Self-Reported Diarrhea in a Control Group: A Strong Association with Reporting of Low-Pressure Events in Tap Water

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In a recently conducted case-control study of sporadic cryptosporidiosis, 6.6% of subjects in the control group reported having had diarrhea in the 2 weeks before completion of the questionnaire. In an analysis of this control group, there was a very strong association between self-reported diarrhea and reported low water pressure at the faucet.

Acute diarrhea is a common symptom in the developed world, especially among the youngest members of our society. Actual estimates of illness vary depending on the method used to ascertain illness rates, on the case definitions, and on the country [1]. In the United States, with use of a retrospective study design, it was estimated that there are 140 episodes of diarrhea for every 100 person-years [2]. In the United Kingdom, retrospective studies estimate illness rates to be 55–95 episodes for every 100 person-years [3–5]. Prospective studies seem to give a substantially lower estimate. In the United Kingdom, a prospective study reported an attack rate of 19.4 episodes per 100 person-years [5], and in a Canadian study, the rate was 76 episodes per 100 person-years among people who did not use water filters [6]. Although only a small proportion of these patients present to the health service, the economic cost of diarrheal disease in the United Kingdom is large: ~£743 million per annum at 1995–1996 prices [7]. In the large majority of cases, it is unclear where people have acquired infection. We recently conducted a large case-control study of the risk factors for sporadic cryptosporidiosis and found that a significant proportion of the control group reported diarrhea in the 2 weeks before receipt of the questionnaire [8]. We took the opportunity to study associations between risk factors and the presence of diarrhea in the control group for this study to determine any indications of possible risk factors for diarrhea in the United Kingdom.

The postal questionnaire–based case-control study was conducted in Wales and the northwest region of England from February 2001 to May 2002. Full details of the study are provided elsewhere [8]. The combined population of the 2 regions covered by this study region is >9 million people and covers both heavily industrialized and rural areas. There are 3 main water utilities supplying these regions, which between them have ~240 water treatment works. Sources of drinking water and treatments vary, but overall, the microbiological quality of the water is excellent, with <0.05% of water samples testing positive for Escherichia coli (http://www.dwi.gov.uk/consumer/qualityinfo6.shtml).

For the purposes of this report, 427 control subjects returned their questionnaires, a 52% response rate. Of these 427 responses, 28 respondents (6.6%) reported having had diarrhea in the 2 weeks before receipt of the questionnaire, and 4 did not answer the question. These 4 persons were excluded from this analysis. Thus, the incidence of diarrhea in our control group was 86 cases per 100 person-years, which is in line with previous retrospective studies in the United Kingdom [3–5]. Statistical analysis in this study was identical to that used for the larger case-control study: the \( x^2 \) test or Fisher’s exact test were used for univariable analysis, and logistic regression analysis was used for multivariable analysis [8]. All analyses were done using SPSS software, version 12.0 (SPSS). All variables that were significant at the \( P < .01 \) level were included in a logistic regression model. The least significant variable was then removed from the model, which was then recalculated. This continued until all variables were significant at the \( P < .1 \) level. The final model is shown in table 1.

Four variables remain significant in the final model. There was a positive association with feeding young children and a negative association with consumption of yogurt at the \( P < .05 \) level. We are unable to explain this latter observation, although it is interesting to speculate whether this could have been the result of a probiotic effect of the bacteria in yogurt [9]. The strong association with contact with someone else who had diarrhea is also not surprising, given the known likelihood of person-to-person transmission of many enteric pathogens. The most surprising finding was the very strong association...
(OR, 12.5; 95% CI, 3.5–44.7; \( P < .001 \)) with reporting of loss of water pressure at the home tap.

Most of the reported episodes of pressure loss were associated with reported disruption of the water supply and are likely to be related to burst water mains. Thus, many of the excess cases of illness identified in this study could be associated with contamination of water during a burst. Even in the absence of an actual burst, low water pressure in distribution systems is a well-known risk factor for outbreaks of waterborne disease, especially in low-income countries [10]. However, there have been few outbreaks reported from developed nations and no epidemiological evidence of an association with sporadic infections or disease. The suggestion that contamination of water in distribution may lead to increased risk of diarrhea—even in developed nations—has been made before, although not in association with low–water pressure events specifically [11]. Recently, workers in the United States have shown that low–water pressure events in otherwise satisfactory water distribution pipes can aspirate enteric organisms that contaminate the soil surrounding the pipe [12].

The question remains whether the observed association could be an artifact; the study was not designed to test the hypothesis that low–water pressure events were associated with self-reported diarrhea, the questions were not specifically designed to look for events occurring before the onset of diarrhea, and there remains the possibility of recall bias. The study design asked persons to self-report diarrhea and water pressure loss in the 2 weeks before receipt of the questionnaire, so we are unable to confirm that the loss of pressure events preceded the diarrhea, although it is difficult to understand how an association could occur in which diarrhea preceded the loss of water pressure other than by chance. Given that this was a postal questionnaire–based study, we were unable to analyze stool specimens and are not able to confirm the nature and cause of the diarrheal illness. With regard to recall bias, loss of water pressure was just one of many possible risk factors that were investigated in the questionnaire. Although Cryptosporidium species have caused several waterborne outbreaks of diarrhea in the northwest region, loss of water pressure was not associated with cryptosporidiosis in the larger study, and many other water-related variables, such as discoloration, were not associated with diarrhea. The very strong association found in this analysis suggests that our results are unlikely to be an artifact.

If our finding is repeatable, then a substantial proportion of cases of gastrointestinal illness in the United Kingdom and probably in the United States (up to ~15%) may be associated with the consumption of drinking water that has been contaminated as a result of a burst water main or other loss of pressure in the distribution system. The costs of illness related to such low–water pressure events could exceed £100 million per annum in England and Wales (15% of the total annual cost of diarrheal disease discussed above). Such an observation has significant policy implications and will affect the cost–benefit analyses for improving the state of the aging water supply distribution system in many industrialized nations. Such a finding would also lead to significant changes in how low–water pressure events in public water supplies are managed.

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