The Relationship Between E. coli Indicator Bacteria in Well-water and Gastrointestinal Illnesses in Rural Families

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A groundwater quality survey that sampled farm wells across Ontario in 1991-1992 found that about 30% of the farm wells exceeded the safety standard for coliform bacteria.1 Indicators of fecal contamination, such as coliform, fecal coliform, and Escherichia coli counts, have been used to determine the safety of drinking water.2 A positive association between gastrointestinal illness and drinking water measures, such as coliform bacterial counts and turbidity, has been described for rural as well as urban populations.3,4 Additionally, relative to the population served, well-water sources are involved in a large proportion of reported outbreaks associated with drinking water in North America.5,6 The health effects among rural families that rely on individual wells for drinking water have not been reported. Given the high level of exposure to indicator bacteria and evidence that exposure is associated with illness, there is, potentially, a substantial health risk associated with drinking substandard well-water. Therefore, the purpose of this longitudinal study was to determine if the presence of E. coli indicator bacteria in well-water is associated with gastrointestinal illness in rural Ontario families.

METHODS

Study population
The families in this study were selected from participants in the Ontario Farm Groundwater Quality Survey (1991-1992).7 Based on the results of the 1991-1992 survey, 442 families from southern Ontario were identified for potential inclusion in this study, and were classified as having well-water with either “contamination” or “no contamination”. The “no contamination” group (N = 247) consisted of families that had no coliform bacteria isolated in either of the 1991 and 1992 samples. The “contamination” group (N = 195) consisted of families that had coliform bacteria identified from water samples on both tests with at least one well-water sample exceeding established bacteriological standards (exceeding 5 colonies of coliform bacteria per 100 ml of water or any E. coli isolate in 100 ml) set by the Ministry of Environment (MOE).7 Families were excluded if: 1) they were no longer using the same well as used in the 1991-1992 study, 2) there would be fewer than two people in full-time residence during the study period, 3) they did not drink the well-water, or 4) they routinely treated the water (e.g., by chlorination or UV light). Children under one year of age at the beginning of the study and any individuals that were absent from the premises for more than two months during the study were excluded from the analysis. A total of 181 families (91 - no contamination; 90 - contamination) agreed to participate in the study and information from 156 families (531 individuals) was available for analysis.

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Measurement of exposure status

Well-water from each household was tested five times (February, March, June, and October, 1994 and February, 1995) for *E. coli* bacteria. At the five test times, investigators collected well-water samples from the kitchen tap into 250 ml sterile plastic bacteriological bottles that contained the preservative sodium thiosulphate. Samples were stored at 5°C and sent the following day to the Palmerston Laboratory of the Ontario Ministry of Health for bacteriological evaluation using standard methods. Wells were considered positive when *E. coli* was present in any of the five samples tested during the study.

Measurement of illness status

One contact person in each household completed a daily family health diary booklet for each family member from February 1994 to February 1995. Information was collected on the following illness events: nausea, vomiting, diarrhea, fever, cramps, muscle pain, cold or flu, earache and sore throat. Trained interviewers telephoned the contact person for each family at approximately monthly intervals to collect the diary information. Information was also collected concerning well-water consumption and any well-water treatment at each monthly telephone interview.

Definition of illness episode

Illness events were grouped into episodes defined as symptoms occurring for one or more days with at least five symptom-free days separating episodes. Gastrointestinal illness episodes included all episodes in which diarrhea, with or without vomiting, was reported. Non-gastrointestinal episodes included all illness episodes except episodes of vomiting or diarrhea. Whenever an illness episode occurred, information was collected on the number of days the individual stayed home from work or school, stayed in bed, visited a doctor, or was hospitalized. An individual or family was defined as positive for an illness if they experienced an episode of illness any time during the study period.

Measurement of other risk factors

Well factors, such as well construction-type, depth, and distance from the septic tank, were determined at a site visit by investigators. A self-administered questionnaire was used to obtain information on the household (e.g., family member attendance or employment at a day care centre, presence of livestock on a farm, household income) and the individual level (e.g., age, gender, occupation, education, chronic medical conditions, medications, food allergies and raw milk consumption).

Analysis

Individual and family level analyses were performed. The relationships between health outcomes and *E. coli* status were evaluated using Pearson’s chi-square test. The 95% confidence intervals (CI) for the difference between crude proportions of exposure groups with an episode were calculated. The associations between *E. coli* status and illness episodes were examined using general linear models to control for known confounders and other risk factors. Associations examined at the individual level were also adjusted for correlation within families using the generalized estimating equation (GEE) regression models with exchangeable correlation structure (GEE1, SAS Macro, M. Rezual Karim, Department of Statistics, The John Hopkins University, 1989). Confidence intervals for interaction estimates were calculated.
WELL-WATER AND GI ILLNESSES

Two-hundred thirteen gastrointestinal and 945 non-gastrointestinal episodes were reported during the study period for rates of 0.40 and 1.78 per person-year, respectively. The gastrointestinal episodes were most frequent in the months of February and March and fluctuated throughout the study period (Figure 2).

Family level analysis
At least one episode of gastrointestinal illness was reported by 64.5% of the families with E. coli positive wells compared to 46.4% of the families with E. coli negative wells. However, this difference was not statistically significant (difference = 18.1%, 95% CI [-0.9%, 37.1%]). In the adjusted family-level analysis, the association between E. coli status of the wells and gastrointestinal illness approached but did not reach statistical significance (p = 0.09; odds ratio 2.11 [95% CI 0.90, 4.94]).

Individual level analysis
At least one episode of gastrointestinal illness was reported for 31.6% of the individuals with E. coli positive wells compared to 25.8% of the individuals with E. coli negative wells (difference = 5.8%, 95% CI [-3.6%, 15.2%]). A significant association between well-water E. coli status and gastrointestinal illness was observed after adjusting for significant risk factors and confounders. These factors were age of the individual, depth of the well and distance from the well to the septic tank. The relationship between E. coli status of the wells and gastrointestinal illness was significantly modified by the distance from the septic tank to the well. When the well was positive for E. coli and the septic tank was greater than 20 metres from the well, the odds ratio for gastrointestinal illness episode was 2.16 [95% CI 1.04, 4.42]. When the well was within 20 metres of the septic tank, the odds ratio was 0.46 [95% CI 0.07, 2.95].

Alteration of daily activities
Only 101 (19.0%) participants reported some disruption of daily activities during gastrointestinal episodes for an average of 0.54 days per person-year. There were no hospitalizations reported from gastrointestinal episodes. No statistically significant differences in daily activities or medical consultations were reported between the individuals in the E. coli positive and negative groups for either gastrointestinal or non-gastrointestinal illness.

DISCUSSION

At the level of the individual family member, consumption of E. coli contaminated well-water was significantly associated with gastrointestinal illness after adjusting for significant confounders. The incidence of gastrointestinal episodes was consistent with previous studies from urban areas despite differences in family structure, episode definitions and exposures. Furthermore, the degree of E. coli contamination in the study wells was substantial and consistent with previous studies in southern Ontario.

The association between E. coli status of the wells and gastrointestinal illness approached but did not reach statistical significance in the family-level analyses. Additionally, the associations between coliform contamination (greater than five total coliform bacteria per 100 ml water on any of the five samples) and gastrointestinal illnesses while adjusting for family, individual and well factors followed similar
patterns and levels of significance to those found with E. coli (not shown). Thus, future studies to evaluate these relationships should consider larger sample sizes than the present study.

The reason for the interaction between E. coli status and proximity of the well to the septic tank is unknown. It is possible that the source of E. coli and accompanying pathogenic microbial agents would be different for wells that were located at a greater distance from the septic tank than those in closer proximity. It is also possible that individuals with septic tanks closer than 20 metres have a higher level of immunity to gastrointestinal infections as a result of higher levels of exposure which are more consistently present over time.

It should be noted that the families in the study had been residents of the premises and drinking their well-water for at least three years prior to the study. Urban residents visiting such premises and consuming contaminated well-water would be expected to have a greater probability of detecting pathogenic microbial agents as they are not exposed to such persons would be expected to have a lower degree of immunity to gastrointestinal illnesses. This is understandable since the participants were selected on the basis of exposure, making unlikely the probability of detecting rarer but more serious illness (e.g., E. coli O157:H7 infection).

CONCLUSION

The results of this study provide evidence of an association between consumption of contaminated rural well-water in Ontario and gastrointestinal illness. Our results further suggest that E. coli can be useful in the detection of wells that pose a potential human health threat. This study thus highlights the importance of programs to test private wells for E. coli indicator bacteria and of the need to undertake remedial measures for wells that are substandard.

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REFERENCES


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