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An outbreak of norovirus gastroenteritis associated with wedding cakes

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SUMMARY

We sought to determine the source of a norovirus outbreak among attendees of 46 weddings taking place during a single weekend. Norovirus-compatible illness was experienced by 332 (39%) of wedding guests surveyed; the outbreak affected up to 2700 persons. Illness was associated with eating wedding cake provided by a bakery common to the weddings (adjusted RR 4·5, $P<0·001$). A cake requiring direct hand contact during its preparation accounted for the majority of illness. At least two bakery employees experienced norovirus-compatible illness during the week preceding the weddings. Identical sequence types of norovirus were detected in stool specimens submitted by two wedding guests, a wedding hall employee, and one of the ill bakery employees. It is likely that one or more food workers at the bakery contaminated the wedding cakes through direct and indirect contact. These findings reinforce the necessity of proper food-handling practices and of policies that discourage food handlers from working while ill.

INTRODUCTION

Norovirus can cause an acute gastrointestinal illness characterized by diarrhoea, abdominal cramps, nausea, or vomiting. Infections with norovirus are estimated to cause 23 million cases of gastrointestinal illness per year in the United States. The incubation period has a range of 12–48 h; duration ranges from 12 to 60 h. Asymptomatic infection is also possible; approximately one third of norovirus infections do not cause illness [1]. However, symptomatically and asymptomatically infected individuals may still shed virus in stool [1, 2]. Viral shedding peaks during the first 72 h of infection but is sometimes detectable in stool for up to 13 days [2].

Transmission of norovirus is faecal–oral and is often foodborne via an ill or recently recovered food handler [3–10]. Direct and indirect person-to-person transmission is also well documented [9–11]. Indirect person-to-person transmission is likely aided by a low infectious dose [12] and the widespread dissemination and hardiness of norovirus in the environment [13, 14].

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On 30 April and 1 May 2002, the Bureau of Communicable Disease Control at the Massachusetts Department of Public Health (MDPH) was notified by local health departments of three weddings that occurred during the weekend of 26–28 April, after which a substantial number of guests became ill. Guests experienced gastrointestinal illness within 24 h of each wedding, consisting of nausea, vomiting, diarrhoea, and fatigue lasting 24–48 h.

Onset times and symptoms of illness were indicative of point-source norovirus outbreaks. Separate investigations of each of the three wedding halls hosting receptions were pursued until it was learned that all three of the weddings served wedding cake supplied by the same local bakery. At that point, we suspected the wedding outbreaks were linked and that the bakery wedding cake was the most likely vehicle for infection.

Forty-six wedding cakes, served at weddings with 7169 guests and 439 wedding hall employees combined, and hundreds of smaller non-wedding cakes were prepared by the local bakery for the 26–28 April weekend. Our initial contact with either the wedding couple or wedding hall manager of 42 of the 46 weddings and the response to a press release soliciting reports of illness from consumers of non-wedding cakes prepared by the local bakery indicated a widespread outbreak.

We investigated the outbreak of gastrointestinal illness among attendees of weddings where wedding cake prepared by the same local bakery was served. Our specific aims were to determine whether wedding cake was the vehicle for infection, which types of wedding cake were the most efficient vehicles, the source and mode of cake contamination, and the infectious agent.

METHODS

Epidemiological investigation

Forty-six weddings serving cake from the same bakery were held on the weekend of 26–28 April 2002. The wedding couple or wedding hall manager of 42 of these weddings was contacted; 36 were solicited for recruitment into a cohort study. For each participating wedding, we received a list of the guests or wedding hall employees and the menu of all foods served.

Standard questionnaires, with questions regarding food consumption and illness, were mailed either directly to the wedding guests and wedding hall employees or via the wedding couples or wedding hall managers. While we suspected the wedding cake to be the most likely vehicle for infection, we treated each wedding as a separate outbreak and considered all food items served at each wedding as possible vehicles for infection. To this end, each wedding had a unique questionnaire including all of the foods served at the wedding.

Any wedding with fewer than 20 respondents was excluded from the study. Because of a suboptimal response rate among wedding hall employees, only guests were included in the analysis. A case was defined as illness in any wedding guest with onset within 3 days of the wedding and at least one of the following four symptoms: vomiting, diarrhoea, nausea, or abdominal cramps.

Using cohorts comprising guests of the weddings, as individuals and by wedding, we examined whether the wedding cake was the vehicle for illness and the types of cake most associated with illness. For the latter, we focused on the different wedding-cake fillings because they are not cooked before serving and are applied to the cakes by hand or by a hand-held implement. We were unable to evaluate the association between frostings or cake decorations and developing illness because all of the wedding cakes were frosted and decorated with the same food products.

To measure the association between eating specific food items served at the weddings and developing illness, we calculated Mantel–Haenszel estimates of the crude relative risk (RR) for each food item for each wedding. To evaluate the association between specific wedding-cake fillings and illness, we calculated adjusted Mantel–Haenszel estimates (aRR) for each filling for all weddings combined, stratified by wedding. For cake fillings found to have a statistically significant association with illness in the univariate analysis, we used multivariable logistic regression analysis to calculate the adjusted odds ratio (aOR). All statistical analyses were conducted using SAS version 8.0 (SAS Institute Inc., Cary, NC, USA).

Environmental investigation

Local sanitarians and MDPH personnel reviewed general operations and employee health at the local bakery by using hazard analysis critical control point (HACCP) risk assessment. Specifically, we examined the preparation of wedding cakes and attempted to find episodes of gastrointestinal illness among employees. These assessments included on-site reviews

of food preparation, hygienic practices, and employee health and absenteeism. Food items were submitted for laboratory testing, as described below.

Laboratory investigation

Stool samples were tested for bacterial enteric pathogens and for norovirus; food was tested for only bacterial enteric pathogens because of the unavailability of a norovirus assay for food. The specimens were tested at the State Laboratory Institute of MDPH for bacterial pathogens by using conventional microbiological methods and for norovirus by reverse–transcription polymerase chain reaction (RT–PCR) using primers to the viral RNA polymerase gene [15]. All RT–PCR products were sent to the Centers for Disease Control and Prevention for DNA sequencing.

In compliance with MDPH regulations, all 34 bakery employees submitted stool specimens for enteric testing. In addition, two ill wedding guests submitted specimens for enteric testing.

A subset of bakery employees, including all 17 bakery employees who handle food, were asked to submit a specimen for norovirus testing. Three of these 17 bakery employees, including two who reported gastrointestinal illness, submitted viral specimens 9 days after the earlier of the two bakery employees' illness onsets (23 April); the remaining 14 employees submitted viral specimens 6 days later. In addition, six ill wedding guests, including the two who submitted an enteric specimen, and two ill wedding hall employees submitted specimens for norovirus testing. The wedding guests and wedding hall employees submitted these specimens within 48 h of illness onset.

Food items submitted for testing included ingredients used in the cakes prepared for the outbreak weekend and wedding-cake tops provided by different wedding couples.

RESULTS

Epidemiological investigation

Twenty-one wedding couples or wedding hall managers, including 18 who reported illness among their guests or wedding hall employees during initial contact, agreed to participate in the cohort study. A total of 937 persons from 21 weddings, including 851 guests and 86 employees, completed a questionnaire. Twelve weddings, with 850 guest and 35 wedding hall employee respondents combined, met the inclusion criterion of having greater than 20 respondents. These weddings were representative of the total 46 weddings occurring during the outbreak weekend with respect to wedding day, guest list size, and types of wedding cake served.

The median response rate of attendees from these 12 weddings was 60% (range 18–76%) among guests and 5% (range 0–44%) among wedding hall employees. Because of the poor response rate among employees, only the 850 guests from the 12 weddings were included in the analysis (Table 1). In total, 332 questionnaire respondents in this cohort reported illness meeting the case definition, yielding a median attack rate of 38% (range 7–65%).

Forty-eight percent of the ill persons were male, and the median age was 43 years (range 6–83 years). The median incubation period and duration of illness were 35 h (range 6–74 h) and 40 h (range 2–133 h) respectively. Illness onsets ranged from Saturday, 27 April, the day after the first weddings of the weekend, to Wednesday, 1 May (Fig., white bars). Nausea was experienced by 81% of case-patients, diarrhoea by 80%, abdominal cramps by 75%, and vomiting by 60% (Table 2). The likelihood of experiencing vomiting decreased with age ($P<0{\cdot}01$). Medical care was sought by 9% of cases, and 2% were hospitalized.

Wedding cake was the only identified risk factor for developing illness (aRR 4·5, 95% CI 3·1–6·6, $P<0{\cdot}001$, Table 1). For all 12 weddings, the attack rates among guests who reported eating cake were higher than the attack rates among guests who did not report eating cake. Wedding cake was statistically significantly associated with illness for nine of the 12 weddings. The association between cake and illness did not reach statistical significance for the remaining three weddings.

Seven types of wedding cake, defined by the type of cake filling they contained, were served at the 12 weddings in our study (Table 3). Univariate analysis of each of the fillings demonstrated a significant positive or negative association with developing illness for only strawberry (aRR 4·6, 95% CI 3·3–6·4, $P<0{\cdot}001$) and mocha (aRR 0·4, 95% CI 0·21–0·83, $P=0{\cdot}003$) fillings respectively. Multivariable logistic analysis with these two fillings in the model indicated that only strawberry filling was associated with developing illness (aOR 9·3, 95% CI 6·2–13·8, $P<0{\cdot}001$). Ninety percent of the case-patients ate the strawberry-filled cake.

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Table 1. *Response rate, attack rate, and association (RR) between eating wedding cake and developing illness – norovirus outbreak, Massachusetts, 2002*

Wedding	No. guest respondents (response rate)	No. ill (attack rate)	No. ill among cake eaters (attack rate)	No. ill among non-cake eaters (attack rate)	Crude RR (95% CI)	*P* value
1	148 (73%)	72 (49%)	69 (60%)	3 (9%)	6·6 (2·2–19·6)	<0·001
2	77 (76%)	45 (58%)	45 (68%)	0 (0%)	Undefined	<0·001
3	81 (41%)	39 (48%)	33 (70%)	6 (18%)	4·0 (1·9–8·4)	<0·001
4	53 (63%)	13 (25%)	13 (43%)	0 (0%)	Undefined	<0·001
5	62 (52%)	32 (52%)	30 (61%)	2 (15%)	4·0 (1·1–14·5)	0·004
6	62 (31%)	12 (19%)	12 (29%)	0 (0%)	Undefined	0·008
7	55 (58%)	36 (65%)	30 (75%)	6 (40%)	1·9 (1·0–3·6)	0·02
8	73 (73%)	32 (44%)	29 (51%)	3 (19%)	2·7 (0·9–7·8)	0·02
9	65 (76%)	16 (25%)	16 (30%)	0 (0%)	Undefined	0·04
10	43 (26%)	5 (12%)	5 (15%)	0 (0%)	Undefined	0·1
11	45 (18%)	3 (7%)	3 (13%)	0 (0%)	Undefined	0·1
12	86 (70%)	27 (31%)	23 (35%)	4 (19%)	Undefined	0·2
Combined (adjusted for wedding)	850 (60%)	332 (38%)	308 (26%)	24 (4%)	4·8 (3·2–7·0) (4·5) (3·1–6·6)	<0·001 (<0·001)

RR, Relative risk; CI, confidence interval.

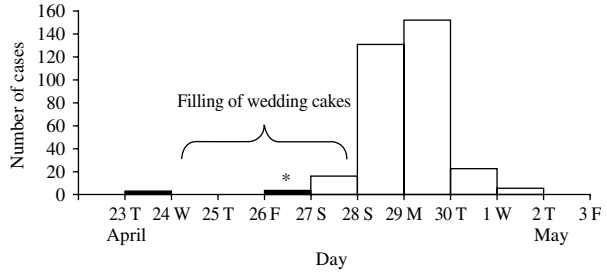

Fig. Timeline of wedding cake filling and illness onset among bakery employees and wedding guests – norovirus outbreak, Massachusetts, 2002. ■, Bakery employees; □, wedding guests. * Bakery employee tested positive for norovirus.

Table 2. *Clinical characteristics of 332 case-patients identified among wedding guests – norovirus outbreak, Massachusetts, 2002*

Clinical description	No. (%) reporting
Nausea	268 (81)
Diarrhoea	264 (80)
Abdominal cramps	247 (75)
Vomiting	199 (60)
Chills	185 (57)
Headache	189 (57)
Myalgia	179 (54)
Fever	141 (42)
Sought medical care	29 (9)
Hospitalized	8 (2)

Environmental investigation

Wedding cakes were composed of individual layers of cake that were each composed of one of several types of baked cakes and one of several types of fillings. Wedding cakes were multilayered, each layer possibly being of a different type of baked cake and filling.

Wedding cake production was a multistep process that occurred over two or more days, beginning on the Wednesday before the wedding weekend. Between Wednesday and Saturday, individual cake layers were baked and filled. On the day of the wedding, the cake layers were assembled and the cake was frosted, decorated, boxed, and delivered.

Of the seven types of cake fillings served at the weddings included in the study, the majority contained a white chocolate mousse filling as a base ingredient. For the strawberry-filled cakes, fresh strawberries washed and sliced the day of cake filling were hand-spread onto the white chocolate mousse. This was the only filling of the seven that involved direct hand contact in its preparation.

Inspection of the bakery premises identified numerous problems with sanitation and hygiene. First, food preparation surfaces, utensils, and equipment were not properly sanitized. Second, the

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Table 3. *Univariate analysis of cake fillings – norovirus outbreak, Massachusetts, 2002*

Type of filling	No. of weddings serving	No. eaters	No. (%) ill among cake eaters	No. (%) ill among cake non-eaters	Adjusted RR (95% CI)	*P* value
Strawberry	12	550	298 (54)	34 (11)	4·6 (3·3–6·4)	<0·001
Chocolate mousse	2	23	11 (48)	321 (39)	1·2 (0·8–2·0)	0·4
Raspberry chocolate	1	15	1 (7)	331 (40)	1·0 (0·1–10·2)	1·0
White chocolate mousse	1	9	4 (44)	328 (39)	1·0 (0·5–2·2)	1·0
Cream cheese	4	25	6 (24)	326 (40)	0·9 (0·5–1·7)	0·8
Mocha	2	30	6 (20)	326 (40)	0·4 (0·2–0·8)	0·003
Chocolate hazelnut	1	2	0 (0)	332 (40)	Undefined	0·7

RR, Relative risk; CI, confidence interval.

strawberry washing and cutting stations were situated next to the main sink; equipment was leaned against the cutting board while being cleaned, and bakery employees were observed touching the cutting board with bare hands. Third, not all employees used gloves correctly, and some were observed wiping their hands on heavily soiled uniforms.

Interviews with management and a review of employee time cards revealed that at least two of the 17 bakery employees had experienced gastrointestinal illness during the week preceding the affected weddings (Fig.). One bakery worker, who prepared cake decorations for the wedding cakes, was off sick on Tuesday, 23 April. A second employee, who prepared cake decorations for non-wedding cakes and transported wedding cake layers before and after assembly, was ill beginning on Friday, 26 April after work, and off sick on Saturday, 27 April. All employees, including the two with documented illness, denied being ill while working.

Laboratory investigation

Stool specimens submitted by two guests from one wedding, a wedding hall employee from another wedding, and the bakery employee who was ill beginning 26 April yielded identical sequence types of norovirus. This specific sequence type had not previously been reported. Testing of stool and food specimens was negative for bacterial enteric pathogens.

DISCUSSION

This investigation describes an outbreak of norovirus illness among attendees of multiple weddings occurring during a single weekend. Illness was associated with the consumption of wedding cakes provided by the same local bakery. A single sequence type of norovirus was identified in the stool specimen of two wedding guests, a wedding hall employee, and an employee of the bakery.

We speculate that norovirus was spreading symptomatically and asymptomatically among the bakery employees, resulting in contamination of wedding cakes. This speculation is based on one bakery employee's testing positive for the outbreak norovirus sequence type, another's being off sick with illness compatible with norovirus infection, the high transmissibility of norovirus [14], and a reported 32% asymptomatic rate among cases [1]. Wedding cakes were probably contaminated directly by infected food handlers, or indirectly via contaminated food preparation surfaces or utensils. The majority of illness was associated with eating cakes with a filling requiring substantial direct hand contact during its preparation, indicating that direct contamination of cake ingredients probably occurred.

A major limitation of our investigation was our inability to document norovirus infection in more bakery food handlers. Most bakery employees submitted specimens ~2 weeks after the first contaminated wedding cakes had been prepared; employees who might have been infected during cake preparation might no longer have been shedding virus by the time specimens were collected. A second limitation was our inability to analyse all cake components. All wedding cakes in our study contained the same frosting, thus, we were unable to determine if cake frosting was a vehicle for norovirus transmission, as has been demonstrated for other foodborne norovirus outbreaks [5].

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That none of the food handlers tested positive for norovirus 2 weeks after the wedding weekend suggests that the norovirus outbreak within this food establishment had a short lifespan. In keeping with this hypothesis, a telephone survey of 22 of the 41 weddings catered by the local bakery the following weekend did not identify any illness clusters. The apparent brevity of illness transmission within the bakery is consistent with previously reported durations of person-to-person norovirus outbreaks [16].

Because we were unable to survey all persons who attended a wedding held on the weekend of 26–28 April, catered by this local bakery, we cannot know the burden of illness attributable to this outbreak. If each of the 46 weddings experienced the same median attack rate of 38% that the wedding guests in this study experienced, ~2700 cases of norovirus illness would have been associated with this outbreak; however, this figure may overestimate the burden of disease if attendees who became ill were more likely to complete a questionnaire than attendees who did not become ill. This figure does not include illness among wedding hall employees nor among consumers of smaller, non-wedding cakes prepared by the bakery during that time.

The occurrence of this outbreak emphasizes the importance of preventing foodborne transmission of norovirus. Certain recommendations can be made for achieving this goal. The first is the necessity of optimal hygiene and food-handling practices, even among seemingly well employees. Second, food establishment employers should adopt employee sick-leave policies that discourage food handlers from working while ill. Lastly, because viral shedding can continue after recovery, employers should exclude food handlers for at least 72 h after the cessation of symptoms for illness suspected to be caused by norovirus.

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