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A one-year intensified study of outbreaks of gastroenteritis in The Netherlands

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SUMMARY

In 2002, in The Netherlands a national study of gastroenteritis outbreaks was performed. Epidemiological information was collected by the Public Health Services (PHS) and the Food Inspection Services (FIS) using standardized questionnaires. Stool samples were collected for diagnostic testing. For foodborne outbreaks, food samples were taken. In total, 281 gastroenteritis outbreaks were included, mainly from nursing homes and homes for the elderly (57%), restaurants (11%), hospitals (9%) and day-care centres (7%). Direct person-to-person spread was the predominant transmission route in all settings (overall 78%), except for restaurant outbreaks where food was suspected in almost 90% (overall in 21% of outbreaks). The most common pathogen was norovirus (54%), followed by *Salmonella* spp. (4%), rotavirus group A (2%), *Campylobacter* spp. (1%) and only incidentally others. In conclusion, most outbreaks were reported from health and residential institutions, with norovirus as the dominant agent. Control should aim at reducing person-to-person spread. In foodborne outbreaks norovirus was common, due to contamination of food by food handlers. *Salmonella*, as the second foodborne pathogen, was mainly associated with raw shell eggs. These results stress the continuous need for food safety education, complementary to governmental regulation.

INTRODUCTION

Gastroenteritis is one of the most common diseases worldwide. Recent studies provided good insight in the incidence and pathogens of gastroenteritis in The Netherlands [1, 2]. However, knowledge of the incidence of outbreaks of gastroenteritis was limited, as routine surveillance is restricted to foodborne outbreaks only. This surveillance consists of mandatory notifications by the Public Health Services (PHS) to the Inspectorate of Health Care and voluntary reports to the Food Inspection Services (FIS). Investigations by the PHS are mainly focused on patients, while suspected food and kitchen hygiene are the starting

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points for investigations by the FIS. Ideally, both authorities are involved in investigations of reported outbreaks, but in practice overlap between reported outbreaks is limited; in 1997, only 27% of outbreaks reported by the PHS were also included in FIS reports. In the period 2000–2002, 80–100 foodborne outbreaks were reported annually by the PHS, while the annual number of reports to the FIS ranged between 300 and 350 [3].

Foodborne incidents with at least three cases, reported to the FIS (part of the Ministry of Agriculture, Nature and Food Safety), are forwarded routinely by fax to one of the five regional FIS and the PHS in the area of the involved outbreak setting. Incidentally, reports to the FIS are anonymous, with reporting consumers objecting to the PHS being notified. The PHS (currently 40) are legally responsible for public health and infectious disease control on behalf of the 500 municipalities in The Netherlands. Of the PHS, approximately 70% do not investigate every reported outbreak. Criteria that are considered in this decision are mainly the timeliness of the report, severity of the outbreak, other infectious disease priorities, available staff and the degree of uncertainty about the causative agent. Investigations do not always include a visit of the outbreak location and collection of stools or questionnaires. If a suspected foodborne outbreak is reported (first) to the PHS, 17% of PHS do not always contact the FIS. The National Institute of Public Health and the Environment (RIVM) is only involved in large outbreaks of gastroenteritis on the explicit request of a PHS or in outbreaks that exceed a single PHS area. Activities of the RIVM may include advising PHS and FIS in the investigation, design of questionnaires, and data analyses. For local outbreaks, on the request of a PHS or microbiological laboratory, the RIVM is involved in performing norovirus diagnostics and typing of pathogens.

Routine microbiological testing of stool samples and food is mainly confined to bacteria. Data from studies of selected outbreaks with the PHS indicated an important role for other pathogens, notably viruses [4, 5]. In recent years, more complete information about the causative agent has been reported by the PHS, with *Salmonella* most commonly identified (43% in 2002), followed by *Campylobacter* (20%) and norovirus (12%) [3]. In 22% of outbreaks the pathogen was unknown. However, in the majority of the relatively smaller foodborne outbreaks reported to the FIS, no causative agent was found (80–90%). Consequently, systematic collaboration between both authorities might further improve quality of data on foodborne outbreaks. Moreover, as mentioned, the relative importance of other possible transmission routes causing outbreaks of gastroenteritis is unknown.

Therefore, a national study was performed in 2002, to assess the settings, the role of specific pathogens (with special attention for viruses and parasites), and transmission routes in outbreaks of gastroenteritis in The Netherlands, in order to provide further leads for future (policy on) prevention and control. Also, it was aimed to improve the process of investigation and management of gastroenteritis outbreaks in The Netherlands. The project was a collaboration between the PHS, the FIS, medical microbiological laboratories and the RIVM. In this paper, the results of this 1-year study are presented.

METHODS

Study design

The national study addressed all outbreaks of gastroenteritis that were reported to either the PHS or the FIS, with date of onset of the first case between 1 January and 31 December 2002. The working case definition of an outbreak was the occurrence of diarrhoea and/or vomiting in at least five cases, with some common factor. In 2001, a pilot study was performed in one region of The Netherlands, covering 19% of the population, to study feasibility, the support of involved authorities and to pre-test the protocol and study materials. Following a positive evaluation of this pilot [6], all PHS and FIS attended regional meetings on the project and were invited to participate. Study materials were distributed with an accompanying instruction to the appointed contact persons in December 2001.

Data and sample collection

(1) The PHS collected background and epidemiological information, using project-designed standardized questionnaires. Data recorded included: number of cases, number exposed, number hospitalized, number died, setting of the outbreak, dates of onset, frequency and type of symptoms, incubation period, duration of illness, most likely transmission route, microbiological results of stool analysis and control measures. For suspected foodborne outbreaks, the FIS completed

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an additional standardized questionnaire covering: suspected food, place where food was prepared and consumed, use of Hazard Analysis and Critical Control Points (HACCP) systems or hygiene codes in these places, method of preparation, processing and storage of the food, contributing factors in causing the outbreak and microbiological results of sampled food.

(2) The PHS were requested to collect a minimum of five and a maximum of 10 stool samples from ill cases. Collection of stools of non-ill individuals involved in the outbreak was not requested by the protocol, but left to the PHS' assessment of usefulness in detecting the causative agent of the outbreak.

(3) For suspected foodborne outbreaks, the FIS was asked to collect food samples and inspect the place of food preparation.

(4) For suspected waterborne outbreaks, water samples were collected by the National Institute of Public Health and the Environment (RIVM).

(5) Evaluation questionnaires, sent to all PHS (47 in 2002) and FIS (5) in January 2003, were used to determine the number of reported outbreaks not included in the study.

Microbiological analysis

(1) All microbiological laboratories routinely collaborating with the PHS were instructed in advance, in writing, to test all submitted stool samples for the project for *Salmonella* spp., Shiga toxin-producing *Escherichia coli* (STEC) O157 (both by routine assays, mainly culture on selective media), and rotavirus group A (mainly by routine latex agglutionation assays or commercially available ELISAs). Additional tests, for *Shigella* spp., *Campylobacter* spp., *Yersinia* spp. (by culture), adenovirus type 40/41 (by ELISA), were performed by mutual agreement between the laboratory and the PHS.

(2) Stool aliquots were immediately forwarded by the laboratories to the RIVM for testing for the presence of norovirus (RT–PCR), *Giardia lamblia* [ProSpect Giardia Microplate assay (Alexon-Trend Inc., Lenexa, KS, USA), positive samples confirmed by microscopy] and *Cryptosporidium parvum* (microscopy of ZN-stained preparations). Results were reported within 2 weeks after receipt. If all test results from the routine laboratory and RIVM were found to be negative or only one sample tested positive, samples were additionally tested at the RIVM for sapovirus (RT–PCR), astrovirus (RT–PCR) and adenovirus type 40/41 (ELISA). If incubation period (less than 12 h) and symptoms in a foodborne outbreak yielded suspicion for an intoxication or infection by toxin-producing bacteria [*Staphylococcus* (*Staph.*) *aureus*, *Bacillus cereus*, *Clostridium* (*Cl.*) *perfringens*], these were added to the panel at the RIVM. All detection methods used at the RIVM have been described in detail elsewhere [1, 2, 7, 8].

(3) The FIS tested the collected food samples for the presence of indicator-organisms, i.e. total aerobic counts and Enterobacteriaceae count, and for *Salmonella*, *E. coli*, *Cl. perfringens*, *B. cereus* and *Staph. aureus*. Incidentally, other microorganisms were added by the FIS (mainly *Campylobacter* spp. and *Listeria* spp.). If either *Cl. perfringens*, *Staph. aureus*, or *B. cereus* was isolated from food, the isolates and the food were sent to the RIVM for further characterization of the toxin-producing capacity of the strain and quantification of the toxin amount. Specific food items [such as (shell)fish, meat, salad, vegetables, fruit (juice), cake, other bakery products, desserts and drinking water] served raw or cold were partially sent to the RIVM to be tested for norovirus and for further development and validation of norovirus detection.

(4) For detection of norovirus in food, four different virus concentration protocols were used. Virus concentration protocols were based on centrifugal membrane filtration (Amicon, Centricon® Plus-20, Millipore, Bedford, OH, USA), PEG/NaCl precipitation or ultracentrifugation. RNA extractions were performed according to Boom et al. [9], or by TRIzol extraction (TRIzol®, Invitrogen Life Technologies, Merelbeke, Belgium) or using RNeasy® Mini kit (Qiagen, Baltimore, MD, USA). For each specific food item one or two of these protocols were selected and adapted if indicated (Lodder-Verschoor et al., unpublished observations).

(5) Typing of detected pathogens was performed at the RIVM. *Salmonella* isolates from stool and food were serotyped by slide agglutination for O- and H-group antigens and phage typed [10]. Genotyping of norovirus was done by sequence analysis of a fragment from the polymerase gene [11]. Rotavirus genotyping was performed by PCR, targeting the VP7 and VP4 genes encoding

the two outer capsid proteins G (glycoprotein) and P (protease-sensitive) respectively [12, 13].

(6) Data from outbreaks that were caused by norovirus were submitted to the common database of the EU project 'Rapid detection of transnational foodborne viral infections and elucidation of transmission routes through molecular tracing and development of a common database' (QLK1-1999-CT-0594) [14].

Data analysis

All questionnaires returned by FIS, PHS and all test results of the RIVM were entered into a Microsoft Access database and exported to the SAS System, release 8.2 (SAS Institute Inc., Cary, NC, USA), for analysis. The attack rate of an outbreak was calculated as the percentage of exposed individuals that developed symptoms during the outbreak. The duration of an outbreak was calculated as the interval in days between the date of onset in the first and the last case of an outbreak. If all individuals fell ill on the same day, duration was set to 1 day. Frequencies and cross-tabulations were made for descriptive analysis of all outbreaks and of foodborne outbreaks separately. Differences in number of cases, attack rates and duration of outbreaks between subcategories of settings, transmission routes and causative pathogens were tested using the Wilcoxon rank sum test (for two-group comparison) and the Kruskal–Wallis test (for three or more groups).

RESULTS

General results

During the study year, 281 outbreaks were reported by the PHS and FIS. In addition, according to the evaluation questionnaires another 33 outbreaks had been reported to five PHS, but were not included in the study protocol. So, 89% of all reported outbreaks were included in the study. Most outbreaks were reported in late autumn/winter (November, December) compared with fewest reports in summer (June–August) (Fig. 1).

A PHS questionnaire was received for 266 (95%) of the reported outbreaks. For the remaining 15 outbreaks, epidemiological data was limited, based on the information provided at first notification and possible follow-up contacts (such as setting of the outbreak, date of onset).

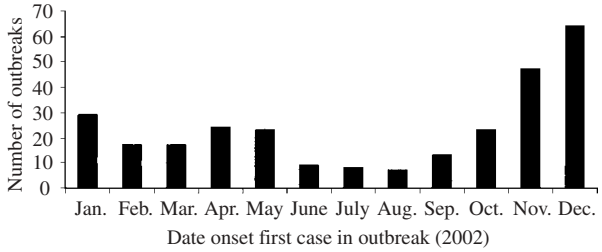

Fig. 1. Number of reported outbreaks by month of onset of illness in the first case, 2002. (For the 19 outbreaks lacking date of onset, date of reporting was used instead.)

In total, at least 8717 cases (based on 268 outbreaks, range 5–151 cases per outbreak) were affected, of which 62 (0·7%) were hospitalized and 16 died (0·2%, all residents of nursing homes or homes for the elderly). The total number of exposed individuals exceeded 28 000 (based on 209 outbreaks). The attack rate among exposed individuals in the outbreaks, varied from 4% to 100%, with a median of 38%. Most common complaints were diarrhoea (reported in 97% of outbreaks; within outbreaks, median, 25th–75th percentile of percentage of diarrhoea: 97%, 48–100%), vomiting (92% of outbreaks; median, 25th–75th percentile of vomiting: 70%, 39–100%), nausea (53% of outbreaks; median, 25th–75th percentile of nausea: 70%, 24–100%), fever (45% of outbreaks; median, 25th–75th percentile of fever: 17%, 8–40%) and abdominal cramps (39% of outbreaks; median, 25th–75th percentile of cramps: 62%, 29–100%). The duration of an outbreak, known for 199 outbreaks, varied between 1 and 58 days, with a median of 9 days. The duration was longest for outbreaks in day-care centres, outbreaks due to person-to-person transmission and outbreaks caused by norovirus (Table 1).

Setting, transmission route, causative agent and size of outbreaks

Most outbreaks were reported from nursing homes and homes for the elderly (57%), followed by restaurant outbreaks (including take-away meals) (11%), outbreaks in hospitals (9%) and day-care centres (7%) (Table 2).

Direct person-to-person contact was the most likely route of transmission for the majority of outbreaks (78%), followed by foodborne transmission (13%) and a combination of foodborne and person-to-person transmission (8%). One waterborne outbreak was reported, which is presented in detail elsewhere [15]. No outbreaks due to direct contact with

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Table 1. *Size, attack rates and duration of outbreaks, by setting, transmission route, and causative pathogen, The Netherlands, 2002*

	Absolute size of outbreaks			Attack rate of outbreaks			Duration outbreak	
	n	Median no. cases	Range (min–max)	*n*	Median (%)	Range (min–max)	*n*	Median (days)
Overall*	268	25	5–151	205	38	4–100	199	9
Setting†								
Nursing homes/elderly	152	34	7–151	107	30	4–83	118	12
Hospital	24	18·5	7–53	16	37·5	16–77	18	10·5
Restaurant/catering	31	11	5–80	28	60·5	8–100	22	2
Day-care centres	19	12	7–27	17	28	8–58	9	14
Transmission route†								
PTP	207	27	6–151	148	32	4–100	153	12
Food and PTP	22	23	5–68	21	50	9–100	17	3
Food alone	36	9	5–110	33	70	8–100	27	2
Pathogen‡								
Norovirus	143	34	7–151	112	33	4–100	116	11
Salmonella	10	11	5–110	10	80·5	8–100	8	1·5

PTP, Person-to-person.
* Totals do not add up to 281 outbreaks due to missing values in number of cases or number exposed.
† Kruskal–Wallis test for difference between exposed subgroups, $P<0{\cdot}0001$ for all three comparisons.
‡ Wilcoxon rank sum test for difference between both pathogens, $P=0{\cdot}003$ for attack rate, $P=0{\cdot}004$ for absolute size, and $P=0{\cdot}013$ for duration of outbreak.

Table 2. *Setting of reported outbreaks and most likely route of transmission, in The Netherlands, 2002*

Most likely route of transmission* … Setting of outbreak	*n*	(%)	PTP (%)	Food and PTP (%)	Food alone (%)
Nursing homes (14 also elderly home)	87	31·0	95·4	2·3	2·3
Homes for the elderly	74	26·3	94·6	5·4	0·0
Restaurants (incl. take-away)	32	11·4	12·5	34·4	53·1
Hospitals	25	8·9	100·0	0·0	0·0
Day-care centres	20	7·1	100·0	0·0	0·0
Other institutions	11	3·9	72·7	9·1	9·1
Private households	6	2·1	0·0	0·0	100·0
Schools	5	1·8	80·0	0·0	20·0
Other†	21	7·5	23·8	23·8	42·9
Total	281	100	77·9	8·2	12·8

PTP, Person-to-person.
* Percentages do not always add up to 100 %, as the waterborne outbreak and two outbreaks with unknown route were excluded from the table.
† These included a.o. three outbreaks in amusement parks, three outbreaks in holiday homes/centres, three company outbreaks, two outbreaks on cruise ships and one outbreak on a dairy farm.

animals or animal manure were reported. For two outbreaks the transmission route was unexplained.

Person-to-person contact was responsible for all or most outbreaks in day-care centres, nursing homes, homes for the elderly, hospitals and other institutions (Table 2). As expected, foodborne transmission dominated (88 %) in restaurant-associated outbreaks.

The median size of the outbreaks was largest for nursing homes and homes for the elderly (Table 1). Outbreaks in restaurants and day-care centres were smaller. The median size of the hospital outbreaks was in between these settings. However, the ranking of settings by attack rate gave a different order, highest for restaurant outbreaks, subsequently followed by

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Table 3. *Causative agent of reported outbreaks in The Netherlands, 2002*

	Outbreaks tested (*n*)	Outbreaks positive (*n*)	% of tested	% of all (*n* = 281)
Norovirus (incl. mixed*)	215	151 (155)	70·2 (72·1)	53·7 (55·2)
Salmonella (incl. mixed*)	220	10 (12)	4·5 (5·5)	3·6 (4·3)
Rotavirus group A (incl. mixed*)	193	5 (6)	2·6 (3·1)	1·8 (2·1)
Giardia lamblia (incl. mixed*)	215	0 (1)	0·0 (0·5)	0·0 (0·4)
Cryptosporidium parvum (incl. mixed*)	215	0 (1)	0·0 (0·5)	0·0 (0·4)
Shigella sonnei	195	1	0·5	0·4
STEC O157	193	0	0·0	0·0
Campylobacter	181	3	1·7	1·1
Adenovirus type 40/41 (incl. mixed*)	58	1 (2)	1·7 (3·4)	0·4 (0·7)
Clostridium perfringens	5	1†	20·0	0·4
Mixed pathogens*	n.a.	5	n.a.	1·8
	No. of outbreaks		% of all (*n* = 281)	
Unexplained	104		37·0	
No or insufficient no. of stools positive	51†		18·2	
Highly incomplete panel tested	13		4·6	
No stool samples collected‡	40		14·2	

* Two outbreaks due to both norovirus and *Salmonella* (Brandenburg, Typhimurium DT104), one due to norovirus and adenovirus, one due to norovirus and rotavirus, one outbreak due to *Giardia lamblia* and *Cryptosporidium parvum*.
† In two of the remaining four tested outbreaks, *Costridium perfringens* was found in food and in either one or four faecal samples of cases, but further investigation of the isolates showed that these were not toxin-producing (therefore both classified as unexplained outbreaks).
‡ In two of these outbreaks, *Bacillus cereus* was isolated from leftovers of suspected food.

hospitals, nursing homes and homes for the elderly and day-care centres (Table 1). The absolute size also differed by transmission route, with largest outbreaks for person-to-person outbreaks and smallest for outbreaks due to foodborne transmission alone (Table 1). Again, the order changed (exactly opposite) when attack rates were considered.

Stool samples of cases were collected for 241 (86%) outbreaks. In total, 1474 stool samples were collected (median five per outbreak, range 1–28). Additionally, for 50 outbreaks, stool samples were taken from 202 non-ill individuals, median four per outbreak. The most common causative agent was norovirus, found to be responsible for 155 outbreaks, including four outbreaks with mixed pathogens (Table 3). In 35 of these outbreaks, non-ill individuals were also tested, with 17 outbreaks (49%) yielding at least one norovirus-positive stool (overall, 21% of control stools tested positive). Of all norovirus outbreaks, 63% occurred in January, November and December. Seven different genotypes of norovirus were observed. The genotype Lordsdale (GGII.4) was most common (86%), especially the new variant within this genotype (75%), which first emerged in several European countries early 2002 [16]. *Salmonella* was the second most important agent, with 12 outbreaks, including two mixed outbreaks: seven times *S.* Enteritidis phage type (PT)4, and 1 outbreak each of *S.* Enteritidis PT6, *S.* Enteritidis PT8, *S.* Brandenburg and *S.* Typhimurium DT104 (one outbreak not typed). These outbreaks mainly (58%) occurred between June and September. Rotavirus group A (four G1:P8, two untyped because samples were not forwarded for typing) ranked third with six outbreaks, all but one observed in March and April. Three outbreaks due to *Campylobacter jejuni* occurred between April and September. Other pathogens were found in less than two outbreaks. Only one outbreak (in a day-care centre in August) was caused by parasites; both *G. lamblia* and *Cryptosporidium parvum*. In 21 outbreaks (12 due to norovirus, 9 unexplained), *G. lamblia* was found in just one stool sample of a case. In 12 of these samples only *Giardia* antigen was detected and no cysts were found.

Characteristics of outbreaks caused by specific pathogens

Of the norovirus outbreaks (excluding mixed outbreaks), 89% ($n = 135$) were reported to be due to person-to-person contact, 8% ($n = 12$) due to a combination of contaminated food and subsequent

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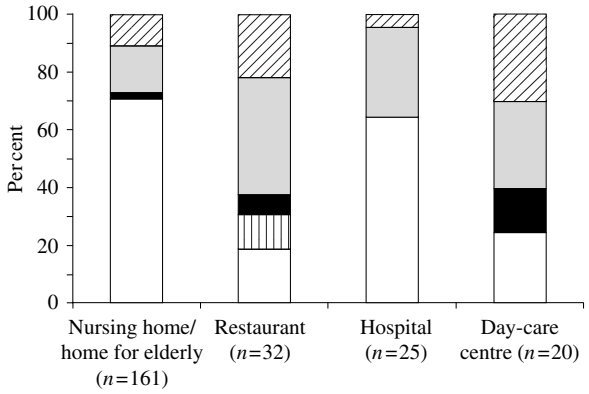

Fig. 2. Causative agent in outbreaks, for the four main settings, The Netherlands, 2002. □, Norovirus; ▨, *Salmonella*; ■, other; ▩, unexplained; ▨, no stools.

person-to-person spread, 2% ($n=3$) due to contaminated food alone and one outbreak due to waterborne transmission. The other viral outbreaks (rotavirus and adenovirus) were all transmitted by person-to-person contact. The 13 *Salmonella* and *Campylobacter* outbreaks were all due to contaminated food, with one *Campylobacter* outbreak also yielding secondary cases by faecal–oral contact during a long-distance bus trip.

Norovirus was the dominant causative agent in all settings, especially in nursing homes, homes for the elderly and hospitals (Fig. 2). In restaurants, bacteria were identified as well (*Salmonella*, *Campylobacter*, *Cl. perfringens*), whereas in day-care centres also rotavirus and the one parasitic outbreak was observed.

Although the absolute size was larger for norovirus outbreaks than for *Salmonella* outbreaks, attack rates were significantly higher for *Salmonella* (Table 1).

Foodborne outbreaks

In total, 59 outbreaks were reported to be (partially, $n=23$) foodborne. Of these outbreaks, 52 (88%) were reported to both the PHS and FIS, three were only reported to the FIS (anonymous reports), and four were reported only to the PHS (who did not contact the FIS). Of the 55 reports to the FIS, for four (all caused by bacteria) the suspected food was consumed abroad. A FIS questionnaire was received for 38 (74%) of the remaining 51 outbreaks. Of these 38 outbreaks, in 8% of the kitchens where suspected food was prepared no HACCP system or hygiene code was in use (unknown for 26%). Overall, 265 food samples were taken for 35 of the 38 outbreaks, with a median of six per outbreak (range 1–22). For 29 outbreaks (83%), no leftovers of the suspected food were available for testing, and control samples were taken instead, i.e. food from the same batch, box, purchase date or prepared at same day or, if these were not available, other food samples from the same kitchen. For six outbreaks (also) leftovers could be sampled. For most outbreaks multiple food items were suspected, of which meat (14 outbreaks) and fish (11 outbreaks) were most frequently reported.

Overall, in nine (26%) of the 35 outbreaks where food was tested, pathogens were found in the food. These included four (67%) of the six outbreaks with sampled leftovers and five (17%) of the 29 outbreaks with control samples. For one outbreak, the pathogen in the food (sambal beans) matched the pathogen found in cases, i.e. toxin-producing *Cl. perfringens*. For two additional outbreaks, *Cl. perfringens* was isolated from the food samples (chicken satay, soup with beef ragout) and from one and four faecal samples from cases respectively. However, further testing of these isolates showed that these were not toxin-producing. Consequently, both outbreaks were classified as unexplained. In one outbreak, *S.* Enteritidis PT4 was isolated from patients, but *S.* Typhimurium DT301 was isolated from pork tenderloin. The suspected food for the *S.* Enteritidis (mashed potatoes prepared with raw eggs), was not available for further testing. For one outbreak, high concentrations of *B. cereus* were found in home-made soup, stored outside the refrigerator. Unfortunately, no faecal samples were collected by the PHS, so it was not possible to draw conclusions about the causal relationship with illness. Also, for one outbreak with *B. cereus* found in fish broth, faecal samples could not be collected because cases refused to participate.

Of seven foodborne norovirus outbreaks, implicated food items could be collected. Of these, various food items have been tested for norovirus (including cream, bavarois, ice cream, cheese, egg, ham, bacon, roast beef, pork, duck mousse, delicatessen meat, minced meat, (smoked) salmon, salmon salad, crab salad, tuna, eel, Russian salad, rye-bread and lettuce), all with negative test results.

Overall, 25% of the 59 foodborne outbreaks were caused by norovirus, mainly the outbreaks with combined food and person-to-person transmission, followed by *Salmonella* (17%), *Campylobacter* (5%), *Shigella* (2%) and *Cl. perfringens* (2%), all mainly transmitted by food alone. The remainder of outbreaks (47%) was unexplained, including 10 (17%)

outbreaks where no stools were collected. Of the norovirus outbreaks, according to the FIS questionnaire at least 31% was caused by contamination of food by food handlers (no questionnaire available for 44% of the foodborne norovirus outbreaks). Of the *Salmonella* outbreaks, for five (50%) consumption of food prepared with raw shell eggs was reported, and for an additional two this was suspected (reports of consumption of chocolate mousse). For the remaining three, meat (on two occasions poultry and once raw minced meat) was reported as the suspected vehicle.

Control measures

Control measures were taken by the PHS for 235 (84%) outbreaks. These were mainly advising hygiene measures, such as hand washing and wearing protective clothes, such as gloves and gowns (216 outbreaks, disinfection of affected areas reported for 94) and keeping ill personnel away from work or giving them tasks without contact with vulnerable groups or food (82 outbreaks). Symptomatic individuals were isolated from healthy individuals in 63 outbreaks. In 34 outbreaks (12%), cases were treated. Finally, for eight outbreaks (six hospitals, one nursing home and one home for the elderly) admission of new patients or inhabitants was stopped, and in another hospital the operating room was closed. Four of these outbreaks were caused by norovirus, for the remaining five no conclusive causative agent was found.

DISCUSSION

In 2002, outbreaks of gastroenteritis were mainly reported from nursing homes and homes for the elderly, followed by restaurants, hospitals and day-care centres. Direct spread from person to person was the predominant transmission route in all these settings, except for restaurants where food was the suspected vehicle in approximately 90% of outbreaks. The most common causative pathogen of the outbreaks was norovirus, especially in health and residential institutions. In addition, in restaurant outbreaks, bacteria played an important role (especially *Salmonella*) and in day-care centres a more diverse spectrum was observed, also including other viruses and parasites. Overall, just over one in five outbreaks was assumed to be, at least partially, foodborne, of which 25% was caused by norovirus and 17% by *Salmonella* spp.

Overall, it was recognized by the FIS that the study improved knowledge on causative pathogens of foodborne disease outbreaks: pathogen known for 53% *vs.* 10–20% in routine practice. Also, four out of five regional FIS reported that contacts with the PHS were reinforced. The PHS mainly reported the practical value of the study, such as improvement of the working processes (reported by 71%) and intensified contact with laboratories, FIS, RIVM or residential and health institutions (57%). During the study period, three out of five FIS did not always receive results of the investigation by the PHS or did not receive any response on the results of the inspection. On the contrary, 17% of PHS reported that inspection results were received only on request, were sent too late or were inadequately explained. Thus, feedback of results between FIS and PHS in both directions is open to improvement and agreements on this matter should be made.

Reported outbreaks to health authorities such as PHS and FIS do not necessarily represent the outbreaks occurring in the community. It can be expected that especially outbreaks in households, restaurants, day-care centres and schools were under-represented in the study, because of under-reporting [17]. In addition, outbreaks due to pathogens with a relatively long incubation period (such as *Giardia*) are less often recognized and, therefore, less completely reported.

In The Netherlands, reporting of unusual numbers of cases with diarrhoea in institutions where vulnerable groups for infectious diseases reside or assemble has been legislated in the Notifiable Disease Act since April 1999. The director of the institution reports to the PHS. Although this Act includes hospitals, the extensive in-house expertise with regard to infectious disease control, hygiene and investigation probably results relatively often in not reporting such incidents. Hospital reports are believed to be selected towards outbreaks where spread from the hospital into the community is anticipated, for instance if personnel or visitors are involved, because notification of these outbreaks is especially stipulated by the Act.

In approximately 25% of the outbreaks reported from hospitals, illness required a stop in the admission of new patients. Also, in institutions for the elderly this occasionally occurred, and more often, recreational activities in these groups were cancelled. Therefore, control of outbreaks in these settings will improve the quality of health care for these vulnerable groups and prevent development of waiting lists.

A recent study in French paediatric wards demonstrated that simple preventive measures can substantially decrease the incidence of hospital-acquired diarrhoea [18]. Some guidelines for control of norovirus outbreaks in institutions have been published [19–21], but are not all quantitatively evaluated with regard to their effectiveness in reducing the magnitude and duration of an outbreak. Although a lot of recommended measures are based on strong rationale and suggestive evidence, for some there is insufficient evidence or no consensus regarding efficacy [19]. Therefore, there is a need for studies in common outbreak settings, comparing the effectiveness of different control strategies, in order to support evidence-based practice. This will also contribute towards getting the support of staff and directors in adopting measures to control an outbreak, especially if economic loss is anticipated, such as during temporary closure of hotels, restaurants, hospital wards and cruise ships. From investigations it seems that norovirus outbreaks can be difficult to stop, requiring very intense cleaning, especially if there is environmental contamination following an episode of vomiting [22–24]. Except for direct infection by aerosolized viral particles [24], there is also evidence that contamination of the environment can be widespread and persistent and can serve as a long-term source of infections [25]. Staff from residential institutions, hospitals, day-care centres and schools, and also parents should be made aware that norovirus is highly contagious.

The presented study was performed during 1 year, because a long-term project was not feasible according to the PHS. However, differences in the relative importance of pathogens can be expected year by year, especially by fluctuation of viral outbreaks. For example, the proportion of outbreaks that were due to norovirus in the pilot study area in 2001 was 56% in comparison to 68% in the same area in 2002. As viruses, compared to bacteria, are more often spread between individuals, this will also influence the relative importance of the different transmission routes. Nevertheless, it is expected that with regard to ranking, norovirus will consistently be the most important pathogen and person-to-person transmission the main route. To reduce the health burden and costs for gastroenteritis, a reduction in these infections will be most effective.

The seasonal pattern of reported outbreaks mainly reflected the number of reported norovirus outbreaks. An unusually high number of norovirus outbreaks were reported in April and May. This coincided with the emergence of a new variant within the GGII.4 genogroup (Lordsdale), also observed in several other European countries [16].

With specific regard to the foodborne outbreaks, again norovirus was found to be the major cause. Most of these outbreaks were propagated by person-to-person spread, in addition to the foodborne route. More importantly, in a substantial number, contamination of food by personnel was considered the crucial factor in starting the outbreak, as described repeatedly in the past [26–30]. Food implicated in outbreaks of norovirus is mainly (shell)fish, who accumulate the virus by filter feeding in contaminated water in which they are grown and harvested, and all kinds of cold-served food (especially when manually prepared), such as salads, fresh fruit, bread rolls, etc. [28, 31–34]. Educational programmes for food producers and food handlers should draw explicit attention to this risk of food contamination during processing.

Of three foodborne norovirus outbreaks, where a number of suspected food items were tested, virus was not detected in any of them. Norovirus is known to be highly contagious and it is thought that an inoculum of as few as 10 particles may be sufficient to infect an individual. Therefore, protocols need to be adapted for each food item to reach optimal virus concentrations and to generate as much virus RNA as possible for the RT–PCR. In this study, for each food item one or two virus RNA concentration and extraction protocols were selected, but in none was this successful. To improve the sensitivity of the RT–PCR detection, it may be indicated to select specific primer pairs based on the norovirus sequences detected in the infected patients involved in the outbreak. In addition, virus RNA concentration and extraction protocols still can be improved. Studies to address these issues are under way.

Most *Salmonella*-associated outbreaks in the study were due to the use of raw shell eggs and to a lesser extent poultry in households and restaurants, both well-known risk factors for salmonellosis. In some countries, raw eggs are still being identified as the most important risk factor for *S.* Enteritidis infection in recent years [35, 36]. In The Netherlands, the total number of *Salmonella* cases has been decreasing since 1996 [37]. However, the estimated relative contribution of eggs as the source to these cases remained rather stable at around 35% and additionally the absolute number of egg-associated cases hardly

declined after 1999 [38]. These observations stress the need for continuous public and professional education about proper food handling (heating, minimizing cross-contamination) and the risk of using raw eggs as an ingredient in food that is not properly heated before consumption. Regulation can be a valuable complement to this food safety education. The Dutch Ministries of Agriculture and of Public Health in October 2001, following an outbreak with five deaths [39], announced legislation for a ban of shell eggs containing *Salmonella* in The Netherlands. However, a draft proposal, agreed by the Dutch Council of Ministers in May 2002, was turned down by the European Commission in 2003. Nevertheless, several hygiene codes in The Netherlands, such as those for the catering industry and for food management in health-care institutions, already include an explicit ban on the use of raw eggs in food that is not properly heated before consumption. Pasteurized eggs (yolk) should be used instead.

Toxin-producing bacteria were confirmed as the causative agent in only one outbreak. However, in another two outbreaks *B. cereus* was suspected as the cause. Although *B. cereus* is one of the most common pathogens found in food samples from foodborne incidents [3, 40], proven disease outbreaks due to this pathogen are seldom reported [41]. This might be explained by difficulties in recovering the bacteria and associated toxins from faecal samples (or vomit), usually collected more than 1 day after onset of illness, and the lack of valid diagnostic protocols and detection tests in routine medical microbiological laboratories. Therefore, the true importance of this pathogen is likely to be underestimated.

Although some large foodborne parasitic outbreaks have been described in industrialized countries, such as for *Cyclospora* and *Cryptosporidium* related to imported fresh fruit (juice) and fresh herbs [42–45], we found no evidence for a foodborne role of these organisms during the study. Although coincidentally, such outbreaks might have been absent in the study year, we currently believe that foodborne transmission is not a significant route for parasites in The Netherlands. It may be that person-to-person spread and waterborne transmission are more important, as observed in other countries [46–48]. In general, outbreak investigations are considered useful as they contribute disproportionately to the understanding of transmission and sources of enteric pathogens [49, 50]. However, because parasitic outbreaks seem rare (recognized) in The Netherlands, while the incidence for *Cryptosporidium parvum* and *G. lamblia* in the community is high [1, 2], for these micro-organisms case-control studies of 'sporadic' cases are likely to be more successful in elucidating the relative importance of different transmission routes.

Comparison with findings from outbreak surveillance systems in other countries is hampered, because outcomes clearly depend on the outbreak definitions, but more importantly, on the type of organization in which the surveillance is implemented, i.e. food-oriented agencies (like the Dutch FIS) or agencies with a more general scope on communicable diseases (like the Dutch PHS). This was demonstrated both for viral gastroenteritis outbreaks in Europe as well as general outbreaks of gastroenteritis in Ireland *vs.* England & Wales [51–53]. In The Netherlands, FIS outbreaks compared to PHS outbreaks are generally smaller (on average 4–6 persons *vs.* 8–13), more often restaurant-associated (79% *vs.* 37%), and seldom household-associated (1% *vs.* 31%) [3]. The low number of household-associated outbreaks in FIS surveillance is because their formal inspection and control task is to investigate only those incidents where there is reasonable doubt of a penal act, for instance by not complying with the Food law. For food, stored and prepared at home, it is difficult to build a case on legal grounds, as several behavioural aspects of the consumer might have caused the contamination or might have supported growth of pathogens.

In conclusion, most outbreaks were reported from health and residential institutions, with norovirus as the most common causative agent. Prevention and control of these outbreaks should aim at effectively reducing person-to-person spread, for which practical protocols need to be developed and evaluated. To monitor the circulation and emergence of (new) genotypes of norovirus, it is recommended that the PHS continue to collect and submit stool samples for analyses for a random subset of these outbreaks. An explicit request for this purpose was forwarded to all PHS for 2003 and was repeated for 2004. This should be continued until detection and typing methods for these viruses are implemented on a large scale in the routine diagnosing laboratories and as such can be covered by the existing laboratory-based surveillance system, ISIS. From a public health perspective, all reported foodborne outbreaks should be investigated jointly by PHS and FIS, either to prevent additional exposure and disease for ongoing problems or for the identification

of risk factors to facilitate development of long-term control strategies. In the study year, norovirus was found to be a common cause of foodborne outbreaks, especially due to contamination of food by food handlers. *Salmonella*, as the second most important foodborne pathogen, was (still) mainly associated with the use of raw shell eggs in food preparation. These results stress the continuous need for public and professional food safety education, complementary to regulation and enforcement by the government.

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