Original Report

Risk of Giardiasis from Consumption of Wilderness Water in North America: A Systematic Review of Epidemiologic Data

Timothy P. Welch, BA*

ABSTRACT

Objectives: A meta-analytic study was conducted to test the hypothesis that consumption of water from North American backcountry sources poses a statistically significant risk for acquisition of giardiasis.

Methods: The biomedical literature was surveyed by accessing Medline, and identified studies were supplemented with references in current reviews, published dissertations, and prior communications with state health departments. Studies were classified by methodologic design and subjected to predetermined inclusion criteria. Odds ratios with 95% confidence intervals, chi-squares, and P-values for epidemiologic surveys were either computed from raw data or abstracted directly from the included studies.

Results: Of 104 articles identified in the initial screening, nine met the inclusion criteria. Neither of two case reports met the criteria of the Centers for Disease Control and Prevention (CDC) for waterborne disease outbreak. Two prospective studies were identified, but neither showed a significant association. Of four case-control studies providing data, three reported an odds ratio of greater than one.

Conclusions: Published reports of confirmed giardiasis among outdoor recreationists clearly demonstrate a high incidence among this population. However, the evidence for an association between drinking backcountry water and acquiring giardiasis is minimal. Education efforts aimed at outdoor recreationists should place more emphasis on handwashing than on water purification. Further studies should attempt to separate the specific risk factor of drinking water from backcountry sources from other behaviors among this group that may contribute to the risk.

Key Words: *backpacking, giardiasis, North America, outdoor recreation, water*

Int J Infect Dis 2000; 4:100–103.

Giardiasis is an enteric infection with the binucleate trophozoite stage of the flagellate protozoan parasite *Giardia lamblia*. Commonly reported modes of transmission have included day care contact, food handling, and sexual activity.[1-3] In 1977, the first of many reports of outbreaks associated with community water was published.[4] Subsequently, a variety of lay literature for backpackers and other outdoor enthusiasts have suggested that consumption of untreated wilderness waters was similarly an identifiable risk.[5] Although this suggestion appears in some medical texts, a recent survey of state health departments was unable to confirm this mode of transmission as a serious problem in the United States.[6,7] Additionally, the consumption rates usually reported in municipal water outbreaks are not consistent with the typical patterns seen in wilderness camping, specifically, serial low-dose exposures to small quantities of water.

There are practical reasons to determine if this widely proposed mode of transmission is a real risk. Currently, education efforts aimed at outdoor recreationists have stressed the importance of water purification, while generally neglecting emphasis on basic personal hygiene. In the case of most other enteric pathogens, control efforts usually start with handwashing. The correlation between handwashing and reduced coliform presence on hands, an indicator of fecal contamination, is well established.

The objective of this study was to test the hypothesis that consumption of water from North American backcountry sources poses a significant risk for acquisition of giardiasis. By using meta-analytic techniques, relevant citations were identified, their quality assessed by predetermined criteria, and odds ratios were either abstracted or computed from raw data. The author is unaware of any previous attempt to systematically survey

*Department of Tropical Medicine, Tulane University School of Public Health and Tropical Medicine, New Orleans, Louisiana.

Presented at the Annual Scientific Assembly of the Wilderness Medical Society, Lake Placid, New York, July 1998.

Received: September 2, 1999; Accepted: January 25, 2000.

Address correspondence to Mr. Timothy P. Welch, Department of Tropical Medicine, Tulane University, 1501 Canal Street, New Orleans, LA 70112. E-mail: twelch2@mailhost.tcs.tulane.edu.

the literature addressing this risk factor, despite the fact that it is widely cited in the aforementioned literature.

MATERIALS AND METHODS

Allocation and Classification of Studies

Medline was accessed to identify post-1965 citations, using the MeSH subject heading "giardia" and the keywords "water" and "microbiology." Next, a manual search of references in current published original reports and reviews was performed. Finally, a search of abstracts indexed in "Dissertation Abstracts Online" was conducted. An additional article was cited by a state health department official in response to an earlier survey.[7]

All identified studies were then classified according to design, and predetermined inclusion criteria were applied for each type. Case reports were non-analytic, observational studies that had to fulfill the CDC criteria for a waterborne-disease outbreak.[8] These required epidemiologic data about exposed and unexposed persons and laboratory isolation of the agent from suspect waters. Prospective cohort studies had to include a cohort of initially unaffected individuals examined after a uniform exposure, with clinical features confirmed by laboratory diagnosis. Retrospective case-control studies needed to provide an odds ratio for various risk factors or, alternately, provide raw data from which an odds ratio could be computed.

Studies were excluded in the initial screening if they were non-North American, were not written in English, or were isolation, treatment methods, or clinical review articles. The geographic exclusion was necessary because these findings are not generalizable to developing countries, where giardiasis may be endemic, and municipal water sources nonexistent. The other types of articles provided technical details concerning water treatment or patient management, but provided no epidemiologic data on the hypothesis under study. Studies that dealt with municipal water sources also were eliminated, as they did not address the risk to outdoor recreationists. To control investigator bias, the abstract of each citation was assessed by two independent reviewers using the same inclusion criteria code.

Statistical Analysis

For epidemiologic surveys, odds ratios and 95% confidence intervals (CI) were calculated from 2 × 2 contingency tables. P-values were calculated from the tables by the chi-squared test.

RESULTS

Of the 104 articles identified in the initial screen, nine met the preliminary inclusion criteria and were further analyzed. Reasons for excluding studies are summarized in Table 1.

Table 1. Reasons for Rejection of Citations from Medline Search

Category	*Studies (n = 104)*
Clinical review, no original data	19
Dealt with municipal water supplies	22
Methods or technical report	22
Non-English, non-North American	32
Total rejected from overview	95
Total eligible for analysis	9

Case Reports

Two case reports were identified; however, neither met the strict CDC criteria for waterborne-disease outbreak, and so they were eliminated on the basis of study quality. One study reported an outbreak of giardiasis among campers on a 2-week trip in Utah.[9] Epidemiologic evidence and fecal coliform levels were said to implicate a mountain stream. However, no cysts were isolated from the water or from the feces of the local mammals that were examined. Food preparation was discounted as an explanation. The second case report implicated giardiasis as endemic in the Northwest, but provided no data of any kind.[10]

Prospective Cohort Studies

Two prospective studies were identified. In one of these, a questionnaire was used to determine that 15% of a group of Utah National Guardsmen had symptoms "suggestive of giardiasis," while on a field exercise.[11] This conclusion relied exclusively on subjective reporting and no attempt was made to isolate pathogens from any respondent. A landmark prospective study attempted to correlate the incidence of symptomatic giardiasis with the cyst concentration in water sources from a high-use area.[12] Two subjects who became cyst-positive were asymptomatic at evaluation, and none of the six individuals with gastrointestinal illness had *G. lamblia* cysts in their stools.

Retrospective Case-Control Studies

Of five case-control studies, four provided adequate data for which an odds ratio could be computed (Table 2). Three had an odds ratio slightly greater than unity, whereas one had a confidence interval that included one. Since the specific question asked in each of the four studies was different, a pooled odds ratio could not be determined.

Wright et al undertook a telephone survey of 256 cases and matched controls in Colorado over a 1-year period.[13] Responses indicated that 38% of cases versus 18% of controls had camped overnight in backcountry areas.

Table 2. Summary of Included Case-Control Studies

Citation	Year	OR and 95% CI	Chi-square	P-Value
Wright et al[13]*	1977	2.67 (1.77–4.02)	22.9	<.001
Harter et al[14]†	1987	0.786 (.32–1.94)	0.267	>.10
Chute et al[15]‡	1987	1.83 (.98–3.4)	3.7	>.05
Isaac-Renton & Philion[16]§	1992	2.20 (1.1–4.4)	1.9	>.10

*Camping out overnight in Colorado; †children aged 1–3 in families engaged in outdoor activities (camping) within the 2 months prior to the interview; ‡camping in northern New England; §and travel and recreational activities in rural British Columbia (swimming, camping) or drinking local water versus those who engaged in similar travel without outdoor recreation or local water.

Harter et al randomly selected 1349 children from birth certificate records in two Washington state counties.[14] Of 518 respondents surveyed, 37 were found to carry *Giardia.* There was no statistically significant difference in prevalence between children from families who had been engaged in outdoor activities within 2 months of the survey and those who had not.

A mail survey of 171 giardiasis patients and matched controls in rural New England was reported by Chute et al.[15] By logistic regression, they identified a positive but unstable risk for camping, but did not address ingestion of untreated water specifically.

Finally, Isaac-Renton and Philion investigated 2186 *Giardia*-positive patients in British Columbia.[16] After interviewing 228 case respondents, the authors concluded that consumption of local water while participating in outdoor activities, such as camping, was associated with a higher risk of giardiasis than in controls who participated in such activities but did not ingest local waters.

DISCUSSION

The association of enteric disease, such as giardiasis, with water consumption is well established.[4] However, this association has primarily been made for community water supplies serving populations that consume large quantities of contaminated water over long periods of time. Additional studies have confirmed an association with daycare center attendance or employment, food handling, and sexual practices.[1-3] The major emphasis in outdoor education literature is on the risks entailed in water consumption, with minimal focus on basic hygiene practices considered standard in other industries. A prior survey of state health departments suggested that the actual risk from untreated backcountry water was practically nonexistent. In the present report, nine studies addressing giardiasis and backcountry water consumption were reviewed to determine if the professional literature supported such a risk.

No convincing case reports were identified. One of these is frequently cited, yet is suspect on several grounds.[9] The attack rate of 63% observed in this report is significantly higher than the rate noted in typical municipal outbreaks, and is more consistent with a single point-source exposure rather than a prolonged low-dose exposure to contaminated water. The temporal clustering of cases also supports such a model. Food preparation was discounted as an explanation, since that was, at the time, unprecedented. However, a fecal-oral dissemination from a food handler on the camping trip could conceivably result in these findings.

No prospective studies have shown a significant association either. One of the identified studies was based solely on a questionnaire, forming its conclusions on clinical symptoms alone. The other prospective study was well designed, and found no association.

The hallmark epidemiologic investigation, the case-control survey, was the primary focus of this analysis. Of five acceptable epidemiologic surveys, only four provided actual data. These studies suggest a trivial or even insignificant risk encountered while camping. The study reporting the highest risk attributable to camping provides an odds ratio that does not even approach the risk from having an infected family member in the home.[17] Importantly, only one of these reports makes any attempt to distinguish water consumption from camping. This is crucial, since as stated, camping may entail other high-risk behaviors, such as communal food preparation and suboptimal hygiene practices.

None of these four acceptable studies could be combined to achieve an overall increased effect size, owing to incompatible methodologic designs. None of the epidemiologic surveys was a randomized prospective cohort study, and assignments to post hoc control groups were made after cases had been identified. Although such studies may provide interesting data, their nonrandomized nature and different case-matching methods prevented them from being subjected to true meta-analysis. What is presented here is a structured, systematic review of the literature addressing this risk factor.

Confirmed cases of water-acquired giardiasis tend to have modest attack rates and depend on continual exposure to source water over a period of time. Typically, these situations occur in municipalities with cross-contaminated water supplies, and often result in widespread outbreaks within the community. Such situations are in no way analogous to most camping situations, where individuals take water in small quantities from many sources over a short time interval. One drawback of this study was the potential exclusion of studies assessing *Giardia* load in wilderness surface waters. Although such an analysis might provide relevant correlational evidence, water sampling techniques are methodologically cumbersome and, therefore, typically limited to industrial-scale municipal settings. Furthermore, positive sampling data alone do not implicate water consumption, since a critical parameter in establishing giardiasis infection and pathogenesis is infectious dose. This would be virtually impossible to quantify in most backcountry situations.

Giardiasis is without question a significant gastrointestinal illness, and it definitely should be considered in the differential diagnosis of steatorrhea in patients returning from backcountry travel. The availability of a simple enzyme-linked immunosorbent assay (ELISA) and effective antiparasitic medication facilitates the diagnosis and treatment of this illness. However, as previously stated, there is minimal evidence that occasional ingestion of backcountry waters poses a significant risk of giardiasis to the outdoor recreationist.

Although campers and other backcountry enthusiasts have a disproportionate incidence of giardiasis, as well as other common enteric infections, this may be attributable more to the relaxed hygiene practices on typical camping trips than to water consumption. An interesting extension of the current work would be a prospective investigation of reduced handwashing as a risk factor, controlling for water consumption. It seems ironic that leading outdoor education programs teach rigid practices for the disinfecting of backcountry water, yet emphasize personal hygiene and food handling procedures that are either misinformed or inconsistent, if any such emphasis is made at all. This discrepancy makes little sense when several studies have shown that the risk from simply having a household contact is so high. Further studies should attempt to separate this specific risk factor from other behaviors that may contribute to the overall risk for acquisition.

ACKNOWLEDGMENTS

The author thanks Thomas R. Welch, MD, for his assistance with study screening and exclusion review. Hussni Mohammed, PhD, provided consultation in statistical analysis.

REFERENCES

1. Steketee RW, Reid S, Cheng T, Stoebig JS, Harrington RG, Davis JP. Recurrent outbreaks of giardiasis in a child day care center, Wisconsin. Am J Public Health 1989; 79: 485-490.
2. Quick R, Paugh K, Addiss D, Kobayashi J, Baron R. Restaurant-associated outbreak of giardiasis. J Infect Dis 1992; 166: 673-676.
3. Moldwin RM. Sexually transmitted protozoal infections. *Trichomonas vaginalis, Entamoeba histolytica,* and *Giardia lamblia.* Urol Clin North Am 1992; 19:93-101.
4. Shaw PK, Brodsky RE, Lyman DO, et al. A community-wide outbreak of giardiasis with evidence of transmission by a municipal water supply. Ann Intern Med 1977; 87:426-432.
5. Cook C. The essential guide to wilderness camping and backpacking in the United States. New York: Michael Densend, 1994:45-46.
6. Nash TE, Weller PF. Protozoal intestinal infections: giardiasis, cryptosporidiosis, trichomoniasis, and others. In: Isselbacher KJ, Braunwald E, Wilson JD, Martin JB, Fauci AS, Kasper DL, eds. Harrison's principles of internal medicine. New York: McGraw-Hill, 1994:910-914.
7. Welch TR, Welch TP. Giardiasis as a threat to backpackers in the United States: a survey of state health departments. Wild Environ Med 1995; 6:162-166.
8. Hughes JM, Merson MH. CDC criteria. J Infect Dis 1975; 132: 336-339.
9. Barbour AG, Nichols CR, Fukushima T. An outbreak of giardiasis in a group of campers. Am J Trop Med Hyg 1976; 25:384-388.
10. Brown JW. Another endemic source of giardiasis. Dig Dis 1978; 23:286.
11. Laxer MA. Potential exposure of Utah Army National Guard personnel to giardiasis during field training exercises: a preliminary survey. Mil Med 1985; 150:23-26.
12. Zell SC, Sorenson SK. Cyst acquisition rate for *Giardia lamblia* in backcountry travelers to Desolation Wilderness, Lake Tahoe. J Wilder Med 1993; 4:147-154.
13. Wright RA, Spencer HC, Brodsky RE, Vernon TM. Giardiasis in Colorado: an epidemiological study. Am J Epidemiol 1977; 105:330-336.
14. Harter L, Frost F, Jakubowski W. Giardia prevalence among 1-to-3-year-old children in two Washington State Counties. Public Health Briefs 1982; 72:386-388.
15. Chute CG, Smith RP, Baron JA. Risk factors for endemic giardiasis. Am J Public Health 1987; 77:585-587.
16. Isaac-Renton JL, Philion JJ. Factors associated with acquiring giardiasis in British Columbia residents. Can J Public Health 1992; 83:155-158.
17. Polis MA, Tuazon CU, Alling DW, Talamis E. Transmission of giardiasis from a day care center to the community. Am J Public Health 1986; 76:1142-1144.