Outbreaks of salmonellosis associated with eating uncooked tomatoes: implications for public health

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SUMMARY

Laboratory-based surveillance of salmonella isolates serotyped at four state health departments
(Illinois, Michigan, Minnesota and Wisconsin) led to the identification of multistate outbreaks
of salmonella infections during 1990 (176 cases of *S. javiana*) and 1993 (100 cases of *S.
montevideo*). Community-based case-control studies and product traceback implicated
consumption of tomatoes from a single South Carolina tomato packer (Packer A) MOR 16·0;
95 % CI 2·1, 120·6; $P < 0\cdot0001$ in 1990 and again in 1993 (MOR 5·7; 95 % CI 1·5, 21·9;
$P = 0\cdot01$) as the likely vehicle. Contamination likely occurred at the packing shed, where field
grown tomatoes were dumped into a common water bath. These outbreaks represent part of a
growing trend of large geographically dispersed outbreaks caused by sporadic or low-level
contamination of widely distributed food items. Controlling contamination of agricultural
commodities that are also ready-to-eat foods, particularly fruits and vegetables, presents a
major challenge to industry, regulators and public health officials.

INTRODUCTION

Changes in the American diet are a major contributor to the changing epidemiology of foodborne diseases [1]. In recent years, there have been a number of public health efforts to prevent cardioavascular disease and cancer and to increase consumption of fresh fruits and vegetables [2]. Annual *per capita* consumption of fresh fruits and vegetables in the United States increased by 50 pounds (27%) from 1970 to 1994 [3]. This increase may be associated with an increased burden of foodborne diseases. Since 1989, multistate outbreaks of salmonellosis have been associated with tomatoes, cantaloupes and alfalfa sprouts [4, 5]. Along with other produce-associated outbreaks, such as *Shigella flexneri* infections associated with scallions and *Cyclospora* infections associated with raspberries, these represent part of a growing trend of large geographically dispersed foodborne outbreaks caused by sporadic or low-level contamination of widely distributed food items [1, 6, 7].

In this report we describe our epidemiologic investigations of two multistate outbreaks of salmonellosis associated with consumption of uncooked, fresh tomatoes. The first outbreak, caused by *S. javiana*, occurred in 1990, and cases were identified in Minnesota, Illinois, Michigan and Wisconsin. The second outbreak, caused by *S. montevideo*, occurred in 1993, and also involved the same four midwestern states. Each outbreak was detected by surveillance reports of a temporal clustering of an uncommon salmonella serotype. These two outbreaks shared numerous epidemiologic features, including an apparent common source. The results of these investigations and subsequent laboratory studies of salmonella and tomatoes have important implications for the detection and control of outbreaks of salmonellosis and gastroenteritis due to other bacterial, viral or parasitic pathogens that may contaminate fresh fruits and vegetables.

METHODS

Surveillance

State Public Health Laboratories in Illinois, Michigan, Minnesota and Wisconsin serve as reference laboratories for serotyping human salmonella isolates from residents of their respective states. Serotype-specific information is used by public health officials for surveillance to detect unusual clustering of cases by time, location or serotype.

When clusters are detected, patients are interviewed by an epidemiologist or public health nurse from the state or a local health department. Interviews are conducted to ascertain foods eaten, date of illness onset, symptoms and whether other family members were ill. If hypothesis-generating interviews fail to identify common restaurants, grocery stores or community events that could link individual cases, epidemiologists from other state health departments and the Centers for Disease Control and Prevention (CDC) are typically notified to determine if the observed clusters are part of larger outbreaks.

Laboratory

Outbreak 1

During 1990, all *S. javiana* isolates from Michigan and a convenience sample of isolates of *S. javiana* from Illinois, Minnesota and Wisconsin were submitted to the Michigan Department of Public Health (MDPH) for plasmid analysis, agarose gel electrophoresis of plasmid DNA and pulsed-field gel electrophoresis (PFGE) of chromosomal DNA to characterize an outbreak-associated strain. For the purposes of the surveillance case totals and case-control study, all patients with *S. javiana* were included unless the patient's *S. javiana* isolate was subtyped and found not to be the outbreak-associated strain.

Outbreak 2

During 1993, molecular subtyping by PFGE was conducted by both the Minnesota Department of Health (MDH) and CDC. Therefore, all isolates of *S. montevideo* from Minnesota and Wisconsin were submitted to MDH and all isolates from Illinois, and a convenience sample of isolates from Michigan, Minnesota, Wisconsin, and other states were submitted to CDC for PFGE [8]. Molecular subtypes defined by PFGE in Minnesota were compared with those identified at CDC to characterize an outbreak-associated strain. Because PFGE results were available for all isolates, only patients with the outbreak-associated strain were included for purposes of surveillance case totals and the case-control study.

Case-control studies

Outbreak 1

Two independent case-control studies were conducted by MDH and MDPH. A case was defined as a patient with the outbreak-associated strain of *S. javiana*

isolated from a stool sample collected in June or July. Cases were matched by age, gender and telephone exchange to one community control. In Minnesota, cases ≤ 19 years of age were matched to controls ± 5 years, and cases ≥ 20 years of age were matched to controls ± 10 years. In Michigan, cases were matched to controls ± 5 years of the case's age. Cases were excluded if a household member experienced a diarrhoeal illness in the 2 weeks preceding the case's illness. Interviews were conducted by telephone to ascertain histories of food consumed in the 5 days before onset of illness for cases and a comparable reference period for controls in both studies. Following the initial results demonstrating an association between illness and consumption of tomatoes, cases and controls in both studies were reinterviewed to elicit details of tomato consumption. In Minnesota, other members of case households were also interviewed to ascertain their histories of tomato consumption and occurrence of diarrhoeal illness. In households where tomatoes were prepared and consumed at home, details of tomato storage and handling also were obtained.

Outbreak 2

Two independent case-control studies were conducted by MDH and Illinois Department of Public Health. A case was defined as a patient with the outbreak-associated strain of *S. montevideo* isolated from a stool sample collected in July. The investigation in Minnesota used similar methods as in 1990 except it included residents of both Minnesota and Wisconsin, and two controls were matched for each case. In Illinois, one control was matched for each case and controls were asked about potential exposures in the most recent 5-day period that matched the 5-day exposure period for cases. For example, a case and matched control would both be questioned about foods eaten from Monday through Friday, but not for the same dates. Both 1993 studies matched controls ± 1 year of age up to 5 years for cases ≤ 5 years, ± 3 years for those between 6 and 19 years, and ± 10 years for cases ≥ 20 years.

In both 1990 and 1993, cases and controls identified the retail grocery store or food service establishment from which they purchased and consumed fruits and vegetables, including tomatoes. In 1990 this was accomplished by reinterviewing cases and controls after tomatoes were implicated during preliminary analyses. In 1993 this was incorporated into the primary interview. Subsequently, the distributors who

supplied these retail stores or establishments were identified. Each layer of the distribution system back to production source was traced to the extent possible by officials from the respective State Departments of Health and Agriculture, CDC and the US Food and Drug Administration. Several distributors and packers provided information on their tomato packing operations and distribution of tomatoes in 1990 and 1993.

Statistical analyses

Univariate matched odds ratios and 95 % confidence intervals were determined with Epi-Info, version 5 (USD Universal, Stone Mountain, GA). All exposures found to be associated with illness at $P < 0.10$ by univariate analyses were included in a conditional logistic regression model through stepwise addition of variables [9]. Combined analyses from the separate case-control studies were conducted in an unmatched manner.

RESULTS

Surveillance

Outbreak 1

In 1990, 176 outbreak-associated cases of *S. javiana* infection were identified in Minnesota (84), Illinois (63), Michigan (21) and Wisconsin (8) with dates of illness onset from 28 June through 24 August (Fig. 1). The median age for cases was 28 years (range: 4 months to 86 years), and 51 % of cases were 20–39 years of age (Table 1). Ninety-four (53 %) cases were female. Within the community-wide outbreak, a smaller cluster of cases was identified with a common exposure. Fourteen cases were teachers or children who attended a single child-care centre in Minnesota. Excluding cases associated with the child-care centre did not change the median age.

Outbreak 2

In 1993, 100 outbreak-associated cases of *S. montevideo* infection were identified in Illinois (59), Wisconsin (30), Minnesota (8) and Michigan (3) with dates of illness onset from 29 June through 2 August (Fig. 1). There were no apparent common exposures among the cases, although three had eaten independently at the same small Illinois restaurant during the first week of July. The median age of cases was 27 years (range: 4 months to 72 years); 54 % of cases
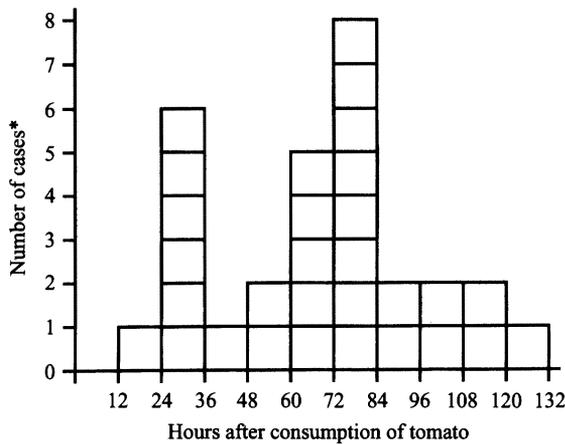
Fig. 1. Outbreak-associated *Salmonella javiana* infections (outbreak 1, 1990) and *Salmonella montevideo* infections (outbreak 2, 1993) in Illinois, Michigan, Minnesota and Wisconsin.

Table 1. *Age distribution of persons with outbreak-associated* Salmonella javiana *or* S. montevideo *infections, Illinois, Michigan, Minnesota and Wisconsin, 1990 and 1993*

Age group	1990 S. javiana*		1993 S. montevideo	
	No.	(%)	No.	(%)
0–9	23	(13)	8	(8)
10–19	17	(11)	19	(19)
20–29	56	(34)	32	(32)
30–39	32	(17)	22	(22)
40–49	23	(13)	12	(12)
> 50	21	(12)	7	(7)

* Age was not reported for four cases of *S. javiana* infection in 1990.

were 20–39 years of age (Table 1). Fifty-four (54%) were female.

Laboratory

Outbreak 1

The outbreak-associated strain of *S. javiana* had a single 50-megadalton plasmid with a common plasmid DNA restriction pattern (12 isolates tested) and a common chromosomal DNA restriction pattern (3 isolates tested). All 9 *S. javiana* isolates tested from Illinois (4), Wisconsin (3) and Minnesota (2) were identified as the outbreak-associated strain. Twenty-

one of 24 Michigan *S. javiana* isolates were identified as the outbreak-associated strain. Three had a different pattern and were related to a local outbreak of *S. javiana* infections associated with a pig roast that occurred earlier in 1990.

Outbreak 2

Thirty-eight (68%) of 56 *S. montevideo* isolates from Wisconsin and Minnesota and 59 (82%) of 72 from Illinois possessed a common chromosomal DNA restriction pattern that defined the outbreak-associated strain. In addition, three isolates from Michigan and one from Missouri also were determined to be the outbreak-associated strain.

Case-control studies and tomato trace back

Outbreak 1

Thirty-four cases and 34 controls were enrolled in the Minnesota case-control study; 12 cases and 12 controls in Michigan. Initial univariate analyses in Minnesota demonstrated that only consumption of tomatoes was associated with illness. Thirty (91%) of 34 cases and 17 (50%) of 34 controls reported eating tomatoes (MOR 7·5%; 95% CI 1·7, 32·8). Eating tomatoes in restaurants was associated with illness in both states. In Minnesota, 25 (74%) cases and 9 (26%) controls reported eating tomatoes in a restaurant (matched odds ratio [MOR] 6·3; 95% confidence interval [CI] 1·9, 21·4; P = 0·001). In Michigan, 10 (83%) cases and 4 controls reported a similar history (OR 10·0; 95% CI 1·1, 118; P = 0·01). Altogether, 35 (76%) cases and 13 (28%) controls reported eating tomatoes in a restaurant (OR 8·1; 95% CI 2·9, 23·1; P < 0·001). In contrast, 22 (52%) cases and 22 (52%) controls reported eating tomatoes from a grocery store. Tomatoes were also identified as a likely source for illness at the child-care centre by a separate case-control study including the first 11 ill teachers and children matched to 11 well teacher and child controls (MOR, 3·0; 95% CI 0·6, 14·9).

Eating lettuce in restaurants appeared to be associated with illness in Minnesota; 26 (76%) cases and 13 (38%) controls reported eating lettuce in restaurants (MOR 5·3; 95% CI 1·6, 18·3; P = 0·01). However, 85% of persons who ate lettuce in restaurants also ate tomatoes in restaurants, and this association disappeared after controlling for tomato consumption (Mantel–Haenszel summary OR 1·5;

95% CI 0·8, 2·8; $P = 0·3$). Tomatoes remained associated with illness after controlling for lettuce consumption (Mantel–Haenszel summary OR 5·0; 95% CI 1·5, 17·1; $P = 0·02$). No other food items were associated with illness.

We ascertained the producer source of tomatoes eaten by the cases and controls in the Minnesota investigation. Twenty-one cases (62%) and six controls (18%) ate tomatoes from restaurant or grocery sources that obtained them from distributors who, in turn, received tomatoes from a tomato packer located in South Carolina (Packer A) (MOR 16·0; 95% CI 2·1, 120·6; $P < 0·001$). No other potential tomato sources were independently associated with illness. The association with Packer A remained when the source of tomatoes was analysed among only those cases and control who ate tomatoes (OR 4·3; 95% CI 1·0, 18·7; $P = 0·02$). The sources of tomatoes eaten by cases in Michigan and Wisconsin were also traced; 9 (75%) of 12 cases in Michigan and 5 (62%) of 8 in Wisconsin ate tomatoes purchased from restaurants or grocery stores supplied, in part, by Packer A. In addition, tomatoes served 2 days before the first onset of illness associated with the outbreak at the child-care facility in Minnesota were obtained from a distributor supplied by Packer A.

Six of the nine Minnesota cases who did not eat tomatoes in a restaurant purchased the implicated tomatoes at a grocery store and consumed them at home. In these households, 8 (62%) of the 13 other household members who ate tomatoes also developed a diarrhoeal illness within 7 days after eating them, while three who did not eat tomatoes remained well (Fisher's exact test, $P = 0·2$). Tomato-handling practices were assessed in five of these households. In three households in which tomatoes were stored in the refrigerator and washed and cored before eating, 7 (64%) of 11 who ate the tomatoes became ill. Thus, these practices, which had been recommended by public health officials in Minnesota, did not appear to prevent infection.
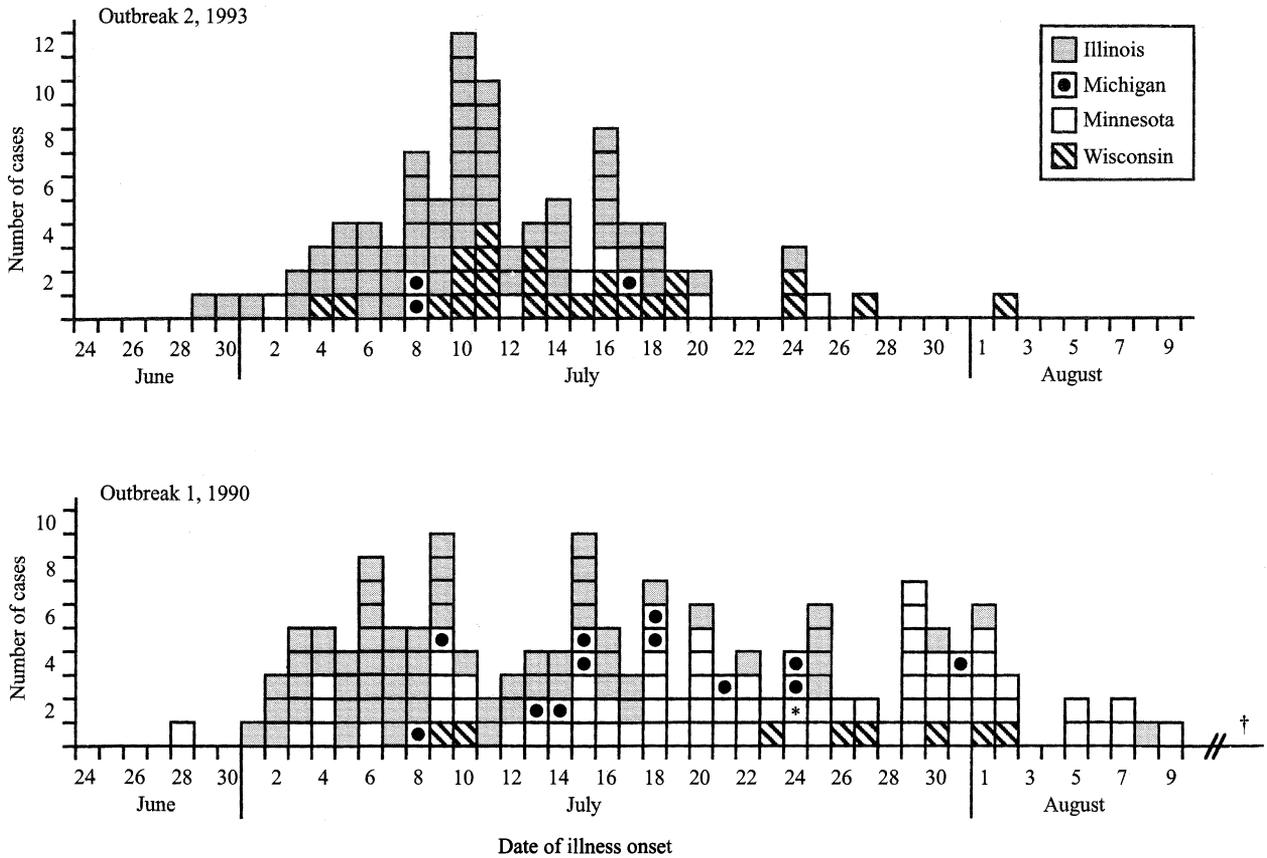
Outbreak 2

Seventeen cases and 34 controls were enrolled in the Minnesota/Wisconsin case-control study; 59 cases and 59 controls in Illinois. Based on our experiences in 1990, we incorporated retail sources of consumption into the initial univariate analysis. Eating tomatoes in restaurants was associated with illness in both Minnesota/Wisconsin (MOR 5·3; 95% CI 1·2, 24·0;

$P = 0·01$) and Illinois (MOR 2·4; 95% CI 1·2, 4·9; $P = 0·01$); overall, 44 (58%) of 76 cases and 25 (27%) of 93 controls in the two studies reported eating tomatoes from a restaurant. In Minnesota/Wisconsin there was a borderline association between illness and eating lettuce in restaurants (MOR 5·5; 95% CI 0·9, 32·2; $P = 0·1$), but this apparent association disappeared after controlling for tomato consumption (Mantel–Haenszel summary OR 1·0; 95% CI 0·2, 6·1; $P > 0·3$). In the Illinois study, the association between lettuce consumption and illness was stronger (MOR 3·4; 95% CI 1·5, 8·0; $P = 0·01$), and all persons who reported eating tomatoes also reported eating lettuce; thus, stratification of lettuce consumption by tomato consumption was uninformative. Further investigation of the types of lettuce eaten in Illinois revealed a strong association between illness and eating lettuce which the restaurant had received as head lettuce (MOR 15·0; 95% CI 2·0, 113·6; $P < 0·01$).

Tracebook of the tomatoes in Minnesota/Wisconsin revealed that cases were more likely than controls to have eaten tomatoes that originated from a tomato packer (Packer A) in South Carolina (MOR 5·7, 95% CI 1·5, 21·9; $P = 0·01$); 13 (76%) of 17 cases versus 12 (35%) of 34 controls ate tomatoes from retail sources that received tomatoes from Packer A.

In both investigations combined, 33 cases reported eating tomatoes at only one restaurant in the 5 days before onset of symptoms. These included 30 (70%) of the 43 cases in the two case-control studies who reported eating tomatoes from a restaurant, and 3 with the outbreak strain of S. montevideo who were identified in other states (2 in Michigan and 1 in Missouri) among persons who had travelled to Illinois during the outbreak and eaten tomatoes at only one restaurant during their visit. Five distributors (two in Illinois and one each in Michigan, Minnesota and Wisconsin) supplied the tomatoes to the restaurants identified by these 33 cases. Four of these distributors, which supplied tomatoes eaten by 31 cases, received tomatoes during the outbreak from Packer A; therefore, tomatoes shipped from Packer A were likely eaten by 31 (94%) of 33 cases selected for traceback.

Traceback of lettuce eaten by cases in Illinois revealed no common sources. Approximately 50% of the restaurants where cases had eaten lettuce received lettuce as head (iceberg) lettuce, half as shredded lettuce. Shredded lettuce was supplied by four commercial shredding companies, head lettuce by eight companies; although all obtained lettuce from Cali-

*Onset of first illness in a day care centre outbreak. Other day care centre cases not individually represented.

†One Illinois case had onset on 14 August; one Minnesota case had onset on 24 August.

Fig. 2. Incubation periods for cases of salmonella infection after consumption of implicated tomatoes.

fornia, the growing and packing sources of lettuce were distinct.

Packer A operations

The South Carolina tomato packing facility of Packer A was in operation seasonally for 3–4 weeks in June and July 1990 and 1993. Packer A obtained tomatoes from 12 independent growers located within several miles of the facility. Tomatoes were grown in raised beds that were covered in plastic. The plants were tied to stakes to keep the ripening fruit off the ground. In fields that were irrigated, water from wells or surface ponds was delivered to the plants by a drip irrigation system. Because environmental inspections occurred after production had stopped for the season, no water samples were collected for microbial culture.

Mature green tomatoes were picked by hand and placed in wooden bins large enough to hold 1500 pounds of tomatoes. These were hauled by truck to the packing house. There, the tomatoes were dumped into a heated, chlorinated water bath located in a

roofed receiving area outside the packing house. Chlorine gas was used to chlorinate the water; however, chlorine levels were not routinely monitored or recorded. Subsequently, the tomatoes were rinsed, sorted by size, waxed and placed in 25-pound boxes. Depending on demand, these boxes were either stored up to a week at the packing house, treated with ethylene gas to ripen for colour, or shipped out. Tomatoes were hauled in refrigerated trailers at 50–60 °F by independent truckers. Each truckload contained as many as 1600 boxes of tomatoes. No common truckers were identified as potential sources of contamination in either 1990 or 1993.

In 1990, Packer A began operations on 11 June, with the first shipment of tomatoes to Minnesota on 15 June. These tomatoes were received by a distributor on 18 June, and the first purchases of tomatoes by a case occurred on 22 June. In 1993, Packer A began operations on 14 June, but did not ship any tomatoes until 21 June. Tomatoes shipped on 21 June were received by an Illinois distributor on 23 June. Tomatoes from this shipment were sent to an Illinois

restaurant on 27 June, and were likely eaten by the first outbreak-associated case on 28 June.

Determination of incubation periods

Thirty cases (11 with *S. javiana* infections in 1990 and 19 with *S. montevideo* infections in 1993) had only one identified tomato meal from the implicated source. These cases had onset of illness 12–120 h after eating the implicated tomato; the median incubation period was 72 h (Fig. 2). Data were similar for the two outbreaks. Our findings may actually underestimate the median incubation period, since exposures more than 5 days before onset of illness were not determined.

DISCUSSION

Extensive independent investigations of these two outbreaks suggest that they were caused by consumption of uncooked, fresh tomatoes that came from a single tomato packer (Packer A) located in South Carolina. Several types of evidence support this conclusion. First, the age distribution of cases suggested a food vehicle not commonly consumed by children [10]. Over half of cases were 20–39 years of age, twice the proportion (26%) in this age range among all salmonella infections reported in CDC in 1993. Second, results of multiple case-control studies conducted during both outbreaks showed an association between tomato consumption and illness in particular, with tomatoes eaten at restaurants. Third, results of tomato tracebacks in Minnesota, Michigan and Wisconsin in 1990 and in Minnesota, Wisconsin and Illinois in 1993 identified Packer A as the most likely source for outbreak-associated tomatoes. Finally, the appearance of the outbreaks coincided with Packer A's seasonal operations in South Carolina.

Although tomatoes are not a commonly recognized vehicle for salmonella, laboratory studies have shown that tomatoes and other fresh fruits and vegetables can support the growth of salmonella and other enteric bacterial pathogens such as shigella and *Escherichia coli* O157:H7 [11–13]. In addition, the potential for tomatoes to serve as a vehicle was demonstrated by two studies financed by the tomato industries of South Carolina and Florida in the wake of these outbreaks [14, 15]. These studies were designed to emulate actual tomato-handling practices. Results indicated that tomatoes placed in water cooler

than the tomato pulp will absorb water and salmonella organisms into the core tissues through the stem scar. In addition, these studies demonstrated that salmonella can survive on the skin of tomatoes and multiply to high numbers on cut or sliced tomatoes held at room temperature. An additional study demonstrated that salmonella inoculated onto a stem scar could be transferred into the tomato by a knife blade used to cut the tomato [16].

Our findings and the results of this applied research suggest some potentially important control strategies to reduce the likelihood of similar outbreaks. Chlorination of the water bath that tomatoes were dumped into at the packing house was a critical control point to prevent contamination of tomatoes from bird droppings, organic debris or other contaminated tomatoes in the tank [17]. Inadequate monitoring of this control point likely contributed to the occurrence of this outbreak. Water used in the processing of all fruits and vegetables should be potable and chlorinated to maintain sufficient levels of free chlorine to compensate for the continual addition of organic material. However, even at very high chlorine levels (> 320 ppm) it may not be possible to eliminate salmonella contamination.

In restaurants, tomato-handling practices such as chopping and pooling large numbers of tomatoes and holding chopped tomatoes at room temperature could have allowed 'one bad tomato to spoil the whole bunch'. Such practices also may have led to cross-contamination of other fresh produce items, such as head lettuce, which also requires extensive handling.

Although handling of tomatoes in restaurants may have amplified the initial source of contamination, tomatoes eaten at home also contributed to these outbreaks. The high attack rate among household members who ate tomatoes and the relative absence of illness among those who did not, suggest that these illnesses were caused by consumption of the contaminated tomatoes. Of note, in most of these households, tomatoes were washed and cored before eating, as was recommended by health officials after the initial findings of the *S. javiana* outbreak investigation were released. Although specific details of how tomatoes were washed at home were not ascertained, this finding and the results of other studies suggest that individual consumers may be limited in their ability to decontaminate fresh produce items [18].

Field-grown produce items are ready-to-eat foods with inherent risks for contamination by enteropathogens. This presents a major challenge to industry

and regulators. Hazard analysis and critical control point (HACCP) plans can be developed by fresh produce handlers and processors; however, these control points are capable of reducing contamination and preventing cross-contamination rather than eliminating it. Packer A continues to operate under a HACCP plan developed after the occurrence of the 1993 outbreak [17]. While no subsequent outbreaks of salmonellosis have been attributed to this operation, eliminating microbial risks from consumption of fresh produce may require the use of technologies such as ionizing pasteurization (i.e. irradiation) to kill pathogenic contaminants.

Our experiences suggest at least four reasons why similar large, geographically dispersed foodborne outbreaks are likely to go unrecognized. First, such outbreaks, if caused by a relatively common salmonella serotype may not be recognized because of the high background level of sporadically occurring cases. Second, if they are recognized, the source of the outbreaks may not be determined unless molecular subtyping is used to exclude unrelated sporadic cases; inclusion of the non-outbreak-associated infections with the same serotype can reduce the likelihood of finding an association. Third, the source of foodborne outbreaks is difficult to determine when, as in these outbreaks, incubation periods extend beyond 72 h. If public health officials only obtain 3-day food histories, critical exposures will not be identified. In addition, longer incubation periods limit accurate recall and reduce the likelihood of implicating a food item. Fourth, when a foodborne outbreak is recognized and a produce item is implicated, the original source of the item is seldom identified because determining the production source of the food item requires an intensive product traceback and the cooperation of regulatory agencies, retailers, distributors and produce packers. Finally, as in these investigations, perishable food items may have been consumed before the investigations were conducted; and may not be available for microbial culture.

These outbreak investigations demonstrate both the usefulness and limitations of current public health surveillance systems. In other salmonella outbreaks caused by widely distributed food items, as few as 0·5% of cases were confirmed by culture and reported [19]. Applying similar estimates to these outbreaks, as many as 35000 cases of S. javiana infection may have occurred in 1990, and as many as 20000 cases of S. montevideo infection may have occurred in 1993. Despite the apparent magnitude of these outbreaks,

their recognition depended on the occurrence of uncommon salmonella serotypes. Although serotyping has been critical for public health surveillance of salmonella infections, additional approaches such as molecular subtyping of common salmonella serotypes are needed to enhance surveillance of these important foodborne pathogens. Most important, clinicians must continue to obtain appropriate stool specimens from patients with diarrhoea and fever or bloody diarrhoea or patients who they suspect may be part of an outbreak. In these cases, physicians should consider not only the treatment of the patient but the broader community benefits of detecting outbreaks of foodborne disease. Without this critical first step, the utility of public health surveillance of foodborne illness will be greatly limited.

ACKNOWLEDGEMENTS

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