

Incomplete sanitation of a meat grinder and ingestion of raw ground beef: contributing factors to a large outbreak of *Salmonella* Typhimurium infection

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SUMMARY

Consumers in the United States continue to eat raw or undercooked foods of animal origin despite public health warnings following several well-publicized outbreaks. We investigated an outbreak of *Salmonella* serotype Typhimurium infection in 158 patients in Wisconsin during the 1994 Christmas holiday period. To determine the vehicle and source of the outbreak, we conducted cohort and case-control studies, and environmental investigations in butcher shop A. Eating raw ground beef purchased from butcher shop A was the only item significantly associated with illness [cohort study: relative risk = 5.8, 95% confidence interval (CI) = 1.5–21.8; case control study: odds ratio = 46.2, 95% CI = 3.8–2751]. Inadequate cleaning and sanitization of the meat grinder in butcher shop A likely resulted in sustained contamination of ground beef during an 8-day interval. Consumer education, coupled with hazard reduction efforts at multiple stages in the food processing chain, will continue to play an important role in the control of foodborne illness.

INTRODUCTION

Among the leading bacterial causes of foodborne illness, *Salmonella* sp., *Campylobacter* sp., and *Escherichia coli* O157:H7 are known to colonize the intestines of farm animals and may contaminate meat of cattle and poultry at the time of slaughter. During subsequent processing, the bacteria-laden meat may contaminate processing equipment (e.g. meat grinders), which can then act as an on-going source of

contamination for subsequently processed meat. Human illness can occur if consumers knowingly or unknowingly eat raw or undercooked meat.

Following widespread, well publicized outbreaks of *Escherichia coli* O157:H7 infection, there have been numerous public health messages informing consumers of the dangers associated with eating raw or undercooked animal products [1, 2]. Despite these messages, some individuals in the United States continue to consume undercooked or raw meat.

Outbreaks of human salmonellosis associated with eating raw ground beef have previously been described [3, 4]. Eating raw ground beef is apparently not an uncommon practice in certain areas of Wisconsin during the Christmas holiday season, both in household settings and also at larger social gatherings. We

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report the investigation of an outbreak of gastrointestinal illness in Wisconsin caused by *Salmonella* serotype Typhimurium associated with eating raw ground beef during the winter holiday season. While investigating the outbreak, we were interested in learning whether previous public health messages regarding the dangers of eating raw or undercooked beef had an impact on behaviour.

METHODS

Background

On 29 December 1994, a physician in a group medical practice in Dodge County, Wisconsin (1994 estimated population: 79 360) notified the Dodge County Human Services and Health Department (DCHSHD) that tartrate-negative *S. Typhimurium* had been isolated from stool specimens submitted by seven patients in his practice. The Wisconsin Division of Health (DOH) was notified on 30 December. A team consisting of epidemiologists of DOH and public health staff of DCHSHD initiated an investigation; when beef was implicated, representatives of the Meat Safety and Inspection Bureau (MSIB), Wisconsin Department of Agriculture, Trade, and Consumer Protection (WDATCP) joined the team for the environmental investigation. During 27 December–29 December 1994, physicians in the medical practice treated 17 patients who had acute gastrointestinal illness characterized by diarrhoea and abdominal cramps. At least 14 of these patients reported having eaten raw ground beef that was served either plain or seasoned with onions and an herb mix during the 72 h before illness onset. Several patients had attended a work-related Christmas party.

Case finding

On 4 January 1995, DCHSHD issued a physician alert to inform health-care providers in the area of this possible foodborne outbreak and to obtain stool samples from patients who had diarrhoeal illnesses. Clinical microbiology laboratories in Dodge County and the four contiguous counties (Fond du Lac, Columbia, Green Lake, and Washington) were asked to refer isolates of *Salmonella* to the Wisconsin State Laboratory of Hygiene (WSLH) for further identification. The DCHSHD issued a press release regarding the dangers of eating raw ground beef, the

risk of secondary (faecal-oral) transmission of gastrointestinal *Salmonella* infection, and the importance of proper hand-washing practices. Laboratory-based active surveillance was established in Dodge and the four contiguous counties. WSLH provided DOH and DCHSHD with line listings of persons in the geographic area of interest whose stool cultures were positive for *S. Typhimurium*.

We defined a probable case of *Salmonella* infection as diarrhoea (three or more loose stools during a 24-h period) or abdominal cramps that began during 22 December 1994–4 January 1995, in a resident of or a visitor to Dodge County or any of the four contiguous counties. A confirmed case additionally had a stool culture positive for tartrate-negative *S. Typhimurium*.

Epidemiologic investigation

DCHSHD and DOH conducted an epidemiologic investigation to assess potential risk factors for illness. We first conducted a cohort study among attendees of a workplace holiday party on 22 December 1994. A roster of the 44 party attendees and a list of the food and beverage items served were obtained. A retrospective cohort study was conducted using a questionnaire administered by telephone that assessed demographic information, gastrointestinal illness during the 4 days following the party, clinical signs and symptoms of illness, and consumption of specific food and beverage items served at the party. Illness in party attendees had to meet the above case definition; non-ill party attendees were enrolled as controls.

We subsequently conducted a case-control study among community members to determine whether illness was associated with consumption of raw ground beef and specifically with consumption of raw ground beef obtained from one butcher shop (butcher shop A – the source of the raw ground beef served at the party). We randomly selected 40 case-patients from the WSLH list of persons who had a stool specimen that was culture positive for tartrate-negative *S. Typhimurium* and an illness compatible with the case definition. These patients had not participated in the cohort study. We identified 40 controls using a systematic telephone-dialing method in which the last digit of the case-patient's telephone number was changed incrementally. The first adult (person > 15 years old) responding to the call was asked whether he or she experienced a gastrointestinal illness with diarrhoea or abdominal cramps with

illness onset date from 22 December 1994 through 4 January 1995. Persons who responded negatively to that question were then administered a telephone survey questionnaire. Case-patients and controls were interviewed using a survey questionnaire that requested (a) each person's history of illness from 22 December 1994 through 4 January 1995; (b) signs and symptoms experienced; (c) history of consumption of raw ground beef; (d) place of purchase of the raw ground beef; (e) the duration of the habit of eating raw ground beef; and (f) knowledge of previous media coverage regarding outbreaks of illnesses related to eating raw or undercooked meat.

Six samples of leftover raw ground beef served in six different homes were obtained from case-patients. All had been purchased at butcher shop A on five different purchase dates during 21–29 December 1994.

Environmental investigation

On 30 December, staff of the MSIB, WDATCP, informed the proprietor of butcher shop A of a potential problem associated with consumption of raw ground beef from the shop and reiterated the need to properly label meat products. On 3 January and 6 January 1995, MSIB inspectors examined sanitary conditions in the shop, obtained invoices indicating the origin and the quantity of the meat used to prepare the ground beef, inspected the production method for raw ground beef, and reviewed selling practices in the butcher shop. During an unannounced visit by MSIB inspectors on 20 January 1995, a more detailed inspection of meat-grinding and other equipment was completed, and the management was interviewed regarding current sanitation practices. Samples for bacterial culture were obtained on 6 January and 20 January; these included 20 environmental swab specimens of the equipment and the areas related to the production of the ground beef, two samples of the raw ground beef produced on the day of the visit, and one sample of the spice mixture added to the implicated product.

Laboratory investigation

Through the physician-alert notice, clinical microbiology laboratories in Dodge County and the four contiguous counties were requested to send isolates of *Salmonella* from stool samples obtained from ill

persons during 12 December 1994–15 January 1995, to WSLH for further serogrouping and serotyping. Stool samples from each of the five butchers at butcher shop A were collected on 10 January 1995, placed in Cary Blair media, and submitted to WSLH for culture of *Salmonella*, *Shigella*, *Campylobacter*, and *E. coli* O157:H7 using standard methods.

Pulsed-field gel electrophoresis (PFGE) using the enzyme Xba-1 for digestion was used to compare 33 of the 40 *Salmonella* isolates from case-patients who were participants in the case-control study (seven isolates were nonviable) with six meat isolates. In addition, disk-diffusion-antibiotic susceptibility testing on two meat isolates and two case-patient isolates was performed; antimicrobials included ampicillin, ampicillin/sulbactam, chloramphenicol, ciprofloxacin, gentamicin, tetracycline, ceftriaxone, and trimethoprim/sulfamethoxazole. Phage typing of the isolates was not performed.

The six raw ground beef samples obtained from case-patients' homes and butcher shop A and all of the environmental swabs obtained during the inspection visits were submitted to WDATCP laboratory for initial culturing for *E. coli* O157:H7 and *Salmonella* using standard methods. The WDATCP laboratory referred *Salmonella* isolates to WSLH for further serotyping.

Statistical analysis

For the univariate analysis, relative risks with Taylor 95% confidence intervals and maximum likelihood estimates of odds ratios with exact 95% confidence intervals were used. For the stratified analysis, stratum specific estimates and summary adjusted relative risks were calculated. (Epi-Info, version 6.02, CDC).

RESULTS

Case finding

Historical data were examined for cases of *Salmonella* infection reported to the DOH during December and January from the five Wisconsin counties affected by the current outbreak. During each of the 5 years before this outbreak, the number of laboratory-confirmed cases of *Salmonella* infection in the outbreak area during December and January ranged from 2–9 cases (mean: 6.6 cases).

From 22 December 1994 through 4 January 1995, a total of 107 confirmed and 51 probable case-patients

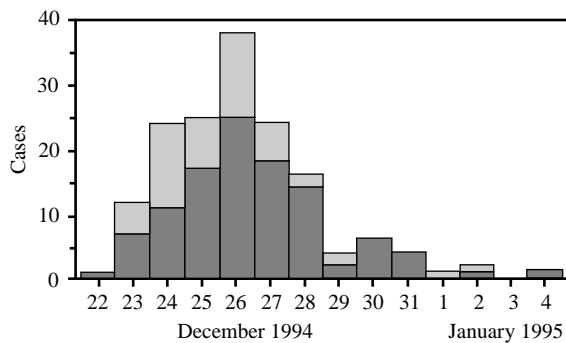


Fig. 1. Confirmed and probable cases of *Salmonella* Typhimurium infection, by date of illness onset, December 1994–January 1995; Dodge, Fond du Lac, Columbia, Green Lake, and Washington counties, Wisconsin. □, Probable cases, $n = 51$; ■, confirmed cases, $n = 107$.

were identified (Figure 1); of these case-patients, 17 (16%) were hospitalized. No deaths were associated with this outbreak. Case-patients' ages ranged from 2 to 90 years (median: 38 years); 62% of cases occurred among males. Predominant signs and symptoms among 128 case-patients (91 confirmed, 37 probable) for whom this information was available included diarrhoea (99%), abdominal cramps (88%), chills (75%), body aches (69%), fever (63%), nausea (59%), bloody stools (42%), and vomiting (32%). Persons who had confirmed and probable cases had similar prevalences of diarrhoea, abdominal cramps, body aches, nausea, and vomiting. Persons who had confirmed cases of *S. Typhimurium* infection had significantly greater prevalence of bloody stools (47/91 vs. 7/37; $P = 0.001$) and fever (64/91 versus 16/37; $P = 0.008$) than did persons who had probable cases of *S. Typhimurium* infection.

Epidemiologic investigation

Cohort study

Among 44 workplace-party attendees who were contacted, 34 participated; 10 attendees did not respond to several requests to participate in the study. Fifteen (44%) respondents met the case definition; 2 were classified as confirmed case-patients and 13 as probable case-patients. The median incubation period among the 15 respondents was 2 days (range: 1–4 days). Univariate analysis of food and beverage items served revealed that three food items were associated with illness: seasoned raw beef, rye bread, and sausage (Table 1). Stratified analysis identified seasoned raw ground beef as the only statistically significant source of infection. Of 18 persons who reported eating the

seasoned raw ground beef, 13 (72%) met the case definition for a confirmed or a probable case, compared with 2 (13%) of 16 persons who did not eat the seasoned ground raw beef [relative risk (RR) = 5.8; 95% confidence intervals (CI) = 1.5–21.8].

Community case-control study

The mean ages of community case-patients (43 years) and controls (47 years) were similar. Of 40 case-patients, 35 (88%) reported having eaten raw ground beef during 22 December–4 January period, compared with 8 (20%) of 40 controls [odds ratio (OR) = 26.3; 95% CI = 7.4–116]. Among 35 case-patients who ate raw ground beef, 34 (97%) ate beef purchased from butcher shop A, compared with 3 (37%) of the 8 controls (OR = 46.2; 95% CI = 3.8–2751).

In the case-control study, we found that the case-patients' knowledge of previous outbreaks involving consumption of raw or undercooked beef was less than but not significantly different from that of the controls; 26 (65%) of 40 case-patients recalled having knowledge of such reports in the past compared with 30 (75%) of 40 controls (OR = 0.6; 95% CI = 0.2–1.8). However, 22 (85%) of the 26 case-patients who reported being aware of previous outbreaks associated with consumption of raw ground beef continued this behaviour compared with 7 (23%) of the 30 controls who had knowledge of previous outbreaks (OR = 16.9; 95% CI = 4–92).

Environmental investigation

Based on invoice data, approximately 1000 pounds of raw ground beef were sold by butcher shop A during the Christmas holiday season (J. Larson, personal communication, MSIB, 1995). Raw ground beef was produced from whole, denuded (skinned) beef rounds (specific cut from the rump of a cow, 8–13 lbs per piece). Individual beef rounds were delivered to the shop in cryopacks. Approximately 80 beef rounds from 35 carcasses obtained from three different suppliers had been ground in the shop from 21 December through 4 January. Raw rounds were ground twice and collected in plastic buckets. Part of the raw meat was then seasoned, the remainder was sold as plain, raw ground beef. Pre-blended spices and chopped onion were added to the raw meat in the plastic buckets; the onions were peeled, washed, chopped separately from the meat, and hand mixed by the butcher to form the seasoned, raw ground beef. Plain ground beef was not mixed, but was handled

Table 1. Food- and beverage-specific attack rate for items served during the workplace party on 22 December 1994. Univariate analysis of data from 34 respondents; outbreak of *Salmonella Typhimurium* infections in Dodge, Fond du Lac, Columbia, Green Lake, and Washington counties, Wisconsin

| Food or beverage item | No. ill* | | RR | 95% CI |
|---------------------------|-------------|---------------------|-----|-----------|
| | No. ate (%) | No. did not eat (%) | | |
| Seasoned, raw ground beef | 13/18 (72) | 2/16 (13) | 5.8 | 1.5–21.8† |
| Plain, raw ground beef | 1/2 (50) | 14/32 (44) | 1.1 | 0.3–4.8 |
| Potatoes | 5/9 (56) | 10/25 (40) | 1.4 | 0.7–2.9 |
| Rye bread | 10/13 (77) | 5/21 (24) | 3.2 | 1.4–7.3† |
| Cheese | 8/13 (62) | 7/21 (33) | 1.9 | 0.9–3.9 |
| Sausages | 8/12 (67) | 7/22 (31) | 2.1 | 1.0–4.4† |
| Water | None | 15/34 (44) | — | — |
| Ice | None | 15/34 (44) | — | — |
| Beer | 8/16 (50) | 7/18 (39) | 1.3 | 0.6–2.8 |

* Illness is defined as meeting the criteria for a confirmed or probable case.

† Statistically significant on univariate analysis.

during grinding. The two different products were then put on trays and placed in the retail case. A plastic scoop was used to portion out product when sold, and product was wrapped with the safe-handling statements preprinted on the wrapping.

However, the safe-handling statement that was used pertained to poultry, not to beef. Leftover product was reported to have been discarded each day and not carried over for sale the next day. All five butchers performed some grinding of meat during the outbreak interval. Interviews with each of the butchers revealed that they ate raw beef during the outbreak interval, but none of the butchers reported becoming ill. No deficiencies in their personal hygiene were observed.

All of the product implicated had been prepared using the same equipment. All parts of the meat grinder, except for the auger housing, were disassembled and individually cleaned and sanitized at the end of each day. This type of grinder allowed easy disassembly of the auger and other smaller parts; however, the auger housing was attached to the grinder with nuts and bolts and required a wrench for removal. Meat remnants were present in the auger housing (i.e. in the attachment groove) when the housing was disassembled from the grinder during the third inspection visit on 20 January 1995. The grinder had received its routine end-of-the-day cleaning on 19 January and had not been used to grind any meat before we performed our inspection. In addition, the

attachment groove appeared rusty and unclean. The cleaning staff had not received instructions regarding removal of the auger housing and had cleaned only the surfaces of the tunnel-like space of the auger housing using a brush. The cleaning crew consisted of two part-time employees of high school age who performed the cleaning of the shop and its equipment. Past sanitation inspections had not indicated a problem with unsanitary conditions in this butcher shop.

Laboratory investigation

Isolates from 107 patients were identified as tartrate negative *Salmonella*, which were serotyped at WSLH as *S. Typhimurium*. No other bacterial enteric pathogens were isolated. All of the 6 meat isolates and 33 case-patient isolates tested using PFGE had an identical band pattern (12 bands). In addition, the 4 isolates (2 meat and 2 human) tested had identical antimicrobial susceptibility results and were susceptible to all antimicrobials evaluated.

One of the five butcher shop A butchers had a stool culture positive for tartrate-negative *S. Typhimurium*; he denied illness and was therefore not included in the case count. He reported having eaten raw ground beef at the shop during the outbreak interval. Cultures of stool specimens from the other four butchers were negative for bacterial enteric pathogens.

All six samples of leftover raw ground beef obtained from the residences of case-patients, which had five different dates of purchase (i.e. 21, 22, 23, 24, and 29 December) from butcher shop A, were culture positive for tartrate-negative *S. Typhimurium*. Raw ground beef purchased on each of these five separate dates was linked with illness in case-patients who had eaten it.

All swabs for bacterial culture obtained from the equipment and other areas in the butcher shop were culture negative for *Salmonella*. All the samples of raw ground beef collected on 6 and 20 January 1995 were also culture negative for *Salmonella*.

DISCUSSION

This outbreak investigation implicated contaminated raw ground beef as the source of *Salmonella* infection. The outbreak occurred during the Christmas holidays. The decline of cases after the Christmas holidays may have occurred because ground beef from the implicated butcher shop was no longer eaten raw, or because the grinder was cleaned more thoroughly after WDATCP personnel spoke with the proprietor of the butcher shop on 30 December 1994.

Some patients reported that eating raw ground beef during the Christmas holidays was a practice brought from Europe by their ancestors. Ethnic populations may observe food consumption practices that place them at risk of foodborne illness [5–9]. Consumer advisories may be more effective if targeted to specific cultural or ethnic groups who engage in these dietary practices.

Our investigation underscores the fact that knowledge of health risks is not consistently associated with desirable changes in behaviour. Despite public health warnings and publicity about related outbreaks, some consumers in Dodge County and contiguous counties, and elsewhere have continued to eat raw or undercooked foods of animal origin. The results of this case-control study provided evidence of the prevalence of the practice of eating raw ground beef in this community. Controls were selected using a systematic telephone-dialing method which is a convenient way to randomly select controls among households with phones. The availability of persons (and their representativeness) during day time might create a selection bias as retired or unemployed persons might be more attainable. However, we limited that problem by phoning persons in the evenings. Controls were likely to be representative of the community.

We discovered that 8 of 40 controls (20%) consumed raw ground beef during the Christmas holiday season. Larger studies have found similar disturbing results. In a telephone survey of a national sample of 1620 adults conducted by the Food and Drug Administration (FDA) during December 1992–February 1993, of those surveyed, 53% had consumed raw eggs; 23%, undercooked hamburgers; 17%, raw clams or oysters; 8%, raw sushi or ceviche; and 5%, steak tartare (raw hamburger meat) [10]. Survey respondents who had more than a high school education were more likely to report high-risk food consumption than those who had a high school education or less.

Prevention measures include the ongoing need to warn consumers of the health risks associated with eating raw ground beef and the need to encourage consumers to thoroughly cook ground beef and adhere to safe food-handling guidelines. Safe cooking and handling labels on raw or partially cooked meat and poultry are now required by the US Department of Agriculture (USDA). However, the presence of safe-food-handling labels does not ensure adherence to safe practices. For example, an investigation of risk factors for sporadic *E. coli* O157:H7 infection indicated that of 43 food preparers who reported reading the safe-food-handling label on meat packages, 33 (77%) admitted to practices specifically discouraged by the warning on label [11].

We are confident that the meat grinder in butcher shop A was associated with the contamination despite the negative environmental culture results. It is unlikely that each of the approximately 80 rounds of beef from separate cattle carcasses ground during 21–29 December 1994, were contaminated with the same tartrate-negative strain of *S. Typhimurium* before delivery to the shop. Cross-contamination in the storage room was ruled out, as each of the rounds of beef was individually cryopacked. The magnitude of this outbreak and the finding that meat samples (raw and seasoned) from five different production days were culture positive for *S. Typhimurium* suggest sustained contamination of a piece of equipment. It also explained how *S. Typhimurium* could persist in the shop during a prolonged period and infect so many people.

We hypothesize that meat remnants persisted from day to day in the housing of the auger, which was not thoroughly sanitized during the period 22–29 December 1994, and provided opportunities for *S. Typhimurium* to survive in the equipment. Once the

pathogen was introduced in the grinder, the raw beef was contaminated as it was ground. Grinding of raw beef provided an opportunity for thorough mixing of the organism into the raw product. The raw ground beef provided *S. Typhimurium* with a good medium for growth; temperature abuse during serving of the product by consumers, coupled with the fact that it was not cooked before serving, permitted growth of the organism. Operators of the shop were informed of a potential problem of foodborne illness by WDATCP staff before the first inspection occurred, which may explain why all environmental swab specimens of the grinder were culture negative.

Beef, from a single supplier, contaminated with *S. Typhimurium* and ground on or before 21 December 1994, probably introduced the pathogen into the meat grinder. The prevalence of *Salmonella* in beef ranges from 1% in raw beef carcasses [12] to 5–7% in ground beef (USDA, Food Safety and Inspection Service, unpublished data, 1994). Conceivably, meat of types other than denuded beef rounds, which was ground in the meat grinder, could have introduced *S. Typhimurium* into the production area.

Alternatively, a food handler could have contaminated the meat grinder. It is unknown when the food handler who tested positive for *S. Typhimurium* became infected because he had an asymptomatic infection. However, the findings that contamination continued during a prolonged period and that all five foodhandlers prepared the raw ground beef suggest that a foodhandler was an unlikely source in this outbreak. The foodhandler would have had to contaminate beef on at least five separate days.

The USDA currently conducts carcass-by-carcass inspection on the basis of the Federal Meat Inspection Act of 1906 and subsequent legislation. However, as has been true since 1906, examination has been restricted to what inspectors can see, smell, and feel. Carcasses may appear healthy and meet all current inspection criteria but still carry human pathogens [12]. Irradiation of raw foods is an effective way to destroy pathogens but is, to date, socially unacceptable in the United States [13]. In 1996, the USDA's Food Safety and Inspection Service mandated changes in the meat and poultry inspection system to improve assessment and control of microbial pathogens in raw meat and poultry [14]. USDA's new inspection rule consists of three parts: (1) new in-plant safeguards (use of anti-bacterial rinses and proper cooling of raw animal products); (2) daily microbiologic testing to minimize bacteria in

meat and poultry foods; and (3) a requirement that every plant set up a detailed Hazard Analysis Critical Control Point (HACCP) plan.

Food-grinding machines have been implicated in previous outbreaks of enteric disease [15]. Grinding equipment should therefore be regarded as a critical point in the system, and industry should design grinding equipment that is easily accessible for cleaning and sanitizing. This includes equipment for large and small butcher shops. However, even with user-friendly machines, employee education and training regarding the recommended methods of cleaning and sanitizing grinding equipment will always be necessary. State regulatory and inspection authorities should adopt and enforce FDA model Food Code guidelines that offer specific recommendations for handling, cooking, and storing raw meat, cleaning and sanitizing equipment and utensils, and designing and constructing equipment [16].

The investigation of this outbreak implicated the eating of raw ground beef from a single butcher shop as the risk behaviour for acquiring *S. Typhimurium* infection. Inadequate cleaning and sanitization of a meat grinder probably resulted in ongoing contamination of ground beef during at least an 8-day interval. Despite messages regarding the dangers associated with eating raw or undercooked animal products, a substantial number of persons cognizant of the messages continue to eat undercooked or raw meat; some became ill during this outbreak. This investigation underscores the important role that consumer education plays in preventing foodborne illness. Although human behaviour is sometimes difficult to change, repetitive health education messages constitute our best long term strategy to achieve success. Coverage of similar outbreaks by the media and introduction of a food safety curriculum in elementary and secondary schools for the younger generations are potential strategies. Specific press statements describing this outbreak were released just before the 1995 Christmas holiday period to capture the interest and the attention of the Wisconsin public. Simultaneous efforts to improve food safety at different levels in the food-processing chain also are required. The licensing and inspection of (a) slaughter facilities, (b) larger meat-processing plants, and (c) smaller butcher shops play important roles in the prevention of foodborne illness.

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