Value of syndromic surveillance in monitoring a focal waterborne outbreak due to an unusual Cryptosporidium genotype in Northamptonshire, United Kingdom, June – July 2008

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The United Kingdom (UK) has several national syndromic surveillance systems. The Health Protection Agency (HPA)/NHS Direct syndromic surveillance system uses pre-diagnostic syndromic data from a national telephone helpline, while the HPA/QSurveillance national surveillance system uses clinical diagnosis data extracted from general practitioner (GP)-based clinical information systems. Data from both of these systems were used to monitor a local outbreak of cryptosporidiosis that occurred following *Cryptosporidium* oocyst contamination of drinking water supplied from the Pitsford Reservoir in Northamptonshire, United Kingdom, in June 2008. There was a peak in the number of calls to NHS Direct concerning diarrhoea that coincided with the incident. QSurveillance data for the local areas affected by the outbreak showed a significant increase in GP consultations for diarrhoea and gastroenteritis in the week of the incident but there was no increase in consultations for vomiting. A total of 33 clinical cases of cryptosporidiosis were identified in the outbreak investigation, of which 23 were confirmed as infected with the outbreak strain. However, QSurveillance data suggest that there were an estimated 422 excess diarrhoea cases during the outbreak, an increase of about 25% over baseline weekly levels. To our knowledge, this is the first time that data from a syndromic surveillance system, the HPA/QSurveillance national surveillance system, have been able to show the extent of such a small outbreak at a local level. QSurveillance, which covers about 38% of the UK population, is currently the only GP database that is able to provide data at local health district (primary care trust) level. The *Cryptosporidium* contamination incident described demonstrates the potential usefulness of this information, as it is unusual for syndromic surveillance systems to be able to help monitor such a small-scale outbreak.

Introduction

As syndromic surveillance systems usually capture data already collected for other purposes, and monitor generic symptoms and/or clinically diagnosed disease, they provide information at an earlier stage of illness (compared with laboratory-confirmed diagnoses), so that action can be taken in time to substantially reduce the impact of disease. Some systems, for example, the Royal College of General Practitioners Weekly Returns Service, are now well established, with many years of historical data that allow monitoring of longer-term disease trends [1]. They have the ability to provide early warning of, for example, seasonal rises in influenza and can trigger public health action, such as a recommendation to prescribe antiviral drugs in line with national guidance [2-4]. They can also provide reassurance to incident response teams and the general public that an incident has not caused adverse health effects – for example, following an explosion at the Buncefield oil storage depot in Hemel Hempstead, United Kingdom (UK), in 2005, syndromic surveillance confirmed that there were no unusual rises in community-based morbidity linked to the incident [5]; following the eruption of the Eyjafjallajökull volcano in Iceland in April 2010 similar assurance was given about lack of impact on community morbidity [6].

Health departments are increasingly expected to monitor health effects of natural events such as heat wave or flooding, or implement surveillance – of which syndromic surveillance plays a major role – for mass gatherings such as the Olympics or football World Cup [7-9]. Systems in France, Australia and Taiwan use data from emergency departments [10-12], a Canadian system uses over-the-counter pharmacy sales [13,14], and in the Netherlands data from both syndromic and surrogate data sources, such as employee absence records and prescription medications dispensed by pharmacies, are included in surveillance systems [15,16]. Currently systems based on Internet searches via search engines or on queries submitted to medical websites are being developed [17,18].

In the UK, the HPA/NHS Direct syndromic surveillance system uses pre-diagnostic syndromic data collected from the NHS Direct telephone helpline [19], while the HPA/QSurveillance national surveillance system uses clinical diagnosis data extracted from general practitioner (GP)-based clinical information systems [20].

The HPA Real-time Syndromic Surveillance Team is a small team that coordinates a number of syndromic surveillance systems within the HPA and takes a lead for syndromic surveillance in England [21]. This paper

Figure 1

Daily NHS Direct calls for diarrhoea in the East Midlands, compared with other regions, United Kingdom, 1 May – 31 August 2008

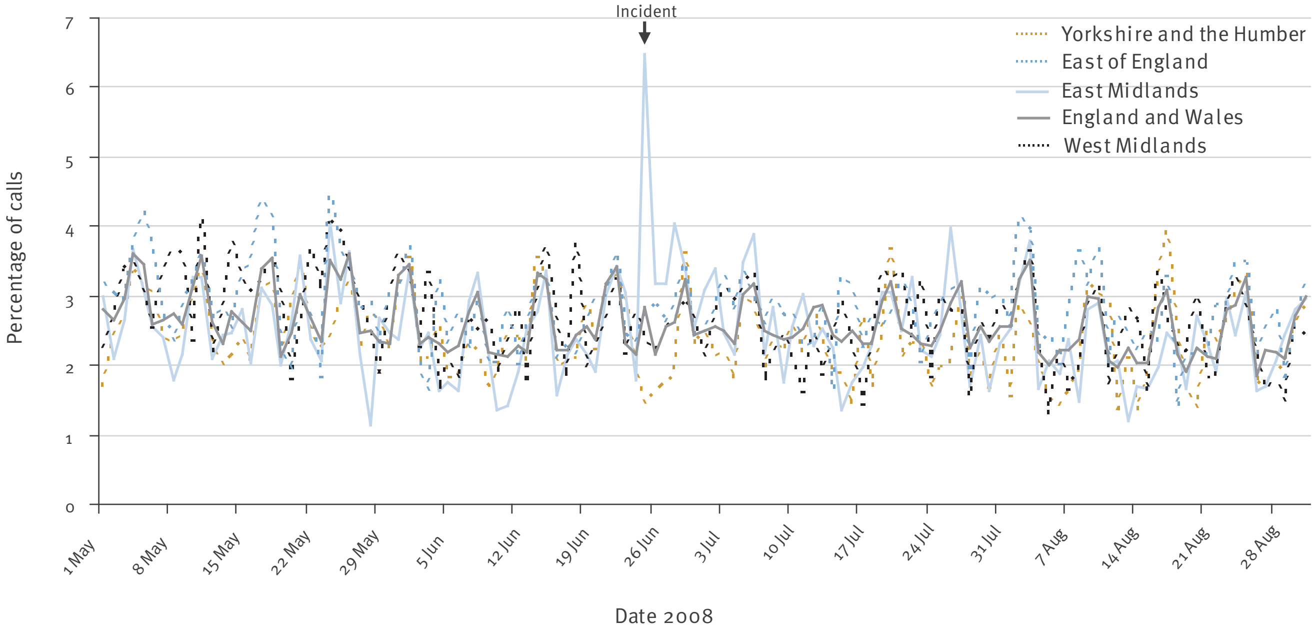
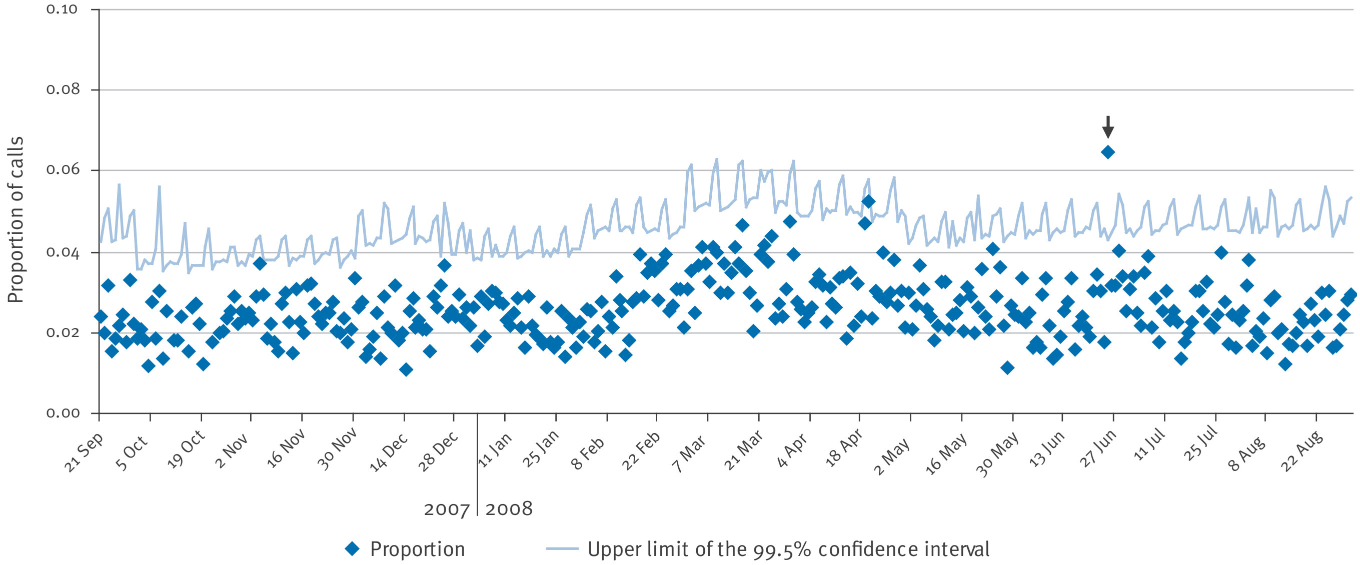


Figure 2

Control chart for NHS Direct calls for diarrhoea in the East Midlands region, United Kingdom, 21 September 2007 – 31 August 2008



The arrow demonstrates the high exceedance in the number of calls on 25 June 2008 following the contamination incident.

Table 1

QSurveillance general practitioner consultation rates for diarrhoea (all ages) per 100,000 practice population by week, Northamptonshire, United Kingdom, 16 June – 6 July 2008[a]

Surveillance region	Week 25 (16–22 June 2008)			Week 26: incident week (23–29 June 2008)			Week 27 (30 June – 6 July 2008)			
	Number of cases	GP consultation rate[b]	SIR[c] (95% CI)	Number of cases	GP consultation rate[b]	SIR[c] (95% CI)	QSurveillance denominator population[d]	Number of cases	GP consultation rate[b]	SIR[c] (95% CI)
East Midlands	617	33.2	113.3 (104.6–122.6)	599	34.1	113.0 (104.2–122.5)	1,922,622	656	34.1	112.8 (104.4–121.9
Trent SHA	284	32.0	109.3 (97.1–122.9)	267	31.8	105.6 (93.5–119.2)	930,841	276	29.6	98.0 (86.9–110.4)
Leicestershire, Northamptonshire and Rutland SHA	333	34.3	116.9 (104.8–130.3)	332	36.1	119.8 (107.4–133.5)	99,1821	380	38.3	126.7 (114.4–140.2)
Daventry and South Northants PCT	28	44.7	152.1 (102.4–222.1)	37	59.0	195.4 (139.0–271.5)	62,698	25	39.9	131.9 (86.6–196.9)
Northamptonshire Heartlands PCT	59	31.3	106.5 (81.6–138.1)	87	41.3	136.6 (109.9–169.1)	189,101	81	42.8	141.6 (113.0–176.7)
Northampton PCT	27	31.6	107.6 (71.9–158.2)	32	46.5	154.1 (106.6–219.5)	94,964	61	64.2	212.4 (163.4–274.2)
United Kingdom	**6,087**	**29.3**	**100.0**	**6,244**	**30.1**	**100.0**	**2,201,5291**	**6,658**	**30.2**	**100.0**

CI: confidence interval; GP: general practitioner; PCT: primary care trust; SHA: strategic health authority; SIR: standardised incidence ratio.

[a] Data are presented using the regional/SHA/PCT boundaries that were in place before October 2006.

[b] Per 100,000 practice population.

[c] Calculated using the United Kingdom as the standard population. If both the upper and lower limits of the 95% confidence interval are above 100, the SIR is considered to be significantly high. In the shaded cells, the standardised incidence ratio is significantly above that of the United Kingdom.

[d] The patient population of GP practices reporting to QSurveillance during week 27.

Source: HPA/Nottingham University National Surveillance System weekly bulletins 188, 189 and 190.

Table 2

QSurveillance general practitioner consultation rates for gastroenteritis (all ages) per 100,000 practice population by week, Northamptonshire, United Kingdom, 16 June – 6 July 2008[a]

Surveillance region	Week 25 (16–22 June 2008)			Week 26: incident week (23–29 June 2008)			Week 27 (30 June – 6 July 2008)			
	Number of cases	GP consultation rate[b]	SIR[c] (95% CI)	Number of cases	GP consultation rate[b]	SIR[c] (95% CI)	QSurveillance denominator population[d]	Number of cases	GP consultation rate[b]	SIR[c] (95% CI)
East Midlands	1,068	57.5	112.7 (106.0–119.7)	1033	58.8	112.3 (105.6–119.4)	1,922,622	1,147	59.6	112.7 (106.3–119.4)
Trent SHA	482	54.4	106.6 (97.4–116.6)	451	53.8	102.8 (93.6–112.8)	930,841	471	50.5	95.6 (87.2–104.7)
Leicestershire, Northamptonshire and Rutland SHA	586	60.3	118.2 (108.9–128.2)	582	63.4	121.0 (111.4–131.3)	991,821	676	68.1	128.7 (119.3–138.9)
Daventry and South Northants PCT	57	90.9	178.0 (135.7–231.9)	71	113.2	216.1 (169.6–273.7)	62,698	65	103.7	195.9 (152.0–250.8)
Northamptonshire Heartlands PCT	101	53.5	104.8 (85.7–127.8)	146	69.2	132.1 (111.8–155.7)	189,101	138	73.0	137.9 (116.1–163.3)
Northampton PCT	40	46.8	91.6 (66.1–125.7)	58	84.3	160.9 (123.0–209.1)	94,964	94	99.0	187.0 (151.7 - 229.6)
United Kingdom	**10,593**	**51.0**	**100.0**	**10,836**	**52.4**	**100.0**	**22,015,291**	**3,276**	**52.9**	**100.0**

CI: confidence interval; GP: general practitioner; PCT: primary care trust; SHA: strategic health authority; SIR: standardised incidence ratio.

[a] Data are presented using the region/SHA/PCT boundaries that were in place before October 2006.

[b] Per 100,000 practice population.

[c] Calculated using the United Kingdom as the standard population. If both the upper and lower limits of the 95% confidence interval are above 100, the SIR is considered to be significantly high. In the shaded cells, the standardised incidence ratio is significantly above that of the United Kingdom.

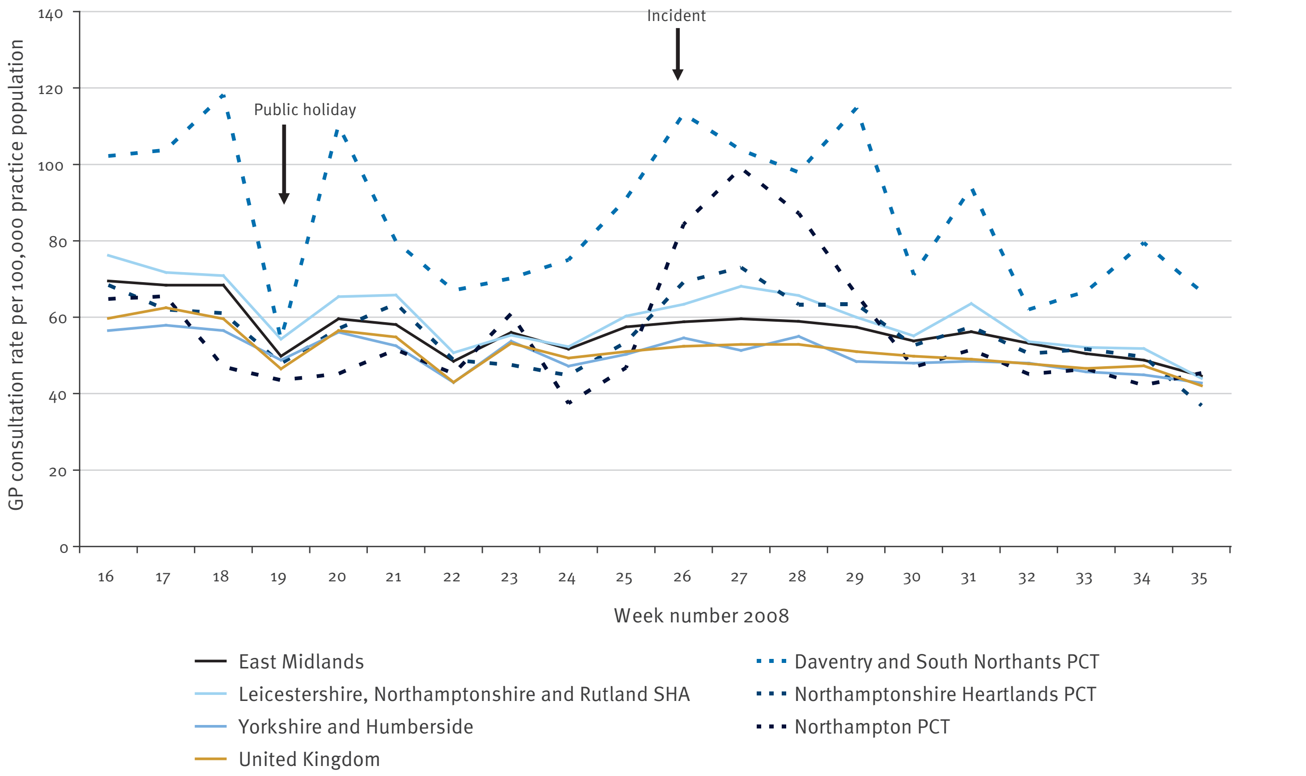
[d] The patient population of GP practices reporting to QSurveillance during week 27.

Source: Health Protection Agency/Nottingham University National Surveillance System weekly bulletins 188, 189 and 190.

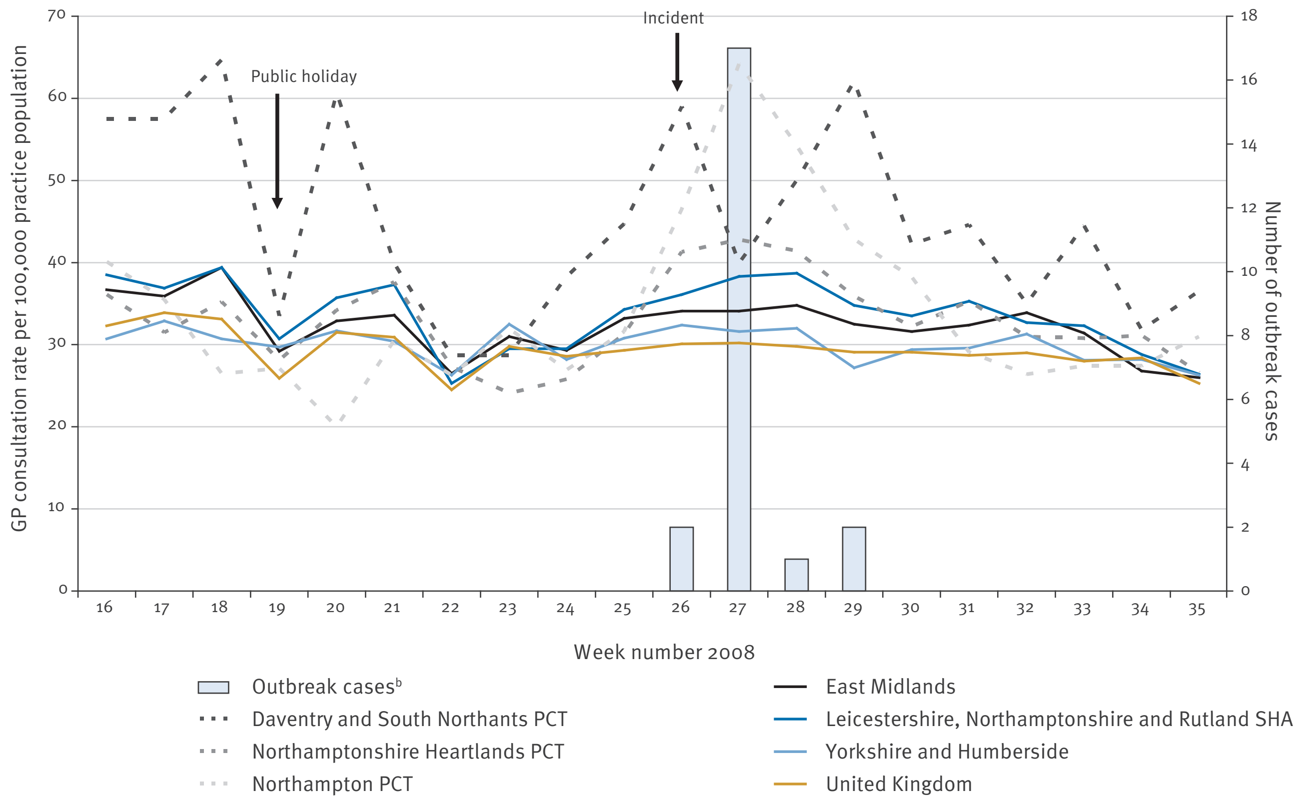
Figure 3

QSurveillance general practitioner consultation rates for (A) diarrhoea (and (B) gastroenteritis by region, strategic health authority and primary care trust (all ages), United Kingdom, weeks 16-35[a], 2008

A



B



Source: QSurveillance database version 1.
GP: general practitioner; PCT: primary care trust; SHA: strategic health authority.
[a] Week commencing 14 April 2008 to week commencing 25 August 2008
[b] Only 22 cases are displayed as date of symptom onset is missing for one case.

describes the support provided by the team to the local incident management team during a local cryptosporidiosis outbreak and shows the use of syndromic surveillance in monitoring the extent of an outbreak using the HPA/NHS Direct and HPA/QSurveillance national surveillance systems.

Cryptosporidiosis

Cryptosporidium is a protozoan parasite that can cause an infection in people, cattle and sometimes other animals [22]. Cryptosporidiosis is most common in children aged between one and five years, but it can affect all ages. Those with impaired immune systems are likely to be most seriously affected. Symptoms usually appear between three and 12 days after initial exposure and include watery diarrhoea, stomach pains, dehydration and fever. In its transmissible form, called an oocyst, the parasite is protected by an outer shell, which allows it to survive in the environment for a long time. Transmission occurs most often via the faeco-oral route through person-to-person or animal-to-person contact, but people may also be infected by consuming contaminated water or food or by swimming in contaminated water. Although uncommon, the largest outbreaks have occurred following contamination of drinking water [23,24]. Normal chlorine disinfection procedures do not kill the oocysts, so they are removed by filtration and water companies carry out routine monitoring of treated water.

Description of the incident

On 25 June 2008 the local Health Protection Unit was informed by Anglian Water of an exceedence in the level of *Cryptosporidium* oocysts found in water supplied from the Pitsford Reservoir in Northamptonshire, United Kingdom, during 19 to 24 June 2008 [25]. The reservoir supplied a population of more than 250,000 in the Northampton area. A notice advising people in the affected areas to boil all drinking water was issued on 25 June 2008 and public health messages were circulated to local health services and to the general public via the media. Those members of the public who were concerned about health risks associated with the incident were asked to ring NHS Direct for clinical advice [26]. The HPA wrote to local GPs and hospitals asking them to monitor potential patients for signs and symptoms of *Cryptosporidium* infection and to submit faecal specimens to the local hospital diagnostic laboratory if patients presented with diarrhoea. Samples from 34 patients where *Cryptosporidium* infection was identified were sent to the UK *Cryptosporidium* reference unit for typing.

On 30 June 2008, the *Cryptosporidium* oocysts found in the reservoir water were confirmed as being of the rabbit genotype *Cryptosporidium* cuniculus [27]. Subsequently, a dead rabbit was found in a treated water tank at the water treatment works. The genotype of *Cryptosporidium* oocysts in the rabbit's large bowel was indistinguishable from that of the oocysts found in the water [27].

After remediation of the water supply and distribution, the 'boil water notice' was lifted on 4 July and the following day the first case of cryptosporidiosis linked to the incident was identified by the reference laboratory (this case was infected with *C. cuniculus*). During the course of the outbreak (24 June – 18 July 2008, the dates of symptom onset in the first and last case, respectively), 23 cases of cryptosporidiosis were confirmed as being infected with *C. cuniculus*; one of the 23 was a secondary case.

The HPA Real-time Syndromic Surveillance Team provided data in order to aid the response to this incident and the first syndromic surveillance report was circulated to the incident management team and other relevant people in the HPA on 27 June 2008. Data from the HPA/NHS Direct and HPA/QSurveillance systems were provided in a series of regular reports, initially daily and eventually weekly, until the final report on 21 August 2008. Each report included a summary

Table 3

HPA/QSurveillance national surveillance system: estimated number of excess cases of diarrhoea by week (extrapolated to primary care trust population), Northamptonshire, United Kingdom, 16 June – 27 July 2008 (n=422)

Week 2008	Estimated number of excess diarrhoea cases			
	Daventry and South Northants PCT	Northamptonshire Heartlands PCT	Northampton PCT	Total[a]
25	6	2	9	17
26[b]	22	30	40	92
27	1	34	77	113
28	12	30	56	98
29	25	15	32	72
30	4	5	22	31
Total[a]	**69**	**117**	**237**	**422**

PCT: primary care trust.

[a] Figures may not add up due to rounding.

[b] Cryptosporidium exceedance in water from the Pitsford Reservoir was reported by Anglian Water in week 26.

Source: QSurveillance database version 1.

interpretation and more detailed data on diarrhoea, gastroenteritis and vomiting indicators.

Methods

Surveillance systems

HPA/NHS Direct surveillance system

NHS Direct is a 24-hour nurse-led telephone helpline that provides health information and advice to the general public. Nurses use a computerised clinical decision support system – the NHS Clinical Assessment System (NHS CAS) – to handle calls. This assessment system uses approximately 200 computerised symptom-based clinical algorithms. Nurses assign the call to the most appropriate algorithm and the patient's symptoms determine the questions asked and the action to be taken following the call (call outcome), which could be guidance on self-care or they could be referred to their GP or advised to attend a hospital emergency department. No attempt is made to provide a formal diagnosis.

Daily NHS Direct data are received by the Real-time Syndromic Surveillance Team, where the number and type of calls received during the previous day are analysed and interpreted. Call proportions are calculated by age group and algorithm against the total number of calls received.

HPA/QSurveillance system

The HPA/QSurveillance national surveillance system was set up by the University of Nottingham, United Kingdom, and Egton Medical Information Systems (EMIS), a supplier of general practice computer systems, in collaboration with the HPA. It comprises a network of more than 3,500 general practices throughout the UK, covering more than 22 million patients (about 38% of the population [28]). Aggregated data on GP consultations for a range of indicators are automatically uploaded daily from GP practice systems to a central database. Data are routinely reported on a weekly basis; however, daily reporting is possible for specific incidents. Reports are provided at national or regional level (strategic health authority, SHA) and by local health district (primary care trust, PCT).

Analysis of surveillance data

NHS Direct call proportions for gastrointestinal syndromes (diarrhoea and vomiting) for the East Midlands region in England, where Northampton is situated, were examined during the outbreak (24 June – 18 July 2008) and compared with those for England and Wales. A series of control charts for diarrhoea calls are routinely used to monitor significant rises in the numbers of calls received. Control charts are calculated by assuming that calls follow a Poisson distribution with the total number of calls as an offset: a model is fitted to each region and symptom separately [29]. The model takes into account call variation caused by weekends, public holidays and the time of year – variables that can affect the number of calls received by NHS Direct. A value above the upper limit of the 99.5% confidence interval would be considered to be unusual. The seven-day moving average for diarrhoea calls was also monitored. The number and percentage of calls for diarrhoea in the East Midlands region were presented by call outcome and the number of calls in the Northampton (NN) postcode districts and in particular the number of calls in the NN11 and NN12 postcode districts, which were most affected by the incident.

QSurveillance national consultation rates per 100,000 population for diarrhoea (in the age groups under five years, five years and over, and all ages), gastroenteritis (all ages) and vomiting (all ages) were compared with rates for the same period in 2007 (data not presented). Consultation rates by region for 2008 for diarrhoea (all ages), gastroenteritis (all ages) and vomiting (all ages) were compared with those for the East Midlands region. The gastroenteritis indicator includes all cases of diarrhoea and/or vomiting.

Consultation rates and standardised incidence ratios (SIRs) – calculated using the UK as the standard population – for diarrhoea, gastroenteritis and vomiting were compared for the UK, Yorkshire and Humberside, East Midlands, Leicestershire, Northamptonshire and Rutland SHA, and Daventry and South Northants PCT, Northamptonshire Heartlands PCT and Northampton PCT. Yorkshire and Humberside was not an affected region but was included as a control. The area supplied by the Pitsford Reservoir included the three PCTs, which were all within the Leicestershire, Northamptonshire and Rutland SHA. The consultation rates and SIRs were compared for the period from week 16 to week 35 of 2008 in order to compare the rates before and after the *Cryptosporidium* exceedance, which took place in week 26.

Estimates of excess numbers of cases of diarrhoea occurring during and following the *Cryptosporidium* outbreak were made by calculating the mean consultation rate over a period of five weeks before and after the incident (weeks 20–24 and weeks 31–35, respectively). For each of the three PCTs, the calculated mean rate was applied to the PCT population to estimate the number of cases that would be expected each week. The actual consultation rates for diarrhoea for weeks 25 to 30 were used to estimate the number of cases for the PCT population each week. The expected number of cases was subtracted from the estimated number of cases in the PCT population to give the estimated number of excess cases.

Results

HPA/NHS Direct surveillance system

A peak in the number of calls for diarrhoea in the East Midlands was recorded in 25–26 June 2008, the period that coincided with the contamination incident and the associated media coverage (Figure 1). The neighbouring areas of the West Midlands, Yorkshire and the Humber, and East of England showed no increase in the number of calls for diarrhoea.

The peak produced a control chart exceedance for calls for diarrhoea on 25 June 2008 (Figure 2), when the proportion of calls exceeded the upper limit of the 99.5% confidence interval. There were further confidence interval exceedances on 26 and 28 June (which were not control chart exceedances).

There was no peak in calls for vomiting or control chart exceedance for these calls in the East Midlands.

HPA/QSurveillance national surveillance system

The East Midlands region had significantly high consultation rates for diarrhoea and gastroenteritis in week 25 (16–22 June), week 26 (23–29 June 2008, when the contamination incident was reported) and in the following four weeks. Within this region. Leicestershire, Northamptonshire and Rutland SHA had slightly raised consultation rates and significant SIRs across weeks 25 to 30 that were not seen in the neighbouring Trent SHA. At PCT level, all three of the PCTs in the area affected by the incident showed increased consultation rates for diarrhoea (Table 1) and gastroenteritis (Table 2) with SIRs significantly above the UK rate in week 26. Daventry and South Northants PCT also had a raised SIR for both indicators in week 25, and although Northamptonshire Heartlands and Northampton PCTs did not have SIRs significantly above that of the UK in week 25, the rise in consultation rates for diarrhoea and gastroenteritis began during week 25.

In Northampton PCT, consultations for both diarrhoea and gastroenteritis peaked in the week following the contamination incident, week 27, returning to normal levels by week 30 (Figure 3A and 3B). A similar effect can be seen in Northampton Heartlands PCT. Daventry and South Northants PCT also showed an increase, but appeared to have consistently higher rates for both indicators. This was the area with the smallest population so the rates were more variable than in the other PCTs and we therefore interpreted these results with caution.

The consultation rates for vomiting during weeks 25 to 30 in the East Midlands were not unusual at SHA or PCT level (data not presented).

Discussion

We have demonstrated the sensitivity of syndromic surveillance in detecting this small *Cryptosporidium* outbreak and the value of the surveillance in being able to describe the extent of its spread. Both the HPA/NHS Direct and HPA/QSurveillance systems showed demonstrable increases in calls and consultations for diarrhoea that were linked to the outbreak. QSurveillance consultations appeared to increase across the PCTs immediately affected but not in the surrounding area. Both the HPA/NHS Direct and HPA/QSurveillance systems showed a clear signal at the time of the incident and we were able to describe the extent of the impact on pre-primary care and primary care services. The HPA/QSurveillance system showed a rise in consultation rates for gastrointestinal symptoms that began the week before the outbreak, consistent with the period when *Cryptosporidium* was present in the water leaving the Pitsford Reservoir (19–24 June 2008) and with the onset of symptoms in the first outbreak case on 24 June. Although only 33 cases were identified by the outbreak investigation team, of which 23 were confirmed as having the outbreak *Cryptosporidium* strain, our syndromic surveillance data detected this limited outbreak.

Data also suggested a more widespread increase in general gastrointestinal symptoms around the time of the outbreak, with an estimated 422 excess diarrhoea cases; these excess cases represented an increase of about 25% above normally expected levels. It is highly probable that a proportion of these excess cases may have resulted from the increased publicity surrounding the incident – for example, it is likely that media reports contributed to the large peak in calls detected by the HPA/NHS Direct surveillance system on the day the boil water notice was issued, and could also have impacted on the GP consultation rate. It has been previously shown that reporting of mumps cases is sensitive to media coverage, with a rise in clinically reported cases following newspaper reports [30]. A similar mechanism could account for some of the excess GP consultations as cases experiencing gastrointestinal symptoms may have been more likely to consult their GP, whereas in normal circumstances they would have cared for themselves at home. It is also possible that the surveillance shows outbreak-associated cases that did not come to the attention of the outbreak team, perhaps because symptoms were not sufficiently severe to warrant further investigation, or stool samples were not provided for testing.

It is interesting to note that there was no demonstrable impact on the number of calls for vomiting (which is not a prominent clinical feature of cryptosporidiosis). Other common community-based pathogens such as norovirus and rotavirus were at low levels, as is normal for that time of year [31].

In this instance, public health authorities had already been alerted to a potential problem by the water company, although the extent of the outbreak was detected by syndromic surveillance. In 2003 the syndromic surveillance systems in the city of New York, United States, were able to detect an increase in diarrhoeal illness following a power outage when there was no other indication of citywide illness [32]. The New York system covers a population of nine million, but does not regularly detect localised outbreaks [33]. It has been shown previously that the HPA/NHS Direct surveillance system would be unlikely to detect a *Cryptosporidium* outbreak unless call volumes are high (72% chance of detection if nine-tenths of cases called NHS Direct) [29], although the value of syndromic surveillance for such outbreaks has been recognised [34]. The system detected the East Midlands *Cryptosporidium* outbreak that affected a smaller population than that covered by the New York system. The three PCTs affected have a combined population of around 600,000, of which just over half use GP practices reporting to QSurveillance, yet this syndromic surveillance system was able to describe an increase in consultation rates for diarrhoea and gastroenteritis around the time of the outbreak.

Limitations of the data

There was extensive media reporting of the incident that may have affected both the HPA/NHS Direct and HPA/QSurveillance systems and contributed to the increase in reported gastrointestinal symptoms around the time of the contamination incident. However, the rise in consultation rates for diarrhoea began before the outbreak had been detected and therefore cannot be attributed to media coverage.

The HPA/NHS Direct and HPA/QSurveillance systems monitor general symptoms and so could only monitor the relevant symptoms of diarrhoea and vomiting. They are not able to detect *Cryptosporidium* cases, as this would require laboratory confirmation of diagnosis, so some of the estimated excess cases could be unconnected with this incident. This outbreak was discovered by other means but both the HPA/NHS Direct and HPA/QSurveillance systems were able to describe the extent of the disease in the general population and provide reassurance that there was no widespread impact.

Compared with other populations, older people and ethnic minorities are less likely to call NHS Direct [29], and although this should not prevent detection of gastrointestinal symptoms as a result of drinking water contamination as this would affect the whole population, this may reduce the signal from the system [35]. With such large surveillance systems, there will be 'background noise' in the data, so procedures must be in place to correctly interpret the data and set appropriate thresholds for action.

Conclusion

To our knowledge, this is the first time that PCT-level data from a syndromic surveillance system, the HPA/QSurveillance national surveillance system, have been able to show the extent of such a limited outbreak at a local level. QSurveillance, which covers about 38% of the UK population, is currently the only GP database that is able to provide PCT-level data and this *Cryptosporidium* contamination incident demonstrates the potential usefulness of this system.

Acknowledgements

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