

Outbreak of diarrhoeal illness in participants in an obstacle adventure race, Alpes-Maritimes, France, June 2015

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An acute gastroenteritis (AG) outbreak occurred among participants in an obstacle race in France in the summer of 2015. An investigation in two phases was conducted to identify the source of infection and document the extent of the outbreak. First, a message on a social media website asked racers to report any symptoms by email to the Regional Health Agency of Provence-Alpes-Côte d'Azur. Second, a retrospective cross-sectional study was conducted through an interactive questionnaire for all participants, followed by an analytical study of potential risks factors. Of 8,229 persons registered, 1,264 adults reported AG resolved within 48 hours. Of adults who reported AG, 866 met the case definition. Age group, departure time and ingestion of mud were associated with AG. Twenty stool specimens tested negative for bacteria. All four stool samples tested for viruses were positive for norovirus genogroup I and genotype 2. No indicator bacteria for faecal contamination were found in drinking water but muddy water of ponds tested positive. The outbreak was possibly caused by human-to-human transmission of a norovirus introduced by one or more persons and transmitted through contaminated mud. Risks related to similar races should be assessed and recommendations be proposed to raise awareness among health authorities and organisers.

Introduction

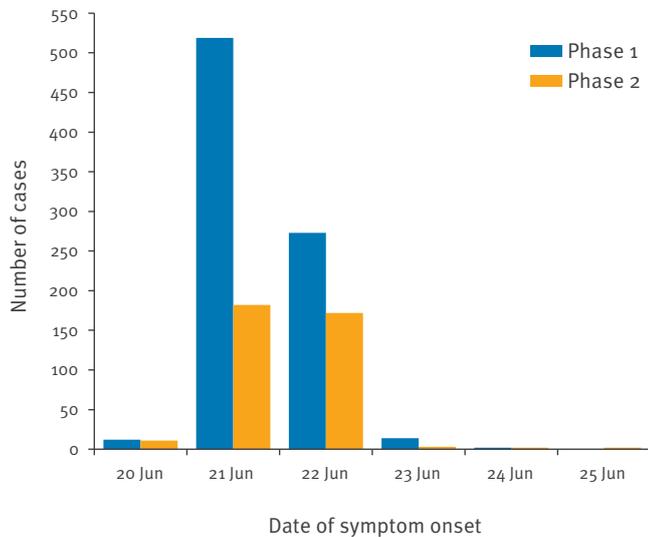
Obstacle races are extreme sport events, combining a difficult path and obstacles. On a distance of several kilometres, obstacles such as walls, nets, ice baths, barbed wires, mud mounds, tunnel crawls, dark rooms, live electrical wires are positioned along the path.

These sport events have been growing in popularity during the last years. They gather several thousands of participants and are now a worldwide phenomenon.

Racers are heavily exposed to mud and water. They frequently fall, face first, into mud or have their heads submerged in water. Sometimes, there is a different path available for children. Events are usually held in rural areas and often include man-made slurry fields (a mixture of soil and water). In areas commonly frequented by animals, topsoil used to make slurry fields can be contaminated with faeces from ruminants or wild animals [1-7]. Multiple exposures to mud can occur in this kind of sport events [2-9]. Mud is an efficient vehicle for pathogenic microorganisms [7]. Ingestion of mud by racers who unintentionally swallow sufficient numbers of pathogens can cause illness, as described in the literature [2-9]. Over the last few years, outbreaks of acute gastroenteritis (AG) have been reported among participants in an obstacle race (with artificial obstacles) and in other endurance races that take place in nature (mountain bike races, triathlons) [1-6]. *Campylobacter* outbreaks have been reported, such as in the United States (US) in 2012, after an obstacle race among military personnel in Nevada [2], and in Norway in 2011, after a mountain-bike race [3]. In the United Kingdom (UK), a case of *Escherichia coli* O157:H7 after a mountain-bike race has been described [4]. Other races, such as triathlons, have been linked to cases of leptospirosis, for example on the Reunion Island in 2013 [8]. Skin wounds caused by *Aeromonas hydrophila*, after a 'mud football' have been described in Australia in 2002 [9].

FIGURE 1

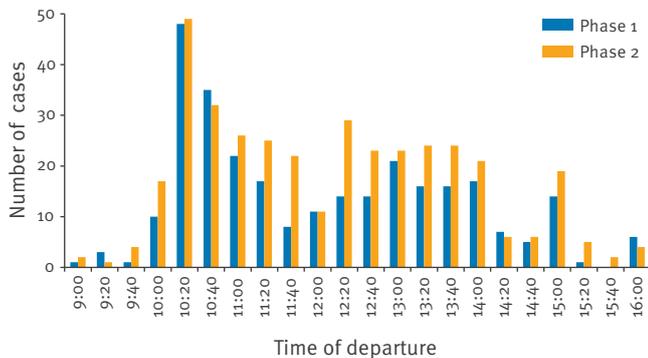
Epidemic curve by onset of signs and symptoms of gastrointestinal disease for phase 1 (n=820) and for phase 2 (n=372) on obstacle adventure race, Alpes-Maritimes, France, June 2015



Self-reported data.

FIGURE 2

Number of people with signs and symptoms of acute gastroenteritis for phase 1 (n=287) and for phase 2 (n=375) by departure wave on obstacle adventure race, Alpes-Maritimes, France, June 2015



Self-reported data.

On 22 June 2015 at 16:00, a hospital near Nice alerted the Regional Health Agency of Provence-Alpes-Côte d'Azur (ARS PACA) of 22 patients with AG after participation in an obstacle race, in the south of France. On a social media website, many other participants reported also suffering from similar symptoms. An investigation was immediately conducted in order to identify the source of infection and document the extent of the outbreak.

Methods

The ARS PACA, responsible for the outbreak investigation and implementation of control measures, requested support of the Regional Office of the French Public Health Agency (Cire Sud).

Epidemiological investigation

The investigation of the outbreak was conducted in two phases. The first phase started immediately, upon receipt of the outbreak alert, on 22 June 2015. ARS PACA and Cire Sud sent a message on a social media website informing the participants of the obstacle race that an investigation was conducted and asked them to report any recent or current gastrointestinal illness by email to a dedicated address of ARS. This information was also relayed by the organisers of the race and the local press.

The second phase, aimed at collecting additional information, was conducted retrospectively through an interactive application, Voozаноо (a secure web-based platform for hosting personal health data) including sections on socio-demographic characteristics, presence of symptoms or not, and sections on potential exposures (catering, means of contact with mud). This short questionnaire (available from the authors upon request) was intended for all participants of the obstacle race, whether or not they had clinical signs of AG. On 30 June, the company that had organised the event sent the Internet link for this survey by email in a newsletter to all the participants of the obstacle race.

Cross-sectional descriptive studies were conducted in two phases, and were followed by an analytical study of the potential risks factors (in the second phase).

Case definitions

A case of AG was defined as a racer in the obstacle race that took place on 20 June, with self-reported gastrointestinal illness (vomiting and/or diarrhoea) associated or not with other symptoms within eight days from the race.

A secondary case of AG was defined as a person who did not participate in the obstacle race as racer, with gastrointestinal illness following at least 24 hours after a contact with a case of AG among racers.

Microbiological investigation

We recommended all laboratories to test stool specimens from the racers for *Salmonella*, *Shigella*, *Campylobacter* and *Yersinia*, and to send stool specimens to the National Reference Laboratory (NRL) for Enteric viruses in Dijon in order to test for norovirus, sapovirus, rotavirus, adenovirus and astrovirus.

Food and environmental investigations

The company organising the event was contacted on 23 June to collect information about the race (organisation, description of the obstacles, digging works, etc.)

TABLE 1

Determinants of signs of acute gastroenteritis, univariate analysis of phase2, obstacle adventure race, Alpes-Maritimes, France, June 2015 (N = 745)

Risks factors	AG cases		Non AG cases		Total	OR	95% CI	p value ^a
Total	(n=375)	%	(n=370)	%	(N=745)	–	–	–
Sex								
Male	200	55	197	54	397	1.05	0.79–1.41	0.73
Female	163	45	169	46	332	Ref	Ref	Ref
Age group (years)								
18–27	141	38	74	20	215	3.19	2.12–4.82	<0.01
28–32	94	25	86	23	180	1.83	1.20–2.79	0.05
33–39	72	19	94	25	166	1.28	0.84–1.97	0.25
40–61	68	18	114	31	182	Ref	Ref	Ref
Department of residency								
Alpes–Maritimes	281	76	305	82	586	Ref	Ref	Ref
Other departments and countries	90	24	65	18	155	1.5	0.78–1.08	0.24
Departure time								
09:00–09:59 (waves 1–3)	7	2	69	19	76	Ref	Ref	Ref
10:00–10:59 (waves 4–6)	98	26	71	19	169	13.61	5.90–31.37	<0.01
11:00–11:59 (waves 7–9)	73	19	61	17	134	11.8	5.05–27.56	<0.01
12:00–12:59 (waves 10–12)	63	17	50	14	113	12.42	5.25–29.40	<0.01
13:00–13:59 (waves 13–15)	71	19	53	14	124	13.2	5.62–31.05	<0.01
14:00–14:59 (waves 16–18)	33	9	37	10	70	8.79	3.55–21.80	<0.01
15:00–16:20 (waves 19–22)	30	8	27	7	57	10.95	4.30–27.91	<0.01
Full race								
Yes	368	99	360	98	728	2.04	0.51–8.24	0.34
No	3	1	6	2	9	Ref	Ref	Ref
Race time								
≤2h30	130	35	129	35	259	Ref	Ref	Ref
>2h30	244	66	239	65	483	1.01	0.75–1.37	0.93
Ingestion of mud								
Yes	195	53	140	38	335	1.78	1.33–2.40	<0.01
No	176	47	226	62	402	Ref	Ref	Ref
Inhalation of mud								
Yes	289	77	247	68	536	1.63	1.17–2.26	<0.01
No	84	23	117	32	201	Ref	Ref	Ref
Eating at feed stations								
Yes	337	90	325	89	662	1.23	0.78–1.96	0.37
No	37	10	44	12	81	Ref	Ref	Ref
Eating food from stalls								
Yes	124	33	106	29	230	1.22	0.89–1.67	0.21
No	250	67	261	71	511	Ref	Ref	Ref
Bringing food								
Yes	104	28	94	26	198	1.13	0.81–1.56	0.47
No	266	72	271	74	537	Ref	Ref	Ref

AG: acute gastroenteritis; CI: confidence interval; OR: odds ratio; Ref: reference.

^a The values in bold are significant.

Self-reported data.

and the catering company, to obtain information about menus and food samples for analysis.

Samples of muddy water were collected on 23 June from the ponds of the race and samples of drinking

water from the city distribution system and tested for bacteria indicating faecal contamination (*Escherichia coli*, total coliforms, *Enterococci*, aerobic microorganisms) and for *Salmonella*, enterovirus, *Vibrio cholerae* and *Vibrio parahaemolyticus*, and free-living amoebae

TABLE 2

Determinants of acute gastroenteritis, final multivariate model of phase 2, obstacle adventure race, Alpes-Maritimes, France, June 2015 (n=722)

Risk factors	OR adjusted	95% CI	p value ^a
Age groups (years)			
18–27	5.10	2.15–12.12	<0.01
28–32	2.50	1.05–5.95	0.39
33–39	1.95	0.80–4.79	0.14
40–61	Ref	Ref	Ref
Departure time			
09:00–09:59 (waves 1–3)	Ref	Ref	Ref
10:00–10:59 (waves 4–6)	12.99	5.52–30.56	<0.01
11:00–11:59 (waves 7–9)	10.56	4.43–25.17	<0.01
12:00–12:59 (waves 10–12)	11.92	4.93–28.82	<0.01
12:00–12:59 (waves 10–12)	12.96	5.39–31.19	<0.01
14:00–14:59 (waves 16–18)	8.18	3.20–20.88	<0.01
15:00–16:20 (waves 19–22)	8.56	3.25–22.51	<0.01
Ingestion of mud			
Yes	1.66	1.21–2.29	0.02
No	Ref	Ref	Ref

CI: confidence interval; OR: odds ratio; Ref: reference.

^a The values in bold are significant.

Self-reported data.

(*Naegleria*). These samples were tested by a laboratory in Lyon. Water samples were tested for *Campylobacter* and norovirus by the Laboratory for Hydrology of the French Agency for Food, Environmental and Occupational Health & Safety (ANSES,) in Nancy. The University Laboratory of Pharmacy in Lyon tested the specimens for species of *Naegleria* [10].

We provided recommendations on measures to prevent secondary spread during a press conference organised on 22 June, through a weekly report of the *Cire Sud*, on the ARS PACA website, and we posted prevention messages on a social media website. The outcome of the investigation was also published on all these websites.

Results

Description of the event

The obstacle race took place over one day. A total of 8,229 participants were registered: 7,804 adults and 425 children (aged 7–12 years). Adult racers completed 13 km and 22 obstacles. Departures took place every 20 minutes, from 9:00 to 16:00, by waves of around 400 participants. On the path, dunes had been constructed and artificial ponds dug and filled with water from the city distribution system mixed with the original soil. The children's path was shorter and did not include ponds of muddy water.

Three feed stations were set up along the race course. Food included pre-wrapped cakes, pre-cut bananas,

dried apricots, all served in plastic containers from which participants picked them with their bare hands. Drinks included bottled water, energy drinks and beer in cups.

The race was held near a riding centre, and some participants reported spontaneously seeing horse dung on or near the track, or smelling sewage.

Epidemiological investigation

Description of the outbreak

Phase 1 of the epidemiological investigation was conducted from 22 to 27 June; we received 1,370 emails, 81% (1,111/1,370) of which had been sent within 24 hours after the message about the outbreak investigation was published on the social media website. Among the respondents, 1,300 AG cases were reported: 1,264 adults (attack rate: 16%; 1,264/7,804) and 36 secondary cases (not included in this analysis).

Phase 2 was conducted from 30 June to 27 July and a total of 748 questionnaires were completed (for 745 adults and 3 children). Among the participants who filled out the questionnaire, more than half (404/748; 54%) did it the day the newsletter came out and one third (247/748; 33%) the day after. There were 375 AG cases and 373 non cases. Secondary cases reported by respondents rose to a total of 177 cases, not included in this analysis.

The mean age of adult respondents was 33 years (range: 18–61 years). The male/female sex ratio was 1.2. Participants came mostly from Alpes-Maritimes (580/745; 78%), followed by other French departments or other countries.

In both phases, no cases were reported among the child racers. Only adults were included in the analysis.

The median incubation period was one day (ranges: 0–4 days for phase 1 and 0–5 days for phase 2).

Self-reported onset of AG symptoms was available for 820 participants (phase 1) and 372 (phase 2). Of the symptoms 97% (792/820) and 95% (354/372) occurred on day 1 and 2 after the race for phase 1 and 2, respectively (Figure 1).

In phase 1, the description of symptoms was available for 1,001 (79%) of 1,264 symptomatic participants and 866 (69%) met the definition of an AG case. The most common symptoms besides vomiting and/or diarrhoea, were abdominal cramps (369/866; 43%) and fever (354/866; 41%). Those symptoms were over or being spontaneously resolved in 48 hours.

In phase 2, 69% of participants notified being ill (513/745) and among them, 73% met the case definition (375/513); of these, 67% (251/375) presented fever and 43% (161/375) other digestive symptoms. The other

symptoms were non-specific, such as chills (215/375; 57%), headaches (101/375; 27%), asthenia (322/375; 86%), and muscle ache (262/375; 70%).

Among the 375 AG cases, 52% (n=196) consulted a general practitioner and 4% (n=16) an emergency service. No hospitalisation was reported. The median duration of AG was two days (range: 1-9 days).

The departure time was available for 287 AG cases in phase 1 and 330 in phase 2 (Figure 2). Cases were identified for all departure waves, except one at 15:40 for phase 1. The number of cases was low for the first waves (range: 1–17 cases), and the highest for the fifth wave, with 48 (phase 1) and 49 AG cases (phase 2). The curves of AG cases over time for the two phases of the investigation follow the same dynamic (trend chi-square not significant).

Study of risks factors

Age group, departure time and ingestion of mud were associated with AG at the $p < 0.2$ level in the univariate analysis (Table 1).

The final multivariable model included age group, departure time and ingestion of mud (Table 2). Younger participants (aged 18–27) years had a significantly higher risk of AG in the multivariate analysis compared with older participants. The risk of AG was higher in the morning, from 10:00 to 14:00 and still high in the afternoon compared with the first hour of departure waves (9:00–10:00). The ingestion of mud is also a significant risk factor of AG.

Microbiological investigations

We obtained the results of 20 stool samples. Results of bacteriological testing were negative for all samples, except one (positive for *Shigella sonnei*). Among the four specimens sent to the NRL for enteric viruses, all were positive for norovirus genogroup I and genotype 2 (GI.2).

Food investigation

During the race, the participants did not carry their own food and drinks. However, they consumed beverages and food distributed in feed stations. One third of the cases reported having eaten food sold by the catering company after the race. No AG case was reported among non-participants, organisers and staff of the event. The catering company had no food samples for microbiological analysis.

Environmental investigation

Drinking-water from the city distribution system and environmental water samples from muddy water ponds were collected on 23 June. All three drinking water samples were negative for the indicator bacteria (total coliforms, *E. coli*, *Enterococcus*), viruses and parasites. Of the environmental water specimens (n=5) taken from five ponds on 23 June, all were found contaminated by aerobic microorganisms at 36°C (with counts ranging

from 86 to 3,200,000 UFC/100 mL) and 22°C (with counts ranging from 2,500 to 1,400,000 UFC/100 mL), indicating bacterial contamination. All specimens were negative for *Salmonella*, *Campylobacter*, Enterovirus, *V. cholerae* and *V. parahemolyticus*. All environmental samples were positive for *Naegleria* spp. (with cells ranging from 400 to 280,000/L), but the pathogenic species *N. fowleri* was not detected. Norovirus genogroup I and II were not detected.

Discussion

A large AG outbreak occurred among the participants of obstacle race in the department of Alpes-Maritimes, France, on 20 June 2015. Of 7,804 adult participants, 1,264 were ill and 866 met the case definition of AG. This outbreak occurred from 20 to 25 June and the epidemiological curves during two different phases of the outbreak investigation were characteristic of a point-source outbreak. Moreover, they were similar and showed a higher number of cases on day 1 and 2 after the race. The clinical characteristics reported, the incubation period of the AG, the presence of vomiting, the resolution of symptoms for most cases within 48 hours and the absence of severe clinical forms, were compatible with a viral origin of the outbreak.

The epidemiological investigation enabled us to identify mud ingestion as the main risk factor of developing AG; no other source of infection was identified.

Several arguments support a common source outbreak of human origin related to the ingestion of contaminated mud. In outbreaks such as the one described here, the first hypothesis usually considers food sources. However, the first information reported by the participants did not support a food source, because of the diversity of supplies (feed stations only for participants in the race, food stalls for everyone, food brought by racers). Information gathered from organisers showed that no case of AG had been reported among the 360 members of the organisation and volunteers who received the food which was also sold at food stalls open to the public.

Unfortunately, no food samples were available for laboratory testing. Among participants, 90% of cases and 89% of non-cases (phase 2) consumed food from mass catering served at food stalls. However, the hypothesis that participants could have contaminated one another when dipping their muddy hands into the plastic containers with pre-cut bananas or dried fruits seems plausible. Another argument for contaminated mud as vehicle in the outbreak is that no child has been reported ill. The children's path was different from the adults' and did not have any obstacle with muddy water. This reinforces the idea of a human contamination in the obstacles with muddy water of the adult path. Secondary spread between ill participants and their relatives happened outside of the context of the race. Norovirus GI.2 was identified in the four stool samples. This strain of human origin [11], was possibly

introduced by one person or more of the team preparing the path or by participants in the first waves. In spite of the negative tests for norovirus in the muddy water, we cannot exclude that it was contaminated with such viruses [12]. Indeed, the sensitivity of the norovirus detection method could have been significantly reduced because only low volumes of muddy water were available for testing. Norovirus can persist in the environment, but the viral contamination of the water may have been partly reduced over the three days that preceded the sampling. Last, it is possible that the most contaminated ponds may have not been sampled. We consider it highly probable that the virus had been disseminated in the days preceding the race or early during the race [13].

Although our investigations led us to identify a point source with probable norovirus contamination as cause of the outbreak, there are some difficulties and limitations. The phase 1 of the investigation had to be conducted quickly, but it would have been better to have the time to ask the participants a few specific questions instead of just asking them to report any AG. This would have led to improved data quality. Nevertheless, participants gave us spontaneously detailed descriptions of their symptoms which allowed us to use the data.

Another limitation is that it was not possible to identify the exact number of cases. Phase 1 listed the participants who reported their illness voluntarily. More than 1,000 replies were sent by email within the 24 hours that followed the request for information from participants in the race. But there is a possibility that a greater number of persons was aware of the message but did not take the time to report their illness, in particular if symptoms were mild.

During phase 2, the response rate was lower, which prevented us from estimating the actual number of cases. As the event company had email addresses of participants, it had been agreed with the organisers to go through them to ask the participants to fill out the questionnaire, at the Internet link provided. The information was sent to the event company on 25 June, but was only inserted in a newsletter sent to the participants on 30 June i.e. 10 days after the event and eight days after the peak of the outbreak. It is likely that this newsletter was seen by more participants than those who replied during phase 1, because the message was sent directly to their email address. However, this email did not trigger as many as replies as expected, maybe because the illness was not that severe and therefore the participants did not feel it was useful to answer.

The investigation (phase 2) showed that several hundreds of persons who suffered from AG went to emergency services and consulted general practitioners. We were only able to trace down 20 stool samples and four were sent to the NRL of enteric viruses, despite many calls and emails from ARS PACA. Studies in French

general population [14] and in general practitioners [15] also indicate that few stool samples are requested. The study indicates that stool samples are requested five times more often in patients with bloody diarrhoea or with a long duration of illness before consultation. Awareness actions among health professionals are needed.

This major outbreak of AG stands out by the way ARS PACA and Cire Sud quickly reacted to it. The most recent channels of communication were used in its investigation and management; social media and email access were extensively used by the target population of this study.

Sport events that tend to exceed one's self limits have been growing in popularity on an international scale. Mud is often found in this type of events and therefore health risks factors have to be taken into account. Despite the high number of people affected, there were no severe health consequences. However, they could have been more serious, depending of the pathogens involved (*E. coli*, *Campylobacter*, *Salmonella*, *Leptospira*) [1-9]. Fortunately, sports people who participate in this type of events are likely to be in good health.

Recommendations for the organisation of events such as obstacle or endurance races should be proposed. Racers and adventure race organisers should be aware of the potential risk of inadvertent ingestion of muddy, possibly contaminated, water during the race. For instance, persons preparing the path or participating in obstacle races should not have diarrhoea or vomiting in the two days before the race. In general, planners of obstacle adventure races should consider building slurry field challenges where animal faecal contamination is unlikely. The courses should be pre-routed to avoid areas heavily contaminated with animal faeces. No unwrapped food should be served. Facilities for washing hands with clean water should be available.

The risks related to obstacle or endurance races should be further assessed, on the one hand to guide health authorities in their vigilance and their prevention measures, and on the other hand to guide organisers in the choice of materials used and raise awareness of potential risk factors.

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Conflict of interest

None declared.

Authors' contributions

Caroline Six: member of the epidemiologic investigation team, drafting and revising the manuscript.

Samer Aboukais: management of the outbreak; revising the manuscript.

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Hervé Terrien: management and selection type of analysis of water samples; revising the manuscript.

Fabrice Dassonville: management and selection type of analysis of water samples; revising the manuscript.

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Katia Ambert-Balay: analysis of human samples, notification of laboratory results; revising the manuscript.

Thierry Chesnot: analysis of water samples, notification of laboratory results; revising the manuscript.

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Michel Pélandakis: analysis of water samples, notification of laboratory results; revising the manuscript.

Patrick Basset: participation in the management of the outbreak; revising the manuscript.

Manuel Munoz Rivero: management of the outbreak; revising the manuscript.

Philippe Malfait: member of the epidemiologic investigation team; comments on the manuscript and revising the manuscript.

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