Joint symptoms after a large waterborne gastroenteritis outbreak—a controlled, population-based questionnaire study

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Abstract

Objectives. Waterborne outbreaks offer an opportunity to study joint symptoms after a simultaneous exposure. In November 2007, a gastroenteritis outbreak due to faecal contamination of tap water took place in a Finnish town. The purpose of this study was to evaluate the occurrence of joint symptoms after the outbreak.

Methods. The authors conducted a controlled, population-based questionnaire survey to study the occurrence of joint symptoms within 8 weeks after the exposure. The survey covered three areas: contaminated and uncontaminated parts of the town and a control town. A total of 1000 residents were randomly selected from each area, and the joint symptoms were first analysed separately and thereafter categorized as arthritis-like if joint swelling, redness, warmth or pain in movement was reported.

Results. A total of 2123 responses could be evaluated. The overall prevalence of joint symptoms was 13.9% in the contaminated group, 4.3% in the uncontaminated group and 1.5% among the control group, and the frequency of arthritis-like symptoms in the groups was 6.7, 2.1 and 0.5%, respectively. Gastrointestinal symptoms predicted joint complaints, diarrhoea and blood in faeces being the most significant. Residing in the contaminated area was associated with any joint symptom [odds ratio (OR) = 4.0, 95% CI 1.8, 9.0] and joint pain (OR = 7.3, 95% CI 2.1, 24.8) without preceding gastroenteritis.

Conclusion. The frequency of joint symptoms was high in the contaminated group and also increased in the uncontaminated group. Furthermore, the risk of joint symptoms was increased in the contaminated group even without gastroenteritis.

Key words: waterborne, outbreak, reactive arthritis, joint symptoms, epidemiology.

Introduction

ReA has long been recognized as a consequence of acute bacterial gastroenteritis [1]. Among the gastrointestinal pathogens, Salmonella, Shigella, Campylobacter and Yersinia are common aetiologies of gastroenteritis preceding ReA [2]. Of these, Campylobacter has become most prevalent in northern Europe during recent decades [3]. In a Finnish population-based study, the annual incidence of Campylobacter-induced ReA was 4.3 per 100 000 [4]. According to the same study, 7% of those infected with Campylobacter developed ReA.
A number of studies have examined ReA after food- or waterborne, single-source outbreaks. According to these studies, ReA has developed in 1-21% of those with gastrointestinal symptoms [5]. However, lack of precise clinical definition makes interpretation of the results difficult [6]. The reported frequency of ReA after the outbreaks depends on whether the findings of synovitis are required or if milder symptoms are also taken into account and whether the diagnosis is verified by a specialist. Furthermore, the frequency depends on the study design, whether the data are based on patient charts, clinical examination or a questionnaire.

Waterborne outbreaks offer an opportunity to study the frequency of gastrointestinal-induced joint symptoms in relatively large cohorts exposed within a short period of time. In a study of a waterborne outbreak caused by Campylobacter and Escherichia coli O157:H7 in Walkerton, Canada, 17.6% of the participants with moderate symptoms and 21.6% with severe symptoms of acute gastroenteritis reported having an arthritis diagnosed by a doctor [7]. In a Finnish study, ReA verified by a rheumatologist was observed in 2.6% within 3 months after a waterborne Campylobacter jejuni outbreak [8].

To date, the largest waterborne epidemic in Finland broke out in November 2007 [9]. The objective of this study was to investigate the frequency of self-reported new joint symptoms occurring within 8 weeks after the exposure and to investigate the correlation between different gastrointestinal and joint symptoms.

**Materials and methods**

**Setting and outbreak**

Nokia (population of 30 000) is a town in southern Finland. At the end of November 2007, ~450 m³ of wastewater plant effluent water was accidentally mixed with the water for household use. A valve between the effluent line and the municipal water distribution line made an inappropriate cross-connection in the plant. This valve had been opened during maintenance work, and by mistake, was left open for 2 days. The household water of over 9500 inhabitants became heavily contaminated with faecal microbes, causing a large outbreak of gastroenteritis [9]. Seven different pathogens were detected from patient specimens, six of them also from water or pipeline samples. Although Campylobacter species were the most common bacterial finding (n = 148) from the stool samples, Salmonella species were also detected. In addition, norovirus was also a major pathogen [9, 10]. In a study on children admitted to hospital because of this outbreak, a high prevalence of viral pathogens and mixed infections was found [11]. Subsequently, 65 cases of giardiasis were diagnosed [12].

**Questionnaire study**

The town was divided into contaminated (population of 9538) and uncontaminated (population of 20 478) areas. The assessment was based on microbiological findings from different parts of the water distribution network and technical modelling of flow directions in the network. Residents of these areas constituted two study groups: contaminated and uncontaminated groups. A control group was recruited from another municipality in the same district, and of the same size (population of 27 259) and demographics of the population. A random sample of 1000 persons was selected from the population register for each study group. Later on, 21 persons were shifted from the uncontaminated to the contaminated group as the boundaries of the areas were defined. The study groups were matched with age and gender. All ages were included, and only one participant per household was allowed [9].

The study was conducted using a 10-page questionnaire mailed 8 weeks after the beginning of the outbreak. A reminder was sent 3 weeks later if the participant had not responded to the first mailing. The participants were asked about the onset and the spectrum of gastrointestinal symptoms between 28 November 2007 and 20 January 2008 (within 8 weeks after water contamination). Gastroenteritis was defined as vomiting and/or diarrhoea (three or more loose stools per day), and the usual daily amount (glasses per day) of tap water consumption for drinking before the outbreak was inquired.

The participants were asked about new symptoms occurring between 28 November 2007 and 20 January 2008, such as joint pain, joint pain in movement, joint swelling, redness or warmth and back pain at rest. After analysing each joint symptom separately, two symptom groups were created: (i) any of the above joint symptoms; and (ii) arthritis-like symptoms if pain in joint movement, joint swelling, redness or warmth was present.

**Statistical methods**

The data were divided into three groups as described earlier. The crude differences between the symptom occurrences were tested using Fisher’s exact test. Univariate logistic regression was employed for all other analyses, with the occurrence of arthritis-like symptoms as a response and gastrointestinal symptoms, fever or water use as a covariate. The analyses were performed separately in groups. In addition, the groups were compared among those reporting any gastric symptoms. The results were reported as percentages or odds ratio (OR) with 95% CI. Calculations were performed using the R System version 2.10.1 [13].

**Ethical considerations**

According to Finnish legislation, immediate outbreak investigations such as the present study can be performed without approval from an ethics committee to ensure prompt measures. The Ministry of Social Affairs and Health was consulted about this interpretation of communicable disease law.

**Results**

A total of 2154 questionnaire forms were received. Thirty-one forms were excluded from the analysis because...
of insufficient content or unidentifiable responder, leaving 2123 responses for the analysis, with an overall response rate of 71%. The rates were 79% (808/1021), 73% (717/979) and 60% (598/1000) for the contaminated, uncontaminated and control groups, respectively. The background characteristics of the three study groups have been presented previously [9]. The gastroenteritis attack rate was 53.0% in the contaminated group, 15.6% in the uncontaminated group, and 6.5% in the control group.

The frequencies of joint symptoms in the study group are presented in Table 1. The frequency of any joint symptom was over 9-fold higher among the contaminated group when compared with the control group (13.9 vs 1.5%, \( P < 0.001 \)), and the frequency was higher among the uncontaminated group as well (4.3 vs 1.5%, \( P = 0.003 \)). Also, the frequency of arthritis-like symptoms was significantly higher in the contaminated group (6.7 vs 0.5%, \( P < 0.001 \)) and the uncontaminated group (2.1 vs 0.5%, \( P = 0.016 \)) when compared with the control group. The participants in the contaminated group had an OR of 9.7 (95% CI 5.1, 18.5) for any joint symptom, 12.5 (95% CI 5.1, 30.4) for joint pain, 11.2 (95% CI 4.1, 30.2) for arthritis-like symptoms and 8.1 (95% CI 2.9, 22.2) for back pain at rest when compared with the control group. In the uncontaminated group, ORs, in comparison with the control group, were 2.7 (95% CI 1.3, 5.5) for any joint symptom, 3.0 (95% CI 1.1, 7.9) for joint pain, 3.3 (95% CI 1.1, 9.7) for arthritis-like symptoms and 2.2 (95% CI 0.7, 6.9) for back pain at rest. The frequency of any joint symptom was 7.1% and that of arthritis-like symptoms was 3.9% among the participants <15 years of age in the contaminated group, while in the uncontaminated group frequencies were 0.8 and 0.0%, respectively.

The predictive impact of the different gastrointestinal symptoms is presented in Table 2. All the gastrointestinal symptoms and fever predicted joint symptoms both in the contaminated and uncontaminated groups. Among those who experienced gastroenteritis, the OR for any joint symptom was 4.8 (95% CI 2.9, 7.9) in the contaminated area and 9.3 (95% CI 4.5, 19.4) in the uncontaminated area, when compared with those without gastroenteritis in the same study group. In this comparison, the OR in the uncontaminated group was consistently higher than that in the contaminated group. Among those without gastrointestinal symptoms, the OR for any joint symptom was significantly increased (4.0, 95% CI 1.8, 9.0) in the contaminated group, but not in the uncontaminated group (1.5, 95% CI 0.6, 3.6), when compared with the control group (Table 3).

Among the participants in the contaminated group, a large volume of tap water consumed daily increased the probability of developing joint symptoms (Table 4). Those drinking more than six glasses per day had a significantly higher risk for all joint symptom categories when compared with those consuming fewer than three glasses. Consuming three to six glasses per day was not correlated with the risk of joint symptoms, except for back pain at rest.

**Discussion**

According to this population-based, controlled questionnaire study, the frequency of new joint symptoms was high in the affected town within 8 weeks from exposure. The authors observed a nine times higher prevalence of any joint symptoms in the contaminated group than in the control group. For arthritis-like symptoms and back pain at rest, the excess prevalence was even greater. These findings demonstrate that a waterborne outbreak can be a major cause of joint complaints.

The present study demonstrated a high prevalence of excess joint symptoms within the usual time span of ReA manifestation [5]. The frequency of joint symptoms in this survey was comparable with that observed (13%) after bacterial gastroenteritis with mixed aetiologies in a prospective US survey [14] and *Campylobacter* infection (16%) found in a Danish study [15]. However, these surveys included only culture-confirmed cases and were not limited to a single outbreak. In the present study, a highly representative sample of the population was studied. The frequency of joint symptoms in this study was lower than that of self-reported arthritis after the Walkerton outbreak.

**Table 1** Frequency of self-reported new symptoms [n (%)] from 28 November 2007 to 20 January 2008 in the three study groups

<table>
<thead>
<tr>
<th>Joint symptom</th>
<th>Contaminated group (n = 808)</th>
<th>Uncontaminated group (n = 717)</th>
<th>Control group (n = 598)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n (%)</td>
<td>P-value</td>
<td>n (%)</td>
</tr>
<tr>
<td>Any joint symptom</td>
<td>112 (13.9)</td>
<td>&lt;0.001</td>
<td>31 (4.3)</td>
</tr>
<tr>
<td>Joint pain</td>
<td>74 (9.2)</td>
<td>&lt;0.001</td>
<td>17 (2.4)</td>
</tr>
<tr>
<td>Arthritis-like symptoms</td>
<td>54 (6.7)</td>
<td>&lt;0.001</td>
<td>15 (2.1)</td>
</tr>
<tr>
<td>Pain in movement</td>
<td>48 (5.9)</td>
<td>&lt;0.001</td>
<td>12 (1.7)</td>
</tr>
<tr>
<td>Joint swelling</td>
<td>13 (1.6)</td>
<td>0.032</td>
<td>3 (0.4)</td>
</tr>
<tr>
<td>Joint redness or warmth</td>
<td>7 (0.9)</td>
<td>0.023</td>
<td>1 (0.1)</td>
</tr>
<tr>
<td>Back pain at rest</td>
<td>39 (4.8)</td>
<td>≤0.001</td>
<td>10 (1.4)</td>
</tr>
</tbody>
</table>

*P*-value for the difference against the control group.

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Participants without symptoms of gastroenteritis

Both the study groups were compared with the control group. The authors included all age groups in this survey, in contrast to the Walkerton study, which excluded subjects <18 years of age. ReA is considered to be uncommon among children [16], and in this study also, the frequency of joint complaints was lower among participants <15 years of age.

In a previous study of this outbreak, the authors observed a significant excess of gastroenteritis in the uncontaminated area [9]. In this study also, the prevalence of joint symptoms was significantly higher in the uncontaminated group compared with the control group. Visiting the contaminated area from the uncontaminated part of the town may have caused exposure to contaminated water. The control group was recruited from a municipality 35 km from Nokia, in a location that makes exposure to contaminated water or mixing with the town’s population unlikely.

Any gastrointestinal symptom during the outbreak increased the odds of experiencing joint symptoms. Among the specific symptoms, diarrhea and blood in faeces were most clearly associated with any joint symptoms and arthritis-like symptoms. The pronounced role of diarrhea seems plausible, because it is the major symptom of bacterial gastroenteritis. However, many of those who fell ill were likely to have been infected with several pathogens.

Apart from joint symptoms developing after gastrointestinal disease, the findings suggest that residents in the contaminated area commonly experienced asymptomatic infections that triggered joint symptoms. This is supported by the stronger association between gastrointestinal symptoms and subsequent joint symptoms in the uncontaminated area than in the contaminated area. In that analysis, participants with possible asymptomatic infection were considered as unaffected, thus weakening the correlation between gastrointestinal and joint symptoms in the contaminated area. In the study of joint manifestations after the Walkerton outbreak, those exposed to contaminated water without subsequent gastrointestinal symptoms reported nearly as high a frequency of arthritis as those with symptomatic gastroenteritis [7].

The dose correlation between the quantity of water ingested and the risk of gastroenteritis has been shown in several outbreak investigations [17–20]. The authors of this study observed no dose response between moderate daily consumption of tap water and the risk of having joint illnesses. The lack of association may be caused by the fact that tap water is so commonly used in Finland that comparison with non-users is not possible. Since the household water was extensively contaminated, small doses of water were probably adequate to cause infection leading to either gastroenteritis or joint symptoms, or both. However, a larger amount of water was associated with an increased risk of joint symptoms. As there were

| TABLE 2 | Univariate analysis of the probability of developing joint symptoms within 8 weeks according to gastrointestinal symptoms and fever in the contaminated and uncontaminated groups |
|-----------------------------------|----------------------|---------------------|------------------------|---------------------|
| **Gastrointestinal symptom or fever** | **Any joint symptom** | **Joint pain** | **Arthritis-like symptoms** | **Back pain at rest** |
| **Contaminated** (n = 428) | 4.8 (2.9, 7.9) | 4.5 (2.5, 8.2) | 6.1 (2.8, 13.1) | 7.3 (2.8, 19.1) |
| **Uncontaminated** (n = 112) | 9.3 (4.5, 19.4) | 12.3 (4.5, 33.3) | 13.5 (4.6, 39.7) | 3.16 (0.9, 10.7) |
| **Vomiting** | 3.8 (2.5, 5.7) | 3.7 (2.3, 6.2) | 4.1 (2.3, 7.4) | 4.8 (2.4, 9.7) |
| **Diarrhoea** | 5.0 (3.1, 8.0) | 4.5 (2.6, 7.9) | 7.9 (3.7, 17.0) | 7.5 (3.1, 18.2) |
| **Blood in faeces** | 9.6 (4.6, 20.0) | 11.2 (4.3, 29.2) | 11.4 (4.1, 31.4) | 4.6 (1.3, 15.8) |
| **Fever** | 5.9 (2.1, 16.6) | 7.1 (2.5, 20.6) | 5.2 (1.6, 16.8) | 7.4 (2.2, 24.6) |

Participants with a specific symptom were compared with those without that symptom within the same study group. The probability is represented as OR (95% CI).

| TABLE 3 | OR (95% CI) for joint symptoms among participants without symptoms of gastroenteritis |
|------------------|------------------|------------------|------------------|------------------|
| **Joint symptom** | **Contaminated group** | **Uncontaminated group** |
| Any joint symptom | 4.0 (1.8, 9.0) | 1.5 (0.6, 3.6) |
| Joint pain | 7.3 (2.1, 24.8) | 1.7 (0.5, 6.8) |
| Arthritis-like symptoms | 3.0 (0.9, 9.9) | 1.1 (0.3, 4.1) |
| Back pain at rest | 1.7 (0.5, 6.4) | 1.6 (0.5, 5.6) |

Both the study groups were compared with the control group.
several pathogens involved in this outbreak, the concentration of some arthritogenic pathogens may have been low in water, and larger ingested volumes might have been required to become infected. It is also possible that those showing joint symptoms were prone to overestimating their water consumption, because they might be aware that the water was a possible reason for their complaints.

Although in outbreak investigations, determination of the prevalence of joint symptoms is commonly based only on those seeking medical care, the authors of this study used a representative random sample population-based design with a control group. On extrapolating the representative survey data to the whole population of the town, it can be assumed that over 2000 people experienced joint symptoms and over 1000 people suffered from arthritis-like symptoms. In a previously published study of this outbreak, all clinically suspected ReA cases were referred to the local rheumatology clinic. In the study of these cases, 45 patients were referred to a rheumatologist and 21 cases of ReA were diagnosed [21]. These observations together suggest that mild forms of joint complaints are far more prevalent than proven cases of ReA. In addition, they also suggest that reliance on self-reported ReA may overestimate the real burden of ReA after a food- or waterborne outbreak.

This study has some limitations. First, the outbreak gained wide attention in the regional and national media. In addition, the residents were publicly informed about the possibility of ReA. This may have led to over-reporting of symptoms. Furthermore, those with gastroenteritis or joint symptoms could have responded more actively, which may have biased the results. This bias is probably not of great significance, because the overall response rate was good. Secondly, the 2-month delay from exposure until survey created an 8-week recall period, which may have caused a limited recall bias. Thirdly, some joint symptoms may have occurred more than 8 weeks after the outbreak, and therefore might have been missed from this study. However, ReA is considered to develop within 1-2 weeks of bacterial gastroenteritis [5].

In conclusion, joint symptoms and symptoms suggestive for ReA were common in the affected town within 8 weeks after the onset of extensive tap water contamination with sewage effluent, and the symptoms of gastrointestinal infection correlated with the probability of experiencing joint symptoms. In addition, living in the contaminated area was related to joint symptoms even without gastrointestinal symptoms. A population-based study design is important in studying the consequences of major outbreaks.

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**Supplementary data**

Supplementary data are available at *Rheumatology* Online.

**References**


