Swimming and Campylobacter Infections

Daniela Schönberg-Norio,*† Johanna Takkinen,* Marja-Liisa Hänninen,* Marja-Leena Katila,‡ Suvi-Sirkku Kaukoranta,§ Leena Mattila,† and Hilpi Rautelin*†

A matched case-control study was conducted to study risk factors for domestically acquired sporadic Campylobacter infections in Finland. Swimming in natural sources of water was a novel risk factor. Eating undercooked meat and drinking dug-well water were also independent risk factors for Campylobacter infection.

Campylobacter jejuni and C. coli are leading causes of human bacterial gastroenteritis in industrialized countries (1,2). In 1998, in Finland, the number of reported Campylobacter cases exceeded that of salmonella for the first time (2). A similar increase in Campylobacter incidence is evident in other industrialized countries (1,3), but the reason for this finding remains unknown (1).

Most human Campylobacter infections are sporadic, and a seasonal peak in the distribution of the infections occurs during the summer months in several countries, including Finland (1–4). A variety of risk factors for Campylobacter infections have been identified, including handling and eating poultry (1,3,5–7) and drinking unpasteurized milk (1,3,5,7) or untreated water (1,8,9). In Finland, several waterborne outbreaks have been reported (10), but risks associated with sporadic Campylobacter infections are largely unknown (Table 1).

In our case-control study, we identified risk factors for and possible sources of infection for domestically acquired sporadic Campylobacter infections in Finnish patients from three geographic areas during the seasonal peak from July 1 to September 30, 2002.

The Study

Three clinical microbiology laboratories that served patients in the southern, central, and eastern parts of Finland participated in this multicenter, matched case–control study. A case-patient was defined as a person with stool culture, collected during the study period and tested at one of the three laboratories, that was positive for Campylobacter jejuni or C. coli. Patients from both outpatient clinics and hospitals were included. When a Campylobacter-positive patient was identified, personnel from the microbiology laboratory contacted the clinic or hospital for more information on the patient’s recent travel history. If the patient had not traveled abroad within 2 weeks before illness, that patient’s physician was contacted by phone and was asked to send to the patient information about our study and a questionnaire and a prepaid envelope to be returned to the researchers.

Two age-, sex-, and municipality-matched controls were chosen for each case-patient. Controls were selected from the Population Register Center, Espoo, Finland, an official register of all Finnish residents. Potential controls were contacted by mail and asked to fill in a questionnaire and mail it back in a prepaid envelope. Exclusion criteria for the controls were Campylobacter infection, at least three loose stools per day, abdominal pain, or fever 30 days before filling out the questionnaire. If the questionnaire was not returned within 2 weeks, a new pair of controls was chosen, leading to a maximum of four controls per case.

The questionnaire sent to patients included questions on the disease, travel in and outside of Finland, dietary intake of food items (meat, fish, vegetables, fruit, and dairy products), quality of drinking water, contact with pets and other domestic animals, and swimming in water from natural sources. The controls answered similar questions except for those concerning illness. Case-patients and controls were excluded if they had traveled abroad within 2 weeks before illness (case-patients) or filling in the questionnaire (controls). The study was approved by the Ethics Committee of the Hospital District of Helsinki and Uusimaa.

For sample-size calculation, the case-control ratio was 1:2. The exposure level among patients and controls was assumed to be 30% and 15%, respectively. The study was based on the estimate that 97 patients would be needed for the 5% significance level with 80% power. Only patients with at least one matched control were accepted for the final study set. Data entry was performed by EpiData 2.1b (EpiData Association, Odense, Denmark), and statistical analyses were made with EpiInfo 2002 (Centers for Disease Control and Prevention, Atlanta, GA). For risk factors with 95% confidence interval (CI) above one, conditional logistic regression examined these independently related to Campylobacter infection.

Of the 316 patients with stool culture–verified Campylobacter during the study period, 208 had no known foreign travel; the 634 controls also had not traveled out-

*University of Helsinki, Helsinki, Finland; †Helsinki University Central Hospital, Helsinki, Finland; ‡Kuopio University Hospital, Kuopio, Finland; and §North Karelia Central Hospital, Joensuu, Finland

This study was in part presented at the 12th International Workshop on Campylobacter, Helicobacter and Related Organisms, Aarhus, Denmark, September 6–10, 2003.
side of Finland. A total of 151 (73%) patients and 309 (49%) controls returned the questionnaire. Of the patients, 11 were excluded because of traveling abroad (according to the questionnaire), 3 for misunderstanding or missing information, 5 for having too long a delay (>37 days) between onset of symptoms and answering the questionnaire, and 11 because the delay between symptoms and answering the questionnaire could not be defined. In addition, a matched control was unavailable for 21 patients. Of the controls, 172 were excluded for the following reasons: traveling abroad (17 controls), gastrointestinal symptoms (56 controls), missing information (21 controls), and previous Campylobacter infection (2 controls); 76 were omitted because of the lack of a matching case. The final analysis was made up of 100 patients and 137 controls.

A total of 99 patients were infected with C. jejuni and 1 with C. coli. All cases were sporadic and not associated with any known outbreaks. Regional distribution and demographic characteristics of patients and controls are presented in Table 2. Patients and controls were matched in doubles (66 patients), triples (31 patients), and quadruples (3 patients). Patients filled in the questionnaires within 3 to 37 days from onset of illness, with a median delay of 16 days. The median interval between onset of illness of the patients and their controls responding to the questionnaire was 32 days. The median delay between patients and controls filling in the questionnaire was 15 days. The total number of exposures analyzed was 82. Factors significantly associated with an increased or a reduced risk for Campylobacter infection are shown in Table 3.

Of the 14 patients who ate undercooked or raw meat, 57% had eaten poultry and 36% minced meat, supporting previous studies that have identified eating undercooked poultry as a risk factor (7,8,11). Except for tasting or eating undercooked chicken meat, preparing or eating chicken was not associated with an increased risk for Campylobacter infection in our study.

Of the four significant risk factors in the initial univariate analysis, three were independently associated with Campylobacter infection in multivariate analysis: tasting or eating undercooked or raw meat, drinking untreated dug well water, and swimming in natural sources of water (Table 1). At least one of these three epidemiologically associated risk factors was found in 67% of the patients.

### Table 1. Matched multivariate analysis of significant risk factors for domestically acquired sporadic Campylobacter infection, July – September 2002, Finland

| Risk factor                                      | Adjusted OR | 95% Cl  | 2-tailed p |
|--------------------------------------------------|-------------|---------|------------|
| Tasting or eating raw or undercooked meat        | 10.79       | 1.31–89.09 | 0.0272     |
| Drinking water from a dug well                   | 3.36        | 1.37–8.24 | 0.0082     |
| Swimming in water from natural sources           | 2.80        | 1.23–6.39 | 0.0145     |

*p* OR, odds ratio; CI, confidence interval.

### Table 2. Patient characteristics

| Characteristic | Patients, N = 100 (%) | Controls, N = 137 (%) |
|----------------|-----------------------|-----------------------|
| Sex            |                       |                       |
| Male           | 42 (42)               | 56 (41)               |
| Female         | 58 (58)               | 81 (59)               |
| Age (y)        |                       |                       |
| 1–4            | 4 (4)                 | 6 (4)                 |
| 5–9            | 1 (1)                 | 2 (2)                 |
| 10–19          | 3 (3)                 | 5 (4)                 |
| 20–29          | 13 (13)               | 18 (13)               |
| 30–39          | 9 (9)                 | 13 (10)               |
| 40–49          | 15 (15)               | 18 (13)               |
| 50–59          | 26 (26)               | 32 (23)               |
| ≥60            | 29 (29)               | 43 (31)               |
| Median age (y) | 51                    | 51                    |
| Municipality   |                       |                       |
| Helsinki       | 35 (35)               | 47 (34)               |
| Kuopio         | 44 (44)               | 62 (45)               |
| Joensuu        | 21 (21)               | 28 (20)               |

### Conclusions

We identified, to our knowledge for the first time, swimming in natural sources of water to be an independently associated risk factor for sporadic Campylobacter infection. As the infective dose for Campylobacter infection is likely low, contaminated surface water may cause infection through swimming; campylobacters are commonly found in natural waters, such as rivers, streams, and lakes (12). However, in contrast to our study, in a recent Norwegian study (9), swimming in the sea, lakes, and swimming pools was associated with a reduced risk for Campylobacter infection.

Our study showed that private water supplies present a significant risk factor for sporadic Campylobacter infection. Kapperud et al. (9) also found that exposure to surface water or drinking nondisinfected water caused an increased risk. In Finland, in addition to the 310,000 households that use private wells, approximately 300,000 summer cottages have private water supplies (13). Dug wells are susceptible to surface water contamination. Furthermore, the summer of 2002 was exceptionally dry in Finland, resulting in poor water quality in these wells because of low groundwater levels. In our study, drinking
water from a large water plant protected against sporadic Campylobacter infection. Large water plants usually have surface water as their source and use multistage purification and disinfection procedures before drinking water is distributed to consumers, which substantially reduces risk for waterborne infections.

Eating strawberries, although a significant risk factor in univariate analysis, was not an independent risk factor in the multivariate analysis. During the same time period but outside the study region, a small cluster of cases was reported for which the suspected source was eating strawberries directly from the field (14).

Reduced risk for the disease was associated with eating other berries, such as red and black currants and blueberries, and carrots. These findings are consistent with the literature (7–9), although no one fully understands the role of these protective factors.

In Finland, because most sporadic Campylobacter infections occur during July to September, our study could not identify risk factors that may have varied seasonally. The median age of our patients and controls was considerably high (51 years of age), which may have influenced the results. This age group, however, may be typical for Finland, since in our previous study sporadic, domestically acquired Campylobacter infections were frequent in certain parts of the country in elderly men (15).

In addition to the known risk factor of eating raw or undercooked meat, this study clearly identified water as an important risk for domestically acquired Campylobacter infections in the summertime in Finland. The novel finding that swimming in water from natural sources was associated with increased risk for infection further emphasizes the importance of other water-related exposure factors.

---

Table 3. Matched univariate analysis of exposure factors for domestically acquired sporadic Campylobacter infection, July –September 2002, Finland

| Risk factor                                    | Patients, n = 100 | Controls, n = 137 | Adjusted OR | 95% CI          | 2-tailed p |
|------------------------------------------------|-------------------|-------------------|-------------|----------------|------------|
| Increased risk                                 |                   |                   |             |                 |            |
| Tasting or eating undercooked or raw meat b    | 14/88             | 3/124             | 12.00       | 1.54–93.77      | 0.0052     |
| Drinking water from a dug well                 | 31/96             | 22/137            | 3.19        | 1.58–6.45       | 0.0017     |
| Swimming in water from natural sources        | 48/100            | 40/134            | 2.27        | 1.24–4.16       | 0.0089     |
| Eating strawberries                            | 70/89             | 79/124            | 2.90        | 1.21–6.95       | 0.0287     |
| Reduced risk                                   |                   |                   |             |                 |            |
| Eating                                         |                   |                   |             |                 |            |
| Black and red currants                         | 17/73             | 73/126            | 0.17        | 0.07–0.41       | < 0.0001   |
| Blueberries                                    | 20/73             | 56/118            | 0.43        | 0.21–0.89       | 0.0115     |
| Carrots                                        | 43/83             | 89/126            | 0.44        | 0.24–0.82       | 0.0039     |
| Yogurt                                         | 51/90             | 83/121            | 0.35        | 0.15–0.85       | 0.0332     |
| Pasteurized milk                               | 55/93             | 99/131            | 0.44        | 0.22–0.85       | 0.0075     |
| Cooked or fried fish                           | 50/93             | 98/128            | 0.35        | 0.18–0.67       | 0.0004     |
| Liver (beef)                                    | 4/69              | 15/105            | 0.18        | 0.04–0.87       | 0.0083     |
| Drinking water produced by a large water plant | 52/97             | 88/137            | 0.52        | 0.26–1.02       | 0.0371     |
| Eating at a friend’s house                     | 24/49             | 44/71             | 0.35        | 0.13–0.96       | 0.0195     |
| Others                                         |                   |                   |             |                 |            |
| Eating                                         |                   |                   |             |                 |            |
| Minced meat (pork)                             | 45/83             | 70/116            | 0.54        | 0.28–1.06       | 0.0438     |
| Minced meat (beef)                             | 64/90             | 97/128            | 0.78        | 0.42–1.46       | 0.3459     |
| Drinking                                       |                   |                   |             |                 |            |
| Water produced by a small water plant          | 23/97             | 34/137            | 0.80        | 0.37–1.72       | 0.4528     |
| Water from bedrock well                        | 20/97             | 17/137            | 1.96        | 0.89–4.34       | 0.1210     |
| Bottled water                                  | 15/97             | 27/137            | 0.75        | 0.37–1.51       | 0.3062     |
| Contact with cat                               | 27/88             | 40/118            | 0.87        | 0.43–1.76       | 0.5768     |
| Contact with dog                               | 53/93             | 76/128            | 1.02        | 0.55–1.89       | 0.9385     |
| Contact with farm animals                      | 4/83              | 9/118             | 0.36        | 0.06–2.14       | 0.1426     |
| Eating outside the home                        | 69/98             | 100/137           | 0.78        | 0.41–1.48       | 0.3686     |
| Eating chicken prepared from                   |                   |                   |             |                 |            |
| Nonmarinated pieces                            | 9/71              | 20/111            | 0.32        | 0.10–1.06       | 0.0274     |
| Marinated pieces                               | 34/81             | 47/111            | 0.76        | 0.38–1.58       | 0.3613     |
| Nonmarinated strips                            | 11/70             | 13/114            | 1.06        | 0.33–3.46       | 0.8357     |
| Marinated strips                               | 19/77             | 40/118            | 0.61        | 0.29–1.28       | 0.1324     |
| Drinking unpasteurized milk                    | 7/80              | 9/111             | 1.40        | 0.45–4.37       | 0.7768     |

aOR, odds ratio; CI, confidence interval.
bOf 14 exposed patients, 13 specified meat type: 8 (57%) had tasted undercooked poultry, and 5 (36%) had tasted minced meat.
cFisher exact test.
Acknowledgments

We thank Heikki Korpela for his comments on the manuscript.

The study was partially supported by grants from Finska Läkearsällskapet, Helsinki University’s Research Funds, and Helsinki University Central Hospital Research Funds.

Dr. Schönberg-Norio works in the Department of Bacteriology and Immunology at Haartman Institute, University of Helsinki. Her research focuses on Campylobacter infections.

References

1. Friedman J, Neimann J, Wegener HC, Tauxe RV. Epidemiology of Campylobacter jejuni infections in the United States and other industrialized nations. In: Nachamkin I, Blaser MJ, editors. Campylobacter. 2nd ed. Washington: American Society for Microbiology; 2000. p. 121–38.
2. Rautelin H, Hänninen M-L. Campylobacters: the most common bacterial enteropathogens in the Nordic countries. Ann Med. 2000;32:440–5.
3. Altekruse SF, Stern NJ, Fields PI, Swerdlow DL. Campylobacter jejuni—an emerging foodborne pathogen. Emerg Infect Dis. 1999;5:28–35.
4. Nylen G, Dunstan F, Palmer SR, Andersson Y, Bager F, Cowden J, et al. The seasonal distribution of Campylobacter infection in nine European countries and New Zealand. Epidemiol Infect. 2002;128:383–90.
5. Studahl A, Andersson Y. Risk factors for indigenous Campylobacter infection: a Swedish case-control study. Epidemiol Infect. 2000;125:269–75.
6. Kapperud G, Skjerve E, Bean NH, Ostrow SM, Lassen J. Risk factors for sporadic Campylobacter infections: results of a case-control study in southeastern Norway. J Clin Microbiol. 1992;30:3117–21.
7. Neimann J, Engberg J, Mølbak K, Wegener HC. A case-control study of risk factors for sporadic Campylobacter infections in Denmark. Epidemiol Infect. 2003;130:353–66.
8. Eberhart-Phillips J, Walker N, Garrett N, Bell D, Sinclair D, Rainier W, et al. Campylobacteriosis in New Zealand: results of a case-control study. J Epidemiol Community Health. 1997;51:686–91.
9. Kapperud G, Espeland G, Wahl E, Walde A, Herikstad H, Gustavsen S, et al. Factors associated with increased and decreased risk of Campylobacter infection: a prospective case-control study in Norway. Am J Epidemiol. 2003;158:234–42.
10. Hänninen M-L, Haajanen H, Pummi T, Wermunden K, Katila M-L, Sarkkinen H, et al. Detection and typing of Campylobacter jejuni and Campylobacter coli and analysis of indicator organisms in three waterborne outbreaks in Finland. Appl Environ Microbiol. 2003;69:1581–6.
11. Evans MR, Lane W, Frost JA, Nylen G. A Campylobacter outbreak associated with stir-fried food. Epidemiol Infect. 1998;121:275–9.
12. Jones K. Campylobacters in water, sewage and the environment. J Appl Microbiol. 2001;90:685–795.
13. Korkka-Niemi K. Cumulative geological, regional and site-specific factors affecting groundwater quality in domestic wells in Finland. Monographs of the Boreal Environmental Research. The Finnish Environment Institute; 2001.
14. Hatakka M, Johansson T, Kauzi M, Majiara R, Pikkala P, Siitonen A. Foodborne and waterborne outbreaks in Finland in 2002. Helsinki, Finland: National Food Agency; 2003.
15. Vierikko A, Hänninen M-L, Siitonen A, Ruutu P, Rautelin H. Distribution of domestically acquired Campylobacter infections in Finland during a seasonal peak. Emerg Infect Dis. 2004;10:127–30.

Address for correspondence: Hilpi Rautelin, Department of Bacteriology and Immunology, Haartman Institute, University of Helsinki, Finland; fax: +358-9-1912-6382; email: hilpi.rautelin@helsinki.fi

OPPORTUNITIES FOR PEER REVIEWERS

The editors of Emerging Infectious Diseases seek to increase the roster of reviewers for manuscripts submitted by authors all over the world for publication in the journal. If you are interested in reviewing articles on emerging infectious disease topics, please e-mail your name, address, curriculum vitae, and areas of expertise to eideditor@cdc.gov

At Emerging Infectious Diseases, we always request reviewers’ consent before sending manuscripts, limit review requests to three or four per year, and allow 2-4 weeks for completion of reviews. We consider reviewers invaluable in the process of selecting and publishing high-quality scientific articles and acknowledge their contributions in the journal once a year.

Even though it brings no financial compensation, participation in the peer-review process is not without rewards. Manuscript review provides scientists at all stages of their career opportunities for professional growth by familiarizing them with research trends and the latest work in the field of infectious diseases and by improving their own skills for presenting scientific information through constructive criticism of those of their peers. To view the spectrum of articles we publish, information for authors, and our extensive style guide, visit the journal web site at www.cdc.gov/eid.

For more information on participating in the peer-review process of Emerging Infectious Diseases, e-mail eideditor@cdc.gov or call the journal office at 404-371-5329.