Mysterious Outbreaks of Gastrointestinal Illness Associated with Burritos Supplied through School Lunch Programs†

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ABSTRACT

From October 1997 through March 1998, three outbreaks of gastrointestinal illness among school children were linked to company A burritos. In September 1998, a similar outbreak occurred in three North Dakota schools following lunches that included company B burritos. We conducted an investigation to determine the source of the North Dakota outbreak, identify other similar outbreaks, characterize the illness, and gather evidence about the cause. The investigation included epidemiologic analyses, environmental investigation, and laboratory analyses. In North Dakota, a case was defined as nausea, headache, abdominal cramps, vomiting, or diarrhea after lunch on 16 September 1998. Case definitions varied in the other states. In North Dakota, 504 students and staff met the case definition; predominant symptoms were nausea (72%), headache (68%), abdominal cramps (54%), vomiting (24%), and diarrhea (16%). The median incubation period was 35 min and median duration of illness was 6 h. Eating burritos was significantly associated with illness (odds ratio, 2.6; 95% confidence interval, 1.6 to 4.2). We identified 16 outbreaks that occurred in seven states from October 1997 through October 1998, affecting more than 1,900 people who ate burritos from two unrelated companies. All tortillas were made with wheat flour, but the fillings differed, suggesting that tortillas contained the etiologic agent. Results of plant inspections, traceback, and laboratory investigations were unrevealing. More than two million pounds of burritos were recalled or held from distribution. The short incubation period, symptoms, and laboratory data suggest that these outbreaks were caused by an undetected toxin or an agent not previously associated with this clinical syndrome. Mass psychogenic illness is an unlikely explanation because of the large number of sites where outbreaks occurred over a short period, the similarity of symptoms, the common food item, the lack of publicity, and the link to only two companies. A network of laboratories that can rapidly identify known and screen for unknown agents in food is a critical part of protecting the food supply against natural and intentional contamination.

Gastroenteritis among school-aged children is a common phenomenon leading to numerous missed school days for students and missed workdays for parents. Gastrointestinal symptoms among groups of school children following a meal have sometimes been considered psychogenic (1, 11, 18). In this article, we describe 16 related school-based outbreaks of gastrointestinal illness. Some were initially considered psychogenic; we present evidence that they were due to an undetected toxin or an agent not previously associated with foodborne gastrointestinal illness.

From October 1997 through March 1998, three outbreaks of acute gastrointestinal illness among school children occurred in Kansas, Florida, and Georgia. Epidemiologic investigations identified an association between illness and eating burritos from company A. The illnesses were characterized by nausea, headache, abdominal cramps, and vomiting beginning within 60 min of eating the burritos and lasting less than 24 h. In April 1998, company A burritos were recalled, and no further outbreaks linked to company A were reported. Despite extensive laboratory testing of the burritos, the causative agent remained a mystery. The possibility of mass psychogenic illness was raised.

On 16 September 1998, an outbreak similar to the three described above occurred following lunch at the elementary, middle, and high schools in a rural North Dakota town (population 12,000). At the elementary school, the fire department was summoned to hose down the school playground because so many children had vomited; 38 children were sent to the local hospital emergency department. All
children in these schools received free lunch in the school cafeteria. The elementary and middle (EM) schools were housed in the same building and shared a kitchen; the high school used a separate kitchen and was located nearby in another building. The food served in the three schools was similar.

We initiated an investigation to determine the source and extent of the outbreak in North Dakota, determine whether similar outbreaks occurred in other parts of the country, characterize the clinical syndrome, and gather evidence to identify the cause of the outbreak.

**MATERIALS AND METHODS**

**Epidemiologic studies: North Dakota investigation.** All children in the EM schools who attended school on 16 September and ate in the school cafeteria were eligible for inclusion for a retrospective cohort study. A case was defined as nausea, headache, abdominal cramps, vomiting, or diarrhea in a person who ate lunch from the school cafeteria on 16 September 1998 and whose symptoms began within the 3 days following lunch. In the EM schools, only 52% of ill students had eaten lunch from the cafeteria, but all ill students had eaten lunch from the cafeteria. Thus, we conducted a cohort study of the EM school students who had eaten lunch in the school cafeteria on 16 September to determine if a specific food item was associated with illness and to institute control measures. We included only students less than 16 years old who satisfactorily completed the questionnaire. We excluded two students who reported only fever and three who reported only chills. We defined the incubation period as the interval between lunch and the onset of nausea, headache, abdominal cramps, vomiting, or diarrhea, and we defined illness duration as the time between the onset and resolution of symptoms. We also conducted retroactive cohort investigations among the EM school staff and high school students. Other than age, the criteria for inclusion were the same as for the study of EM students.

For children in kindergarten through third grade, questionnaires were completed one-on-one with school or health department staff. Students in grades four through twelve and staff completed the questionnaire themselves. On the original questionnaire, EM school students were asked yes-no questions about all foods they ate for breakfast and lunch and the presence and timing of clinical symptoms. A follow-up questionnaire administered to the same students included questions about the number of burritos they had eaten, the part of the burrito eaten, and a description of the taste of the burritos. The high school students and EM staff completed one questionnaire that included questions from both the original and follow-up EM school questionnaire.

Leftover meals from the EM school kitchen were routinely donated to a local housing development. The coordinator for these daily food deliveries provided a list of the 14 households that received burritos on 16 September. A door-to-door survey was conducted among these households to assess illness.

We reviewed the charts of the 39 patients from the three schools who were seen in the local hospital emergency department on 16 and 17 September 1998. Information collected included date and time of arrival, chief complaint, history of present illness, past medical history, physical examination, and laboratory results. In addition, we interviewed physicians from the only other hospital in the surrounding area and reviewed the emergency department log for 16 and 17 September.

**Epidemiologic studies: national investigation.** To identify other outbreaks, we solicited reports of outbreaks from county and state health departments via phone calls and a letter faxed to all state and territorial epidemiologists and public health laboratories. In addition, we contacted the manufacturers of the suspect burritos, companies A and B, schools, and one juvenile detention center that reported illness to company B. For the purpose of this paper, we henceforth refer to the juvenile detention center as a school. Some outbreak sites involved multiple schools in the same county but were counted as a single outbreak for the purpose of analysis. To explore the possibility of intentional contamination caused by a supplier or disgruntled employee, we reviewed work records, interviewed employees and managers, and researched links between suppliers and manufacturers.

**Environmental investigation: North Dakota.** Local sanitarians inspected the school kitchens and interviewed the staff between 16 and 21 September. We met with the dietician, sanitarians, and kitchen staff, and reviewed the inspections, burrito handling, and cooking procedures. The school provided us with leftover intact frozen burritos from the same lot that was served on 16 September, and we recovered leftover partially eaten burritos from the local landfill; both were sent for laboratory testing. We conducted a traceback of the burritos and their ingredients that extended to all distributors and the manufacturer.

**Environmental investigation: national.** In other outbreak locations, school kitchens were inspected by local sanitarians and we reviewed the inspections, burrito handling, and cooking procedures through written reports and conference calls. We requested that the other involved schools and health departments obtain burrito samples and clinical specimens, conducted a national traceback of products from companies A and B and their tortilla suppliers, and reviewed the results of product recalls initiated by the U.S. Department of Agriculture (USDA) and the burrito manufacturers.

We conducted extensive plant investigations of company B and its tortilla suppliers. The investigating team, which included inspectors and epidemiologists from the earlier investigations of company A and its tortilla suppliers, reviewed reports from the company A investigation; examined burrito preparation, cooking, freezing, storage, and shipping processes; evaluated chemical usage, maintenance procedures, pest control, and employee practices; compared the procedures of companies A and B; and reviewed local health department investigation reports of company B’s tortilla suppliers.

**Laboratory investigation: patients.** In North Dakota, complete blood counts and serum electrolyte and glucose levels were measured for 23 of the 38 patients during the emergency department evaluation of patients. A vomitus sample from one patient was cultured. The USDA, Food Safety and Inspection Service arranged for the analysis of one vomit sample for heavy metals and a general drug screen. No further chemical analysis of the vomitus was done because the sample was discarded. The analysis was performed at the Clinical Toxicology Laboratory, New Jersey Medical School, University of Medicine and Dentistry of New Jersey, Newark. No clinical specimens were available from the other outbreaks.

**Laboratory investigation: food.** Burritos and tortillas were analyzed by laboratories at the USDA, U.S. Food and Drug Administration (FDA), and Centers for Disease Control and Prevention (CDC) as well as by the North Dakota Department of Health Division of Chemistry, the California Food and Agricultural Laboratory, and the North Dakota State University Veterinary Toxicology Laboratory. Multiple laboratories were involved because of their expertise in the various analyses performed.
TABLE 1. Characteristics of illness among elementary and middle school students, high school students, and elementary and middle school staff in North Dakota on 16 September 1998

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Elementary and middle school students (n = 375)</th>
<th>High school students (n = 98)</th>
<th>Elementary and middle school staff (n = 31)</th>
<th>Total (n = 504)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nausea (%)</td>
<td>72</td>
<td>73</td>
<td>68</td>
<td>72</td>
</tr>
<tr>
<td>Headache (%)</td>
<td>65</td>
<td>85</td>
<td>53</td>
<td>68</td>
</tr>
<tr>
<td>Cramps (%)</td>
<td>54</td>
<td>51</td>
<td>58</td>
<td>54</td>
</tr>
<tr>
<td>Vomiting (%)</td>
<td>26</td>
<td>18</td>
<td>10</td>
<td>24</td>
</tr>
<tr>
<td>Diarrhea (%)</td>
<td>12</td>
<td>26</td>
<td>32</td>
<td>16</td>
</tr>
<tr>
<td>Incubation, median (h)</td>
<td>0.6</td>
<td>1.2</td>
<td>1.5</td>
<td>0.7</td>
</tr>
<tr>
<td>Duration, median (h)</td>
<td>6.2</td>
<td>6</td>
<td>12</td>
<td>6</td>
</tr>
</tbody>
</table>

We conducted careful analysis of lot numbers and shipments to ensure that the burritos analyzed were from lots associated with illness. In total, burrito and tortilla samples from five outbreak sites were analyzed. Burritos collected from a USDA lunch program and a commercial market that were not associated with any outbreak served as negative controls.

Burritos and tortillas from the five outbreaks were analyzed for *Bacillus cereus*, *Staphylococcal aureus*, and their emetic toxins, mycotoxins (e.g., deoxynivalenol [DON], acetyl-deoxynivalenol, and other tricotothecenes), trace metals, nonmetal ions (e.g., fluorine), plant toxins (e.g., alkaloids), pesticides (e.g., pyrethrins, organophosphates, and chlorinated hydrocarbons), food additives (e.g., glutamate), and spoilage factors (e.g., biogenic amines). In addition, cell culture assays, brine shrimp assays, mouse feeding studies, and gas chromatography and mass spectrometry were performed in an attempt to detect new classes of agents or toxins.

Following completion of the epidemiologic investigation and laboratory analysis, a veterinary toxicologist (A.-R. M. Kadry) reviewed the outbreak reports as did a medical toxicologist (M. Belson), assisted by the use of two databases (12, 13) to help identify chemical, medicinal, and biologic agents that could have caused these outbreaks.

**Statistical analysis.** We conducted statistical analyses with Epi Info version 6.04 (CDC, Stone Mountain, Ga.) and SAS 8 (SAS Institute Inc, Cary, N.C.). We calculated frequencies of clinical characteristics for the three cohorts in North Dakota both individually and combined and examined factors possibly associated with disease with bivariate and multivariate techniques; we considered a *P*-value of ≤0.05 to be significant. Logistic regression was used to examine multivariable models.

**RESULTS**

**Epidemiologic and clinical investigations: North Dakota.** In total, 975 EM school students reported that they ate the school lunch served on 16 September. Of the 950 (97%) of them who ate the lunch and satisfactorily completed the questionnaire, 375 (40%) had illness that met the case definition. The most common symptoms among those who were ill were nausea (72%), headache (65%), abdominal cramps (54%), vomiting (26%), and diarrhea (12%) (Table 1). The median incubation period was 35 min (Fig. 1), and the median duration of illness was 6.2 h. Nineteen percent of ill students sought health care; none were hospitalized or died. Fifty-six percent of ill students and 44% of well students were female. The median age was 11 years (range, 5 to 15 years) among ill students and 8 years (range, 5 to 14 years) among well students. Most children ate the same foods because the same six food items were placed on every child’s lunch tray. Children ate by grade level, and the lower grades generally ate earlier.

Children in higher grades were more likely to be ill (chi-square for trend, *P* < .001). Controlling for children’s grade level in a multivariate logistic regression model, we found that ill students were significantly more likely than well students to have eaten burritos (OR 91 versus 84%; odds ratio [OR], 2.6; 95% confidence interval [CI], 1.6 to 4.2) (Table 2). Ill students were also more likely to have eaten taco sauce. Although this association was marginally significant after we adjusted for burrito consumption (OR 1.5; 95% CI, 1.0 to 2.1), the two exposures were collinear. In addition, case exposure for sauce was substantially less than for burritos; therefore, we did not include sauce in the descriptive model. Too few students responded to the follow-up questionnaire for us to formally categorize observed burrito taste, and there was no consistent pattern to the responses. Taste descriptions ranged from moldy to sour to metallic; none of the students reported a soapy taste. Too

**FIGURE 1. Onset of symptoms by quarter-hour after lunch among elementary-middle school students, September 1998, North Dakota (n = 266 with data).**
The most common symptoms were vomiting (58%), nausea (53%), abdominal cramps (50%), and headache (11%). Students and staff who ate lunch on 16 September and were evaluated the same day. Overall, 504 (41%) of the students and 575 (42%) of the high school students ate burritos. Overall, 97% of ill high school students and 92% of ill EM school staff ate burritos. On the other hand, 9% of the EM students except that the incubation period was slightly longer (Table 1). In response to an open-ended question about the taste of the burritos, high school students and EM school staff also described a range of tastes without a consistent pattern; three noted a metallic taste and two a soapy taste. We found no dose-response relationship or difference in attack rate associated with when respondents ate lunch. In total, 97% of ill high school students and 92% of ill EM school staff ate burritos. Overall, 504 (41%) of the 1,253 students and staff met the case definition.

Interviewers were able to contact someone in 4 of the 14 households that received leftover burritos from the EM school kitchen. In these households, two people reported being ill within 24 h after eating food left over from the 16 September lunch; both had consumed a burrito. Their symptoms included nausea and abdominal cramps.

We reviewed the medical charts of 39 people treated in the emergency department: 36 EM students, two high school students, and one staff member. In our review of the school nurse's records, we found no increase in the number of visits for illness compared with the previous week. However, questionnaire responses revealed that many of these students and many EM school staff also became ill following the 16 September lunch. Symptom profiles for high school students and EM school staff were similar to those of the EM school students except that the incubation period was slightly longer (Table 1). In response to an open-ended question about the taste of the burritos, high school students and EM school staff also described a range of tastes without a consistent pattern; three noted a metallic taste and two a soapy taste. We found no dose-response relationship or difference in attack rate associated with when respondents ate lunch. In total, 97% of ill high school students and 92% of ill EM school staff ate burritos. Overall, 504 (41%) of the 1,253 students and staff met the case definition.

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We reviewed the medical charts of 39 people treated in the emergency department: 36 EM students, two high school students, and one staff member. In our analysis, we excluded one patient because he developed symptoms before 16 September. All had eaten burritos at the school lunch on 16 September and were evaluated the same day. The most common symptoms were vomiting (58%), nausea (53%), abdominal cramps (50%), and headache (11%). Twenty-one patients (55%) had abdominal tenderness, which was reported as mild in 12 (58%) and severe in 9 (42%). No other muscarinic, nicotinic, or central nervous system findings were noted. No students or staff were hospitalized. No visits because of similar illnesses were identified.

### Epidemiologic and clinical investigations: national.

Including the North Dakota outbreak, we identified 16 outbreaks of similar illness in seven states between October 1997 and October 1998 that were associated with eating burritos served in schools. These outbreaks occurred in Florida (5), Georgia (4), Illinois (2), Kansas (2), Indiana (1), North Dakota (1), and Pennsylvania (1). A total of 1,908 people in 125 schools at these 16 sites reported being ill. All outbreaks occurred in schools. Although case finding was not done for adults in most outbreaks, 41 adult illnesses were documented. The extent of case finding and epidemiologic investigation in the different outbreaks varied; formal epidemiologic investigations done in only seven of them (Table 3). In addition, case definitions varied. In some outbreaks for which no formal epidemiologic investigations were conducted, only people who vomited were counted as cases; whereas, in others, people with vomiting, diarrhea, or abdominal cramps were counted. Outbreaks in Florida, Georgia, and Illinois occurred on the same date as the outbreak in North Dakota.

The clinical characteristics of illness were similar in all 16 outbreaks. Nausea, cramps, or vomiting were present in patients in all outbreaks. Headache was present in more than 30% of patients in five of six outbreaks where this information was obtained. The median incubation period ranged from 10 min to 1 h.

Burritos were epidemiologically implicated in seven outbreaks (Table 3). In the nine other outbreaks for which limited epidemiologic investigations were conducted, most or all ill people ate burritos. All of the burritos were made by the same two unrelated companies (companies A and B).

### Environmental investigation.

In North Dakota, we found no major deficiencies in sanitation, food-handling, or burrito-preparation procedures. No kitchen staff at either school had gastrointestinal illness before the lunch. In the other 15 outbreaks, no major deficiencies were reported.

The first three outbreaks, which occurred from October 1997 through March 1998, were linked to burritos manufactured by company A. No major deficiencies or violations were noted in reports of inspections of company A and its tortilla supplier. After company A burritos were recalled in April 1998, no further outbreaks were linked to company A. The next 13 outbreaks, which occurred from May through October 1998, were linked to company B (Fig. 2). All of the outbreaks were linked to burritos made with tortillas from a single supplier Y. In September 1998, company B recalled burritos made with tortillas from supplier Y. The recall was restricted to such products because the outbreaks began a few months after company B changed from tortilla supplier X to supplier Y. Although two outbreaks occurred after the recall, both were linked to product made before the recall. More than two million pounds of burritos were recalled or held from distribution.

Burritos consist of meat or vegetable filling wrapped in a corn or wheat flour tortilla. North Dakota company B burrito filling consisted of water, beef, beans, seasoning (salt, spices, sugar, paprika, paprika extract, onion powder,
dehydrated garlic, dextrose), textured vegetable protein (TVP) (soy protein concentrate, caramel color, zinc oxide, niacin amide, ferrous sulfate, copper gluconate, vitamin A palmitate, calcium pantothenate, thiamine mononitrate, pyridoxine hydrochloride, riboflavin, cyanocobalamin), and tortillas consisted of enriched bleached wheat flour (flour, malted barley flour, niacin, reduced iron, thiamine mononitrate, riboflavin, folic acid), water, vegetable shortening (partially hydrogenated soybean and cottonseed oil), and leavening (sodium acid phosphate, sodium bicarbonate, cornstarch, monocalcium phosphate), salt, calcium propionate, potassium sorbate, monosodium phosphate, annatto color. The fillings of the burritos served in the 16 outbreaks varied: beef and pinto beans in 13 outbreaks, chicken and pinto beans in 1 outbreak, pork-sausage and egg in 1 outbreak, and beef in 1 outbreak. The tortillas in all 16 outbreaks were made with wheat flour. Company A and its tortilla supplier were located in Colorado; company B and its tortilla suppliers were located in Illinois.

All of the burritos were labeled as USDA-inspected and supplied to school lunch programs. The North Dakota schools purchased the burritos with federal funds for the National School Lunch Program; this information was not obtained for the other outbreaks. In 15 outbreaks, the burritos were prepared and frozen at company A or B and then heated at the schools. In the other outbreak, the filling was prepared in the schools from ingredients purchased locally and wrapped in tortillas supplied by company B. In that outbreak, company B had purchased tortillas from supplier Y and repackaged them for distribution in a company B box.

The spices and minor ingredients did not vary substantially. Companies A and B had no common first-line suppliers of ingredients. However, the tortilla supplier for company A obtained approximately 40% of its wheat from North Dakota, and all the wheat for the tortillas used by company B was from North Dakota. Grain from North Dakota used to make the tortillas was reportedly stored in silos on farms and later as flour in silos at the tortilla producer's factory. During the season that the grain was harvested for the tortillas, flooding had occurred in North Dakota, and farmers and mill operators reported that some of the grain crop was moldy.

To allow for appropriate cooling, company B reported that burritos should be shipped 72 h or more after packaging. In reviewing records of shipping times, we found that burritos associated with outbreaks were often shipped early. This analysis, however, was limited by incomplete shipping records. For example, at some outbreak sites, lots were identified that were not listed in the shipping records and therefore could not be included in the analysis. Records were available for 858 lots shipped during the outbreak period from May through August 1998. These records included lots that were involved in outbreaks in seven school districts. The lots were shipped from less than 1 day to 133 days after being produced and packaged. Three (50%) of six lots shipped within 1 day of packaging were associated with outbreaks as were 3 (23%) of 13 lots shipped within 2 days, and 2 (6%) of 32 lots shipped within three days of packaging (chi square = 0.047). Although the records were less precise for lots shipped 3 or more days after packaging, only between 1 and 3% (between 11 and 22 of 807) of such lots could be linked to outbreaks.

Plant inspections of companies A and B and their re-

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### TABLE 3. Burrito-associated outbreaks for which formal epidemiologic evaluations were conducted in the United States from October 1997 through October 1998

<table>
<thead>
<tr>
<th>Date</th>
<th>State</th>
<th>No. ill</th>
<th>Company</th>
<th>Association with burrito consumption</th>
<th>Measure of OR or RR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>October 1997</td>
<td>Kansas</td>
<td>226</td>
<td>A</td>
<td>OR</td>
<td>21.2</td>
<td>5.8-101.3</td>
</tr>
<tr>
<td>February 1998</td>
<td>Florida</td>
<td>18</td>
<td>A</td>
<td>RR</td>
<td>14.8</td>
<td>3.4-64.0</td>
</tr>
<tr>
<td>March 1998</td>
<td>Georgia</td>
<td>155</td>
<td>A</td>
<td>RR</td>
<td>7.1</td>
<td>3.8-13.0</td>
</tr>
<tr>
<td>August 1998</td>
<td>Florida</td>
<td>635</td>
<td>B</td>
<td>OR</td>
<td>40.0</td>
<td>5.0-850.0</td>
</tr>
<tr>
<td>September 1998</td>
<td>North Dakota</td>
<td>500</td>
<td>B</td>
<td>OR</td>
<td>5.5</td>
<td>1.5-24.0</td>
</tr>
<tr>
<td>September 1998</td>
<td>Georgia</td>
<td>107</td>
<td>B</td>
<td>RR</td>
<td>2.2</td>
<td>1.5-3.2</td>
</tr>
<tr>
<td>October 1998</td>
<td>Florida</td>
<td>58</td>
<td>B</td>
<td>OR</td>
<td>8.8</td>
<td>1.8-47.6</td>
</tr>
</tbody>
</table>

*OR, odds ratio; RR, relative risk; CI, confidence interval.
*a Case definitions varied from more inclusive (e.g., North Dakota: nausea, headache, abdominal cramps, vomiting, or diarrhea) to more restrictive (e.g., Kansas: nausea, abdominal cramps, or vomiting.*
testing was not done.
grew a pure culture of complete blood counts, serum electrolytes, and glucose lev-
early department evaluation in North Dakota had companies A and B.

Laboratory investigation. All 23 patients from the emergency department evaluation in North Dakota had complete blood counts, serum electrolytes, and glucose levels within normal laboratory reference ranges. The vomitus sample collected at the hospital emergency department grew a pure culture of Staphylococcus aureus; enterotoxin testing was not done.

Extensive chemical and microbiological testing was performed in nine laboratories (six federal, one state, and two academic) from November 1998 through February 2001. The results for all analyses on burritos and tortillas were negative (Table 4) with two exceptions. The aluminum concentration was above the reference range. Octicizer, an organophosphate ingredient used in the production of plastics, was detected in trace amounts in the burrito and tortilla samples that were associated with the outbreaks and in control burritos. The concentration of octicizer could not be quantified; however, the amount in the control burritos was lower than in those associated with the outbreak.

DISCUSSION

We identified 16 outbreaks of a distinctive acute gastrointestinal syndrome linked to burritos over a 13-month period. The variety of fillings in outbreak-associated burritos, the fact that outbreaks linked to company B burritos began shortly after that company changed its tortilla supplier, and the association of one outbreak with burritos produced with locally made filling but tortillas from an implicated company strongly suggest that the etiologic agent was in the tortillas. These outbreaks affected over 1,900 people participating in school lunch programs. A recall of burritos likely prevented further cases. The remarkably short incubation period, the clinical symptoms, and negative laboratory data suggest that these outbreaks were caused by an undetected toxin or an agent not previously associated with foodborne illness.

Mass psychogenic illness is an unlikely explanation for these outbreaks for several reasons: the number and location of sites where outbreaks occurred over a short period, the similarity of symptoms, the common food item, the lack of publicity, and the link to only two companies. However, it is possible that a psychogenic component contributed to the number of reported cases of illness in some locations.

The short incubation period and the symptoms of the illness suggest that a preformed toxin or other short-acting agent that targets the stomach or upper intestine is the etiologic agent. However, the symptom complex in these outbreaks does not fit the usual clinical spectrum for the known causes of short-incubation gastrointestinal illness. The agent's likely introduction in two unrelated tortilla plants and the recognition of outbreaks with only certain batches of tortillas both suggest that the agent was introduced intermittently possibly via a contaminated ingredient or piece of equipment. The early shipping of burritos before appro-

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priate cooling may have provided an environment that allowed the causative agent to flourish or produce toxin if it were living. Characteristics of the etiologic agent might include the ability to survive the baking, storage, or reheating processes; moderate to high potency; and indistinct organoleptic properties.

In outbreaks caused by Bacillus cereus emetic toxin and S. aureus enterotoxin, headache is not a prominent feature, and the usual incubation period is 2 to 4 h (10, 14). Because S. aureus is routinely found in the oropharynx, we did not consider a single culture of S. aureus isolated from a vomitus sample to be significant. Moreover, food samples from five outbreaks were negative for B. cereus and S. aureus organisms and toxins. In norovirus outbreaks, the incubation period is longer (24 to 48 h), the duration of illness longer (12 to 60 h), and the proportion of patients with vomiting is higher (over 50%) than in the burrito-associated outbreaks. In addition, secondary transmission of noroviruses to household members occurs commonly (9) but was not reported in the burrito-associated outbreaks.

Pesticide poisoning typically causes additional symptoms that were not described in these outbreaks, nor were pesticides, alkaloids, or biogenic amines detected in the burritos or tortillas. Some metals, such as cadmium, copper, iron, tin, barium, and zinc, can irritate mucosal membranes and cause sudden gastrointestinal illness; however, the only metal that was mildly elevated in the burritos was elemental aluminum, which has not been reported to cause these symptoms (3, 8). Calcium chloride ingestion can cause rapid-onset nausea and vomiting, but in amounts large enough to induce symptoms, the food would likely taste too salty to be palatable. Moreover, the calcium levels in the burritos and tortillas were not elevated. Two metals not included in the screen were thallium and antimony. However, thallium poisoning is typically associated with neurologic symptoms, and antimony food poisoning usually occurs when the metal is leached by acidic foods in a metallic container. Signs and symptoms of people who became ill were not compatible with thallium poisoning, and the burritos and tortillas were packaged in plastic bags or cardboard boxes.

Several plant toxins, such as phytohemagglutinin, may survive cooking and cause gastrointestinal symptoms; however, previous outbreaks associated with phytohemagglutinin have been linked to red kidney beans and not pinto beans, which were an ingredient in some of these burritos (17). Furthermore, beans were not in the filling of burritos associated with two of the outbreaks, and results of tests for these compounds were negative. The soy protein found in TVP may cause gastroenteritis; however, TVP can also cause other symptoms such as difficulty breathing, facial flushing, and swelling of the tongue, lips, or face (7). Moreover, TVP was not an ingredient in burritos associated with two of the outbreaks.

Although octicizer was detected in trace amounts in outbreak-associated burritos, this organophosphate seems an unlikely cause of these outbreaks. Burritos were not in direct contact with plastic before consumption. They were placed in a cardboard box; the box was then wrapped in
TABLE 4. Laboratory testing of burrito and tortilla samples from five outbreaks in the United States from October 1997 through October 1998

<table>
<thead>
<tr>
<th>Type of analysis</th>
<th>Analyte</th>
<th>Burrito sample</th>
<th>Methods</th>
<th>Results</th>
<th>Laboratory*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace metals</td>
<td>Aluminum, arsenic, barium, boron, cadmium, calcium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, sodium, tin, zinc</td>
<td>Whole, filling, tortilla</td>
<td>AAS</td>
<td>Aluminum: tortilla, 44.8–178 ppm; filling, 5.62–15.3 ppm. Other metals: within expected range</td>
<td>ND DOH; USDA, FSIS, East</td>
</tr>
<tr>
<td>Nonmetal ions</td>
<td>Bromates</td>
<td>Whole, filling, tortilla</td>
<td>GC-EC</td>
<td>Nondetectable</td>
<td>USDA, FSIS, East</td>
</tr>
<tr>
<td>Bacterial culture</td>
<td><em>Staphylococcus aureus</em></td>
<td>Whole</td>
<td>Culture</td>
<td>Negative</td>
<td>USDA, FSIS, East</td>
</tr>
<tr>
<td>Bacterial toxins</td>
<td><em>Bacillus cereus</em> enterotoxin</td>
<td>Whole</td>
<td>ELISA, ELFA</td>
<td>Nondetectable</td>
<td>USFDA CFSAN</td>
</tr>
<tr>
<td>Mycotoxins</td>
<td>Vomitoxin (deoxynivalenol [DON]), 2-tetraolufusarenone-</td>
<td>Whole, flour, tortilla</td>
<td>GC-MS; LC-DAD</td>
<td>Vomitoxin: tortilla, 0.1–0.4 ppm; flour, 0.6 ppm. Other mycotoxins: nondetectable to 0.2 ppm</td>
<td>NDSU; USFDA CFSAN</td>
</tr>
<tr>
<td>Plant toxins</td>
<td>Alkaloids</td>
<td>Whole</td>
<td>LC-DAD</td>
<td>Nondetectable</td>
<td>USFDA FCC</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Organochlorine pesticides</td>
<td>Whole</td>
<td>GC-EC</td>
<td>Nondetectable</td>
<td>USDA, FSIS, West</td>
</tr>
<tr>
<td>Food additives</td>
<td>Glutamate</td>
<td>Whole</td>
<td>LC</td>
<td>Below level of concern</td>
<td>USDA, FSIS, West</td>
</tr>
<tr>
<td>Spoilage</td>
<td>Biogenic amines: putrescine, spermidine, spermine, cadaverine, tyramine</td>
<td>Whole</td>
<td>LC</td>
<td>Below level of concern</td>
<td>USDA, FSIS, Midwest</td>
</tr>
<tr>
<td>Chemical</td>
<td>Chlorinated pesticides, organophosphate pesticides, n-methyl carbamate pesticides</td>
<td>Whole</td>
<td>LC-FD</td>
<td>Nondetectable</td>
<td>CA/DFA</td>
</tr>
<tr>
<td>Chemical</td>
<td>Volatile and semivolatile contaminants; visual appearance</td>
<td>Whole</td>
<td>Examination under UV and visible light; pH testing; headspace GC, GC-FID following acid/base extraction</td>
<td>Nondetectable</td>
<td>USFDA FCC</td>
</tr>
<tr>
<td>Chemical</td>
<td>2-Clorocitric</td>
<td>Whole, filling, tortilla</td>
<td>GC-AED; GC-MS</td>
<td>Positive, not quantifiable</td>
<td>CA/DFA</td>
</tr>
<tr>
<td>Brine shrimp toxicity</td>
<td>Unknown material causing acute toxicity in brine shrimp</td>
<td>Whole</td>
<td>GC-AED; GC-MS</td>
<td>Negative</td>
<td>USDA ARS</td>
</tr>
<tr>
<td>Mouse toxicity</td>
<td>Unknown material causing acute toxicity in brine mice</td>
<td>Whole</td>
<td>Brine shrimp bioasssay</td>
<td>Negative</td>
<td>USDA ARS</td>
</tr>
<tr>
<td>Cell cytotoxicity</td>
<td>Bacterial toxins</td>
<td>Whole</td>
<td>Mouse bioassay</td>
<td>Negative</td>
<td>CDC/FDDB</td>
</tr>
</tbody>
</table>

*a* For certain analyses, the flour, filling, and tortilla were analyzed separately and as part of the whole burrito.

*b* AAS, atomic absorption spectroscopy; ELISA, enzyme-linked immunosorbent assay; ELFA, enzyme-linked fluorescent assay; GC-EC, gas chromatography–electron capture detection; GC-AED, gas chromatography–atomic emission detection; GC-MS, gas chromatography–mass spectrometry; LC-DAD, liquid chromatography–diode array detection; LC-FD, liquid chromatography–fluorescence detection.

*CA/DFA, California Department of Food and Agriculture; CDC/FDDB, Centers for Disease Control and Prevention, Foodborne and Diarrheal Diseases Branch, Atlanta, Ga.; ND DOH, North Dakota Department of Health Division of Chemistry; NDSU, North Dakota State University; USDA, FSIS, East, U.S. Department of Agriculture, Food Safety and Inspection Service, Eastern Laboratory; USDA, FSIS, West, U.S. Department of Agriculture, Food Safety and Inspection Service, Western Laboratory; USDA, FSIS, Midwest, U.S. Department of Agriculture, Food Safety and Inspection Service, Midwestern Laboratory; USFDA CFSAN, U.S. Food and Drug Administration Center for Food Safety and Nutrition; USFDA FCC, U.S. Food and Drug Administration, Forensic Chemistry Center; USDA ARS, U.S. Department of Agriculture, Agricultural Research Service.*
plastic. While tortillas were packaged in plastic bags, several tortillas were in each bag and only the tortillas that were on the outside had much direct contact with the bag. On the other hand, after the outbreak, investigators used plastic to wrap the burrito samples that were shipped to laboratories for testing. This could have introduced octicizer from the plastic into the burrito samples. Octicizer irritates the skin and, if ingested, may cause vomiting. Octicizer, like other organophosphate compounds, may also produce muscarinic, nicotinic, and central nervous system effects such as miosis, lacrimation, dyspnea, and frequent urination. These types of symptoms were not reported in these outbreaks and none of these findings were identified during the emergency department chart review.

Outbreaks with symptoms similar to those described in this report have occurred in China and India, where they have been linked to consumption of products made with grains contaminated with fungi. Some fungi produce heat-stable trichothecene mycotoxins called vomitoxin or DON (6) that in high doses cause vomiting in pigs (19). In China, 35 outbreaks affecting 7,818 people during 1961 through 1985 were attributed to consumption of foods made with moldy grain (15). Corn and wheat samples collected during these two outbreaks had higher levels of DON than those collected at other times. In 1987, 97 people in India became ill after consuming wheat products following heavy rains (5). DON and other trichothecene mycotoxins were detected in the implicated wheat products, and the extracted toxins caused vomiting in puppies. Damp conditions, such as occurred during the growing season in North Dakota when grain was harvested for these tortillas, can cause molds to form. However, results of laboratory tests of burrito samples showed DON levels to be within the acceptable FDA advisory level of 1 ppm for finished wheat products (2). Testing for rare mycotoxins was also negative.

Several detergents and cleaning materials were present in the building where burritos and tortillas were made. These compounds may cause nausea, vomiting, and abdominal cramps, but good screening tests for detergents in food do not exist. Although burritos were not specifically tested for individual detergents, detergents often contain phosphate, which was not elevated in the metal screen. In addition, detergents generally have low toxicity, and a dose high enough to cause illness would likely be accompanied by a soapy taste, making the food unpalatable. Nevertheless, we cannot eliminate the possibility that a detergent caused these illnesses.

Although the burrito testing was broad and much more extensive than routine testing for toxins in food, laboratory analyses did not include tests for some toxic chemicals, such as boric acid, iodine, and nitrates, and some plant toxins, such as ricin and cardiac glycosides. We considered most of these toxins or chemicals unlikely to be the causative agent for the following reasons: their likely degradation in the preparation, storage, or cooking process; the presence of incompatible symptoms or the absence of pathognomonic symptoms; and the absence of typical organoleptic signs in case subjects. We considered other possible agents to be unlikely because of the color of emesis and the absence of particular symptoms (e.g., autonomic dysfunction suggesting nitrates; arrhythmias suggesting ricin or oleaner). Alkaline cleaning solutions were thought unlikely to be the cause, given the absence of oropharyngeal involvement and the similar pH in outbreak and control burritos.

Many more cases of this illness likely occurred than were recognized. Most of these outbreaks came to the attention of public health officials because they occurred in schools where many people eat the same meal at the same time in the same place. Some outbreaks may not have been recognized, such as the high school outbreak in North Dakota, which was not initially detected. While the manufacturers primarily produced burritos for purchase by schools, they also sold burritos and tortillas to restaurants and supermarkets. Some other people who ate these products may have become ill; however, because their symptoms would likely have been self-limited, they may not have recognized them as food related and may not have received medical attention; thus, their illnesses would not have been reported to public health authorities or the companies. The variation in symptom frequencies reported in the different outbreaks may be related to differences in case finding methods and case definitions.

Even outbreaks of mild illnesses in school children elicit intense concerns among parents and school officials (4) and can have important implications for the communities involved. For example, in North Dakota, some parents of school children reportedly feared that the government was poisoning their children and lost confidence in the school lunch program. Following the outbreak, some children brought lunch from home, and the school stopped donating food to the local housing community. School officials feared losing federal funding from the National School Lunch Program because of the decline in participating students.

Recognizing outbreaks of illness is key to ensuring that investigations to identify the food item are conducted and that control measures are instituted quickly. Parents and teachers should be encouraged to report possible outbreaks among students to their local health department because some outbreaks may only be recognized in schools (16). Symptoms should not be dismissed too quickly as psychogenic illness. The cause of these outbreaks remains a mystery. If future outbreaks of a similar illness should occur, we recommend quickly obtaining clinical specimens (urine, serum, vomitus, and stool) in consultation with the local health authorities and the CDC. It is also critical to save leftover food samples, food shipping containers, and receipts; too often food is quickly discarded and therefore cannot be analyzed. The thorough and timely investigation of outbreaks among school children and other groups is an important component of maintaining a safe food supply. Given the possibility of intentional contamination of the food supply, a critical need exists for a network of laboratories that can rapidly test large numbers of clinical and food specimens for a broad spectrum of agents and to screen for unknown agents. To meet this need, the CDC is building the Laboratory Response Network for Bioterror-
ism, a multilevel system designed to link state and local public health laboratories with advanced capacity clinical, military, veterinary, agricultural, and water- and food-testing laboratories.

Note added in proof. Ten similar outbreaks were reported to the Massachusetts Department of Public Health and are described in the January 2006 Morb. Mortal. Wkly. Rep. ("Multiple outbreaks of gastrointestinal illness among school children associated with consumption of flour tortillas, Massachusetts 2003–2004").

ACKNOWLEDGMENTS

We thank the following individuals and organizations for their assistance with the epidemiologic investigation and laboratory testing in these outbreaks: H. Casper and B. Tacke, North Dakota State University, Veterinary Toxicology Laboratory; G. Holcomb, Jr. and P. L. Lacey, Hall County Environmental Health, Hall County Health Department, Georgia; T. W. McCoy and M. A. Stancil, Health District 2, Georgia; J. A. Benson, L. L. Cobb, M. L. Ray, M. M. Park, E. A. Franko, and M. E. Scarborough, Georgia Department of Human Resources; P. J. Vukelic, L. A. Shireley, and Del Streit, North Dakota Department of Health; M. Friedman, N. Richey, and R. Hammond, Bureau of Environmental Epidemiology, Florida Department of Health; M. Lee, California Department of Food and Agriculture; L. Duphenais and J. Check, Indian Health Service; Center for Food Safety and Applied Nutrition and Office of Regional Operations, Food and Drug Administration, Office of Public Health and Science; C. L. Reding, M. Niemann, T. Hoepper, L. Manis, D. Gomez-Trost, P. Rappolee, D. Blank, M. Lankford, M. Prat, J. Hutchins, V. Cook, M. Head, B. Cray, J. Drees, C. Henry, T. Mallinson, J. Groneck, E. Grandy, J. Donohue, K. Holland, R. Wilson, S. Hafner, A. Self, B. King, K. Gultrie, and B. Stancel, Food Safety and Inspection Service, U.S. Department of Agriculture; W. P. Norred, C. W. Bacon, and K. A. Voss, Agricultural Research Service, Toxicology and Mycotoxin Research Unit, Athens, Ga.; M. Belson, Health Studies Branch, National Center for Environmental Health, CDC; C. A. Bopp, P. Mead, and R. Tauxe, Division of Bacterial and Mycotic Diseases, National Center for Infectious Diseases, CDC.

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