



Public Health
England

Epidemiological investigation of an outbreak of gastrointestinal illness following a mass-participation swim in the River Thames London October 2012



Final report

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ABSTRACT

Introduction: Following an open-water swimming event in the River Thames on 07 October 2012 with 1,100 competitors, the Health Protection Agency was made aware of several cases of gastrointestinal illness among participants on Friday 19 October. An outbreak investigation was initiated to describe the outbreak; identify factors associated with illness and explore illness following previous events.

Methods: A retrospective cohort study was conducted. Cases were defined as race participants with either diarrhoea or vomiting, or abdominal cramps or nausea lasting over 48 hours, with symptom onset up to nine days after the event and who did not meet the exclusion criteria. An online survey was used to collect information on symptoms, behaviours during and following the swim and level of open water swimming experience. Descriptive and analytical analysis was conducted using STATA v.12. and MS Excel™. Multivariable analysis testing associations between exposures and illness was conducted using backward stepwise regression with a robust Poisson model to derive Relative Risk measures.

Results: Valid survey response was 61%. Fifty-three percent of survey participants (n=338) met the case definition and assuming all non-responders were not ill then at least 31% of swimmers were affected. The median age of survey respondents was 41 years old and 64% were male. The median incubation period was 34 hours and symptoms lasted a median of four days. Few positive microbiological results were obtained for outbreak cases: four of Giardiasis and one of Cryptosporidiosis. The Thames is not classed as bathing water and is known to be regularly contaminated with human pathogens; however no routine monitoring of water quality for bathing is conducted. Two factors were independent risk factors for illness: people wearing a wetsuit were seven times more likely to become ill (Relative Risk (RR) 6.96) and people swallowing water during the swim were 42% more likely to become ill (RR 1.42). Protection was afforded by having previously swum in a river open swim event in the past 24 months (RR 0.78) and being over 40 years old (RR 0.83). Self-reported level of experience, awareness of infection risks and post-race showering and hand washing were not found to be significantly associated with illness. Seventeen percent of respondents reported illness after swimming in previous events in the Thames.

Discussion: People participating in this Thames swimming event had a very high risk of developing gastrointestinal illness. We recommend that effort should be made to increase the awareness of the infection risks associated with this type of swimming among participants, to advise on measures to reduce the risk of illness in future events and to clarify roles and responsibilities for protecting the health of participants.

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BACKGROUND

The alert

On Friday 19 October 2012 the Health Protection Agency (HPA) London Regional Epidemiology Unit (now the Public Health England Field Epidemiology Service, Victoria Office) was informed of a hospitalised patient with severe headache, nausea, fever and sweating who reported recently swimming in a large open water swimming event in the River Thames. The case was admitted to hospital on Wednesday 17 October and discharged on Saturday 20 October.

The index case provided contact details for two friends who also swam in the event and had been ill. Staff from the London Regional Epidemiology Unit and South West London Health Protection Unit interviewed these cases over the weekend. Through these interviews the Regional Epidemiologist was alerted to a Facebook webpage where around 40 swimmers had reported experiencing illness, mostly gastrointestinal illness, following the event.

The event

The event was a 2.25 mile swimming race between Hampton Court and Kingston Bridge in the River Thames and took place on Sunday 07 October (see Figure 1).

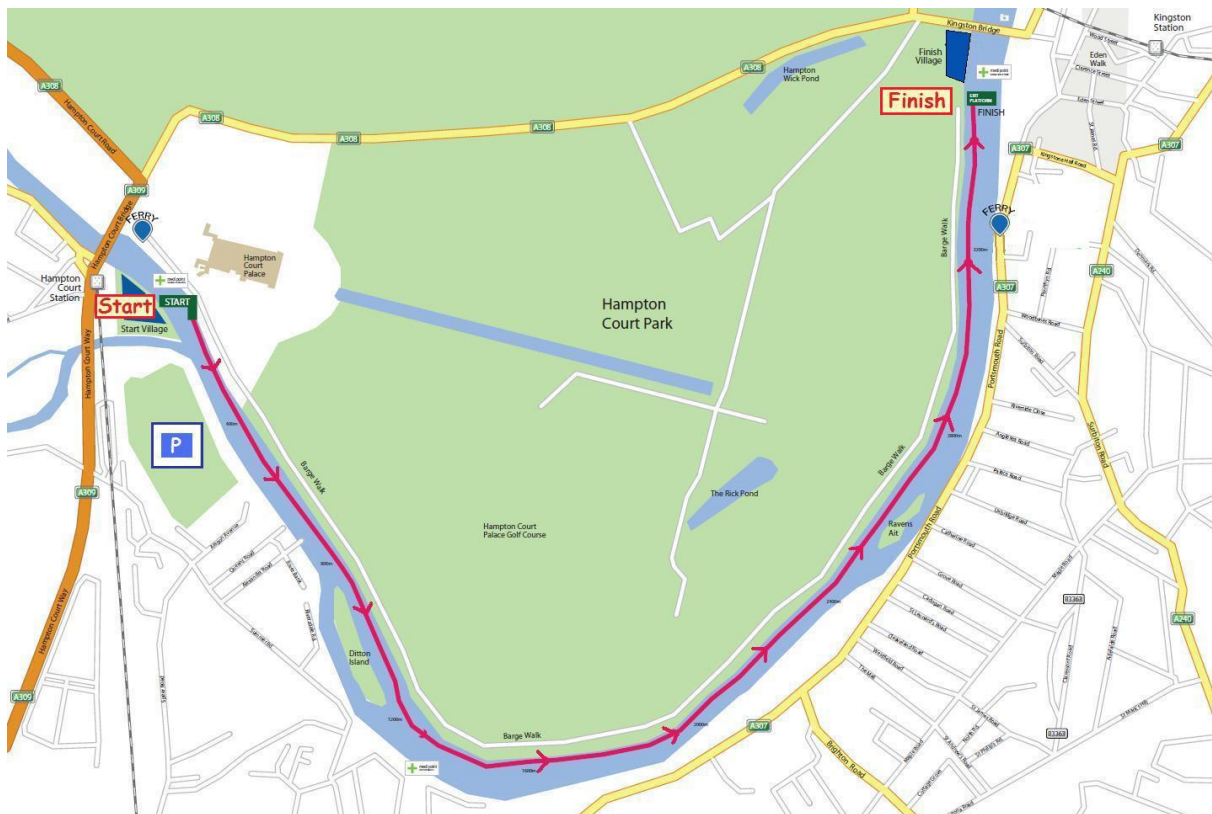


Figure 1: Map showing the swimming race course in the River Thames

The organisers were a major professional sports event company who had been organising events nationwide for around 10 years, including open water swimming, triathlons, running and cycling events both for experienced athletes and first time participants. The race between Hampton Court and Kingston Bridge had been organised as an annual event by the company for three years.

The number of swimmers who participated in the event was 1,100. Swimmers included experienced athletes and first time participants. Swimmers were encouraged by the company to fundraise for charity by getting friends and family to sponsor them.

Participants were arranged into eleven different starting time slots, termed “waves” with approximately 100 swimmers per wave, beginning at 08:30 and then staggered every 10 minutes until the last wave started at 10:10. On exiting the river at Kingston Bridge, swimmers entered a temporary reception area on the river bank where they were handed a medal and offered a complimentary energy bar, tea and coffee. Temporary toilets and hand-washing sinks were available. No showering facilities were provided. No on-site catering was provided.

Prior to the event the organisers informed Elmbridge Borough Council, Kingston First & Kingston Borough Council Leisure Services, Hampton Court Royal Palaces and the Environment Agency. The event had been rescheduled from July 2012 following advice from the Environment Agency on safety concerns related to water flow.

Evidence base on water quality in the River Thames

The Environment Agency (EA) is responsible for monitoring the River Thames for a wide-range of recreational users. This is done by monitoring the river flow and communicating this to recreational users by means of a traffic light board system (‘red’ warning against use, ‘amber’ use with caution and ‘green’ safe to use). The EA also regularly tests the river for a range of chemicals, monitoring the quality of the water for potable abstraction, as water is abstracted at several points along the river by a wide range of industry including water companies, manufacturing and irrigation.

The Thames is not classified as water suitable for bathing by the EA. Several ‘combined sewer overflows’ (CSO) are distributed along the river, and following heavy rain will relieve the sewerage system by releasing storm sewage (untreated sewage mixed with rainwater) directly into the river (see Figure 2). The river also receives discharges of treated sewage, which are not disinfected, and surface water

run-off, including from agricultural land, which may be contaminated. The water is therefore considered likely to be polluted and likely to contain pathogenic microorganisms.

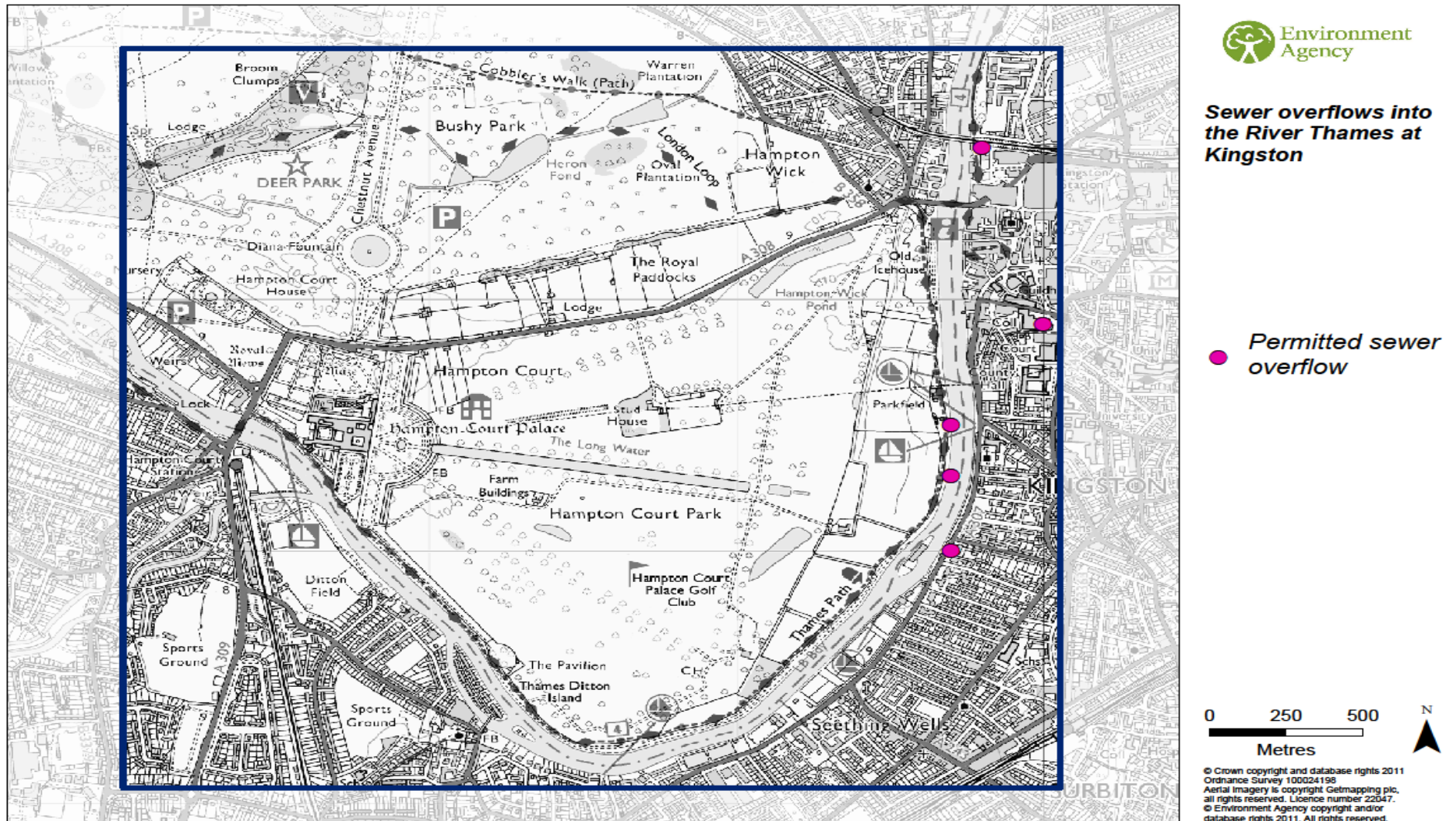
Limited data on the microbiological quality of water in the River Thames was identified prior to the investigation. One study conducted regular water testing of the Thames (sampling between Teddington, downstream from Hampton Court, and Crossness, east of the City of London) between 2005 and 2006 [1]. The study found that on 91% of the days sampled, the water was classified as “poor water quality” according to the European Commission bathing water quality guidelines, with *Escherichia coli* counts exceeding 1000cfu/100ml. Frequent contamination with potential human pathogens was detected with *Campylobacter* spp, *Salmonella* spp, Enteroviruses and other pathogens identified on 99% of occasions. The study also found that recreational river users participating in the study (these were rowers and canoeists rather than swimmers) experienced an elevated risk of gastrointestinal illness for 2-4 days after CSO discharge events.

Evidence base on the health risks associated with open water swimming

‘Open water’ or ‘wild’ swimming, defined as swimming in ‘naturally occurring’ or outdoor, unchlorinated bodies of water, such as rivers, lakes and oceans, is growing in popularity. A number of websites for open water swimming interest groups can be found online, as can several companies organising mass-participation open water swimming events.

While there has been growing participation in open water swimming and particularly, organised open water swimming events, limited literature is available on the potential risks to swimmers from infectious diseases resulting from ingesting water contaminated with human pathogens. One systematic review of 22 epidemiological studies investigating the association between bathing water quality and gastrointestinal illness found that most studies reported a dose-response relationships with increased illness associated with increased indicator-bacteria count [2]. The authors concluded there was evidence of a strong association between bathing water quality and gastrointestinal illness. This is particularly a concern where events are held in water courses not considered safe for bathing, such as events in the River Thames. The outbreak control team (OCT) was not aware of any previous outbreaks related to open water swimming events having been reported to the HPA.

Figure 2: Map of race course showing Combined Sewer Overflows in



Data source: Environment Agency

Coordination of the investigation

An outbreak control team (OCT) was formed on 22 October. Given the scale of the event, the large number of participants apparently reporting illness following the event, together with the lack of an evidence base on the infection risks associated with open water swimming events in the UK, which are growing in popularity, the OCT decided that epidemiological investigation was required.

Objectives of the investigation

The objectives of this outbreak investigation were to:

- Obtain information on water quality in the race course at the time of the race
- Obtain the results of any microbiological testing on samples submitted by outbreak cases
- Describe the outbreak in terms of time place and person
- Quantify the risk of illness among participants in the swimming race
- Identify factors associated with illness among swimmers
- Estimate the frequency of illness among respondents following previous open water swimming events.

METHODS

Environmental investigation

In order to obtain information on the water quality at the time of the race we sought data on:

- Whether any chemical incidents in the River Thames had been reported to the HPA's Centre for Radiation, Chemicals and Environmental Hazards (CRCE).
- Whether any microbiological testing had been conducted by the Environment Agency or Thames Water, and the results of this testing if available,
- A description and the results of the water testing conducted privately by the event organisers prior to the event
- The weather conditions in the Thames catchment area recorded by the UK Meteorological Office in the five days before the event.

Microbiological investigation

In order to obtain the microbiological results on any samples submitted by outbreak cases we asked all cases completing the epidemiological survey if they had submitted a sample for testing, what the test results were, and if they permitted us to follow up their test results. If we were granted permission, we contacted the cases' GPs or the appropriate laboratories to ask what testing had been conducted and what results had been found.

Laboratories were asked if any stool samples remained in storage. If they were available arrangements would be made to send the samples to the London Public Health Laboratory for further testing.

Epidemiological investigation

Study design

A retrospective cohort study was conducted.

Hypothesis

The hypothesis tested was that cases were more likely than non-cases to have ingested river water or greater quantities of river water either directly (swallowing water whilst swimming) or indirectly (contact with surfaces contaminated with river water, such as food handled with unwashed hands).

Study population

The study population was individuals who swam in the 07 October 2012 Hampton Court Swim in the River Thames.

Case definition

The following case definition was used in this outbreak:

A participant in the Thames swim on 07 October who experienced diarrhoea (≥ 3 loose stools in 24 hours) and/or vomiting and/or abdominal cramps and/or nausea with illness for over 24 hours with symptom onset within 9 days after the race.

The nine day time limit for symptom onset was set by using 'The Second Study of Infectious Intestinal Disease in the Community' to estimate the baseline incidence of gastrointestinal illness in the cohort to identify for how many days incidence exceeded baseline¹ [3] .

¹ The study estimated a baseline community incidence of 274 cases of gastrointestinal illness per 1000 years. This equated to one case every 2 days in our cohort.

Individuals who met the above case definition were excluded from the dataset if they met the following exclusion criteria:

- Symptom onset preceded the swim
- Travelled outside the UK in the 7 days before symptom onset
- Member of the household ill with diarrhoea and vomiting in the 7 days before symptom onset.

Exposure

Exposure was assumed to have started from the time participants entered the water, which was taken to be their race start time. Twenty-five participants did not provide their start time, and were deemed arbitrarily to have entered the water in the middle wave, 09:20.

Data collection

An online survey using “Select Survey” (see Appendix A) was conducted. All race participants had registered online to participate in the event and the organisers held the email addresses of all registered participants.

Possible exposures were identified through discussion with HPA colleagues, the race organisers and a brief literature review of similar outbreak investigations.

The questionnaire included questions on 20 exposure variables that were considered to be potentially associated with illness. These included questions on behaviours that may have affected ingestion of water during or after the race and participants previous experience of open water swimming. The questionnaire was piloted by open water swimmer staff at Human Race Ltd.

A link to the questionnaire was sent out to all participants by Human Race Ltd. on Tuesday 30 October. The content of the covering letter was agreed between the HPA and the organisers (see appendix B). Participants were given three weeks to complete the survey, which was closed on 19 November at 17:00. A reminder to complete the survey was sent by email to all participants by Human Race Ltd. one week before the deadline.

Following the dissemination of the survey a number of participants contacted the Field Epidemiology Services – London asking about the cause of illness and other related enquiries. In response a letter responding to frequently asked questions was prepared by the OCT and circulated to participants by Human Race Ltd in January 2013 (see Appendix C).

Data analysis

Survey results were exported from Select Survey into MS Excel™ and then imported into STATA v12 for data cleaning and analysis. Description of the outbreak by time, place and person was conducted, including the production of a histogram of onset times and bar charts of symptoms and symptom duration. Comparisons between characteristics of cases and non-cases were made using appropriate significance tests (e.g. ranksum test and χ^2 test). All explanatory variables were summarised individually, with categorical variables described using proportions and continuous variables summarised by central tendency, range and quartiles. For post-race hygiene behaviours (showering, hand-washing and antibacterial gel) 30 minutes was arbitrarily set as a cut off, e.g. washed hands within 30 minutes of leaving water.

Univariate analysis using robust Poisson regression was conducted for each exposure variable, enabling relative risks (RRs) to be estimated. For the variables associated with illness at significance level $P < 0.2$ and where appropriate, dose response was analysed using univariate robust Poisson regression and tested for significance using the χ^2 test. Stratified analysis was conducted, stratifying all variables significantly associated with illness at univariate analysis at $P < 0.2$ by the exposure most strongly associated with illness at univariate analysis and vice versa. Both protective factors and risk factors were included.

Factors associated with illness at $P < 0.2$ in univariate analysis were then included in a backward stepwise multivariable robust Poisson regression model, to derive relative risks. Both apparent risk factors and protective factors were included in the multivariable regression model.

RESULTS

Environmental Results

Investigation of possible chemical exposures

No chemical incident affecting water quality in the River Thames around the time of the race was reported by either the Environment Agency or the HPA's Centre for Radiation, Chemicals and Environmental Hazards (CRCE). No concern regarding pesticide concentration was raised by Thames Water who routinely monitor this.

Microbiological quality

As the River Thames is not classed as bathing water by the EA no routine microbiological testing of the River Thames is conducted by the EA, and therefore no data on microorganisms in the water on the race day was available. Thames Water tests for *Giardia* cysts and *Cryptosporidium* oocysts in the water from their intake site and reported that no unusual increase in frequency was observed around the race day. No further routine microbiological testing of river water prior to intake into the drinking water processing system is conducted by Thames Water. Thames Water confirmed that there were no acute occurrences of spillages of undiluted raw sewage into the river from the sewage treatment works in the days prior to the race.

The organisers did conduct water testing prior to the event, taking samples on 05 October and 07 October (race day) from the site of the race start. The testing was undertaken by a private laboratory in London. Samples were tested for nitrates, carbonates, *Escherichia coli* (as an indicator of faecal contamination) and blue green algae. No other pathogens were tested for. The organisers reported that "no concerns" were raised from these test results.

Weather conditions

The weather conditions in the five days preceding the race were reported anecdotally to be poor, with heavy rain. Data provided by the UK Meteorological Office confirmed this, showing high rainfall was recorded in weather stations in the Thames Valley area on 05 and 06 October, with 18.4 mm recorded in High Wycombe and 17.8 mm in Reading on 05 October, compared to an average daily rainfall in October of 2-3 mm in the Thames Valley. In the week before the race the Environment Agency had put up the red boards on the River Thames, meaning that the river was effectively closed for recreational use due to safety concerns. By the day of the event water flow had improved and the river was given an amber rating by the EA.

Microbiological Results

Forty-two respondents stated that they had provided samples for microbiological testing. Twenty-six respondents provided stool samples, twenty-three provided blood samples and nine provided another type of sample (urine, saliva). Thirty-seven respondents gave permission for the HPA to find out their laboratory results.

Test results for 31 respondents were successfully obtained through follow up (see Table 1). Follow-up for the remaining six respondents was not possible either because GP contact details were not provided or we were unable to successfully contact their GP. Fifteen samples (48%) were tested for *Salmonella*, *Shigella* and *Campylobacter* (table 1). Only a minority of samples were tested for viruses: Hepatitis A (6%), Rotavirus (6%), Adenovirus (3%) and Norovirus (3%). In addition, sixteen patients had various haematology tests, including liver function tests. These may have been requested because a diagnosis of Leptospirosis and/or Hepatitis A was being considered by the GPs.

The HPA was informed of four cases of Giardiasis among swimmers, including two who did not participate in the survey. One other survey respondent informed the HPA that they had received a diagnosis of Cryptosporidiosis. The HPA is not aware of any other positive microbiological results among swimmers.

Only one stool sample was sent to the London Public Health Laboratory for further testing. Laboratories reported that they typically stored clinical samples for one week, and this had elapsed by the time the investigation team had received the survey results and consent from participants to contact the laboratories.

Organism tested	Number of individuals with samples tested	Proportion tested among individuals with samples	Positive results
<i>Salmonella</i>	15	48%	0
<i>Shigella</i>	15	48%	0
<i>Campylobacter</i>	15	48%	0
<i>E. coli</i> O157	9	29%	0
<i>Cryptosporidium</i>	8	26%	1
<i>Giardia</i>	9	27%	4*
Norovirus	2	6%	0
Rotavirus	2	6%	0
Adenovirus	1	3%	0
Hepatitis A	2	6%	0
<i>Leptospira</i>	1	3%	0

Table 1: Results of microbiological testing on survey respondents who provided samples where laboratory test results were successfully obtained (n=23)

* 2 swimmers who were diagnosed with Giardiasis did not complete the survey

Epidemiological results

Survey response

The online survey received 763 responses (see Figure 3 for timeline of survey responses). Fifty-six percent of respondents completed the survey on the day it was launched and 86% completed the survey within the first three days. Following data validation, 88 responses were excluded as they were either blank or incomplete entries (n=74), duplicate entries (n=12) or from individuals who did not participate in the race (n=2), leaving 675 valid responses (61%).

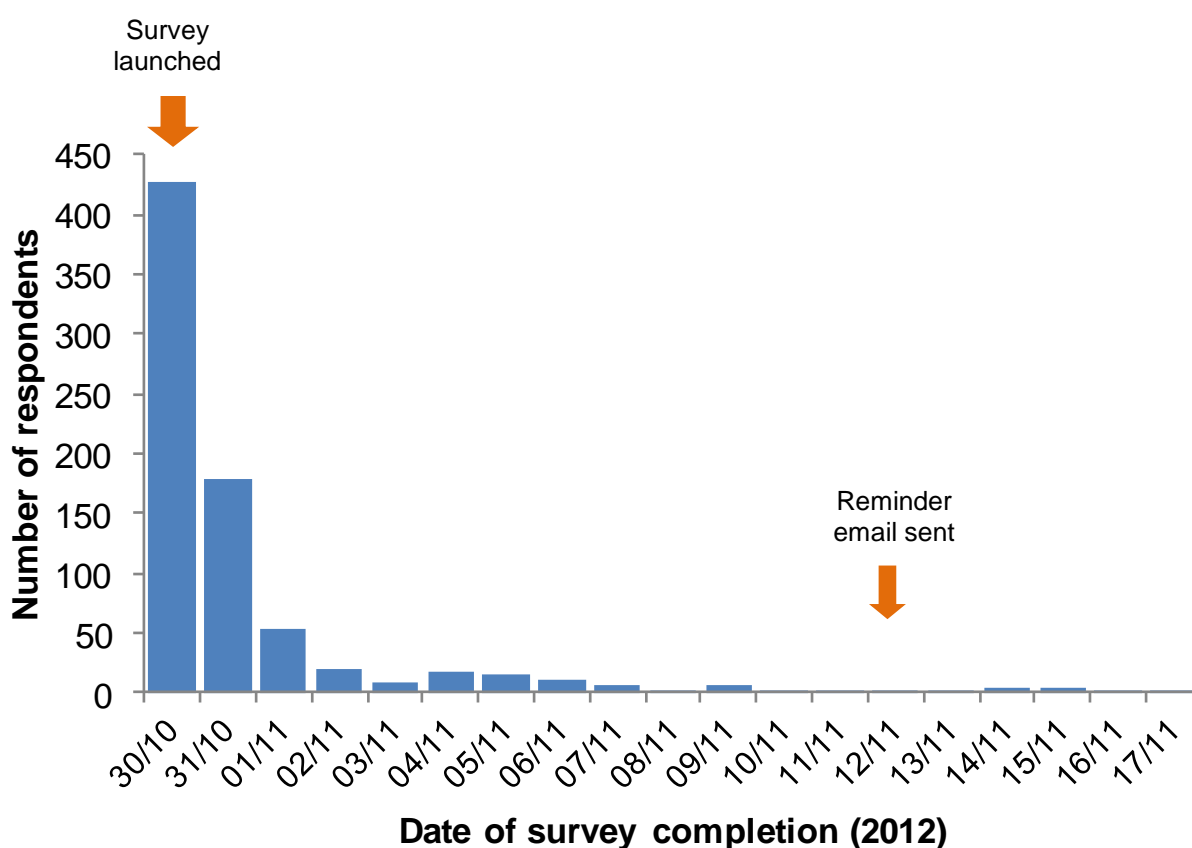


Figure 3: Response to Thames Open Water Swim survey October 2012 (n=763)

Study population

The number of people finally included in the analytical study was 636 as 39 people were excluded as they did not provide details on their symptoms (n=11), reported symptoms prior to the event (n=2), or met the exclusion criteria (n=26).

The median age of respondents was 40 years (range 15 to 72, inter-quartile range (IQR) 33 – 47). Sixty-four percent of respondents were male.

Description of cases

A total of 338 respondents (53%) met the case definition.

Cases were younger than non-cases: 38 years for cases (inter-quartile range 31-46) and 41 years (IQR 35-48) for non-cases (Ranksum test, $p=0.001$). No significant difference in attack rate by sex was observed (χ^2 test, $p=0.75$).

Among cases, the most common reported symptoms were nausea (78%), diarrhoea (75%) and abdominal cramps (70%) (Figure 4).

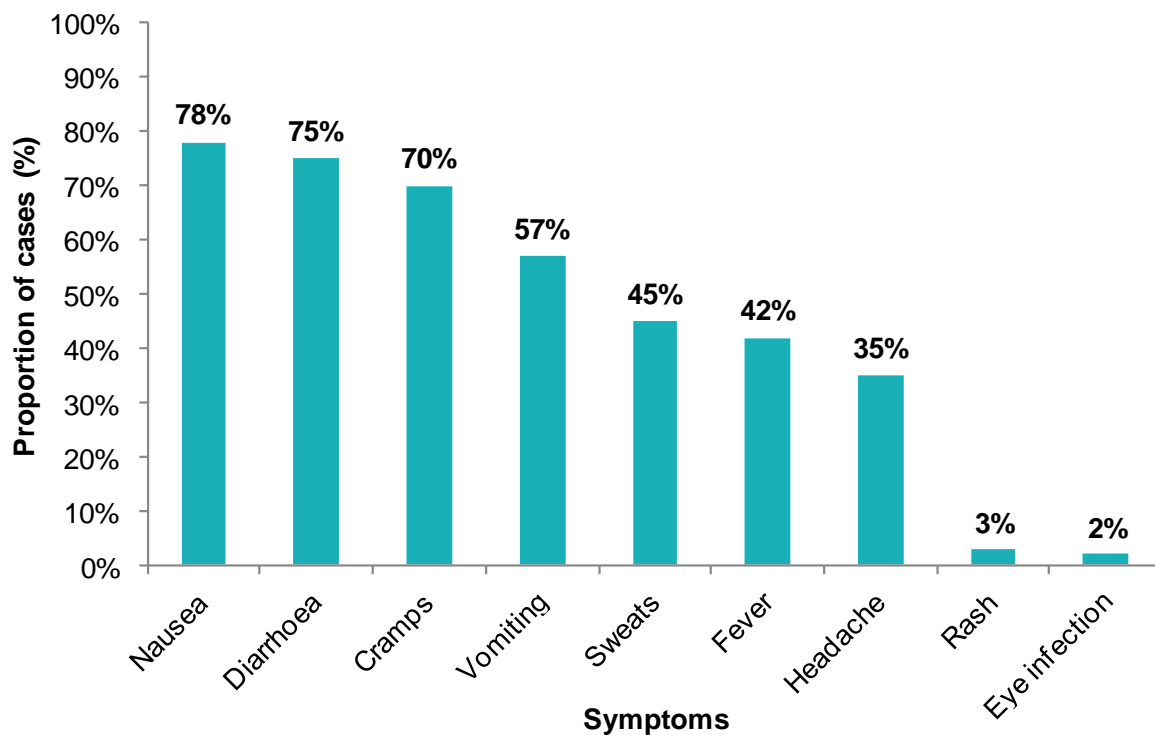


Figure 4: Frequency of reported symptoms among respondents meeting case definition (n=338), Thames open water swim, October 2012

The median duration of symptoms was 4 days (range 1-36 days, inter-quartile range 2-7 days).

Eight cases attended Accident and Emergency departments and four were admitted overnight to hospital related to their illness. Seventy-six cases (22%) visited their GP because of symptoms related to the swim.

Two-hundred and seventeen cases (64%) took time off work on account of their illness. The mean number of days off work was 2.3 (range 0.5 – 14 days, inter-quartile range 1-3 days).

Timing of symptom onset among cases

The median time from exposure to onset of the first symptoms in cases (the incubation period) was 34 hours (range 4-227 hours, IQR 23-44 hours). Ninety-six percent of cases had symptom onset within 5 days of the event. A graph showing the distribution of onset times is provided in Figure 5.

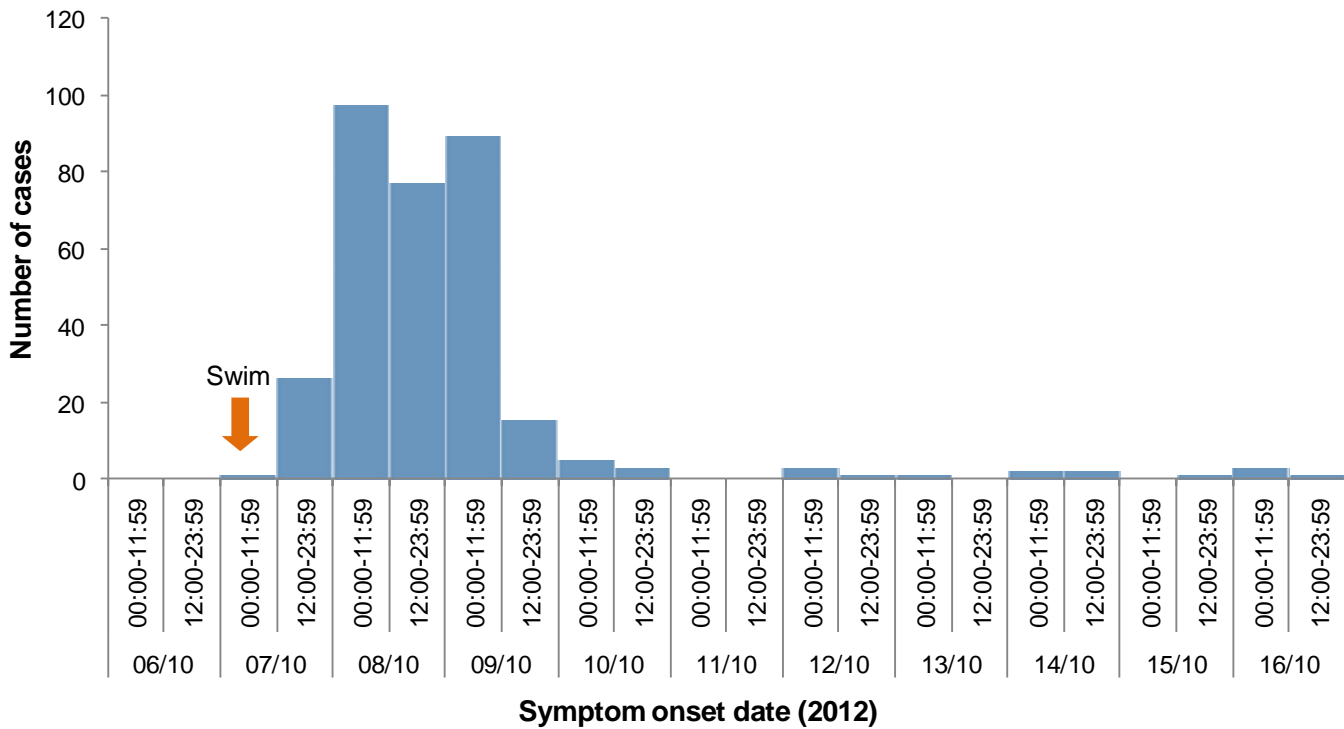


Figure 5: Distribution of symptom onset times among respondents meeting the case definition (n=327*), Thames open water swim, October 2012

*11 cases did not provide the time of their symptom onset and are not shown

Exposure variables

The response to exposures investigated in the questionnaire is summarised in Table 2.

Exposure	Proportion of total exposed (%)	Median (interquartile range)
Behaviour during race		
Duration in water	-	40 minutes (37-45)
Swam front-crawl	94	
Swam breaststroke (head underwater)	14	
Swam breaststroke (head above water)	13	
Swam backstroke	3	
Swam butterfly	0	
Wore wetsuit	94	
Water in mouth whilst swimming	85	
Swallowed water	73	3 mouthfuls (2-5)
Behaviour after race		
Drank before washing hands	86	
Ate food before washing hands	69	
Washed hands within 30mins of leaving water	6	
Used antibacterial hand gel within 30 mins of leaving water	6	
Showered within an hour of leaving water	4	
Previous experience open water swimming		
Beginner to open water swimming	19	
Intermediate open water swimmer	57	
Advanced open water swimmer	24	
Swam in an event in the Thames in the past 24 months	49	
Swam in an event a river (not Thames) in the past 24months	55	
Ill following an event in past 24 months	14	

Table 2: Summary of exposures experienced by swimmers in the Thames open swim, London October 2012

Univariate analysis

Seven variables were associated with either an increased or decreased risk of illness at a significance level of $P \leq 0.05$ (see table 3).

Table 3: Factors associated with illness among swimmers, Thames open water swim, October 2012

Exposure variable		n	Ill (%)	RR (95% CI)	P	
Wore a wetsuit*	No	18	11	ref		
	Yes	600	55	4.91 (1.33-18.15)	<0.001	
Swallowed any water*	No	69	35	ref	-	
	Yes	465	53	1.53 (1.10-2.14)	0.004	
Washed hands within 30 minutes of race finish**	No	562	52	ref	-	
	Yes	48	65	1.24 (0.99-1.56)	0.093	
Beginner to open water swimming	No	503	52	ref	-	
	Yes	116	56	1.08 (0.90-1.29)	0.443	
Ever sick after a swim (in last 24 months)	No	550	53	ref	-	
	Yes	86	56	1.06 (0.86-1.29)	0.593	
Used antibacterial hand gel within 30 minutes after race	No	566	53	ref	-	
	Yes	48	56	1.06 (0.82-1.38)	0.666	
Smoked within 30 minutes after race**	No	578	53	ref	ref	
	Yes	7	29	0.53 (0.17-1.73)	0.190	
Showered within 1 hour of race finish**	No	583	54	ref	-	
	Yes	27	41	0.76 (0.48-1.20)	0.188	
Swam in an open water event in a river in the last 24 months*	No	286	61	ref	-	
	Yes	350	47	0.77 (0.67-0.89)	<0.001	
Aware of infection risks*	No	50	66	Ref	-	
	Yes	566	51	0.78 (0.63-0.97)	0.048	
Age (median 40)*	40 years or under	338	59	ref	-	
	Over 40 years	298	46	0.79 (0.68-0.92)	0.002	
Swam in an open water event in the Thames in the last 24 months*	No	326	59	ref	-	
	Yes	310	47	0.79 (0.68-0.92)	0.002	
Swam in any open water swim event in the last 24 months*	No	121	61	ref	-	
	Yes	515	51	0.84 (0.71-0.99)	0.050	
Had a drink after race before washing hands **	No	68	62	ref	-	
	Yes	548	55	0.84 (0.68-1.03)	0.121	
Swam with water in mouth	No	79	59	ref	-	
	Yes	540	52	0.87 (0.72-1.07)	0.226	
Ate food after race before washing hands	No	179	55	ref	-	
	Yes	441	52	0.94 (0.80-1.11)	0.475	
Sex	Female	230	53	ref	-	
	Male	401	53	0.98 (0.84-1.14)	0.754	
Duration in water (median 40 minutes)	40 min or under	335	54	ref	-	
	Over 40 mins	267	53	0.98 (0.84-1.14)	0.780	
Start time	1 st session (08:30)	59	46	ref	-	
	2 nd session (08:40)	62	58	1.27 (0.89-1.80)	0.182	
	3 rd session (08:50)	63	63	1.39 (0.99-1.94)	0.056	
	4 th session (09:00)	48	44	0.96 (0.63-1.46)	0.836	
	5 th session (09:10)	58	62	1.36 (0.94-1.90)	0.082	
	6 th session (09:20)	54	61	1.34 (0.94-1.90)	0.105	
	7 th session (09:30)	59	51	1.11 (0.76-1.61)	0.581	
	8 th session (09:40)	57	42	0.92 (0.61-1.39)	0.692	
	9 th session (09:50)	63	57	1.24 (0.88-1.77)	0.215	
	10 th session (10:00)	55	38	0.83 (0.54-1.29)	0.416	
	11 th session (10:10)	42	62	1.35 (0.94-1.95)	0.105	
	Not known	12	67	1.46 (0.89-2.37)	0.130	
Stroke	Breast stroke (head above water)	No	150	56	ref	-
		Yes	80	51	0.92 (0.71-1.18)	0.491
	Breast stroke (head underwater)	No	159	57	ref	-
		Yes	87	54	0.94 (0.75-1.20)	0.628
	Backstroke	No	170	58	ref	-
		Yes	20	55	0.94 (0.63-1.43)	0.782
	Front crawl	No	4	25	ref	-
		Yes	599	53	2.12 (0.39-11.58)	0.265
	Butterfly	No	180	58	-	-
		Yes	0	-	-	-

* significant at P≤0.05; **significant at P≤0.2

Stratified analysis

No significant confounding or effect modification was identified between variables during stratified analysis.

Multivariable analysis

In the final robust Poisson regression model two variables were found to be significantly associated with increased risk of illness following the swim ($P \leq 0.05$): wearing a wetsuit RR 6.96 and swallowing any water during the swim RR 1.42 (Table 4). Two variables were associated with reduced risk of illness: previously swimming in a river open water swim event in the past 24 months RR 0.78 and age over 40 years RR 0.83. Two variables were excluded from the model at the outset: previously swam in the Thames and swam in any open water event in the past 24 months because of collinearity.

Exposure	Adjusted RR	P-value	95% CI
Wore wetsuit	6.96	0.046	1.04-46.72
Swallowed any water	1.42	0.033	1.03-1.97
Swam in a river open swim event in previous 24 months	0.78	0.003	0.67-0.92
Aged over 40 years	0.83	0.033	0.70-0.98

Table 4: Factors associated with illness among swimmers, Thames open water swim, October 2012, results from final multivariable robust Poisson regression model

Dose response

No dose response was observed for the number of mouthfuls of water swallowed (mhoods test for trend, $P = 0.3585$).

Illness associated with previous open water swims

Five-hundred and fifteen participants (81%) reported that they had participated in another open water swim event in the previous 24 months (Table 5), including 49% who reported swimming previously in the Thames. The highest frequency of reported illness following swimming events was after swimming in the Thames (17%). The type of illness experienced was not specified in the questionnaire.

Open water setting	Respondents who participated in other open water events N (%)	Proportion of respondents ill following previous events (%)
Thames	310 (49%)	17
River (excl. Thames)	110 (17%)	4
Lake	423 (67%)	7
Sea	236 (37%)	5

Table 5: Frequency of illness experienced by survey respondents following previous open water events, Thames open water swim October 2012

DISCUSSION

Open water swimming is growing in popularity and large scale events like this one in the River Thames are becoming more frequent. This is the first report of an epidemiological investigation into an outbreak of gastrointestinal illness following an open water swimming event that we are aware of and we believe this is an important addition to the evidence base.

Main findings:

Burden of illness

The attack rate of gastrointestinal illness meeting our case definition among survey respondents was 53%. Sixty-one percent of participants completed the survey. If we conservatively assume that all race participants who did not complete the survey were not cases, then the minimum overall attack rate for this outbreak was 31%.

Illness was generally mild and the majority of cases did not seek medical treatment for their symptoms. However, four people were hospitalised due to their illness.

It is also notable that 217 cases (64%) reported that they took time off work because of their illness, highlighting that illness did result in economic impacts in terms of lost work days.

From this study it is not possible to conclude whether the high attack rate we found in this outbreak associated with swimming in the River Thames is exceptional or not. The absence of routinely collected microbiological data on water quality during the race means we cannot determine whether the concentration of pathogens in the water was greater than normal. Given that high aggregated rainfall levels were observed in the Thames Valley 2-3 days before the race, it is possible that this resulted in raw sewage being discharged from the CSOs. Thames Water has confirmed that there were no spillages of undiluted raw sewage from sewage treatment works into the river in the days before the event. The organisers are unaware of similar large-scale illness among participants following any of their previous swims suggesting that illness on this scale following events may either be uncommon or not previously reported.

However regardless of the water quality on 07 October 2012, many of our survey respondents reported illness following previous open water swims, and a substantially greater proportion reported illness following swimming in the Thames, suggesting that illness following open water swims is not uncommon.

Water in the Thames is classified as poor quality for bathing and human pathogens are abundant and rowers and canoeists on the Thames experience a burden of gastrointestinal illness related to their exposure [1]. Therefore, whilst the attack rate could have been particularly high in this outbreak, we anticipate that swimmers in other open water swims in the River Thames are at increased risk of gastrointestinal illness following their exposure.

Likely causal pathogen

Given that the vehicle of infection was water from the River Thames, it is possible that more than one pathogen resulted in the illness observed following the swim. The HPA is aware of five positive diagnoses among swimmers: four cases of *Giardia* and one case of *Cryptosporidium*. However, neither of these organisms are likely to have been the predominant cause of illness, for the following reasons. The main reason is that the median incubation period observed among cases was 34 hours, compared to a mean incubation period of 7 days for *Cryptosporidium* and a median incubation period of 7-10 days for *Giardia* [4]. *Giardia* is also unlikely to circulate in significant concentrations in the Thames as incidence is relatively low (3000-4000 cases per year in England and Wales), humans are the primary reservoir and infection is often associated with travel abroad [5]. *Cryptosporidium* is likely to be present in greater concentrations than *Giardia* as livestock are a major reservoir and therefore run-off from livestock farms in the Thames Valley area during periods of heavy rain is a possible source of contamination. Annual incidence of *Cryptosporidium* typically peaks in Spring and Autumn, possibly related to rainfall [6]. Based on the characteristics of cases, the absence of positive microbiological test results and knowledge of circulating seasonal pathogens, a gastrointestinal bacteria or virus is a possible predominant causal pathogen.

Factors found to affect risk of illness

Two factors increased risk of illness: wearing a wetsuit and swallowing water. Previously swimming in an open water event in a river in the past 24 months and age over 40 years was associated with reduced risk.

The size of effect for wearing a wetsuit was large with swimmers wearing wetsuits seven times more likely to be ill. The confidence intervals for this association are wide suggesting that the true effect could have been much smaller, with just a 4% increased risk, or much larger, with 47 times more risk. The association between wearing a wetsuit and becoming a case is difficult to explain. With 94% of race participants wearing a wetsuit, and just 18 participants reporting not wearing one, among whom two were ill, it may be that the association is confounded by characteristics we have not measured regarding these 18 participants, who were substantially less likely to become sick. None of these 18 participants were beginners to open water swimming, all had participated in other open water swimming events in the past 24 months, and despite 87% swallowing water during the race, only 8% of those who swallowed the water became ill, compared to 44% among the wetsuit wearers. It is possible that these 18 participants have had greater resistance to infection than the rest of the cohort.

Alternatively, perhaps the association between wearing a wetsuit and illness is a true effect, not the result of confounding. Wetsuits retain river water and can promote the growth of microorganisms such as bacteria and fungi from the river water and handling the wetsuit after the event may create and prolong an infection risk. [7]

The finding that participants who swallowed any water while swimming were 42% more likely to become ill after the race fits with the study hypothesis that cases were more likely to ingest water than non-cases.

The finding that age over 40 years and having experience of swimming in a previous open water river event in the last 24 months were both protective factors could be related to experience, either related to behaviour whilst swimming or after swimming, or perhaps signifies enhanced immunity resulting from greater previous exposure. Interestingly, the variables on experience and awareness of infection risks were not found to have a significant association in the multivariable analysis.

Hygiene behaviours

The majority of respondents reported that they had not washed their hands (94%) or used antibacterial hand gel (94%) within 30 minutes of finishing the swim and had eaten food before cleaning their hands (69%). This could have resulted from low awareness of the benefits of hand hygiene among participants and/or a lack of hand-washing facilities at the end of the race, both of which should be addressed in future events. The majority (96%) of respondents did not shower within 30 minutes of leaving the water. Provision of showers on-site or nearby may be more difficult to arrange, however this should be considered for future events.

Urban myths and health protection

Fifty respondents commented in the survey that they drank a carbonated beverage following the race under the impression that this would 'kill off' any microorganisms swallowed during the race. A few commented further that the organisers should ensure the beverage is readily available at future events. It is unclear on what basis it is thought to offer protection from gastrointestinal illness; several respondents stated that this was an "old wives' tale"; some reported they were following the advice of the organisers. We did not investigate consumption of the beverage as an exposure in this outbreak. We are not aware of any scientific evidence that drinking carbonated beverages offers protection from gastrointestinal illness

Roles and responsibilities for ensuring event safety

During the investigation we found that no public agency is responsible for overseeing the microbiological safety of the River Thames for swimming, as it is not classified as bathing water. Therefore, no routine microbiological monitoring of water quality is conducted. To fulfil its statutory obligations, the Environment Agency carries out ecological, chemical and hydrometric monitoring of the River Thames. This included the traffic light system of boards at

lock sites to advise river users on flow conditions on the river. No guidance is currently available to swimming organisers on what microbiological testing they should conduct and how to interpret the results if they intend to do this, as the organisers did. Currently therefore no agency has authority to advise organisers to postpone mass-participation events on the basis of concerns about water quality. This needs attention.

An appropriate role for Public Health England would be to develop evidence based guidance for swimmers and race organisers, to conduct timely outbreak investigations and to develop research studies as appropriate.

Limitations of the epidemiological investigation

We had a high response rate in this outbreak which would have reduced the possibility of selection bias. The delay between the event and circulating the survey was three weeks and this may have resulted in recall bias with some exposures, which could have resulted in misclassification of exposure.

No significant dose response between the number of mouthfuls of water swallowed and risk of illness was found. Recall bias may have been present, as over 100 respondents could not remember how many mouthfuls they had swallowed. A closed question format may have been a better way to prompt respondents to respond in categories (e.g. $\frac{1}{2}$, $\frac{3}{4}$, 1-2) rather than the open ended format used.

It is not possible to determine which of the two explanations for the apparent association between wearing a wetsuit and illness is more tenable on the basis of the data collected. Similar future investigations would benefit from asking questions on handling and cleaning the wetsuit after the race and if possible, questions about the participants susceptibility to infection.

We relied on obtaining microbiological results retrospectively which meant we were dependent on the tests requested by the respondents' GPs. Most GPs requested only a typical bacterial screen, including E.coli and Salmonella, rather than more typical causes of infection from bathing water, including gastrointestinal viruses, *Cryptosporidium*, *Giardia* and leptospirosis. We may have had more success identifying a causal organism if we had prospectively arranged specific tests for symptomatic respondents.

The absence of microbiological results and the anticipation that more than one pathogen might have been responsible for the illness complicated defining an outbreak case in microbiological terms. Whilst the median incubation period was 34 hours and 75% of cases had an onset 44 hours or less, the time threshold used in the case definition was nine days. This may have resulted in some misclassification of cases, with those with a longer incubation period the result of some other exposure than swimming in the river. If this occurred, the analysis would be biased towards null. Conversely, the threshold encompasses the average incubation periods for *Giardia* and *Cryptosporidium*, but not their maximum incubation periods (25 days for *Giardia* 12 days for *Cryptosporidium*). It is therefore possible that respondents who were well at the time they completed the questionnaire later became sick related to the swim. In this scenario,

those defined as non-cases during the analysis would include cases, and therefore bias the results towards null.

One of the objectives of the investigation was to explore the frequency of illness following open water swimming events in general. Some respondents described occasions of swimming in open water rather than participation in large-scale races such as the Hampton Court Swim. The frequency of reported illness was relatively high. It is possible that the true frequency maybe higher after large scale events than if an individual swims independently in open water. Coordinated public large-scale swimming events inevitably involve crowding during the swim and involve increased splashing and swallowing of water. As some respondents also reported open water swimming outside of mass participation events, the frequency of illness associated with previous open water swimming events may have been underestimated in our study.

CONCLUSION

We have reported a very large outbreak of gastrointestinal illness affecting at least 338 people following a large open water swimming event in the River Thames in October 2012. The attack rate among survey participants was very high (53%). Although *Giardia* and *Cryptosporidium* were isolated from a very small proportion of cases, it is unlikely that they were the cause of the majority of illness.

A moderate level of illness associated with previous open water swimming events was also reported, particularly those in the River Thames where 17% of respondents reported becoming ill.

The River Thames is not designated as bathing water and therefore no routine microbiological monitoring of water quality is conducted. Additionally, no agency is currently responsible for advising/supervising organisers arranging events in the Thames on reducing infection risks. It may be possible for swimmers to reduce their risk of infection by following precautions. This study found that wearing a wetsuit and swallowing water during the swim were risk factors.

Further research to develop evidence-based recommendations is required. It is recommended that effort should be made to raise awareness of the risks of illness associated with these events and to reduce the risk of illness in future open water swim events in the Thames and other settings, as described below.

RECOMMENDATIONS

- Organisers should ensure that swimmers are aware of the risks of gastrointestinal illness associated with open water swimming events so they can make an informed decision on whether to participate
- The organisers of open water swimming events should seek advice from Public Health England (PHE) and local authority environmental health departments on ensuring appropriate hygiene facilities are available for swimmers post-race, such as hand-washing, promotional materials reminding swimmers to minimise ingesting water during the swim and to wash their hands before eating or drinking and showers if practicable
- Information summarising this advice should be developed by PHE and circulated to major open-water swim organisers for promotion amongst their participants.
- Post-race wetsuit cleaning provisions should be considered by organisers.

- PHE to consider conducting a prospective study investigating risk factors and protective factors for open water swimmers to inform the development of evidence based recommendations for swimmers.
- Although the River Thames is not designated as bathing water, PHE should share this report with the DEFRA bathing water forum to alert the partners involved to the results of this investigation and to consider if any actions are required to minimise risk to health from the River Thames, in relation to open water swimming and recreational use.

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- [4] Heymann D ed. 'Control of Communicable Diseases Manual' 19th edition, 2008
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APPENDICES

Appendix A: Cover letter to participants

Appendix B: Questionnaire

Appendix C: Hampton Court Swim Frequently Asked Questions,
 circulated to participants on 10 December 2012

APPENDIX A

Dear Participant

We are contacting you regarding the Hampton Court Swim on Sunday 7 October 2012 which you were registered to take part in. We are aware that several participants became ill following the event and are working with The Health Protection Agency (www.hpa.org.uk) - a public body with responsibility for investigating and controlling outbreaks of infections. We see this as a vital step in understanding the River Thames in more detail and to ensuring that we remain at the forefront of water safety in the mass participation sports industry.

The HPA would like to find out how many people became ill, the cause of the illness and what factors may have increased or reduced the risk of becoming ill. Human Race & The HPA would be grateful if you could spare 10 minutes to complete an online survey.

Please can you complete the survey by Monday 19th November whether you became ill or not. This is so the HPA can compare those who did not become ill to those who did, as they may have acted differently during and after the race.

The information provided in the online survey is stored securely and confidentially by the HPA. Individual responses will not be shared with the organisers. The HPA may want to contact some of the people who were ill, to try and find out more about their illness e.g. any diagnoses made. They will only do so if you clearly give them with permission within the survey.

The survey can be accessed through this hyperlink below:

<https://www.hpa-surveys.org.uk/TakeSurvey.aspx?SurveyID=I1KK583M>

If you are unable to access the survey through this hyperlink, please copy the web address and paste it into your internet browser address bar, which should allow you to access it.

If you have any queries about the survey or the investigation, please contact the investigation team at the HPA using the following email address: LondonEpiUnit@hpa.org.uk

Human Race is committed in leading the mass participation sports event industry with world class events and, in our fast moving world, are constantly reviewing our processes. The Open Water swimming events we stage are increasingly popular and water quality is a topic that we are focused on supporting further research into to ensure our 2013 events are delivered in as safe an environment as possible.

Yours sincerely,

Nick Rusling

CEO, Human Race Ltd

Hampton Court Swim Survey

The Health Protection Agency (HPA) has been notified that several participants became ill following the Hampton Court Swim event on the River Thames on 7th October 2012. With the support of the event organisers at Human Race Limited, the HPA is conducting an investigation to find out how many participants became ill after the event and what factors may have made people more or less likely to become ill. If you swam in the Hampton Court Swim event on 7th October 2012 we would be very grateful if you could complete this survey to help us with our investigations.

Did you swim in the Hampton Court Swim event on 7th October 2012?*

- Yes
- No

Your details

This survey should take 10 minutes to complete. Your data will be kept confidential and any reports will be anonymised. If you have any queries about this survey then please contact us at LondonEpiUnit@hpa.org.uk. Please fill the questionnaire before Monday 19th November.

Your first name

Your surname

Please state your age (in years)

Please select your gender

- Female
- Male

Please provide your postcode

Have you been ill following the swim on 7th October 2012?*

Yes No

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Illness details

Have you experienced any of the following symptoms since you swam in the Hampton Court Swim event on 7th October 2012?

	Yes	No
Nausea	<input type="radio"/>	<input type="radio"/>
Headaches	<input type="radio"/>	<input type="radio"/>
Fever	<input type="radio"/>	<input type="radio"/>
Sweats	<input type="radio"/>	<input type="radio"/>
Vomiting	<input type="radio"/>	<input type="radio"/>
Diarrhoea (3 or more loose stools in 24 hours)	<input type="radio"/>	<input type="radio"/>
Stomach cramps/abdominal pain	<input type="radio"/>	<input type="radio"/>
Eye infection/conjunctivitis	<input type="radio"/>	<input type="radio"/>
Skin rashes	<input type="radio"/>	<input type="radio"/>
Other (please describe below)	<input type="radio"/>	<input type="radio"/>

Other symptoms:

What date did the first of these symptoms start?

What time did the first of these symptoms start? (e.g. 12:30)

Are you still ill?

Yes
 No

If you are no longer ill, how many days were you ill for?

Have you seen your GP for your symptoms?

- Yes
- No

Did you go to A&E for your symptoms?

- Yes
- No

Were you admitted overnight to hospital for your symptoms?

- Yes
- No

If you were admitted to hospital overnight, please provide the name of the hospital:

Did you take any time off work because of your symptoms?

- Yes
- No

How many days did you take off work because of your symptoms?

Have you submitted any of the following samples for testing?

	Yes	No
a) Blood	<input type="radio"/>	<input type="radio"/>
b) Stool	<input type="radio"/>	<input type="radio"/>
c) Other	<input type="radio"/>	<input type="radio"/>

What was the result of the testing (eg. Salmonella, Campylobacter, etc)?

Please provide details of where you gave your sample (e.g. GP name and address, hospital name and address)

If you do not know the test results on your sample, do you give us your permission to try and find out the results?

- Yes

No

If you are happy for us to find out your test results, please can you provide the following contact details to enable us to do this:

Date of birth
(dd/mm/yyyy)

E-mail
address

In the seven days before the race, has anyone else in your household had similar symptoms?

Yes

No

In the seven days before the race, did you travel outside the UK?

Yes

No

If you went swimming in the seven days before the race, please state where you swam

Are you happy for someone from the Health Protection Agency to contact you about this survey again if necessary?

Yes

No

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Information on your swim

What time did you get in the water?

How long (in minutes) were you in the water?

What stroke(s) did you swim? (please tick all that apply)

	Yes	No
a) Front crawl	<input type="radio"/>	<input type="radio"/>
b) Breaststroke (head underwater)	<input type="radio"/>	<input type="radio"/>
c) Breaststroke (head above water)	<input type="radio"/>	<input type="radio"/>
d) Butterfly	<input type="radio"/>	<input type="radio"/>
e) Backstroke	<input type="radio"/>	<input type="radio"/>

Do you remember getting any water in your mouth whilst you swam?

- Yes
- No

Approximately how many mouthfuls of water did you swallow during your swim?

Did you wear a wetsuit during your swim?

- Yes
- No

Approximately how many hours after the swim did you first shower?

Approximately how long after your swim did you first wash your hands?

Did you use hand sanitiser/antibacterial gel within 30 minutes of leaving the water?

- Yes
- No

Did you eat any food (including sweets, gels and energy bars) after the race before washing your hands?

- Yes
- No

Did you drink anything after the race before washing your hands?

- Yes
- No

Did you smoke after the race?

Are you aware of the risks of infection associated with open water swimming?

- Yes
- No

Excluding the event on 7th October, please provide the following information on your experience of other open water swimming events in the past 24 months:
(for example, you may have swum in 4 other open swim events in lakes in the last 24 months and been ill following one of these swims)

	Number of events participated in	Number of new episodes of illness in the 7 days following an event
Events in the River Thames	<input type="text"/>	<input type="text"/>
Events in other rivers	<input type="text"/>	<input type="text"/>
Events in lakes	<input type="text"/>	<input type="text"/>
Events in the sea	<input type="text"/>	<input type="text"/>

How experienced are you with open water swimming?

Do you have any further comments about this incident?

Thank you for taking the time to complete this survey. Please click on "Done" to finish.



Hampton Court Swim Frequently Asked Questions

I am still unwell following the swim – what should I do?

The HPA is a public body with responsibility for investigating and controlling outbreaks of infectious diseases. The HPA is unable to provide medical advice to members of the public. Please contact your GP about your symptoms or call NHS Direct on 0845 4647 (for 24 hour health advice).

I have been unwell following the swim – do I need any tests?

The HPA is unable to provide medical advice to members of the public but please contact your GP to discuss your symptoms. Your GP will assess your clinical symptoms and advise you if any tests may be appropriate based on these.

I have been tested for illnesses following the swim. How do I make sure these results inform your investigation?

If a diagnosis is made by your GP that is relevant to the swim, please email LondonEpiUnit@hpa.org.uk, including the contact details of your GP. With your consent, the HPA may contact your GP for further information.

How will we find out the outcome of the investigation?

A report of the investigation will be written by the HPA and shared via Human Race Ltd with those who completed the questionnaire. It will also be made publicly available. The questionnaire is confidential and the report will not include any personally identifiable information.

When will the report be published?

Investigations of this nature and analysing questionnaires can be complex and time consuming. We cannot provide a specific date of publication but we are aiming to complete the report by early 2013.

How many people were ill and what was the cause?

The aim of our investigation is to answer these questions. Prior to launching the questionnaire we were anecdotally aware of around 40 reports of illness. The symptoms reported include nausea, headache, fever, diarrhoea and vomiting which would suggest a gastrointestinal infection.

The investigation is ongoing and to date we have not identified a single source of illness although we are following up reports of cases of giardia and cryptosporidium. In general we have received very little information on any diagnoses or test results and so it is possible that people may have been infected with different illnesses.

Many microorganisms (including viruses and bacteria) can cause gastrointestinal infections and, because of this, symptoms, incubation periods and modes of transmission can vary. In most cases, an illness such as an upset stomach will be mild and self-treatable. However, if symptoms persist or become severe it is advisable to contact a GP for advice.

Why are you conducting this investigation?

The HPA is a public body with responsibility for investigating and controlling outbreaks of infectious diseases. We hope that this investigation may help identify some lessons which will help open water swimmers reduce the chances of becoming ill in future to ensure that it remains a fun and satisfying leisure activity.

Is there any health advice for open water swimmers?

We know that open water environments such as rivers are not sterile and there is always a small chance that people who use the water for leisure purposes will become ill. We would expect the risk of becoming unwell to be higher in people who swallow the water or who do not take adequate hygiene precautions following contact with the water.

The HPA advises the following steps for people using rivers for leisure to reduce the risk of illness:

- Wear appropriate protective clothing, gloves or protective footwear.
- Cover cuts, scratches or sores with a waterproof plaster and thoroughly clean cuts or abrasions received during a river activity.
- Avoid splashing the water into your mouth.
- Do not swallow the water.
- Wash or shower promptly after water sports.
- Wash your hands with soap and water to ensure that all river water is removed, particularly before eating.
- Observe local river safety advice.

Do you think this could be Weil's Disease?

We are not aware of any cases of Weil's Disease (leptospirosis) associated with the Hampton Court Swim. In general, leptospirosis is uncommon in the UK. There are usually 50-60 cases per year in England and Wales - about one case per million of the population per year. If you suspect that you have symptoms of Weil's Disease you should contact your GP. Symptoms include a mild flu-like illness, or severe illness with jaundice and kidney failure. Symptoms usually develop 7-21 days after initial infection, though rarely the incubation period can be as short as two to three days or as long as 30 days.

www.hpa.org.uk