jejuni* isolates and 1 (2.6%) of the 38 *C. coli*

TABLE 1 Antimicrobial susceptibility of 440 *C. jejuni* subsp. *jejuni* and 38 *C. coli* isolates from Montreal, Quebec, Canada, 2002 to 2013^a

Organism	Erythromycin (% R ^b)	Tetracycline (% R)	Ciprofloxacin (% R)
<i>Campylobacter jejuni</i> subsp. <i>jejuni</i>	3.6	62.3	41.6
<i>C. coli</i>	18.4	52.6	50.0
P	0.001	0.3	0.4
RR (95% CL) ^c	0.20 (0.09–0.45)	1.18 (0.87–1.61)	0.83 (0.59–1.16)

^a One isolate per patient and per outbreak included.

^b R, resistant.

^c RR, relative risk; 95% CL, 95% confidence limits.

isolates were isolated from blood ($P = 0.5$; relative risk [RR] [95% confidence limits {CL}], 0.63 [0.08 to 4.94]); 4 *C. jejuni* subsp. *jejuni* bacteremic patients also had stool cultures positive for the same *Campylobacter* sp. than the one isolated from their blood. Overall, 475 *C. jejuni* subsp. *jejuni* and 37 *C. coli* isolates were obtained from stools, with a 2.25% positive rate for these species in stools during those years. *C. jejuni* subsp. *jejuni* and *C. coli* were isolated more frequently from blood than reported previously (i.e., 0.15% of *Campylobacter* infections [2]). The automated blood culture systems and patient immune statuses were variables that influenced the bacteremia rates (1, 2). In the week before symptom onset, 148 *C. jejuni* subsp. *jejuni* isolates (30.9%) and 21 *C. coli* (55.3%) isolates were acquired abroad, outside the province of Quebec, and 331 (69.1%) *C. jejuni* subsp. *jejuni* and 17 (44.7%) *C. coli* isolates were acquired locally ($P = 0.004$; RR [95% CL], 0.56 [0.41 to 0.77]), data similar to those reported previously (6).

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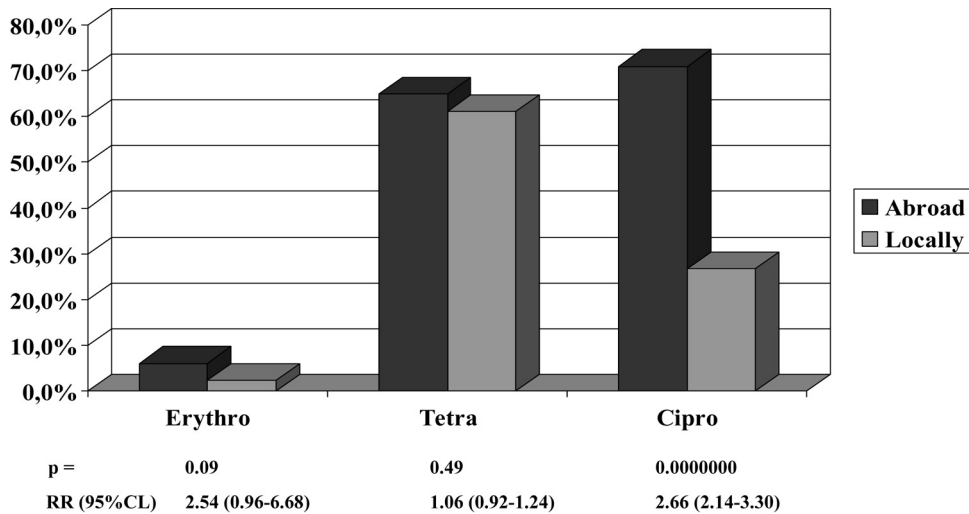


FIG 1 Rates of resistance of 148 and 292 *Campylobacter jejuni* subsp. *jejuni* isolates acquired abroad or locally, respectively, in Montreal, Quebec, Canada, 2002 to 2013.

Among these 479 *C. jejuni* subsp. *jejuni* isolates, 3 clusters were documented (7; our unpublished data) and only 1 isolate per outbreak was included in our susceptibility study, for a total of 440 *C. jejuni* subsp. *jejuni*. One *C. coli* isolate was involved in a documented outbreak (8), and all 38 *C. coli* isolates were included in our susceptibility study.

The 38 *C. coli* isolates were significantly more resistant to erythromycin, but not to tetracycline or ciprofloxacin, than the 440 *C. jejuni* subsp. *jejuni* isolates (Table 1), similar to data reported previously (1, 2, 9). The 148 *C. jejuni* subsp. *jejuni* and 21 *C. coli* isolates acquired abroad were more resistant to ciprofloxacin, but not to tetracycline or erythromycin, than the 292 *C. jejuni* subsp. *jejuni* and 17 *C. coli* isolates acquired locally (Fig. 1 and 2). In three 4-year time periods (2002 to 2005, 2006 to 2009, and 2010 to 2013), *C. jejuni* subsp. *jejuni* isolates acquired abroad were more resistant to ciprofloxacin than were the *C. jejuni* subsp. *jejuni* isolates acquired locally ($P \geq 0.0002$) (data not shown). In

each of these 12 years, the number of ciprofloxacin-resistant *C. jejuni* subsp. *jejuni* isolates acquired abroad did not increase significantly (chi-square for linear trend, $P = 0.052$), but the number of ciprofloxacin-resistant *C. jejuni* subsp. *jejuni* isolates acquired locally increased significantly (chi-square for linear trend, $P = 0.00000$) (data not shown). In some studies, travel was associated with increased resistance to ciprofloxacin (9, 10, 11). With the availability of fluoroquinolones in veterinary and clinical practice, increased resistance of *C. jejuni* subsp. *jejuni* and *C. coli* to ciprofloxacin has been documented along with decreasing efficacy in the treatment of infections with these pathogens (1, 2, 9, 11).

From 2002 to 2013 at CHUM–Hôpital Saint-Luc, 7 of the 38 *C. coli* (18.4%) and 8 of the 440 *C. jejuni* subsp. *jejuni* (1.8%) isolates were erythromycin, tetracycline, and ciprofloxacin resistant ($P = 0.00005$; RR [95% CL], 10.13 [3.88 to 26.43]), which are data not reported previously, to the best of our knowledge. Eight of the 148 *C. jejuni* subsp. *jejuni* (5.4%) isolates acquired abroad and 0% of

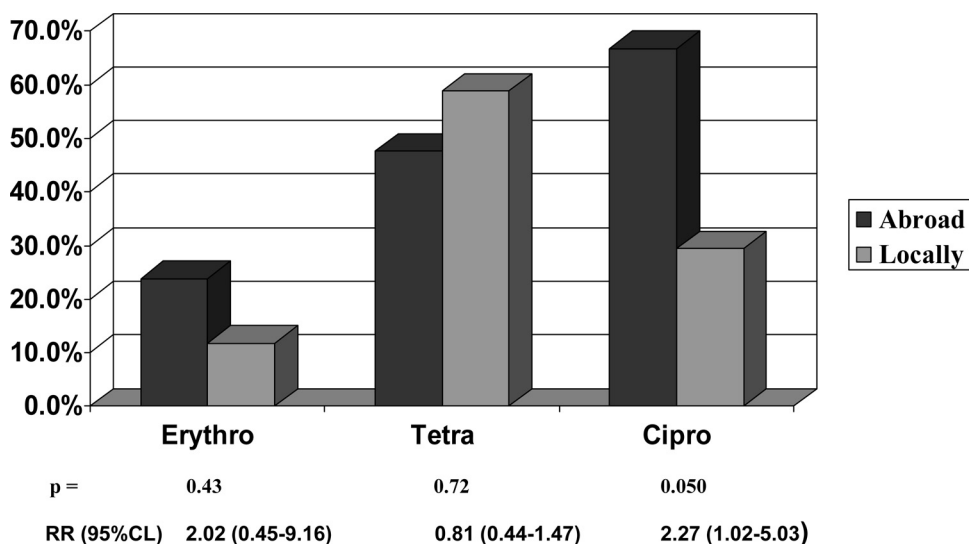


FIG 2 Rates of resistance of 21 and 17 *Campylobacter coli* isolates acquired abroad or locally, respectively, in Montreal, Quebec, Canada, 2002 to 2013.

TABLE 2 Continent of acquisition of erythromycin-, tetracycline-, and ciprofloxacin-resistant (multidrug-resistant) *C. jejuni* subsp. *jejuni* and *C. coli* isolates from Montreal, Quebec, Canada, 2002 to 2013

Continent of isolate acquisition ^a	No. of <i>C. jejuni</i> subsp. <i>jejuni</i> and <i>C. coli</i> isolates	No. (%) of multidrug-resistant <i>C. jejuni</i> subsp. <i>jejuni</i> and <i>C. coli</i> isolates ^b
The Americas	63	10 (15.9)
Europe	24	2 (8.3)
Asia	31	1 (3.2)
Africa	49	0 (0)
Total	167	13

^a No *C. jejuni* subsp. *jejuni*/*C. coli* isolates were acquired from Oceania. The continent of acquisition was unknown for 2 *C. jejuni* subsp. *jejuni*/*C. coli* isolates.

^b $P = 0.013$.

the 292 *C. jejuni* subsp. *jejuni* isolates acquired locally were erythromycin, tetracycline, and ciprofloxacin resistant ($P = 0.0001$), also data not reported previously; they were isolated in 2006, 2008, and 2011 to 2013. Five of the 21 *C. coli* (23.8%) isolates acquired abroad and 2 of the 17 *C. coli* (11.8%) isolates acquired locally were erythromycin, tetracycline, and ciprofloxacin resistant ($P = 0.43$; RR [95% CL], 2.02 [0.45 to 9.16]); they were isolated in 2006, 2010, and 2012 to 2013. The continent of acquisition was known for 167 of the 169 *C. jejuni* subsp. *jejuni* and *C. coli* isolates acquired abroad, and no *C. jejuni* subsp. *jejuni* or *C. coli* isolates were acquired from Oceania. Erythromycin-, tetracycline-, and ciprofloxacin-resistant isolates represented 0% to 15.9% of *C. jejuni* subsp. *jejuni* and *C. coli* isolates acquired in one or the other of the 4 other continents ($P = 0.013$) (Table 2). Of the 15 erythromycin-, tetracycline-, and ciprofloxacin-resistant *C. jejuni* subsp. *jejuni*/*C. coli* isolates, 3 and 12 isolates were resistant and susceptible, respectively, to amoxicillin-clavulanic acid (MICs, 64 to 128 and 0.12 to 2 mg/liter, respectively), 1 and 14 isolates were resistant and susceptible, respectively, to gentamicin (MICs, >256 and 0.12 to 2 mg/liter, respectively), and all 15 isolates were susceptible to imipenem (MICs, 0.015 to 0.25 mg/liter). Two of the 292 *C. jejuni* subsp. *jejuni* isolates acquired locally, but none of the 148 *C. jejuni* subsp. *jejuni* isolates acquired abroad and none of the 38 *C. coli* isolates, were erythromycin and ciprofloxacin resistant and tetracycline susceptible.

Erythromycin, tetracycline, and ciprofloxacin susceptibilities were epidemiological markers of *C. jejuni* subsp. *jejuni* and *C. coli* isolates obtained in our hospital (7, 8; this study). In the United States, *Campylobacter* isolates obtained from 2009 to 2011 had resistance rates of 2% to azithromycin, 23% to ciprofloxacin, and 24% to one or the other (11). Patients who were infected with resistant *Campylobacter* may have a longer disease duration, increased morbidity, and higher costs (1, 2, 11). Erythromycin and ciprofloxacin susceptibility should at least be assessed routinely for all *C. jejuni* subsp. *jejuni* and *C. coli* isolates (4). Education on

how to prevent *Campylobacter* infections and surveillance of their antibiotic resistance levels are recommended (1, 2, 11). New oral drugs are needed for the treatment of enteric *Campylobacter* infections.

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