

Municipal drinking water and cryptosporidiosis among persons with AIDS in Los Angeles County

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(Accepted 22 April 1994)

SUMMARY

To assess unfiltered drinking water as a source of cryptosporidium infection in patients with the acquired immunodeficiency syndrome (AIDS) the prevalence of cryptosporidiosis among persons with AIDS in Los Angeles County was assessed by water service area. One water distributor, serving approximately 60% of the county's residents (area B), has consistently employed filtration. The other company, which serves the remainder of the county (area A), did not institute filtration until mid-December 1986. This difference provided a 'natural experiment' in which to assess the effect of municipal water filtration on the level of cryptosporidiosis among persons with AIDS. The prevalence of cryptosporidiosis among AIDS patients was compared for the two water service areas for the time period (1983–6) preceding the implementation of filtration in area A. From 1983 to 1986 the age-standardized prevalence of cryptosporidiosis among AIDS patients was 32% lower in area A (4.2%), which received unfiltered water, than in area B (6.2%). Following addition of filtration in area A, the prevalence of cryptosporidiosis among AIDS patients decreased by 20%; however, a decline, of 47%, was also observed in area B. The similar baseline levels of cryptosporidiosis and the corresponding post-filtration decline in both areas suggest that filtration had no effect on levels of cryptosporidiosis among persons with AIDS. Thus it does not appear that municipal drinking water is an important risk factor for cryptosporidiosis in AIDS patients residing in Los Angeles County.

INTRODUCTION

The enteric protozoan *Cryptosporidium* has been recognized as an increasingly important cause of both outbreak-related and sporadic disease in humans [1]. In the immunocompetent host the organism causes a self-limited infection. However,

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in immunocompromised patients cryptosporidiosis is a severe and often fatal condition. Infection in such patients typically causes an unremitting diarrhoea that is intractable to therapy [2]. In the United States, cryptosporidiosis is reported in as many as 10% of patients with acquired immunodeficiency syndrome (AIDS) and is associated with appreciable mortality [3]. Although it is a major source of illness in persons with AIDS, sources of infection and risk factors for infection in this group are unknown.

Water-borne cryptosporidiosis in immunocompetent populations is a well-established phenomenon. Several outbreaks have been associated with contaminated municipal water sources, and contact with surface water has been demonstrated to be a risk factor for sporadic cases [4–7]. *Cryptosporidium* oocysts are commonly recovered from a variety of surface water sources, including supplies intended for community distribution [8]. These oocysts survive for long periods of time in water and are not inactivated by chlorine levels typically applied by municipal water systems [9]. Moreover, evidence suggests that cryptosporidium has a low infectious dose, even in the immunocompetent host, [10, 11] and that the organism lacks strict host specificity [12]. Probable water-borne transmission of cryptosporidiosis to persons with AIDS during a community outbreak has been documented [13]. These findings suggest that unfiltered drinking water may be a source of infection in persons with AIDS.

Several community water systems serving large numbers of persons with human immunodeficiency virus (HIV) infection continue to use unfiltered surface water. Although oocysts may also be recovered from post-filtration municipal water, the commonly used filtration systems remove or inactivate > 90% of oocysts [14]. Therefore, if drinking water is a source of cryptosporidium infection, filtration should substantially decrease exposure to viable oocysts and result in a decrease of cryptosporidiosis in a given population.

Two major municipal water distributors serve Los Angeles County residents. The distributor for one area (area B), which provides water for approximately 60% of Los Angeles County's 8 million residents, has used flocculation and filtration for several years. The other company, which serves the remainder of the county (area A), did not institute flocculation and filtration until December 1986. The municipal water source for both areas includes over 75% surface water; both cryptosporidium and giardia, another waterborne enteric protozoan that frequently causes diarrhoeal illness, have been recovered from these sources. Initial differences in the application of filtration in the two areas and the change to water filtration for area A in 1986, provide a 'natural experiment' to assess the effect of water filtration on the occurrence of cryptosporidiosis among AIDS patients. Specifically it allowed us to determine if persons residing in an area receiving unfiltered municipal water were at increased risk of cryptosporidiosis.

METHODS

AIDS has been a reportable condition in the state of California since 1983. Active surveillance mechanisms are used to ensure a high level of case ascertainment. A standardized case report form developed by the Centers for

Disease Control (CDC) for national AIDS surveillance is used for collecting demographic, clinical, and risk behaviour information on all patients whose illness satisfies the CDC AIDS surveillance case definition. Case information is obtained from primary care providers, medical records review, and hospital infection control practitioners.

AIDS-indicative chronic cryptosporidiosis is defined as laboratory-confirmed illness of greater than one month duration in an HIV-infected person. While the occurrence of chronic cryptosporidiosis (and other AIDS-defining conditions) is recorded in the surveillance registry, the date of onset of cryptosporidiosis is not. Therefore, the surveillance data obtained measure the prevalence of this condition at the time the medical record is reviewed. Additional data, including age and place of residence at the time of report, gender, race/ethnicity, and HIV risk group are also obtained. AIDS case reporting in Los Angeles County is estimated to be approximately 90% complete [15].

The crude prevalence of cryptosporidiosis among AIDS patients residing in area A and in area B was calculated from the surveillance registry. The pre-filtration prevalence of cryptosporidiosis among persons with AIDS was compared between residents of the area receiving filtered water (area B) and residents of the area receiving unfiltered water (area A). Crude odds ratios (OR) and 95% confidence limits (CL) were computed. Adjusted estimates, controlling for age, race, gender, HIV risk group, and country of origin as potential confounders, were also calculated using Mantel-Haenszel stratified analysis. When standardized prevalences were computed, the total population of AIDS patients served as the standard. In addition, we assessed the prevalence of cryptosporidiosis among AIDS patients after filtration was implemented in area A.

Water treatment in area A during the pre-filtration period consisted of applying chlorine disinfectant and in-reservoir clarification using flocculent chemicals. The method of treatment during the post-filtration period included a direct filtration process consisting of pre-ozonation, coagulation, flocculation, high rate filtration through anthracite coal media, and post-filtration application of free chlorine. The water distributor for area B has used flocculation and a conventional sand filtration system with post-filtration chloramination for several years. No significant changes in the management of catchment areas were instituted during the study period.

RESULTS

A total of 10988 cases of AIDS were reported in Los Angeles County during the 8-year (1983–90) study period. Homosexual and bisexual men accounted for 87% of the reported AIDS cases and 90% of the cryptosporidiosis cases (Table 1). The overall prevalence of cryptosporidiosis among AIDS cases during the study period was 3.7%. The 8-year rate of reported AIDS was 234/100000 in area A and 73/100000 in area B.

During the 4-year pre-filtration period (1983–6) the age-standardized prevalence of cryptosporidiosis was 32% lower in area A (4.2%) which received unfiltered water, than in area B (6.2%) (OR = 0.75, 95% CL 0.49, 1.16, Table 2). These estimates were not confounded by race, gender, reported HIV risk group or country of origin (United States versus foreign-born) (Table 3).

Table 1. *Cryptosporidiosis among persons with AIDS by HIV exposure category and water service area, Los Angeles County, 1983-90*

HIV exposure category	Area A		Area B		P value*
	Total no.	Cryptosporidiosis (%)	Total no.	Cryptosporidiosis (%)	
Homosexual or bisexual male	6069	226 (3.7)	2704	106 (3.9)	0.65
Injection drug user (IDU)	302	8 (2.6)	179	8 (3.4)	0.28
Homosexual or bisexual male/IDU	574	28 (4.9)	247	10 (4.1)	0.60
Heterosexual contact	103	6 (5.8)	88	3 (3.4)	0.50
Adult transfusion	116	2 (1.7)	92	0 (0.0)	0.50
Adult haemophiliac	32	0 (0.0)	19	0 (0.0)	1.00
Adult undetermined	243	4 (1.6)	129	4 (3.1)	0.46
Paediatric	58	4 (6.9)	33	1 (3.0)	0.65
Total	7497	278 (3.7)	3491	132 (3.8)	0.85

* Chi square or Fisher exact test, comparing cryptosporidiosis for areas A and B by risk group.

Table 2. *Age-standardized cryptosporidiosis prevalence among persons with AIDS for water service areas A and B, Los Angeles County, 1983-6*

Area	No. with AIDS	No. with cryptosporidiosis	Prevalence (%)	OR* (95% CL)	P value†
A	1946	92	4.2	0.75 (0.49, 1.16)	0.11
B	533	33	6.2	Referent	

* Adjusted odds ratio by Mantel-Haenszel method.

† Mantel-Haenszel chi square test.

Table 3. *Crude and adjusted odds ratios and 95% confidence limits for the prevalence of cryptosporidiosis among persons with AIDS residing in area receiving unfiltered water (Area A), Los Angeles County, 1983-6*

	OR	95% CL	P value*
Crude	0.75	0.49, 1.16	0.17
Stratified by†			
Age	0.75	0.49, 1.16	0.18
Gender	0.75	0.49, 1.16	0.17
Race/ethnicity	0.77	0.50, 1.18	0.21
HIV risk group	0.75	0.48, 1.15	0.16
US-born	0.76	0.49, 1.17	0.19

* Mantel-Haenszel chi square test.

† Mantel-Haenszel method.

During the 4-year post-filtration period, the age-standardized prevalence of cryptosporidiosis among AIDS patients declined by 20% in area A, from 4.2 to 3.4% (97/2958). However, a decrease was also observed in area B, where the prevalence decreased by 47% from 6.2 to 3.3% (186/5551). Moreover, the level of reported cryptosporidiosis had begun to decline in area A before filtration was implemented (Fig. 1). The prevalence has stabilized in both areas since 1986.

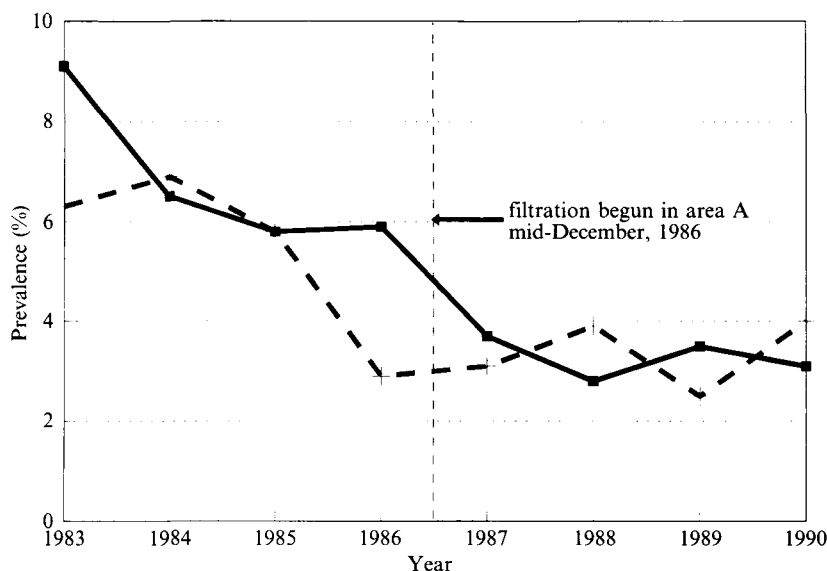


Fig. 1. Cryptosporidiosis prevalence among persons with AIDS for water service areas A (+ --- +) and B (■ — ■), Los Angeles County 1983–90.

No outbreaks of water-borne cryptosporidiosis among immunocompetent persons were detected during the study period.

DISCUSSION

Although filtration was not part of the water treatment methods for area A until late 1986, the pre-filtration prevalence of cryptosporidiosis among persons with AIDS residing in this area was lower than among AIDS patients residing in area B which used filtration. Moreover, although the prevalence of cryptosporidiosis declined in area A following institution of comprehensive water filtration, the concurrent decrease in area B, where there was no change in water treatment, suggests that these declines were unrelated to changes in water treatment. The apparent lack of a demonstrable filtration effect suggests that unfiltered drinking water was not an important source of cryptosporidium infection in AIDS patients in Los Angeles County during the pre-filtration period. This assessment is supported by the fact that the common exposure to municipal water would translate into a large attributable fraction, or population effect, even if the risk associated with unfiltered drinking water was relatively small. Under such circumstances even a modest effect of filtration should be readily detected. Adjustment of cryptosporidiosis prevalence by several potential confounders did not alter our findings. In addition, we observed similar trends in the two areas in the occurrence of community giardiasis, another enteric protozoan frequently transmitted through water, which further suggests that residents receiving unfiltered water were not at elevated risk of water-borne parasitic infection.

Several explanations for our observations are possible. Data suggest that very small numbers of cryptosporidium oocysts occur in local source water. A series of non-random samples from source water for area A taken from 1990 to 1991 found

oocysts present in a concentration of approximately 4/10000 litres (City of Los Angeles Department of Water and Power, unpublished data). Furthermore, since the species and viability of oocysts recovered from local water supplies has not been determined, it is possible that these oocysts may not be viable or infectious or may be species of cryptosporidium incapable of infecting humans. Therefore, the lack of a demonstrated effect of filtration may simply reflect an absence of any significant contamination. However, no data exist for the time period 1983 to 1986 and the low levels of contamination observed in 1990–1 may not accurately reflect the situation during the study period. It is also possible that our findings are a result of differences in herd immunity between the two areas. If residents of the area receiving unfiltered water were more commonly exposed to cryptosporidium, and therefore more likely to be immune, such differences in susceptibility could obscure any water-related risk. Finally, although surface water constituted the predominant source for each water distributor the catchment areas differed and our results could reflect differences in contamination in these catchment areas.

In contrast to the small number of oocysts detected in local source water, a person infected with cryptosporidium can shed as many as 9×10^6 oocysts/ml of stool [16]. Moreover, the relative ubiquitous nature of the organism and the existence of multiple other recognized environmental exposures including travel, child care contact, swimming, animal exposure and sexual contact, suggest that transmission of cryptosporidiosis in HIV-infected persons is likely to occur through vehicles other than drinking water [12, 17–19]. Sexual contact and travel have been implicated as possible risk factors for cryptosporidium infection among persons with AIDS in Los Angeles [20]. The decreasing temporal trend in the prevalence of cryptosporidiosis observed has been attributed to decreased sexual transmission of cryptosporidium among homosexual and bisexual men [20].

Our results must be viewed with caution for several reasons. First, our study possessed adequate power (80%) to detect moderate to small increases, 75% or more, at a 95% confidence level, an exposed to unexposed ratio of 2.5, and a disease prevalence of 4%. However, our data lacked sufficient power to detect a smaller, yet potentially important, increased risk. Given the widespread exposure to drinking water (> 50%), a small increased prevalence (e.g. 20%) would translate into an important population effect or attributable prevalence (10%). Yet, such small increases in prevalence, even if detectable, would be difficult to interpret in view of potential biases and residual confounding. Consequently, small increased risks of cryptosporidiosis associated with municipal water are unlikely ever to be evaluated with much certainty.

Another potentially important limitation is in the ecologic study design [21]. Exposure information was only available by area, so our study lacked information about the quantity and sources of water consumed by individuals. In addition, some local filtered water supplies are stored in open reservoirs without undergoing further filtration; this presents the opportunity for post-treatment contamination which could negate some of the benefit of prior filtration. Moreover, local conditions of contamination and treatment may vary between communities, and so our conclusions cannot necessarily be extrapolated to other localities.

Although testing for cryptosporidium is routinely done in AIDS patients with diarrhoea, and asymptomatic infection with cryptosporidium is uncommon,

ascertainment biases in our surveillance registry probably underestimate the occurrence of cryptosporidiosis among AIDS patients. The AIDS Surveillance Registry records information on the AIDS-defining conditions that a patient has been diagnosed with at the time the medical record is reviewed. Data on the development of subsequent infections are not routinely obtained. However, active surveillance for AIDS-related cryptosporidiosis is conducted at local laboratories by surveillance staff and makes under-reporting less likely. Since surveillance procedures are identical for both areas and have remained essentially unchanged over time, differential ascertainment of cryptosporidiosis by area seems unlikely. Nevertheless, several factors, including the apparent low sensitivity of current diagnostic techniques [22] and varying methods and expertise among laboratories and technicians, could introduce diagnostic error and bias.

We believe the available evidence indicates that municipal water in Los Angeles County is not a significant vehicle of cryptosporidium infection. However, it is important to recognize that our findings may not be generalizable to other areas. Moreover, despite the lack of a protective effect for water filtration in our study, comprehensive filtration still has a role in preventing water-borne parasitic infections. The benefit of filtration in the prevention of outbreaks of giardiasis is well documented [23], and filtration probably provides protection during periods of heavy cryptosporidium contamination.

ACKNOWLEDGEMENTS

We are grateful for the thoughtful comments of Drs Sander Greenland, Dennis Juranek, Jim Seidel, and Peter Kerndt and for the careful review and editing of the manuscript by Donnell Ewert and Phyllis Moir.

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