

Outbreak of *Escherichia coli* O157:H7 Infections Associated with Nonintact Blade-Tenderized Frozen Steaks Sold by Door-to-Door Vendors

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ABSTRACT

Steaks have not been recognized as an important vehicle of *Escherichia coli* O157:H7 infection. During 11 to 27 June 2003, the Minnesota Department of Health (MDH) identified four O157 infection cases with the same pulsed-field gel electrophoresis (PFGE) subtype. All four case patients consumed brand A vacuum packed frozen steaks sold by door-to-door vendors. The steaks were blade tenderized and injected with marinade (i.e., nonintact). Information from single case patients in Michigan and Kansas identified through PulseNet confirmed the outbreak. The MDH issued a press release on 27 June to warn consumers, prompting a nationwide recall of 739,000 lb (335,506 kg) of frozen beef products. The outbreak resulted in six culture-confirmed cases (including one with hemolytic uremic syndrome) and two probable cases in Minnesota and single confirmed cases in four other states. The outbreak PFGE subtype of O157 was isolated from unopened brand A bacon-wrapped fillets from five affected Minnesota households. A fillet from one affected household was partially cooked in the laboratory, and the same O157 subtype was isolated from the uncooked interior. The tenderizing and injection processes likely transferred O157 from the surface to the interior of the steaks. These processing methods create new challenges for prevention of O157 infection. Food regulatory officials should reevaluate safety issues presented by nonintact steak products, such as microbiologic hazards of processing methods, possible labeling to distinguish intact from nonintact steaks, and education of the public and commercial food establishments on the increased risk associated with undercooked nonintact steaks. Information on single cases of O157 infection in individual states identified through PulseNet can be critical in solving multistate outbreaks in a timely manner.

Escherichia coli O157:H7 (O157) was first documented as a cause of epidemic gastroenteritis in 1982, after an outbreak associated with hamburgers from a fast-food restaurant chain (19). Over the past two decades, O157 has been recognized as a frequent cause of diarrhea with bloody stools and the primary cause of hemolytic uremic syndrome (23), a severe sequela with a 5% fatality rate (11). O157 causes an estimated 73,000 infections and 61 deaths annually in the United States (17). Cattle are the primary reservoir for O157, although other ruminants such as sheep, goats, and deer can also be sources (11). Outbreaks of O157 infection have been reported from direct contact with cattle (9), environments contaminated with cattle manure (29), recreational (10) and drinking (15) water, unpasteurized milk (14), apple cider (2), and produce items such as lettuce (12) and sprouts (4) that were likely contaminated directly by animal manure or indirectly from unclean irrigation water prior to harvesting or packing. However, the leading food vehicle for O157 outbreaks is undercooked ground beef (11), which is also a documented risk factor for sporadic cases of O157 infection (13). Steaks have not been

implicated as an important vehicle for O157 infection. In 2003, we investigated an outbreak of O157 infections caused by blade-tenderized, marinade-injected steaks sold vacuum packed and frozen by door-to-door vendors. The objective of the investigation was to determine the scope of the outbreak and its implications for food safety in the United States.

MATERIALS AND METHODS

Foodborne disease surveillance in Minnesota. State rule mandates that both O157 infection and hemolytic uremic syndrome be reported to the Minnesota Department of Health (MDH). All Minnesota residents with a culture-confirmed O157 infection are routinely interviewed with a standard questionnaire about symptom history, food consumption, and other potential exposures occurring in the 7 days prior to onset of illness. Clinical laboratories are required to forward all O157 isolates to the MDH Public Health Laboratory for confirmation and pulsed-field gel electrophoresis (PFGE) subtyping. The utility of routine PFGE subtype-specific surveillance in the detection of O157 outbreaks in Minnesota has previously been documented (1). PFGE subtypes are entered into the National Molecular Subtyping Network for Foodborne Disease Surveillance (PulseNet) database. PulseNet, the national electronic communications network for public health laboratories and the Centers for Disease Control and Prevention

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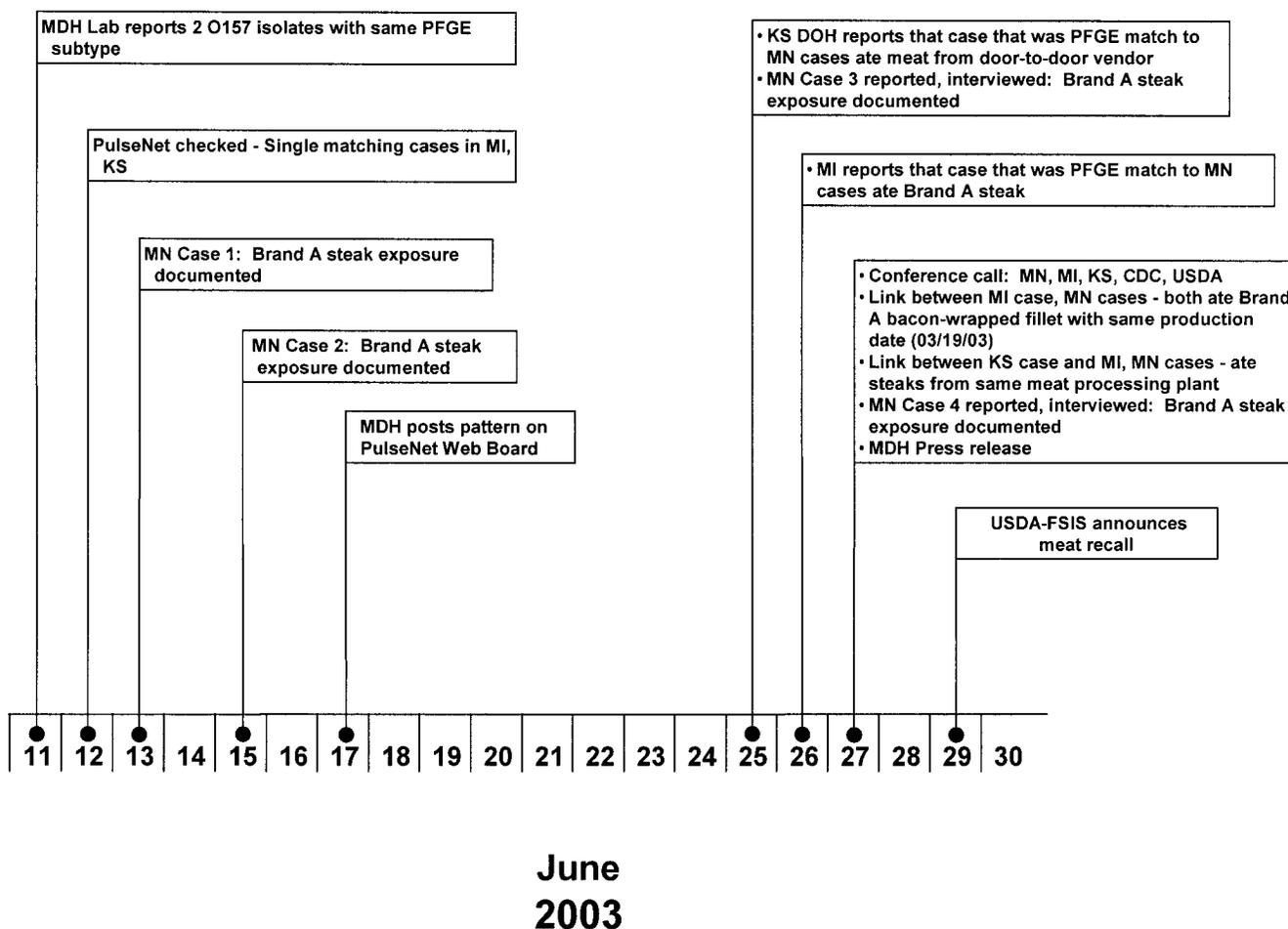


FIGURE 1. Timeline of selected events during an outbreak of *E. coli* O157:H7 infections.

(CDC), has been instrumental in the detection of several multistate foodborne outbreaks (22).

Outbreak case definition and isolate subtyping. For this outbreak, a confirmed case was defined as a Minnesota resident with a culture-confirmed O157 infection and a history of consuming brand A steaks in the 7 days prior to onset of illness. A probable case was defined as a person who did not have a culture-confirmed O157 infection but who reported diarrhea with bloody stools, had a history of consuming brand A steaks in the 7 days prior to onset of illness, and had a brand A steak that tested positive for O157 with the outbreak-associated PFGE subtype.

PFGE after digestion with the enzyme *Xba*I is performed on all O157 isolates received at MDH. Those isolates with the pattern common to this outbreak (EXHX01.0047) were also tested by PFGE after digestion with a second enzyme, *Bln*I. All isolates with the EXHX01.0047 *Xba*I pattern that were also indistinguishable after digestion with *Bln*I were given the additional PulseNet designation EXHA26.0015.

Meat testing. Frozen, vacuum-packed uncooked steaks were collected from all confirmed and probable Minnesota case patients and submitted to the Minnesota Department of Agriculture (MDA) for O157 culture. The meat was cultured according to the protocol outlined by the U.S. Department of Agriculture (27) with the following modifications: the amount of sample varied, cefixime-tellurite sorbitol MacConkey agar and sorbitol MacConkey agar plates were used instead of rainbow agar, and steps q, r, and s listed in section 5.6 of the protocol were not followed as written.

The O157 isolates from meat samples were subtyped by PFGE at the MDH.

The MDA laboratory conducted an experiment to determine whether O157 could be cultured from the interior of a partially cooked bacon-wrapped fillet. One package of intact vacuum-wrapped fillet from the freezer of an affected household was aseptically opened, and the bacon was removed and discarded. Using sterile tongs, a beef fillet approximately 60 mm in diameter and 35 mm thick with an approximate weight of 100 g was placed into a hot nonstick pan and seared on each surface for 20 to 40 s. The tongs were dipped in 95% EtOH and flamed between rotations of the fillet. The objective was to cook the surface but leave an uncooked core. The searing cooked the fillet to a depth of 5 to 10 mm. Following the searing, approximately 5 mm of the cooked surface was trimmed off with a sterile knife, and the sample was cultured for O157.

RESULTS

Epidemiologic investigation and traceback. A timeline of selected outbreak events is given in Figure 1. On 11 June 2003, the MDH identified two O157 isolates with an indistinguishable PFGE subtype pattern after digestion with the enzyme *Xba*I; these types were designated as PulseNet pattern EXHX01.0047. These two isolates were submitted to the MDH from clinical laboratories through routine statewide laboratory-based surveillance. By 15 June, interviews with the two case patients had revealed

that both had recently consumed vacuum-packed frozen steaks purchased from door-to-door vendors from a Minnesota-based company (brand A). An epidemiologic investigation was initiated.

On 17 June, a message describing the epidemiologic characteristics of the cluster and encouraging other states to share information on any PFGE matches was posted on the PulseNet web board. MDH epidemiologists contacted epidemiologists at the Michigan and Kansas state health departments because each state had a single O157 case whose isolate was indistinguishable from the Minnesota isolates by PFGE using both *Xba*I and *Bln*I. Both state agencies worked with their local health departments to gather epidemiologic information on these cases.

By 27 June, the MDH had identified two additional Minnesota residents with O157 who had consumed brand A steaks, bringing the total number of Minnesota cases to four. The case patients had all purchased brand A variety packs, which included multiple boxes of steaks, each box containing a different type of steak. The steaks were flash-frozen and packaged in individual vacuum-packed portions. On 27 June, a conference call was held with officials from the Michigan and Kansas state health departments, the Foodborne and Diarrheal Diseases Branch of the CDC, and the Food Safety and Inspection Service of the U.S. Department of Agriculture (USDA-FSIS). MDH confirmed with both Michigan and Kansas that each of their case patients had consumed steaks that were purchased from door-to-door vendors. Based on USDA establishment numbers on the product labels, the steaks consumed in Minnesota, Michigan, and Kansas all originated from the same processing plant in Illinois. The Michigan case patient had consumed brand A bacon-wrapped fillets during the 7 days prior to illness onset. The production date that appeared on the package in the Michigan case, 19 March 2003, was the same as the production date of bacon-wrapped fillets consumed by one of the Minnesota case patients (3). The Kansas case patient had consumed a different brand (brand B) of frozen vacuum-packed bacon-wrapped fillets during the 7 days prior to illness onset; however, brand B steaks originated from the same processing plant as did the brand A steaks (24).

Later on 27 June, the MDH issued a press release to inform consumers of the association between the O157 cases in Minnesota and brand A steaks. On 29 June, USDA-FSIS announced that the implicated processing plant was voluntarily recalling 739,000 lb (335,506 kg) of frozen beef products. The nationwide recall included product produced from 17 through 22 March 2003. The recalled meat had been distributed nationwide to restaurants, institutions, and retailers under several different brand names.

Case characteristics. This outbreak ultimately resulted in six confirmed O157 cases in Minnesota and single confirmed cases with the same outbreak PFGE subtype in Michigan, Kansas, Iowa, and North Dakota (7). Each case patient consumed vacuum-packed frozen steaks that were all produced at the same plant. In Minnesota, in addition to the six confirmed cases identified through laboratory-based surveil-

lance, two probable cases were identified when individuals called the MDH with complaints of illness following news accounts of the outbreak. Both probable case patients reported bloody stools. Stool samples were collected from both of these individuals several weeks after their illnesses, but these samples were culture negative for O157.

Five of the six confirmed Minnesota case patients had O157 isolates with PFGE patterns that were indistinguishable by the two enzymes. One of the six case patients had an O157 isolate with a unique PFGE pattern, designated PulseNet pattern EXHX01.1356&; this PFGE subtype was two bands different from the outbreak PFGE subtype.

Date of illness onset for the six confirmed Minnesota cases ranged from 27 May to 23 September 2003. Four of the confirmed cases had onset dates from 27 May to 18 June. Two additional confirmed cases occurred in Minnesota after the recall was announced on 29 June: one in early August and another in late September. These two case patients were unaware of the recall and had eaten brand A steaks that had been in their freezers for several months. One of the probable Minnesota case patients reported an onset date of 12 June, but for the other probable case an exact onset date could not be established.

The median age of the Minnesota case patients was 27 years (range, 5 to 59 years). Each individual resided in a different county dispersed throughout Minnesota. All eight case patients had diarrhea and cramps, seven (88%) had bloody stools, three (38%) had fever, and three (38%) had vomiting. The median incubation period was 3 days (range, 2 to 5 days), and the median duration of illness was 8 days (range, 6 to 30 days).

Three of the case patients were hospitalized. Two were hospitalized for 2 days each with gastroenteritis. One 52-year-old case patient was hospitalized for 25 days with hemolytic uremic syndrome and was discharged with residual neurological deficits, including expressive aphasia.

Meat testing, traceback, and plant investigation. The case patients in Michigan, Iowa, and North Dakota all reported consuming brand A steaks; the Michigan and North Dakota case patients specifically recalled eating bacon-wrapped fillets, whereas the Iowa case patient recalled eating a variety of fillets (24). The Kansas case patient had eaten bacon-wrapped fillets of a different brand, but that brand was produced at the same plant as the brand A steaks (24).

Leftover brand A steaks were collected from all six confirmed and two probable case patients in Minnesota and submitted to the MDA laboratory for O157 testing. Two of the confirmed case patients had purchased a variety pack, which included bacon-wrapped beef fillets, boneless beef fillets, chopped beef steaks, beef loin T-bone steaks, boneless beef strip loin steaks, and fillet of beef sirloin ball tip steaks (24). These two case patients were unsure which specific type(s) of brand A steak they had consumed in the week prior to illness. No product packaging was available. Leftover ball tip and strip loin steaks from these case patients were culture negative for O157.

The remaining six Minnesota case patients (four confirmed and two probable) reported consuming brand A

bacon-wrapped fillets. All had leftover bacon-wrapped fillets in their freezers still in intact vacuum-wrapped packages. Fillets from all six of these cases, including the case from which O157 of a different PFGE subtype was isolated, were culture positive for the outbreak-related *Xba*I and *Bln*I PFGE subtypes of O157. One fillet was also positive for O157 of an additional PFGE subtype that was eight bands different from the outbreak subtype; no cases of human illness due to this subtype were identified. The MDA laboratory isolated O157 of the outbreak-associated PFGE subtype from the interior of a bacon-wrapped fillet that had been partially cooked in the laboratory.

Three Minnesota case patients with O157 culture positive bacon-wrapped fillets still had the original boxes. The boxes all listed a 19 March 2003 production date. The Michigan case patient also had bacon-wrapped fillets that were culture positive for the outbreak PFGE subtype of O157; the original box for these bacon-wrapped fillets also listed a 19 March 2003 production date (3).

Processing plant investigation. The steaks implicated in this outbreak were nonintact cuts of beef; according to the package label, the steaks were injected with a 12% solution that included water and flavorings. The USDA investigation of the processing plant revealed that these steaks underwent multiple passes through a blade-tenderizing apparatus. Blade tenderization is a process whereby meat is placed on a conveyor system and passes through a series of blades that cut through the meat tissues and fibers (21). On a daily basis, the plant performed a general physical washdown of the injectors followed by the application of a sanitizer. On a weekly basis, there was a complete disassembly of the equipment with a washdown and sanitizer application (24).

DISCUSSION

This is the first reported outbreak of O157 infection associated with steak products. Eight cases (six confirmed by culture) in Minnesota and four cases in other states were identified. Investigation of this outbreak emphasized the importance of the nationwide PulseNet system and timely epidemiologic follow-up to outbreak recognition and the rapid identification and recall of an outbreak vehicle. Information from single cases in a particular state identified through PulseNet can be critical in the investigation of multistate outbreaks, as illustrated by the Michigan and Kansas cases in this outbreak. The information from the single cases in these two states was a primary factor in the decision to issue a press release on 27 June rather than waiting for additional epidemiologic or laboratory data to be gathered within Minnesota.

Although outbreaks of O157 involving intact (non-ground) beef have occasionally been reported (5, 20), steaks have not been considered a likely vehicle for O157 infection. Unlike ground beef, the interior of the steak should be free of pathogenic bacteria. Cooking just the surface should be adequate to destroy any contamination that might be present. However, the steaks implicated in this outbreak were nonintact cuts of beef; the muscle surface had been

breached during the blade tenderizing and marinade injection processes. These processes probably led to cross-contamination between individual steaks and introduced O157 into the interior of the steaks. In 1999, the USDA announced that nonintact cuts of beef contaminated with O157 were to be considered adulterated (25).

Blade-tenderized or injected steaks are a newly recognized vehicle for O157 infection. Although in one research study translocation of O157 from the surface to the interior of blade-tenderized beef steaks was considered unlikely to result in illness when the steak was oven-broiled and cooked to an internal temperature of at least 140°F (60°C), the same study revealed that grilling with gas was a less effective cooking method and required temperatures of at least 150°F (66°C) for a 5-log reduction in bacteria (21). This finding led the USDA to state that “non-intact, blade tenderized beef steaks do not present a greater risk to consumers if the meat is **oven broiled** and cooked to an internal temperature of 140°F or above” (emphasis in original) (26). The individuals in this outbreak cooked their steaks on the grill and did not check the temperature with a thermometer. Several of the Minnesota case patients reported that they cooked the steaks directly after removal from the freezer, as per the vendor’s recommendation. This contradicted the safe handling instructions on the package, which stated “thaw in refrigerator or microwave,” and may have hindered thorough cooking of the steak.

A key issue highlighted by this outbreak is how well cooked consumers prefer their steaks to be. Consumers generally do not eat their steaks thoroughly cooked. In a survey conducted by the CDC/FDA/USDA Foodborne Diseases Active Surveillance Network, 50% of individuals who had consumed steak in the past week reported eating it pink (6). Therefore, consumer education and labeling may be needed to encourage thorough cooking of nonintact steak products. In a 2002 report to the USDA, the National Advisory Committee on Microbiological Criteria for Foods concluded that there were insufficient data to warrant a labeling requirement to distinguish intact from nonintact beef (26), but the USDA may need to revisit this issue in light of the present findings. Because these nonintact beef products also may be served in restaurants, the food service industry should be aware of the potential increased risk posed by undercooked nonintact steaks. In 2004, the Conference for Food Protection adopted a recommendation that the USDA and the U.S. Food and Drug Administration develop guidelines for retail establishments describing the safe cooking of blade-tenderized steaks (8).

Frozen food products have a long shelf life in the home and therefore present a special risk to the public as possible outbreak vehicles; inevitably, some consumers do not hear of the recall of these products and subsequently consume the product and develop illness (16). In the outbreak described here, two affected individuals in Minnesota were unaware of the recall and ate the implicated steaks between 1 and 3 months after the press release and the recall announcement. This example illustrates some of the deficiencies in the nation’s food recall system that were described in a recent report by the U.S. Government Accountability Office (28).

Although primary consumer education and early outbreak detection and response are important preventive measures, elimination of consumer exposure to contaminated steaks is ideal. The USDA should consider reevaluating the microbiologic hazards of technologies used in the production of nonintact steaks. Irradiation of these products (18) could provide valuable additional protection, particularly given consumer preferences for undercooked steaks.

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