Review

Foodborne Outbreaks in Canada Linked to Produce

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ABSTRACT

Examples of foodborne outbreaks traced to fresh fruits and vegetables can be found worldwide. The quantity of produce eaten per capita has been increasing steadily over the past two decades, creating a heightened potential for produce-related foodborne disease. A number of outbreaks identified during this time period were reviewed, with particular emphasis placed on incidents that have occurred in Canada. The collective information highlights the diversity of infectious agents and produce items involved, with a view to the prevention of fresh produce-related foodborne disease in the future.

The variety and availability of fresh fruits and vegetables on our grocery store shelves are increasing rapidly. Today’s consumer is becoming better educated about the health benefits of fresh fruits and vegetables and the additional benefit of consuming produce in the raw state. Our increased knowledge is due, in part, to educational and promotional programs, including publication and widespread distribution of Canada’s Food Guide, which recommends the eating of 5 to 10 servings of fruits and vegetables (raw or cooked) each day (2). In the United States, a 1991 joint venture sponsored by The National Cancer Institute and a nonprofit consumer education foundation, the Produce for Better Health Foundation, started a national program titled “5 a Day for Better Health.” The programs’ objectives are to help increase awareness of the importance of eating five to nine servings of raw or cooked fruits and vegetables per day and to provide consumers with information on how they can add these foods to their diets (21, 63).

Vegetarianism, which became popular in the 1960s and 1970s, is now being challenged by a more stringent diet known as raw foodism (19, 46). The proponents of this diet eat only organically grown, uncooked, and unprocessed fruits, vegetables, and seeds (20, 46), claiming the heating process alters the nutritional components of all foods—fruit, vegetable, and animal—to such a degree that the quality of our lives, including our life expectancy, is seriously diminished (35, 36). The vast majority of individuals will likely never embrace such a radical change in eating habits; nevertheless, our expanded awareness and the subsequent increase in the amount of raw and fresh-cut produce eaten have led to new safety concerns.

With modern modes of transportation and communication making our world smaller, we no longer rely exclusively on the local farmer to provide produce for our evening meal, particularly when harsh weather makes growing these foods difficult to impossible. In today’s world, the fresh alfalfa sprouts in your sandwich may have originated in the Netherlands; the lettuce in your salad, from Mexico; and your cantaloupe dessert may have been picked by a Chilean farmer 2 days earlier. This globalization of the food chain has also led to the introduction in our diets of foods previously unknown to many of us. A further influence, particularly in North America, is the marked change in demographics over the past 20 years. North America has become home to people from all over the globe, who have brought with them their unique culinary traditions. This has led to an unprecedented demand for fresh fruits and vegetables, previously unfamiliar and unavailable.

In response to consumer demand, food establishments began changing their menus. Gradually, restaurants, including fast food restaurants, began serving more raw produce, often in the form of self-serve salad bars, and raw vegetarian main courses. Inadequate washing and storage of the produce can lead to the growth and spread of pathogenic organisms. In addition, there is an increased potential for cross-contamination by both food handlers and restaurant patrons.

Another notable influence on our eating habits is the fact that, in general, people today tend to lead more hurried lives than in the past. In addition to the rapid rise in the number of fast food restaurants, we are now demanding more take-home, ready-to-eat foods. Our grocery stores and delicatessens are providing us with a variety of in-store prepared foods, including ready-to-eat prepackaged fresh fruits and vegetables. New packaging technologies, such as modified atmosphere packaging, have been evolving in an attempt to increase the shelf life of fresh-cut fruits and vegetables. Under modified atmosphere conditions, pathogens can potentially grow at a faster rate than the food spoilage organisms, whereas under normal atmospheric circumstances, pathogens may not be given the opportunity to multiply. This is particularly dangerous when the produce appears to
be safe, while at the same time, pathogens have grown to levels that can cause illness (42, 43).

Along with the increased amount of fresh produce consumed, there has been a corresponding rise in the number of reported cases of foodborne disease linked to produce. The Centers for Disease Control and Prevention (CDC) in Atlanta, Ga., has documented that the number of produce-related outbreaks reported in the United States doubled between 1973 and 1987 and again between 1988 and 1991 (68). Certain mitigating factors must be kept in mind when interpreting these numbers. One important consideration is the number of newly identified pathogens, as well as pathogens previously not associated with foodborne illness, that have emerged in the last 20 years (67). A partial list of these organisms includes *Escherichia coli* O157:H7, *Listeria monocytogenes*, *Campylobacter jejuni*, *Cryptosporidium parvum*, and *Cyclospora cayetanensis*, all of which have been implicated in produce-related foodborne outbreaks in the past two decades. In addition, diagnostic methods, including methods that allow for the molecular typing of isolates, have improved significantly. These techniques have increased our ability to identify specific microorganisms that may be present in low numbers or be sublethally injured, as well as to establish the clonality of food and clinical isolates. Widespread use of computer-linked databases and the Internet has resulted in more efficient worldwide surveillance systems, which in turn have increased awareness of the role fresh produce plays in the spread of foodborne illness (68).

The main focus of this paper is a review of the foodborne outbreaks that have occurred in Canada, which have been specifically linked to produce. The causative agent responsible for each incident, the circumstances that contributed to the outbreak, and the lessons learned from them will be examined.

**PRODUCE OUTBREAKS WORLDWIDE**

The serious nature and scope of this issue can be seen in outbreaks that have occurred globally. They include a variety, but by no means an exhaustive account, of microorganisms that have been implicated in foodborne incidents, from bacteria to viruses to parasites, as well as a wide range of implicated fruit and vegetable products. For example, in the spring and summer of 1996, radish sprouts (kaiware daikon) contaminated with *E. coli* O157:H7 were found to be the predominant vehicle of infection in 14 clusters of illness involving more than 10,000 people in Japan (75). The largest of these clusters affected 6,400 school children and staff from 62 elementary schools in Sakai City, as well as 160 secondary contacts. One hundred one patients developed hemolytic uremic syndrome, resulting in two deaths (4). In a second cluster, 47 factory workers in nearby Kyoto became ill, with one death reported from hemolytic uremic syndrome-associated encephalopathy (5, 75). Pulsed-field gel electrophoresis (PFGE) and randomly amplified polymorphic DNA patterns from both clusters were identical (75). Health authorities have speculated that the water beds in which the kaiware were grown may have been contaminated (5). Sprouts have been implicated in several additional foodborne outbreaks throughout the world. Among them was a 1994 multinational outbreak of *Salmonella Bovismorbificans* in Finland and Sweden, which was traced to alfalfa sprouts grown from the same lot of Australian seeds. Approximately 400 people were known to have contracted salmonellosis from this source (55). Contaminated alfalfa sprout seeds originating from the same seedlot were again implicated in 64 cases of *E. coli* O157:H7 in the U.S. states of Michigan and Virginia in the summer of 1997 (12).

In 1993, the CDC identified enterotoxigenic *E. coli* O6:NM as the causative agent in 168 reported illnesses in Rhode Island and New Hampshire. Fresh U.S.-grown carrots were found to be the vehicle of infection (3). Green onions from Mexico were implicated in an unusual number of illnesses attributed to *Shigella flexneri* 6A in several U.S. states (68). Cantaloupe was the source of a 1989 to 1990 outbreak of *Salmonella Chester*, in which there were 245 reported cases in at least 30 U.S. states resulting in two deaths. It was estimated that 25,000 people were likely affected—the vast majority, as is usually the case, being unreported (1, 64). Two notable vegetable-related incidents of *Shigella sonnei* infection occurred in 1994 in northwestern Europe and in 1998 in Denmark. The first was traced to iceberg lettuce imported from Spain (34, 48), while in the second outbreak, uncooked baby maize imported to Denmark from Thailand was considered the most likely source of illness in at least 25 of 140 reported cases (15). Before these incidents occurred, a 1986 outbreak of *S. sonnei* in Texas sickened 347 patrons who had eaten at three separate restaurants between 30 August and 7 October. Follow-up studies implicated shredded lettuce supplied from a single lettuce shredding plant. It was suspected that the contamination originated from a food handler and that the processing method, including a failure to wash food contact surfaces until the end of the day and holding the finished product at or near 14°C for up to 6 h, may have led to the spread of the infectious agent. Research on the outbreak strain showed that the organism was able to multiply rapidly on shredded lettuce held at 22°C and survive refrigeration for at least 7 days (32). A similar study using shredded cabbage revealed that the organism can survive and sometimes multiply after 3 days of storage at refrigeration temperatures. Vacuum packaging, modified atmosphere packaging, and aerobic storage of the cabbage all yielded similar results (60).

There are few reports of produce-associated botulism in the literature. However, one such incident occurred in Denver, Colo., in 1992. In this case, a mother and son developed the disease as a result of eating potato salad that had been temperature abused. It was theorized that there were *Clostridium botulinum* spores on the surface of the raw potatoes. These spores survived cooking, then germinated and produced toxin when held at room temperature (28). A botulism outbreak in 1987 sent four circus performers in Sarasota, Fla., to the hospital. Shredded cabbage, used in coleslaw and most likely packaged in a modified atmosphere, was the implicated vehicle of infection (62).

A recent addition to the growing list of organisms...
known to cause human foodborne disease related to produce is the parasite *C. cayetanensis*. *C. cayetanensis* is a protozoan pathogen that can cause prolonged diarrheal illness in humans. Untreated, the symptoms can last for several weeks, with remitting relapses sometimes occurring over a 1- to 2-month period (31). Because the oocytes are noninfectious when excreted and must sporulate in the environment to become infectious, direct person-to-person transmission is deemed unlikely. Food and water are considered to be the main vehicles responsible for the dissemination of this parasite (29, 31). Since 1996, there have been numerous foodborne illness reports associated with *Cyclospora* in both Canada and the United States. Illness has been primarily, but not exclusively, linked to the spring harvest of raspberries grown in Guatemala.

In 1997, fresh mesclun, a mixture of various types of baby lettuce leaves, was implicated in several clusters of *Cyclospora*-related food poisoning. An outbreak in mid-March caused illness in 29 patrons of a Tallahassee, Fla., restaurant. The source of the lettuce in this outbreak was either the United States or Peru. The latter is an area known to be endemic for *Cyclospora* (53). Two additional clusters, possibly linked to mesclun and possibly related to the Tallahassee outbreak, were reported in early April. The first involved five people who had eaten in a restaurant elsewhere in Florida, and the second caused illness in at least 45 people on a cruise ship that had sailed out of Florida in late March. In early December 1997, salad (which included mesclun) imported from Peru was implicated in 12 cases of illness associated with a catered dinner in Orlando, Fla. (33, 38).

Fresh basil was the vehicle in a *C. cayetanensis* outbreak in the Virginia, Maryland, and District of Columbia area in June and July of 1997. Fifty-seven clusters were reported, affecting 341 people. Circumstances relating to where and how the basil became contaminated could not be conclusively determined; however, the possibility that the product was contaminated locally could not be discounted (7, 11, 38). A second basil-associated outbreak occurred in Missouri in July 1999. At least two clusters and 64 cases of illness were reported. It was considered unlikely that the product, which originated from a Mexican or U.S. farm, was contaminated by handlers involved in the food preparation. This was the first U.S. outbreak in which *Cyclospora* was detected in the implicated food, as most cases involve fresh produce, and leftovers are usually unavailable for testing (38).

Viruses, most notably hepatitis A, have also been identified as being responsible for a number of outbreaks associated with eating fresh fruits and vegetables. One such example occurred in the United States in 1997. It was a multistate outbreak causing illness in more than 230 people, primarily children, from 36 schools in Maine and Michigan, as well as sporadic cases in various other states. Frozen strawberries grown in Mexico, processed in California, and served as part of the federal school lunch program were ultimately found to be strongly associated with this outbreak (8, 9, 44). Molecular typing of isolates showed that various clusters of illness were related. The point of entry of the virus into the berries could not be firmly established, although it is speculated that contamination may have occurred during harvest, as toilet and hand-washing facilities were poor, and harvesters were required to hull each berry by hand (44).

Imported salad items were linked to two separate outbreaks of hepatitis A in Finland in 1996 to 1997 (54), and, in 1998, calicivirus, one of the small round structured viruses, was responsible for an outbreak, again in Finland, involving hundreds of office workers who had eaten frozen raspberries in the company canteen (56).

### PRODUCE OUTBREAKS IN CANADA

Statistics published by Health Canada in its annual “Foodborne and Waterborne Disease in Canada” reports help define the scope of the foodborne disease problem in Canada (see Table 1). The reports collate data from across the country, categorized by etiological agent and broad and specific food types. Analysis of the fresh produce data available from 1984 to 1993 reveals that the number of reported incidents and cases in this time period varied significantly from year to year, with no discernible pattern emerging. For example, the number of incident and case reports in the coleslaw and vegetable salad category in 1992 was 24 and 131, respectively, while in 1988, only five incidents and seven cases of illness were recorded. The 1985 figures for raw fruits showed 21 and 55 incident and case reports, with no documented cases on record for 1993 (70–73). When adjusted for the high percentage of unreported cases, the actual number of outbreaks and cases is significantly higher. One figure used in Canada in an attempt to estimate the true scope of foodborne disease is 350 unreported cases for every one reported (69).

Using the above ratio of 1/350, the number of people in Canada who contract foodborne illness per year is estimated to be 2.2 million. The total economic cost, including the value of deaths, was calculated in the range of $1.335 billion (Canadian) in 1985. When converted to the year 2001 dollar equivalent, this cost is an estimated $2.081 billion (69).

The following paragraphs provide an account of fresh produce outbreaks that have occurred in Canada.

### Bacterial: *L. monocytogenes*

The only Canadian produce-related outbreak associated with *L. monocytogenes* occurred in the Maritime provinces between March and September of 1981. Forty-one cases were identified during this period, comprising 34 perinatal cases and seven nonpregnant adults. Of the 34 perinatal cases, there were five spontaneous abortions, four stillbirths, and 23 live births of seriously ill full-term or premature infants. Six of the 23 babies delivered later died. Significant clinical manifestations were absent in only two of the 34 perinatal cases diagnosed. Six of the seven adult cases developed bacterial meningitis, and one was diagnosed with aspiration pneumonia and sepsis. Two of the six meningitis cases were fatal. This was the first outbreak where the vehicle responsible for foodborne transmission of listeriosis to humans was clearly demonstrated. The successful investigation was the result of col-
laboration among the Laboratory Centre for Disease Control in Ottawa, the CDC, and public health personnel from Nova Scotia, New Brunswick, and Prince Edward Island, as well as medical experts from Dalhousie University in Halifax, Nova Scotia. Case control studies traced the cause of the outbreak to cabbage used by a regional producer to prepare coleslaw. Bacterial analysis of an elderly patient’s sputum and blood, as well as leftover coleslaw found in the man’s housekeeping accommodations, revealed the presence of *L. monocytogenes* serotype 4b, the same serotype associated with the outbreak. This led to coleslaw being added to the case control questionnaires and the revelation that all the pregnant mothers involved in the outbreak had eaten coleslaw sometime during their pregnancy. Investigators identified a farm where two sheep had died from listeriosis (circular disease) in 1979 and 1981. Both raw and composted sheep manure were used to fertilize the farm’s cabbage fields, and a large portion of the harvested crop was put into cold storage over the winter and early spring. *L. monocytogenes* was most likely introduced into the cabbage by means of the infected manure, and, because *L. monocytogenes* is able to survive and reproduce at refrigeration temperatures, the prolonged cold storage may have allowed the organisms to proliferate while the non-pathogenic spoilage organisms were decreasing in numbers. In addition, two unopened packages of the implicated coleslaw, purchased at two separate supermarkets and subjected to prolonged cold storage, tested positive for *L. monocytogenes* serotype 4b (41, 61).

**Bacterial: Salmonella.** In the summer of 1991, 78 confirmed cases of *Salmonella* Poona, a serovar seldom isolated from humans, were reported to the Laboratory Centre for Disease Control in Ottawa. The national distribution included Ontario (69), Quebec (3), Manitoba (3), Saskatchewan (2), and Newfoundland (1). During this same time period, more than 300 lab-confirmed human *Salmonella* Poona infections were reported in 23 U.S. states. Case control studies determined that cantaloupe from fruit salad and salad bars was the vehicle of infection. Traceback studies on the cantaloupe revealed that they were likely imported from Texas, although it is unknown whether they were actually grown in Texas or in another, more southern location, such as Mexico (2). It has been suggested that in most, if not all, instances, the contaminated melon pieces were left at room temperature for several hours before being eaten, thus providing favorable conditions for the *Salmonella* to multiply. Investigators were unable to isolate *Salmonella* from the fruit, as in most cases it had been consumed or discarded.

Clustering of an uncommon serotype—in this case, *Salmonella* Oranienburg—led to the identification of another cantaloupe-related outbreak in May and June of 1998. The outbreak occurred in southern Ontario, where 22 cases of illness were reported to the Ontario Ministry of Health. This compared to 10 and 14 cases identified in 1996 and 1997, respectively. Case control studies conducted on 20 of the cases revealed that 17 and possibly 18 of those affected had consumed cantaloupe during the period in question. Phage typing and PFGE on isolates from 19 of the 20 cases were indistinguishable. During the months of May and June, cantaloupes purchased in Ontario are imported from various southern locations, including the United States, Mexico, and Central America. An attempt to trace the cantaloupe back to a common supplier was unsuccessful (20).

A study conducted by the Food and Drug Administration in the United States estimated that approximately 1% of cantaloupe and watermelon rinds are contaminated with *Salmonella* (1). The latter study included melons from many growing areas in several countries. Melons grow in contact with the ground; therefore, their surfaces are potentially exposed to animal excrement and a large number of parasites and bacterial species, including pathogens, which can survive and grow in the soil. As with many fruits, the cantaloupe rind provides a natural biological barrier preventing contamination of the edible interior. Problems occur when the melon is sliced and *Salmonella* or other foodborne pathogens are transferred from the outer surface onto the edible fruit inside. The situation is exacerbated if the fruit is time abused, temperature abused, or both, thus allowing bacteria to multiply (64).

Foodborne pathogens were first identified in alfalfa sprouts in 1973 (57), but it was not until 1995 that sprouts became recognized internationally as a serious and relatively frequent vehicle of foodborne infection. In the spring of 1995, an international outbreak of *Salmonella* Stanley caused illness in approximately 242 individuals in Finland and 17 U.S. states. Thirty isolates of the same strain were also reported from British Columbia (BC), Canada, during this time period (49, 59). The outbreak was traced to alfalfa seeds supplied by the same Dutch shipper (49). Molecular typing and antimicrobial resistance patterns, concurrent with an uncommon serotype, aided in the recognition that these outbreaks originated from a common source (58).

Between 1 December 1995 and 14 January 1996, 26 isolates of *Salmonella* Newport were reported by the BC Provincial Laboratory at the BC Centre for Disease Control. This compares to only 15 reports of this serotype in the first 11 months of 1995. During this same time period, the state of Oregon was experiencing a similar increase in the isolation of *Salmonella* Newport (76). In total, 133 outbreak-related cases were identified in these two geographic areas (74). Case control studies undertaken in both BC and Oregon pointed to alfalfa sprouts as the causative agent. Further investigation found that the implicated sprouts were from a single contaminated seedlot purchased from a U.S. distributor, who had imported the seeds from the Netherlands. The Dutch exporter in turn had bought the seeds from various countries, but, due to inadequate record keeping, it was not possible to trace them to their country of origin. Isolates from both countries were forwarded to the Laboratory Centre for Disease Control for phage typing, PFGE, and antibiotic profiles. Fifty-eight of 61 BC isolates tested had matching antibiogram profiles and were phage type 2, a type rarely identified in Canada. The six isolates analyzed by PFGE exhibited indistinguishable banding pat-
terns. Analogous tests on the Oregon cultures matched the BC findings (74, 76).

In February through May of 1996, Quebec experienced an unusual increase in the number of Salmonella Newport isolates. Sixty cases were identified, with epidemiological studies again pointing to alfalfa sprouts. Salmonella Newport was isolated from sprout samples obtained from a Quebec producer. Further study revealed that the path of the Quebec seeds from farm to fork paralleled that of the BC-Oregon outbreak. Phage typing, antibiograms, and PFGE patterns on the human and alfalfa sprout isolates provided additional confirmation that the outbreaks were linked (76).

Between August and October of 1995, six states in the central and eastern regions of the United States had reported an unusual increase in the number of Salmonella Newport isolations. Studies of these cases, as well as an outbreak in Denmark in June of that year, showed that in all likelihood, these cases were also manifestations of the same widespread protracted outbreak (74).

In the fall of 1997, an unusual increase in the number of human isolates of Salmonella Meleagridis was reported to Canada’s National Enteric Surveillance Program. Seventy-eight cases of this rare serotype were reported between January and October, with 43 of those cases originating in Alberta. Between 1993 and 1995, only 10 cases of this serotype had been recorded in Canada. In an attempt to explain this anomaly, epidemiological case control studies were conducted in the province of Alberta. Food histories compiled during visitation to seven homes revealed that six cases had consumed alfalfa sprouts; sprouts recovered from one of these homes tested positive for Salmonella Meleagridis. The Alberta production plant and the company’s other plants in Ontario and Saskatchewan used imported seeds; sprouts were grown from these seeds were implicated in the cases. Phage typing conducted on isolates from all three provinces exhibited identical results (30). The final case count at the end of this outbreak totaled 124 (17).

There are many opportunities for sprout seeds to become contaminated with foodborne pathogens. If pathogens are present, even in small numbers, the germination and sprouting process, with its high moisture conditions, nutrients, pH, and temperatures of between 21 and 25°C, provides an ideal climate for many pathogenic organisms to survive and multiply (51). Furthermore, sprouts are generally eaten raw, often without washing, with no kill step before they are consumed (74). Conditions and practices in the sprouting facilities appear to play a significant role in the safety of sprouts. Conditioned seedlots should contain a minimum of 50% (by weight) seed that is viable and sproutable to reduce the risk of contamination. Germination and sprout quality. One of the obstacles to effective treatment is the possibility that organisms hide in the crevices of the seeds between the cotyledon and testa and are relatively inaccessible to treatment (26, 47, 65, 66).

**Bacterial: E. coli.** Most outbreaks and sporadic cases of E. coli O157:H7 in Canada have been associated with products of bovine origin, including roast beef, unpasteurized milk, and, most frequently, undercooked ground beef. However, in 1995, 21 people associated with the Peel Memorial Hospital, an acute care facility in southern Ontario, contracted verotoxigenic E. coli O157:H7 infection. Among those ill were 8 patients, 10 staff members, and 3 volunteers. Two additional cases of secondary transmission to family members were also reported. Although no food samples were available for testing, epidemiological studies concluded that a single box of imported iceberg lettuce was the vehicle of infection. On receipt of the lettuce, kitchen staff had filed an incident report, citing heavy spoilage. Stool samples were obtained from 19 cases, with 15 testing positive for E. coli O157:H7. The four patients who were E. coli O157:H7 negative had recently been on antibiotic therapy. Each isolate was further tested for the presence of verotoxin genes by a polymerase reaction method; all were positive for VT1 and VT2. Subtyping identified all isolates as being phage type 10, a phage type that has rarely been isolated in Canada, with only three identified between 1990 and 1995. Although most verotoxigenic E. coli O157:H7 infections cause mild diarrheal symptoms, progression to more serious symptoms is not infrequent. Some of the more dangerous sequelae include hemorrhagic colitis, hemolytic uremic syndrome, and thrombocytopenic purpura. Death can result in the most severe cases. All cases involved in this outbreak recovered without sequelae occurring (10).

E. coli O157:H7 was again implicated in a 1998 outbreak in Nova Scotia. In May of that year, 194 people in a small geographical area met the case definition for E. coli food poisoning. Thirty-nine cases were laboratory confirmed, and there was one death. E. coli O157:H7 was isolated from potato salad left over after a fund raiser at which potato salad was sold. Investigators were unable to determine the mode of contamination (24).

**Bacterial: Shigella.** In early August of 1998, three members of an Ontario family fell ill with S. sonnei food poisoning. All had attended a fair where they purchased food from a single kiosk. Further investigation revealed 32 additional cases of shigellosis in people who had either eaten at the same kiosk or at a restaurant that had supplied it with food. An additional five cases occurred at a day care center, a result of secondary contact with a child who had eaten at the kiosk. Twenty of these individuals were questioned regarding their recent food history. All recalled eating a smoked salmon pasta dish made with fresh parsley. Stool samples from 6 of 16 food handlers, including four who had handled the parsley, tested negative for S. sonnei. It subsequently became apparent that this was not an isolated outbreak, but was associated with seven additional clusters of illness affecting more than 400 people in Ontario and Alberta and four U.S. states. All clusters were traced.
<table>
<thead>
<tr>
<th>Organism</th>
<th>Year</th>
<th>Vehicle</th>
<th>Province</th>
<th>Venue</th>
<th>No. ill[1]</th>
<th>Events or conditions leading to outbreak</th>
<th>Possible corrective action</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Listeria monocytogenes</em></td>
<td>1981</td>
<td>Coleslaw</td>
<td>Nova Scotia</td>
<td>Various</td>
<td>41; 17 deaths (5 spontaneous abortions, 4 stillbirths, 6 full-term babies, 2 adults)</td>
<td>Cabbage was grown on a farm where two sheep had died of listeriosis; raw and composted sheep manure were used to fertilize cabbage fields, and prolonged cold storage may have allowed <em>L. monocytogenes</em> to grow.</td>
<td>When using animal manure as fertilizer, ensure that it is well treated, particularly if it is to be used on foods that are consumed raw or if it may be held in cold storage for prolonged periods.</td>
<td>61</td>
</tr>
<tr>
<td><em>Salmonella Poona</em></td>
<td>1991</td>
<td>Cantaloupe</td>
<td>Ontario, Quebec,</td>
<td>Various</td>
<td>Canada—78 (U.S.—&gt;300)</td>
<td>Melons grow on the ground and are easily contaminated by dirt, excreta, etc. The outer rind of the melons may not have been washed adequately, resulting in pathogens being transferred onto the flesh during cutting. The sliced fruit was probably left sitting at room temperature for several hours before being eaten.</td>
<td>When preparing melons, ensure that they are thoroughly washed with potable water before cutting; use properly cleaned utensils and surfaces; hold cut melons at ≤7°C (45°F) until served or sold (≤7°C is the U.S. standard for refrigeration, ≤4°C [39°F] is the standard used in Canada), and limit display of unrefrigerated cut melon to less than 4 h. When purchasing precut melons, ensure that they have been refrigerated or displayed buried in ice.</td>
<td>1, 22, 64</td>
</tr>
<tr>
<td>*Salmonella Oran-</td>
<td>1998</td>
<td>Cantaloupe</td>
<td>Ontario</td>
<td>Various</td>
<td>22</td>
<td>See <em>Salmonella Poona</em> above</td>
<td>See <em>Salmonella Poona</em> above</td>
<td>16</td>
</tr>
<tr>
<td><em>Salmonella Stanley</em></td>
<td>1995</td>
<td>Alfalfa sprouts</td>
<td>British Columbia</td>
<td>Various</td>
<td>30 (Finland and 17 U.S. states—242)</td>
<td>Sprouts are generally eaten uncooked. Seed contamination may have occurred in the field as a result of contaminated fertilizers or from runoff and irrigation of contaminated fertilizers or from runoff and irrigation water. There was evidence of rodents and birds within the seed-conditioning facility. Sprouting conditions of high heat and humidity allow for a rapid rise in bacterial populations.</td>
<td>Strict control measures must be followed at all stages of sprout production. Effective means of reducing or eliminating pathogens from the seeds while maintaining the quality of the sprouts are currently being investigated.</td>
<td>26, 47, 49, 59, 65, 66</td>
</tr>
<tr>
<td>*Salmonella New-</td>
<td>1995–1996</td>
<td>Alfalfa sprouts</td>
<td>British Columbia, Quebec</td>
<td>Various</td>
<td>121 (also U.S. and Denmark—estimated number of actual cases 20,000)</td>
<td>Seed contamination may have occurred in the field from contaminated runoff and irrigation water, fertilizers, or animal droppings. Sprouting conditions of high heat and humidity allow for a rapid rise in bacterial populations.</td>
<td>See <em>Salmonella Stanley</em> above.</td>
<td>74, 76</td>
</tr>
</tbody>
</table>

[1] The number of illnesses reported may vary depending on the source of the information.
<table>
<thead>
<tr>
<th>Organism</th>
<th>Year</th>
<th>Vehicle</th>
<th>Province</th>
<th>Venue</th>
<th>No. ill$^a$</th>
<th>Events or conditions leading to outbreak</th>
<th>Possible corrective action</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salmonella Meleagrisis</td>
<td>1997</td>
<td>Alfalfa sprouts</td>
<td>Alberta, Ontario, Saskatchewan</td>
<td>Various</td>
<td>124</td>
<td>See <em>Salmonella</em> Stanley above. Sprouts were reported to have been “organically grown” with no chlorine presoak.</td>
<td>See <em>Salmonella</em> Stanley above. Pre-treatment of the seeds prior to sprouting appears to be beneficial in eliminating or reducing contamination.</td>
<td>17, 30, 51</td>
</tr>
<tr>
<td>Salmonella Paratyphi B var. Java</td>
<td>1999</td>
<td>Alfalfa sprouts</td>
<td>Alberta, British Columbia, Saskatchewan</td>
<td>Most purchased from grocery stores</td>
<td>46 (Alta.—35, BC—8, Sask.—3)</td>
<td>All from the same brand or from a common seed source.</td>
<td>See <em>Salmonella</em> Stanley above.</td>
<td>52</td>
</tr>
<tr>
<td>Salmonella Enteritidis</td>
<td>2000</td>
<td>Alfalfa sprouts</td>
<td>Alberta, Saskatchewan</td>
<td>5 Vietnamese restaurants</td>
<td>8 confirmed (2 unconfirmed—26 Jun 00)</td>
<td>Two different growers received beans from a single BC supplier, who had imported them from China. There were no lot numbers or dates on the 2000 bag shipment from China. Such identification would have enabled investigators to identify specific farms where the contamination may have originated.</td>
<td>See <em>Salmonella</em> Stanley above. An improved system for tracing seeds back to their origin is required.</td>
<td>45</td>
</tr>
<tr>
<td><em>Escherichia coli</em> O157:H7</td>
<td>1995</td>
<td>Imported iceberg lettuce</td>
<td>Ontario</td>
<td>Acute care hospital</td>
<td>23</td>
<td>Kitchen staff reported heavy spoilage on receipt of lettuce.</td>
<td>Because of obvious signs of spoilage, the lettuce should have been discarded upon receipt.</td>
<td>10</td>
</tr>
<tr>
<td><em>E. coli</em> O157:H7</td>
<td>1998</td>
<td>Potato salad</td>
<td>Nova Scotia</td>
<td>Fund-raising event</td>
<td>194 (1 death)</td>
<td><em>E. coli</em> O157:H7 was isolated from leftover potato salad. The mode of contamination could not be definitively determined; however, possible contamination by food handlers could not be discounted.</td>
<td>Education of food handlers, both in the home and in food establishments, is paramount. They must be aware of the importance of keeping uncooked meat, contaminated surfaces, and utensils separate from cooked and ready-to-eat foods and foods that will be eaten raw; produce should be thoroughly washed, and frequent hand washing is essential; care must be taken that potluck and buffet foods are not left at inadequate temperatures for an extended period and that proper serving utensils are provided to reduce the possibility of cross-contamination by guests.</td>
<td>24</td>
</tr>
<tr>
<td>Organism</td>
<td>Year</td>
<td>Vehicle</td>
<td>Province</td>
<td>Venue</td>
<td>No. ill</td>
<td>Events or conditions leading to outbreak</td>
<td>Possible corrective action</td>
<td>References</td>
</tr>
<tr>
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<td>------------</td>
</tr>
<tr>
<td><em>Shigella sonnei</em></td>
<td>1998</td>
<td>Imported chopped uncooked parsley</td>
<td>Ontario, Alberta</td>
<td>Food fair kiosk and day care center</td>
<td>40 (U.S.—450)</td>
<td>Recirculated, unchlorinated water in a hypochlorater was used to chill the parsley after harvest and to make ice used during transportation. Workers had limited knowledge of hygiene and limited sanitary facilities. Parsley was often chopped in the morning and left at room temperature for many hours.</td>
<td>Use properly chlorinated water for chilling and icing. Provide proper sanitation facilities, and educate workers in proper hygienic practices. Keep chopped parsley refrigerated, as chopping releases nutrients that could contribute to bacterial growth. Chop in smaller batches, and decrease storage time.</td>
<td>18</td>
</tr>
<tr>
<td><em>Staphylococcus aureus</em></td>
<td>1988</td>
<td>Potato salad</td>
<td>Saskatchewan</td>
<td>Social event</td>
<td>49</td>
<td>Food was prepared at home by a food handler who had an infected cut on his hand. He mixed the salad with his bare hands.</td>
<td>Wearing clean gloves while preparing food is recommended. This is of particular importance if the food handler has a known skin infection that could possibly come in contact with food.</td>
<td>71</td>
</tr>
<tr>
<td><em>Cyclospora cayetanensis</em></td>
<td>1996</td>
<td>Guatemalan raspberries (Blackberries may also have been involved.)</td>
<td>Ontario, Quebec</td>
<td>Various—homes, hotels, restaurants, clubs, etc.</td>
<td>195 (Ontario—189, Quebec—6) (U.S.—1,270)</td>
<td>The cause of contamination could not be definitely determined. Possible explanations include the use of contaminated water when applying insecticides and fungicides, dropings from birds, or cross-contamination from workers’ hands as the berries were hand picked and sorted.</td>
<td>Strict implementation of control measures, including the use of only potable water at all stages—such as spraying, cleaning contact surfaces, hand washing, etc.—improved sanitary facilities, and employee education. (The Guatemalan Berry Commission implemented measures to address these issues.) Improved package labeling is required, so source farms can be readily identified. Better laboratory methods of identification are needed, as well as epidemiological studies and mandatory reporting of cases. International collaboration and cooperation are essential.</td>
<td>39</td>
</tr>
<tr>
<td><em>C. cayetanensis</em></td>
<td>1997</td>
<td>Guatemalan raspberries (Blackberries may also have been involved.)</td>
<td>Ontario</td>
<td>Restaurant</td>
<td>31 (U.S.—981)</td>
<td>The cause of contamination could not be definitely determined. It is likely that control measures instituted in 1996, some of which dealt with water quality problems, were not fully implemented, were ineffective, or did not address the real cause of the problem.</td>
<td>Canada suspended importation of Guatemalan raspberries in May 1997. Further implementation and better monitoring of improvements outlined in 1996 are required (above).</td>
<td>40</td>
</tr>
</tbody>
</table>
### TABLE 1. Continued

<table>
<thead>
<tr>
<th>Organism</th>
<th>Year</th>
<th>Vehicle</th>
<th>Province</th>
<th>Venue</th>
<th>No. ill*</th>
<th>Events or conditions leading to outbreak</th>
<th>Possible corrective action</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>C. cayetanensis</em></td>
<td>1998</td>
<td>Guatemalan raspberries</td>
<td>Ontario</td>
<td>Various, including a hotel</td>
<td>315</td>
<td>No well-defined clusters occurred in the United States, which had banned importation of Guatemalan raspberries between 15 March and 15 August 1998. The outbreak in Canada occurred despite measures that allowed only low-risk farms to export berries to North America. The definitive cause of the problem was unknown; however, the same factors associated with the 1996 and 1997 outbreaks likely played a role in 1998.</td>
<td>The Guatemalan Berry Commission and the Guatemalan government, with the help of health departments in Canada and the United States, began developing a more comprehensive plan for the growing and handling of raspberries. The Model Plan of Excellence was drawn up, which addresses quality assurance, employee training, surveillance of risk factors, point of origin, and traceback.</td>
<td>14, 33</td>
</tr>
<tr>
<td><em>C. cayetanensis</em></td>
<td>1999</td>
<td>Guatemalan blackberries suspected</td>
<td>Ontario</td>
<td>Banquet hall</td>
<td>104</td>
<td>Canada disallowed the importation of raspberries from Guatemala in the spring of 1999.</td>
<td>A <em>Cyclospora</em> outbreak test kit was developed, and polymerase chain reaction methodology was improved to aid in the identification of <em>Cyclospora</em> in food. The Ontario Ministry of Health and Long-Term Care added cyclosporiasis to their list of reportable diseases in the spring of 2000.</td>
<td>25</td>
</tr>
<tr>
<td>Calicivirus</td>
<td>1992</td>
<td>Salad</td>
<td>Ontario</td>
<td>Catered event</td>
<td>27</td>
<td>Salad was served at a potluck meal. The vegetables may have been improperly washed or cross-contaminated by a food handler or an infected guest.</td>
<td>See <em>E. coli</em> O157:H7 (1998).</td>
<td>73</td>
</tr>
<tr>
<td>Calicivirus</td>
<td>1997</td>
<td>Imported Bosnian raspberries</td>
<td>Quebec</td>
<td>2 separate events</td>
<td>&gt;200</td>
<td>It is likely that the berries were contaminated before shipment from Bosnia, possibly by hand contact or contaminated irrigation or spray water. Calicivirus is resistant to freezing; because of the irregular shape of raspberries, washing may not remove all of the microorganisms present.</td>
<td>Cooking the berries prior to serving would eliminate the virus.</td>
<td>37</td>
</tr>
</tbody>
</table>

* Unless otherwise specified, there were no reported deaths.
to fresh parsley. The use of DNA fingerprinting (PFGE) and PulseNet, an electronic database developed to compare DNA patterns, aided in recognizing the relationship between these geographically diverse clusters. In addition, all isolates tested were resistant to the same five antibiotics—ampicillin, trimethoprim-sulfamethoxazole, tetracycline, sulfisoxazole, and streptomycin (18).

Provincial and state health departments, the Canadian Food Inspection Agency, the CDC, and the Food and Drug Administration worked together to determine the origin of the contaminated parsley. A Mexican farm was recognized as a probable source in six outbreaks, while four farms in California were possibly linked in two to four outbreaks. Field investigators found that municipal water supplied to the packing shed on the Mexican farm was unchlorinated and recirculated, thus providing opportunities for bacterial contamination of the parsley, as well as allowing for the spread of contaminants from one box to another. This same water was also used to make ice in which the parsley was packed for transport. Adding to the list of risk factors were inadequate sanitary facilities and a limited knowledge of good hygienic practices among farm workers. Six of the eight implicated restaurants reported that the parsley had been washed before chopping; however, the washing and chopping were generally done in the morning, and the herb was stored at room temperature until served to patrons, often several hours later (18). Of particular concern is the low infective dose required to cause illness. A recent study has demonstrated that the number of \textit{S. sonnei} g of chopped or whole parsley increased when the product was kept at room temperature (21°C), in contrast to a 1-log decrease per week when parsley was kept under refrigeration (4°C). This same study found that treatment of whole parsley with 250 ppm free chlorine reduced an initial \textit{S. sonnei} population of 6 log_{10} CFU/g to undetectable levels, and a count of 7.07 log_{10} was also reduced to undetectable levels after a 5-min treatment with 7.07% acetic acid (77).

\textbf{Protozoan parasites: 1996.} As previously mentioned, there had been few reports of cyclosporiasis in North America before 1996, with most reported cases being associated with international travel, particularly to developing countries (13). This changed in 1996 when, between the months of May and July, a total of 1,465 cases of \textit{C. cayetanensis} infection were recorded. Because most clinical parasitology labs were not routinely testing for \textit{Cyclospora,} and the vast majority of diarrheal disease cases go unreported, the actual number of people affected was probably much higher. The geographical areas involved covered the Canadian provinces of Ontario (189) and Quebec (6), as well as 20 U.S. states and the District of Columbia (1,270). Both the sporadic and cluster-associated cases were considered part of the same outbreak, as the dates associated with the onset of symptoms in both categories showed a similar distribution pattern (39). A cooperative effort between local and national health authorities in Canada and the United States was instrumental in linking these cases together and tracing them to a common source (6).

There was an approximately equal balance between the number of cluster-associated and sporadic reports. Cluster-associated cases encompassed 55 events, including seven in Ontario and one in Quebec (39). The first cluster in Canada was identified in the North York area of Ontario in May of 1996, when 32 of 49 guests who had consumed a catered meal became ill. Stool samples from 13 of the 32 guests tested positive for \textit{Cyclospora.} Six additional clusters were subsequently identified, as well as 129 sporadic laboratory-confirmed cases. Case control studies were undertaken to identify the causative agent responsible for this unprecedented outbreak. A strawberry flan dessert, which also included some raspberries and blueberries, proved to be the only food significantly associated with illness in the initial Canadian outbreak. Investigation of the six additional Ontario clusters also pointed to berries as a significant risk factor. Univariate analysis at this stage identified fresh raspberries, strawberries, or both as the most likely vehicle of infection. These results were consistent with the U.S. findings (50).

Produce consumed in both countries comes from many sources, both domestic and international. The complexity of the distribution routes and the handling involved made traceback of the fruit from farm to fork difficult. An additional complication was the fact that standardized detection methods were not yet available (6). Further study pointed to fresh raspberries as the most likely vehicle in the majority of the events investigated internationally. Of the 55 events examined, raspberries were definitely or possibly served at 50 and 4 events, respectively. One notable exception was an event held in Ontario where no raspberries were served. A fruit mixture, which included blackberries from Guatemala, was served at that event. Well-documented records as to the origin of the berries were found in 29 of the 54 raspberry-associated events. In 21 events, the berries were definitely traced to Guatemala, while the remaining eight could have originated, at least in part, from Guatemala. Attempts made to identify specific importers and exporters were relatively successful, but because exporters generally combine berries from multiple farms into a single shipment, only a limited number of source farms could be identified (39).

International investigators examined agricultural and handling practices, looking into such areas as water source, quality, and runoff; proximity of the berry fields to animals, birds, and sewage facilities; and personal hygiene and sanitation facilities for workers, as well as picking and sorting practices. Unfortunately, the origin of the contamination could not be definitely determined. The most plausible explanations were that the insecticides and fungicides that were sprayed onto the berries were mixed with water from contaminated sources, or that droppings from birds were deposited onto the fruit (38). Another possible explanation was contamination by pickers, sorters, or other workers who directly handled the fruit (33).

\textbf{Protozoan parasites: 1997.} In the spring of 1997, authorities in Canada and the United States again began receiving reports of widespread \textit{Cyclospora} infection. Canada recorded 31 cases of illness, including 7 cases in a single
Ontario cluster and 24 sporadic cases. In the United States, 13 states and the District of Columbia identified a total of 981 cases, which included 40 clusters totaling 755 cases (188 laboratory confirmed) and 226 laboratory-confirmed sporadic cases. The only food singled out as being common to all 41 clusters was fresh raspberries, and, in nine events, raspberries were the only type of berry served. Well-documented traceback information was available for 33 events. Records showed that in 31 of these events, the raspberries either definitely came from Guatemala (8 events) or could have come from there (23 events). The North American outbreak ended shortly after the exportation of Guatemalan raspberries was voluntarily suspended. No cases of Cyclospora were reported during the fall raspberry harvest in either 1996 or 1997. The mode of contamination of the parasite onto the raspberries remained unsolved. An explanation as to why there seems to be a seasonal variance may assist authorities in finding the answer (40).

Protozoan parasites: 1998. Despite the implementation of measures designed to help control contamination of the Guatemalan berry crop, and restrictions put on importation, whereby only berries from low-risk farms were allowed to enter Canada, reports of another outbreak of Cyclospora emerged in Ontario in the spring of 1998 (the Food and Drug Administration in the United States imposed a ban on the importation of the 1998 spring crop of Guatemalan raspberries). Thirteen clusters of cyclosporiasis affecting 315 people were reported during this time period (38). The initial cluster involved guests at a dinner in a Toronto hotel. Of the 128 guests interviewed, 29 met the case definition for cyclosporiasis, with three cases being laboratory confirmed. A berry garnish consisting of raspberries, blackberries, strawberries, and possibly blueberries was a strongly associated risk factor for illness. These fruit mixtures were served at 12 of the 13 events, with raspberries being the only berry served at one event. Traceback studies of eight events found that Guatemala was the only source of raspberries in all cases. Again, the source of contamination could not be determined. Partial explanations for the outbreak included the possibility that control measures were not properly put into place on the farms; that these actions were ineffective or inadequate; or that the source of the problem was not accounted for by these measures. With assistance from Canadian and U.S. officials, the Guatemalan Berry Commission began work on the development of a more comprehensive plan for reducing the risk of Cyclospora contamination of raspberries (14, 38).

Protozoan parasites: 1999. Although a restriction was placed on the importation of Guatemalan raspberries into Canada in the spring of 1999, reports of Cyclospora infection were noted in the Toronto, Ontario, area in June of that year. A private event held in a banquet hall on 29 May 1999 was identified as being the common time of exposure. One hundred four of the 400 guests met the case definition for Cyclospora infection, and statistical analysis showed that an ice cream crêpe dessert was significantly associated with illness. The ice cream was garnished with three types of berries—fresh strawberries from California, frozen raspberries from Chile, and fresh blackberries from Guatemala. In-depth data analysis suggested that Guatemalan blackberries were the most likely cause of illness; however, because of the multiple types of berries served, this result was inconclusive. Traceback studies identified a group of farms where the berries originated, but were unable to pinpoint the specific farm (25, 38).

Ninety-four cluster-associated cases of Cyclospora, also in May of 1999, were reported from a number of U.S. states. These cases were linked to a convention in West Palm Beach, Fla., between 12 and 16 May of that year. Subsequent investigation showed that the vehicle of infection was most likely one of several types of fresh berries served during the convention. These berries included non-Guatemalan raspberries (both foreign and domestic were possible), imported blackberries (some may have originated in Guatemala), as well as strawberries and blueberries. It is unclear whether or not the Canadian and U.S. outbreaks were related. Both countries allowed the importation of Guatemalan blackberries in the spring of 1999. The United States permitted raspberries from farms that met very strict standards, and, as mentioned, Guatemalan raspberries were disallowed in Canada during this period (25, 38).

Viral. In 1992, 27 people contracted calicivirus after eating salad at a potluck supper in Stratford, Ontario. The cause of infection was not established; however, contamination by an infected food handler or guest or improper washing of the vegetables were the most plausible explanations (73).

Quebec City was the site of another calicivirus outbreak in July and August of 1997. The outbreak affected more than 200 people attending two separate events. Epidemiological investigation led to the identification of raspberries as the vehicle of infection. The berries, which originated in Bosnia, were part of a raspberry mousse dessert served with a raspberry sauce. Southern blot hybridization and sequence analysis showed that the viruses isolated from both the raspberries and the stool samples were identical. It was concluded that the berries were probably contaminated in Bosnia before exportation to Canada (37).

**DISCUSSION**

At no period in our history has society undergone more dramatic change than that witnessed in the past two decades. For example, our eating habits have undergone considerable transformation in recent years, affecting not only the variety of foods we eat, but also how they are produced, packaged, transported, and consumed. As a result of improvements in these areas, fresh fruits and vegetables, including many that have a relatively short shelf life, are no longer excluded from exportation to distant foreign markets. This comes at a time when changing demographics have given rise to the coexistence of many diverse cultures, thereby bringing broader exposure to once culturally distinct foods. Because consumers have developed a better understanding of the health benefits associated with eating produce, these foods are increasingly being served in the home, in restaurants, and as ready-to-eat prepackaged
foods, developed for the convenience of today’s hurried consumer. This cumulation of factors has given rise to an increase in foodborne disease associated with eating raw produce, leaving producers, scientists, and consumers with increased challenges and responsibilities relating to the identification and prevention of foodborne illness. The Canadian incidents described encompass a variety of circumstances that were key to the development of produce-related foodborne illness.

These can be summarized in the paragraphs that follow.

(i) The use of raw sheep manure as fertilizer led to the contamination of cabbage by *L. monocytogenes* and subsequent fatalities. If manure is being used, it should be treated to eliminate pathogenic organisms. This can be accomplished by proper composting of the waste material, thereby exposing the microorganisms to sufficient heat to cause cell death (27).

(ii) Several outbreaks of *Salmonella* infection traced to cantaloupe were likely the result of a combination of factors. First, because melons grow on the ground, they are easily contaminated by dirt, excreta, etc. In these outbreaks, investigators concluded that the outer rind was not adequately washed before slicing, resulting in pathogens being transferred to the edible fruit inside. If the sliced melon was then left sitting at room temperature for several hours, as was thought to be the case in these outbreaks, the combination of time, temperature, and the nutrients released from the cut surfaces likely allowed pathogens to multiply and thus cause foodborne disease. The cantaloupe outbreaks have demonstrated the need to take preventive measures when handling melons. These measures include thoroughly washing the outer rind of the fruit in potable water, to remove as much surface contamination as possible before slicing (the rough outer skin of a cantaloupe is more likely to harbor contaminants after washing than the surface rind of smoother melons); ensuring that utensils and preparation surfaces are clean and sanitized; storing the melon at or below 7°C until served or sold; and limiting the time sliced melon is held at ambient temperature to no more than 4 h. Any fruit remaining after 4 h should be discarded. When buying precut melon, ensure that it has been either refrigerated or displayed buried in ice, not merely lying on top of it (5, 22, 64). These same lessons also apply to any fresh produce items that are not subjected to a “kill step” and are particularly crucial if the food is grown on the ground or could potentially have fallen and been picked from the ground.

(iii) The many outbreaks of foodborne disease associated with various sprout products in recent years are a cause for concern. This situation has arisen both in Canada and throughout the world. The reasons for the widespread contamination of this product are not entirely clear, but it is known that most incidents originate from the seeds and can involve many factors. In Canada, evidence has pointed to the possibility of contaminated fertilizers, irrigation water, and farm runoff. In the *Salmonella* Stanley outbreak, there were signs of bird and rodent infestation in the seed conditioning facility (49), and in the 1997 *Salmonella* Meleagridis outbreak, it was determined that the sprouts were organically grown with no presoak step before germination (30). If the seeds become contaminated at any point preceding the germination process, the sprouting conditions of high moisture and temperature, favorable nutrients, and pH combine to cause rapid proliferation of any microorganisms present. Because the potential for contamination of these products is high, and because sprouts are often consumed raw, it is particularly important that control measures be put in place from farm to fork. These should comprise good agricultural and manufacturing practices, including seed cleaning, as well as hygienic storage, transportation, and handling practices (51). Consumers should also be made aware of potential problems and handle the product accordingly. They should follow proper hygiene practices in the home, including proper hand washing, refrigerated storage, and prevention of cross-contamination. Some sprouts—e.g., bean sprouts—can be fully cooked before they are eaten; however, for many sprout types, this procedure is impractical. Research is ongoing in an attempt to find a satisfactory means of completely eliminating pathogenic organisms from sprout seeds without compromising product quality (26, 47, 65, 66).

(iv) The lettuce, which was implicated in the 1995 *E. coli* O157:H7 outbreak, was probably contaminated before it reached the kitchen. The exact origin of the contamination could not be determined; however, it may have been the result of contaminated soil, irrigation water, or improperly composted manure. Inadequate storage or transportation conditions also cannot be discounted. Because there were obvious signs of spoilage upon receipt, the lettuce should have been discarded outright, thereby preventing the outbreak. As previously stated, producers must ensure that any manure used is properly composted and that irrigation water is drawn from sources not at risk of contamination. High-risk situations include, for example, water that is in close proximity to animal pastures, barns, or feedlots or water that may have been contaminated by improperly treated sewage. Spray irrigation of wastewater is also a potential hazard, as pathogen-laden aerosols can be dispersed long distances through the air and deposited onto fruits and vegetables (27). Proper temperature control and cleanliness are required during transport and storage of fresh produce.

(v) The international outbreak of *S. sonnei* in parsley was also due to a chain of events that most likely began on a Mexican farm where recirculated, unchlorinated, municipal water in a hypochloriner was used to chill the parsley after harvest. Pathogenic organisms originating in the water or on the parsley could have survived and contaminated other boxes of parsley. This same water was used to make ice for cooling the product during transport. In addition, the farm workers had minimal knowledge of hygiene and were provided with limited sanitary facilities. The majority of food handlers reported washing the whole parsley before it was chopped; however, it was routinely left at room temperature for several hours before being served. As with melon, the nutrients released from the chopped parsley provide a more favorable media for microbial growth. To aid in preventing a recurrence of this situation, a change is
required in postharvest control measures. Only potable, preferably uncirculated water should come in contact with the product. Farm workers need to be educated in proper hygienic practices and be made aware of the reasons why these practices are necessary. Means must be found to provide farm workers with proper sanitary facilities, as well as ensuring that hygienic standards are followed. Chopping the parsley in smaller quantities, refrigeration, and holding for shorter periods before use will also decrease the risk of foodborne infection (18).

(vi) The widespread international outbreaks of *C. cayetanensis* in recent years, traced primarily to fresh Guatemalan raspberries, present a puzzling situation. Despite exhaustive investigation into the origin of the contamination, complemented by the implementation of stringent standards restricting the importation of berries into Canada that originated from compliant Guatemalan berry farms, *Cyclospora* infections continue to be reported. Some hypotheses presented include the use of contaminated water when applying insecticides and fungicides and the possibility that cross-contamination from workers’ hands occurred as the berries were picked and sorted. Also, contamination from animals and birds could not be discounted. Washing the fruit did not prevent the spread of illness. This suggests that the infectious dose is probably low or that the chlorine-resistant infective oocytes hide in the crevices of the berries, rendering washing ineffective (39). Improved methods of identification, including molecular typing, mandatory reporting of cases, and continued international cooperation, will aid in improving our understanding of the problem. Awareness that vehicles other than berries can lead to the spread of *Cyclospora* infection can be seen in several U.S. outbreaks traced to mesclun and fresh basil (38).

(vii) Food handlers play a significant role in the prevention of foodborne disease. An infected food handler or guest at a potluck meal was identified as the possible source of the 1992 calicivirus outbreak that sickened 27 Ontario residents. Inadequate washing of salad items was also not discounted (73). Two food handler-related Canadian outbreaks, not previously described, serve as additional examples underlining the importance of food handler education. The first was a *Staphylococcus aureus* outbreak, which resulted in 49 reports of illness linked to a food handler with an infected cut on his hand (71). The second outbreak was traced to beans contaminated with *Bacillus cereus*, which caused diarrheal illness in 16 residents of a nursing home. Food handlers must be familiar with good hygienic practices, including the proper washing of produce in potable water, frequent hand washing, and the use of clean gloves, particularly when they have a possible wound infection. They also should avoid the preparation of food during the infectious stage of a gastrointestinal illness (which often includes several days after symptoms have subsided), and must be aware of the storage conditions required for each food item. The prevention of cross-contamination is another area of crucial importance. Food handlers must ensure that there is no opportunity for potentially contaminated items coming into contact with foods that are to be eaten raw or foods that will not be subjected to further heat treatment. As well, all cutting and contact surfaces and utensils must be properly cleaned. These same safeguards apply equally to the consumer who is preparing food in the kitchen.

Some of the outbreaks described exemplify how cooperation among health authorities, both on a local and an international level, as well as improved testing methods and electronic communication, can be invaluable in recognizing foodborne illness and their subsequent linkage to similar outbreaks worldwide. There is no room for complacency when dealing with the issue of food safety. It must be understood by everyone involved that a weak link anywhere in the sequence of events, from the farm to the table, can have devastating and far-reaching consequences.

**Note added in proof.** After acceptance of our article for publication, information concerning an additional produce outbreak in Canada was received. The information is as follows. Organism: *Salmonella* Enteritidis Phage type 913. Year: 2001. Vehicle: Mung bean sprouts. Province: Alberta, British Columbia, and Saskatchewan. Venue: 13 restaurants (Vietnamese, Chinese, and Japanese) in the Edmonton, Alberta area. No. ill: 84 (no deaths). Events or conditions leading to outbreak: The seeds were originally grown in China. Restaurants purchased the sprouted seeds from a single Edmonton supplier in February 2001. Prior to the outbreak, health authorities had raised concerns regarding plant sanitation, hand washing practices and quality control/assurance. Each bag of mung bean sprout seeds carried a warning of possible contamination, as well as a recommendation to disinfect the seeds; however, disinfection was not carried out. Possible corrective action: See information for *Salmonella* Stanley given in Table 1 on p. 1868. Reference: Anonymous. 2001. Outbreak of *Salmonella* Enteritidis Phage Type 913 gastroenteritis associated with mung bean sprouts—Edmonton, 2001. Can. Comm. Dis. Rep. 27:151–155.

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**REFERENCES**