Increased Exposure to Cryptosporidia among Dairy Farmers in Wisconsin

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Cryptosporidium **infection is an important cause of diarrhea in humans and livestock; no effective therapy is known. A self-administered questionnaire and an ELISA were used to assess the risk of exposure to cryptosporidia among 70 dairy farmers and 50 who were not dairy farmers in Wisconsin. Dairy farmers (44.3%) were more likely to be seropositive for cryptosporidia than were other persons (24.0%; relative risk = 1.9). Among dairy farmers, age ≥50 and use of a canister method of milking were associated with seropositive status. Among persons who were not dairy farmers, feeding or milking cows was associated with being seropositive. These findings suggest that dairy farmers and other persons who have contact with cattle are at greater risk of *Cryptosporidium* infection than are persons who do not have such contact. Identification and avoidance of farming practices associated with *Cryptosporidium* infection may reduce the risk of infection among dairy farmers.**

Cryptosporidium parvum is a coccidian parasite that can cause chronic, life-threatening diarrhea in immunocompromised persons and self-limited diarrhea in immunocompetent persons [1, 2]. Effective therapeutic or prophylactic agents have not been developed. While oocysts have been found in the stools of <5% of symptomatic persons examined in the United States [2, 3], estimates of seroprevalence in the United States have been much higher, ranging from 17% to 35% [4–6].

Livestock, including cattle, can also become infected with cryptosporidia. Infection of young dairy calves with cryptosporidia typically causes self-limited diarrhea but has been associated with intractable diarrhea and death [1, 2]. Studies in California [7], Maryland [8], and Idaho [9] found that 5%–39% of dairy calves had oocysts in their stools. Each year in the United States, an estimated $6.2 million is lost from cryptosporidiosis in calves [2].

Cattle have been implicated as a source of human cryptosporidiosis. Infection among rural persons in Finland [10] and Israel [11] and animal handlers in the United States [1] has been associated with cattle. Infected cattle may also contribute to waterborne outbreaks of cryptosporidiosis [6]. Person-to-person transmission [4, 11] may subsequently increase the number of human infections.

Received 6 March 1992; revised 23 November 1992.

Grant support: National Institutes of Health (HL-37121); Marshfield Medical Research Foundation.

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The Journal of Infectious Diseases 1993;167:1252–5

0022–1899/93/6705–0046$01.00

While these reports have documented isolated incidents associated with infected livestock, no studies have evaluated the risk for persons in the United States who have frequent contact with potentially infected animals, such as dairy farmers, and who may thus be at increased risk of exposure to cryptosporidia. We studied a cohort of persons in central Wisconsin to estimate the seroprevalence of *Cryptosporidium* infection among persons in this agricultural area to determine if persons with frequent exposure to cattle are at increased risk for *Cryptosporidium* infection and to identify demographic and behavioral characteristics associated with exposure.

Methods

Marshfield is an agricultural, principally dairy, community in north-central Wisconsin. In 1975, 2097 persons living or working on randomly selected farms in the Marshfield area were asked to participate in a longitudinal study of respiratory disease at the Marshfield Medical Research Foundation; 72% agreed [12]. Fifty-eight percent were male and 98% white. Identified from the original cohort by their serologic reactivity to antigens associated with farmer's lung disease, 115 farmers consented to participate in a longitudinal study of respiratory disease and the present study, conducted in 1990. Sixteen nonfarming participants were volunteers from employees of the Marshfield Clinic.

Demographic, occupational, and farm information were obtained by a self-administered questionnaire. All participants were classified according to their reported farming status: current farmers, ex-farmers, and never farmers. Ex-farmers were persons who reported having quit farming since being enrolled in the original study in 1975. The 16 participants from the Marshfield Clinic, who were considered never farmers, had never been employed on a farm, and 6 had never had any farm experience (e.g., helping with hay-making). For the other 10, the median time since any farming experience was 26 years (range, 12–47).

n addition to being classified by farming status, participants ve classified by their reported dairy farming status. All farmers rrent farmers or ex-farmers) who reported their principal ming activity as dairy were considered dairy farmers. Persons o were considered not to be dairy farmers included those who re never farmers as well as current farmers and ex-farmers o reported their major farming activity to be nondairy (e.g., f, poultry); however, current farmers and ex-farmers in this up may have milked or fed cows.

Farm information included type and size of farm, number and e of adult animals on the farm, and the methods for feeding milking cows by dairy farmers. Dairy farmers in the sample ed either a canister method of milking, in which milk from ch cow is collected into a canister carried to a central dumping tion for cooling, or a pipeline method, in which milk is col- ted from each cow and pumped through a pipeline to a cool- tank.

An ELISA [13] was used to determine the presence of IgG tibodies to cryptosporidia in serum samples collected at the e the questionnaire was completed. The sensitivity and speci- ity of this assay compared with stool examination have each en reported to be 95% [13].

In univariate statistical analysis, we calculated the relative risk R) of being seropositive to cryptosporidia for various expo- res; SE and 95% confidence intervals (CI) for each RR were lculated [14]. If we were unable to calculate an RR because unexposed persons were seropositive, the difference in pro- rtions was tested with the Mantel-Haenszel χ^2 test ($P < .05$) 4]. Linear trends in proportions were assessed by the χ^2 test for nd ($P < .05$) [14]. Finally, factors that were significant ($P <$ 5) in univariate analysis were examined with logistic regres- n to examine their independence; odds ratios (OR) and SE re calculated [15].

sults

Characteristics of participants Serologic test results from participants were indeterminate and were excluded from analysis. All 11 individuals were current farmers or ex- mers; 8 (72.7%) were dairy farmers (7 current farmers), d 3 (27.3%) were not dairy farmers (1 current farmer).

Of the remaining 120 participants, 102 (85.0%) were male. 104 (86.7%) were born in Wisconsin. All were white. median age was 52 years (range, 28–78). Of all 120 rticipants, 74 (61.7%) were current farmers, 30 (25.0%) ex-farmers, and 16 (13.3%) were never farmers. A total 0 persons (67.3%) were dairy farmers (64 current farmers ex-farmers) while 50 (32.7%) were not dairy farmers. dairy farmers, the average number of cattle milked was while the average number of acres farmed was 289.

participants. Among the 120 participants, 43 (35.8%) e seropositive for cryptosporidia. Dairy farming (RR = 95% CI, 1.1–3.2) was associated with seropositive status. nder, age, education, and number of years in Wiscon- ere not (table 1). Thirty-one current farmers (41.9%) ropositive, compared with 9 ex-farmers (30.0%) and 3

Table 1. Relative risks for exposure to cryptosporidia, Marshfield, Wisconsin, 1990.

	Positive (n = 43)	Negative (n = 77)	Relative risk (95% CI)
Sex			
Male	36	66	0.9 (0.5–1.7)
Female	7	11	—
Age (years)			
≥50	24	43	1.0 (0.6–1.6)
<50	19	34	—
High school education			
No	9	17	1.0 (0.5–1.7)
Yes	34	60	—
Years in Wisconsin			
≥45	26	40	1.3 (0.8–2.1)
<45	17	37	—
Dairy farmer			
Yes	31	39	1.9 (1.1–3.2)
No	12	38	—
Birthplace			
Wisconsin	41	63	3.2 (0.8–11.8)
Other	2	14	—
Farming status			
Current farmer	31	43	2.2 (0.8–6.4)*,†
Ex-farmer	9	21	1.6 (0.5–5.1)*
Never farmer	3	13	—

NOTE. CI, confidence interval.

* Compared with never farmers.

† Current farmer vs. ex-farmer vs. never farmer: χ^2 for linear trend = 3.625; P = .057.

never farmers (18.8%) (linear trend, P = .06). Compared with never farmers, current farmers and ex-farmers were 2.2 (95% CI, 0.8–6.4) and 1.6 (95% CI, 0.5–5.1) times more likely to be seropositive, respectively. Among ex-farmers, the length of time since leaving farming ranged from <1 year (n = 1) to >5 years (n = 17) and was not significantly associated with serologic status.

Dairy farmers. Of the 70 dairy farmers, 31 (44.3%) were seropositive for cryptosporidia. Persons ≥50 years of age had a 90% greater risk of being seropositive than did persons <50 years of age (RR = 1.9; 95% CI, 1.1–3.3) (table 2). Dairy farmers who reported using a canister method of milking had almost twice the risk of being seropositive as did farmers who used pipeline milking (RR = 1.9; 95% CI, 1.2–3.2). Dairy farmers who had been farming ≥25 years, milked <50 cows, or only fed animals inside were more likely to be seropositive than were farmers who had been farming for <25 years, milked ≥50 cows, or fed animals outside as well as inside, respectively; however, these associations were not statistically significant. In logistic regression analysis with age and method of milking as independent variables, being ≥50 years of age was associated with seropositive status (OR = 3.3; 95% CI, 1.2–9.0); the association with using a canister method of milking was not statistically significant (OR = 2.8; 95% CI, 1.0–8.0).

Table 2. Relative risks for exposure to cryptosporidia, dairy farmers, Marshfield, Wisconsin, 1990.

	Positive (n = 31)	Negative (n = 39)	Relative risk (95% CI)
Sex			
Male	27	34	1.0 (0.5–2.2)
Female	4	5	—
Age (years)			
≥50	19	13	1.9 (1.1–3.3)
<50	12	26	—
High school education			
No	8	9	1.1 (0.6–2.0)
Yes	23	30	—
Time farming			
≥25 years	21	21	1.4 (0.8–2.5)
<25 years	10	18	—
Birthplace			
Wisconsin	29	35	0.8 (0.2–2.4)
Other	2	4	—
Milking method*			
Canister	14	7	1.9 (1.2–3.2)
Pipeline	15	29	—
Number milked			
≥50	19	18	1.4 (0.8–2.5)
<50	12	21	—
Feeding location*			
Inside only	19	19	1.4 (0.8–2.6)
Inside and outside	9	16	—

NOTE. Farmers includes current farmers or ex-farmers (n = 70). CI, confidence interval.

* The cells do not add up to 70 because of missing values.

Persons who were not dairy farmers. Among the 50 persons who were not dairy farmers, 12 (24.0%) were seropositive for cryptosporidia. Twelve (30%) of 40 persons born in Wisconsin were seropositive, compared with 0 of 10 born elsewhere (P = .04). Among persons who were not dairy farmers, the percentage that were seropositive varied inconsistently with age. Three of 5 persons who reported currently milking or feeding cows (e.g., on a hobby farm) were seropositive, while 9 (20%) of 45 who reported no such activity were seropositive (RR = 2.9; 95% CI, 1.2–7.6). In logistic regression analysis, neither of the independent variables, birthplace in Wisconsin and currently milking or feeding cows, was significantly associated with being seropositive.

Discussion

In this study, the risk of being seropositive for cryptosporidia was ~1.9 times higher for dairy farmers than for other persons. This finding, along with a suggestion of increased risk for persons who fed or milked cows even though they were not dairy farmers, supports our hypothesis that frequent exposure to cattle is associated with increased risk of *Cryptosporidium* infection.

Overall, 35% of study participants were seropositive for cryptosporidia; this is within the range (17%–35%) of seroprevalence estimates from other studies in the United States [4–6]. Our estimate of seroprevalence in Marshfield may be at the upper limit of this range because of the large percentage (58.3%) of dairy farmers in our sample population. The seroprevalence among persons in this study who were not dairy farmers (24.0%) is more centrally located within this range of estimates.

Among dairy farmers, the percentage who were seropositive increased with age; among other persons, this association was not observed. These findings suggest two hypotheses. First, older dairy farmers may have had a history of more intense, prolonged, or frequent exposure to cryptosporidia (independent of farming practices) than was experienced by younger dairy farmers. We are unable to adequately address this hypothesis because detailed lifetime exposure histories were not assessed and the rate at which anti-cryptosporidial antibody decays between exposures or in the absence of reexposure is unknown.

Alternatively, older dairy farmers may be more likely to engage in specific farming practices that increase the risk of exposure to cryptosporidia than are younger dairy farmers. Although not associated with age in this study, one such practice, using a canister method of milking, was associated with exposure in univariate analysis. Other potential high-risk practices that were not measured, such as the use of group housing for young calves [2], may be more common among older farmers.

Inconclusive serologic results have previously been associated with intermittent or low-level exposure to cryptosporidia [13]. If such were the case in this study, we may have underestimated the risk of exposure associated with dairy farming since we excluded the 11 participants with an indeterminate result. Eight (72.7%) of these 11 were dairy farmers, and 1 of the 3 who were not dairy farmers reported currently milking or feeding cattle.

Our study has several limitations. As is possible with all studies that rely on self-reported exposure, the ability to recall specific exposures may have differed between persons who were seropositive and those who were seronegative. However, we consider it unlikely that recall bias was a substantial problem because the questionnaire focused on exposures for respiratory rather than gastrointestinal disease.

The results may not be generalizable to other farmers because the original sample was drawn from a limited geographic area. In addition, the farmers in this study were not entirely representative of the original, randomly selected, sample. Although the original sample and the farmers in this study were similar by race, mean age of the original sample (in 1975) was 41 years compared with 51 years for farmers in the current study (in 1990). Males made up 58% of the original sample compared with 85% of farmers in this study; however, we did not find gender to be associated with serologic status.

Because we used available data from a 15-year cohort dy that was intended to assess the risk for selected respira- y diseases among farmers, we were unable to adequately dress several possible confounding factors. These factors ld include the presence and number of calves on the m, the prevalence of infection among calves, and the fre- ency and duration of farmer contact with calves. Though gth of time as a farmer was measured, its effect was diffi- t to assess in this study because of its high degree of corre- ion with age. We were also unable to assess the existence other non-farm-related exposures to cryptosporidia, in- ding drinking water [6] and the presence in the household children who attend day care centers [2].

Despite these limitations, we found that dairy farmers re at higher risk of exposure to cryptosporidia than were her persons in this study. Additional work is needed to ntify specific farming practices that may elevate this risk, determine the risk of secondary transmission of farm-ac- ired infection to family members and other close contacts, d to define the morbidity associated with such transmis- n. Identification of high-risk farming practices could lead the development of recommendations and strategies to terrupt transmission of cryptosporidia to humans and re- ce cryptosporidia-associated morbidity and mortality ong calves and the resulting economic toll.

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