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Initially unrecognized distribution of a commercially cooked meat product contaminated over several months with *Salmonella* serotype Infantis

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SUMMARY

An outbreak of salmonellosis occurred among 63 wedding participants. The outbreak was investigated through cohort, laboratory, and environmental studies. Consumption of rice-dressing made from a commercially cooked, meat-based, rice-dressing mix was strongly associated with illness. Nineteen patient isolates, six company/grocery store isolates cultured from the rice-dressing mix, and one environmental isolate from a pump in the production line were of an identical outbreak strain of *Salmonella* Infantis characterized by pulsed-field gel electrophoresis. In the production line, cooked rice-dressing mix tested negative for *S.* Infantis before and positive after contact with the contaminated pump. The dressing-mix had an estimated 200 colony-forming units of salmonella per gram of product, and > 180000 pounds were distributed in 9 states for $\geqslant 2$ months before contamination was recognized. Food manufacturers should be required to use systematic, hazard analysis critical control point risk management practices for all processed meat products, validated by periodic microbiologic monitoring of the end product.

INTRODUCTION

In the United States, an estimated 5·2 million foodborne-related illnesses from known pathogens are caused by bacteria; salmonella is the causative agent for approximately half of all outbreak-reported cases [1]. The economic burden of salmonellosis is estimated to be as high as US $3·9 billion annually [2, 3].

Most outbreaks and sporadic gastrointestinal illness caused by salmonella are linked to raw or undercooked animal products – mainly eggs, poultry, and beef products [4–7]; some are associated with fresh produce grown from contaminated seeds, on the ground, fertilized with untreated manure, or irrigated with contaminated water [8–11].

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Outbreaks linked to commercially cooked and distributed products are uncommon. Those that have been reported usually have occurred in localized venues and have been associated with improper food-handling procedures, which include undercooking of foods by kitchen chefs, or contamination from other foods or from ill food-handlers [12–16]. Thorough cooking of food products at high enough temperatures (i.e. 140–165 °F) likely destroys bacteria in meats and other foods [17].

Packaged food products sold commercially in the United States are regulated by government agencies to enhance their safety. The Food Safety and Inspection Service of the US Department of Agriculture is responsible for ensuring the labeling and safety of meat, poultry, and egg products and focuses on inspection of raw animal products [18]. The Food and Drug Administration (FDA) develops guidelines with recommendations for food preparation, including the cleaning and sanitizing of equipment [19]. Food

processing equipment has previously been implicated in the contamination of raw animal products [5], but has only rarely been implicated in the contamination of cooked products.

We report the investigation of a large outbreak of gastroenteritis caused by *Salmonella* Infantis associated with a commercially cooked and distributed product. Contamination occurred during the production process after the meat ingredients had been cooked. The product had been distributed to nine US states over a period of several months without notice by public health or food regulatory agencies.

BACKGROUND

On 18 August, 1998, an infection-control nurse notified the Louisiana Office of Public Health (OPH) about several patients with symptoms of gastroenteritis. The patients had attended a wedding reception on 15 August, 1998. An estimated 200 guests attended the wedding.

METHODS

Because the organizers of the wedding had invited guests by word of mouth (i.e. without a written guest list), we identified wedding participants by asking known participants to provide additional names of persons who attended the wedding and by questioning patients with gastrointestinal illness seen at local hospitals in the immediate days after the wedding.

Using a questionnaire administered by telephone, participants were asked about demographic information, symptoms of gastrointestinal illness experienced since the wedding, and consumption of foods and beverages served at the wedding. A case was defined as diarrhoea, defined as any loose stool in a 24 h time period, with onset occurring during 15–18 August, 1998. Univariate analyses were performed for the association of food exposures with illness using relative risks with 95% confidence intervals (Epi-Info, version 6.04b, CDC).

OPH staff interviewed relatives and friends who prepared the foods for the wedding about ingredients used, food-preparation procedures, and food-handling techniques, including serving practices at the reception. Participants with diarrheal illness were encouraged to submit stool specimens to be tested for salmonella.

After rice dressing was implicated as a possible vehicle for infection, leftover rice dressing from the wedding and a rice-dressing mix sample with an unknown production date provided by a relative of the bride were obtained for salmonella testing. On 1 September, OPH staff obtained three additional rice-dressing mix containers with a date of production before 14 July, 1998, from a local grocery store. On 15 September, OPH staff inspected the production plant and reviewed the production process. Environmental swab specimens were taken from several locations of the food processing equipment after it had been cleaned using routine cleaning procedures. Rice-dressing mix also was sampled from several steps in the production line; samples of dressing mix with production dates before 15 September were obtained from Company X's storage room. In addition, OPH staff obtained two samples of 'roux' (a sauce used as a base in cooking Cajun food) prepared in the same cooking vat as the rice-dressing mix that had production dates of 13 August and 15 September (the date of the visit). Food and environmental swab samples were tested using procedures described by FDA in the 1995 Biological Analytical Manual.

All stool, food, and environmental isolates positive for *Salmonella* Infantis were evaluated for their relatedness through the analysis of chromosomal DNA restriction patterns by pulsed-field gel electrophoresis (PFGE) using a standardized laboratory protocol for molecular subtyping [20]. In addition, PFGE was performed on isolates from all stool specimens positive for *Salmonella* Infantis from patients residing in Louisiana that were reported to OPH from January to December 1998. On 29 September, staff of the Centers for Disease Control and Prevention (CDC) contacted State Health Departments from the nine states to which the rice-dressing mix was distributed to report patients diagnosed with *Salmonella* Infantis in 1998. Patients infected with *Salmonella* Infantis with a PFGE pattern identical to the outbreak pattern were questioned about food consumption in the 7 days before becoming ill.

The Louisiana Department of Agriculture obtained 10 additional rice-dressing mix samples from the production plant in September. These samples were tested at Louisiana State University (LSU) laboratories to quantify the amount of salmonella contamination.

RESULTS

Outbreak investigation

We were able to identify 162 wedding participants by

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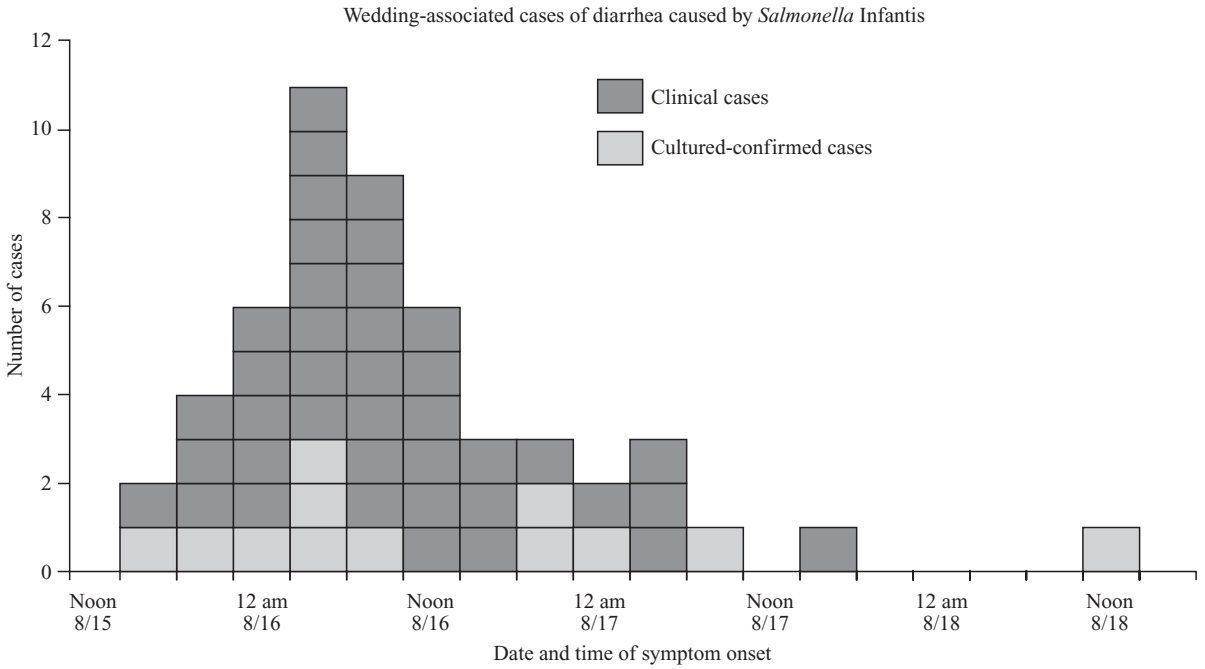

Fig. 1. Wedding-associated cases of diarrhoea caused by salmonella. ■, Clinical cases; □, Culture-confirmed cases.

Table 1. *Food and beverage-specific attack rate and relative risk for food items served at the wedding reception on 15 August, 1998*

Food or beverage item	Persons consuming item III/total (attack rate %)	Persons not consuming item III/total (attack rate %)	Relative risk	95% Confidence interval
Rice dressing	59/95 (62)	3/16 (19)	3·3	1·2–9·3*
Cochon du lait	32/50 (64)	29/60 (48)	1·3	1·0–1·9
Cake	30/48 (63)	31/62 (50)	1·3	0·9–1·7
Punch	33/54 (61)	26/50 (52)	1·2	0·8–1·7
Ice in drink	27/45 (60)	29/56 (52)	1·2	0·8–1·6
Fruits	17/29 (59)	45/81 (56)	1·1	0·7–1·5
Pork 'n beans	45/78 (58)	17/33 (52)	1·1	0·8–1·6
BBQ Chicken	48/85 (56)	14/26 (54)	1·1	0·7–1·6

* *P*-value = 0·001.

name; of these, we completed questionnaires for the 114 (70%) participants for whom we had sufficient information to contact. A total of 63 (55%) participants met the case definition (Fig. 1); 27 case-patients sought medical care for their symptoms, 9 of whom were hospitalized; 5 case-patients reported bloody diarrhoea. Additional predominant symptoms included cramps (89%), nausea (75%), headache (68%), fever (65%), chills (53%), and vomiting (49%). The median incubation period was 21 h (range: 2–69 h), and the median duration of illness was 3 days (range: 1–6 days). Stool specimens were obtained and tested for 23 ill persons who self-reported that they were wedding participants. *Salmonella* Infantis was isolated from stool specimens of 19 persons; all 19 isolates showed an identical PFGE pattern. Questionnaires were completed for 16 of the 23 ill persons tested, all 16 case-patients tested positive.

Univariate analysis of the risk from foods and beverages served at the reception demonstrated that only rice dressing was significantly associated with illness (Table 1). Of 95 participants who ate rice dressing, 59 (62%) developed illness meeting the case definition compared with 3 (19%) of 13 participants who did not eat rice dressing (relative risk [RR] = 3·3; 95% confidence interval [CI] = 1·2–9·3). Rice dressing was served in two different batches. Twenty (95%) of

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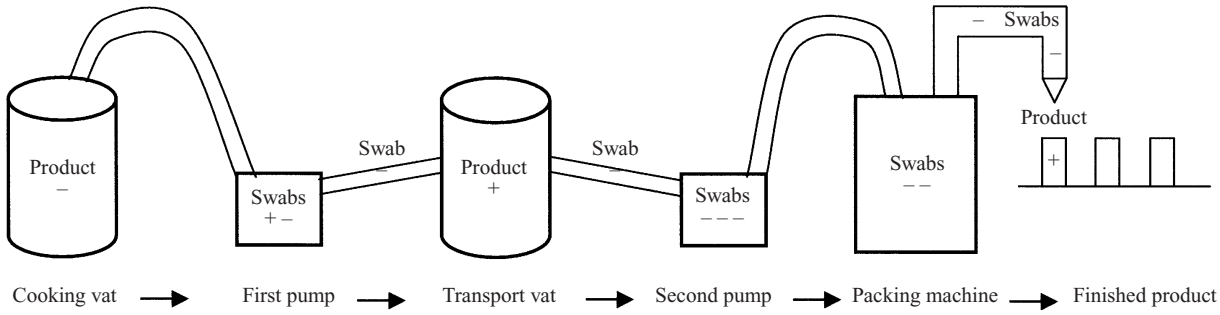

+ = Positive for *Salmonella* infantis

− = Negative for *Salmonella* infantis

Fig. 2. Schematic diagram of production plant and test results of environmental swab specimens and the cooked product 15 September, 1998. +, positive for *Salmonella* Infantis; −, negative for *Salmonella* Infantis.

21 participants who ate only from the second batch of dressing met the case definition compared with 9 (33%) of 27 participants who ate only from the first batch (RR = 2·9; CI = 1·6–4·9). Of the remaining 47 participants, 5 ate from both batches (including 2 case-patients) and 42 did not recall from which batch they ate (including 28 case-patients).

Environmental investigation

The rice dressing was prepared with use of commercially cooked and distributed rice-dressing mix bought at Company X's store. Rice-dressing mix consists mainly of pork, pork liver, chicken gizzards and spices and other flavourings. On 15 August, a relative of the bride added the commercially cooked rice-dressing mix to chicken gizzards, pork livers, vegetables and spices and cooked the mixture for approximately 30 min. The finished dressing was then stored in the original dressing-mix containers. The relative also prepared rice to be mixed with the dressing. The food was prepared early in the morning and was stored without refrigeration at the reception hall until it was served during 4:00–7:00 pm.

All eight rice-dressing mix samples with production dates earlier than 15 September tested at the State laboratory were positive for *Salmonella* Infantis. These samples included (*a*) leftover rice dressing and rice-dressing mix obtained from the relative of the bride who prepared the dressing; (*b*) all three dressing-mix samples obtained at a local grocery store; and (*c*) all three dressing-mix samples obtained from Company X's storage room. Both samples of 'roux' obtained during the visit of Company X tested negative for salmonella.

Company X had begun to indicate the date of production on the dressing mix containers on 14 July, 1998. The three specimens obtained at a local grocery store must have been produced before 14 July, because they did not have a date of production marked on their containers. Production for salmonella-positive dressing-mix samples with known production dates ranged from 4 August to 15 September, 1998. In 1998, the production plant produced approximately 20000 pounds of rice-dressing mix per week. Thus, a minimum of 180000 pounds of rice-dressing mix were produced and distributed during $\geqslant 9$ weeks of contamination (from before 14 July to 15 September). Although most of the product was sold in Louisiana, it was also distributed to Arkansas, Florida, Georgia, Idaho, Michigan, Mississippi, Tennessee, and Texas.

Rice-dressing mix was prepared in the production plant in five main steps (Fig. 2): (*a*) the raw meat ingredients (which included pork, chicken gizzards and pork liver) were ground and put into a cooking vat where they were cooked and then cooled; (*b*) the mix was transferred from the cooking vat into a transport vat by means of stainless steel pipes and a 'Waukesha' pump (consisting of two rotating cloverleaf-shaped stainless steel disks that force the cooked rice-dressing mix through the pipes); (*c*) the transport vat was wheeled into a packaging room; (*d*) the mix was pumped by a second pump into a packing machine, and (*e*) the cooked mix was funneled into 1-pound containers. Although the plant produced roux in the same cooking vat used for the rice-dressing mix, roux was filled into containers directly from the cooking vat without being pumped into the transport vat. All of the machinery was taken apart and cleaned every evening with an abrasive detergent, after which it was rinsed several times. The production manager

reported that he inspected each piece of equipment before it was reassembled.

Environmental sampling

Of 11 environmental swab specimens obtained during the visit at the production plant on 15 September, only one tested positive for *Salmonella* Infantis; this specimen was obtained from the first 'Waukesha' pump, which was located between the cooking and transport vat. Also positive for *Salmonella* Infantis were two of three dressing mix samples taken from different steps in the production process – one obtained from the transport vat and the other from the finished product at the end of the production line. The one dressing mix sample negative for *Salmonella* Infantis came from the cooking vat before being pumped into the transport vat.

An environmental swab taken from the pump located between cooking and transport vat tested positive for *Salmonella* Infantis; as a result, managers from the production plant completely disassembled the pump. A rubber gasket within the pump was cracked and possibly leaking. Before this disassembling, staff at Company X had not been aware of the rubber gasket or that the pump could be disassembled to this extent. Consequently, the gasket and the area around it were never included in the daily cleaning process.

Product recall

On 22 September 1998, the United States Department of Agriculture (USDA) issued a recall of rice-dressing mix products produced before 15 September. The recall asked that retail stores remove all packages of the product, and that consumers return unused products to the store of purchase. The recall resulted in the recollection and disposal of 90000 pounds of dressing mix.

Retrospective surveillance

In 1998, isolates of *Salmonella* Infantis from 28 ill persons were submitted to the Louisiana OPH. Twenty-five of those showed an identical PFGE pattern, including the 19 case-patients related to the wedding outbreak. Of the 6 sporadic cases with a PFGE pattern matching the wedding outbreak strain, 3 patients could be contacted. One likely had eaten the implicated rice-dressing mix in the 7 days before becoming ill. Her date of onset was in December 1998, 3 months after the recall of the product. She had stored the locally purchased dressing mix in the freezer for months and was not aware of the recall of the product. The other 2 patients did not recall having eaten the implicated product before becoming ill. Of the other 8 states to whom Company X's products were shipped, only the Texas Department of Health (TDH) reported cases of *Salmonella* Infantis with the outbreak pattern in 1998. One of 16 isolates examined with PFGE showed an identical pattern to the outbreak pattern. The patient was a 70-year-old man, who reported having eaten the implicated rice-dressing mix within the 7 days before becoming ill with diarrhoea on 25 August, 1998.

All rice dressing samples and the one environmental swab positive for salmonella had a PFGE pattern identical to the pattern of the stool specimens obtained from outbreak-related case-patients. Quantitative analysis of rice-dressing mix showed 50–200 salmonella colony forming units (c.f.u.) per gram.

DISCUSSION

This outbreak of salmonellosis was caused by a commercially cooked rice-dressing mix product. The product had likely become contaminated at the plant through contact with a deteriorated rubber gasket of a pump in the production line after the product had been cooked. Before this investigation, contaminated dressing mix from Company X had been sold for more than 2 months to nine US states without notice. Improper food preparation and storage by the organizers of the wedding probably contributed to the high attack rate of illness in wedding participants, which then alerted local infection control practitioners to the problem. As a result of the subsequent investigation, USDA implemented a national recall of the product.

This outbreak was unusual, in that a commercially cooked and distributed meat product was the source of illness. According to Company X's log book, the meat ingredients used in the preparation of the dressing mix were cooked at high enough temperatures to destroy bacteria; however, this could not prevent contamination at a later step in the production process. In addition, the label on the rice-dressing mix containers made consumers believe they had purchased a 'fully cooked' product that only

required 'simmering for 10 minutes' before being served. Consumers thought the product to be safe without any additional cooking, or as a participant of the wedding stated, 'You can eat it right out of the container, after all it's already cooked'.

The first environmental sample in the steps of the production line positive for *Salmonella* Infantis came from a 'Waukesha' pump, which is thus believed to be the source of contamination. The isolate had a PFGE pattern identical to the outbreak pattern. Also, the cooked product, which tested positive after having been pumped through the 'Waukesha' pump, tested negative in earlier steps of the production process. The original contamination of the pump may have been caused by pumping an undercooked, contaminated batch of dressing mix through the pump; parts of the dressing mix were trapped in the deteriorated rubber gasket.

In 1995, a nationwide ground chicken microbiological survey of the Food Safety and Inspection Service within the US Department of Agriculture found a prevalence of salmonella in ground chicken of 44·6% and in hog and swine carcasses of 8·7% [21, 22]. In 1998, 1 year after the implementation of the Hazard Analysis and Critical Control Point (HACCP) Systems by Food and Safety Inspection Service, salmonella was found in 36·4% of ground turkey, reduced from 49·9% in baseline studies [23]. This illustrates possible positive implications of HACCP as a system targeted to reduce contamination of enteric pathogens in animal products through improved inspection procedures at production plants.

The implicated plant has been officially operating under HACCP guidelines since January 1999 [18]. Although this program may reduce the percentage of raw meat that is contaminated with salmonella, it will not eliminate it. Meat processing plants will continue to work under a risk that raw meats will contaminate equipment, which if not completely disassembled and cleaned can then contaminate cooked products.

Although the product was contaminated at the level of production, food-handling by the organizer of the wedding contributed to the outbreak. Cooking large amounts of rice dressing probably did not result in high enough temperatures to destroy the bacteria in the purchased product. The rice dressing was then kept at warm, outdoor temperatures for many hours, which likely allowed bacteria to further multiply before being served. A later serving with longer storage time may have contributed to the higher attack rate of the second batch of rice dressing. No differences in the preparation of the first and second batch could be elicited. The public needs to be warned about risks involved in consumption of processed meat products, and educated about proper food-handling and storage.

At least two factors might have led to the fact that contamination of the product was unrecognized by food inspection services or public health departments for months before the outbreak occurred. First, *Salmonella* Infantis is a commonly occurring *Salmonella* serotype in many states in the United States [24], so its identification does not immediately alert public health officials that something unusual is happening. Second, because the implicated product was widely distributed, possible cases were likely interpreted as sporadic illness. Geographically widespread outbreaks of common pathogens likely go unrecognized without evidence of an apparent linkage between the cases [25–27]. In most states, serotyping of salmonella strains is concentrated in public health laboratories, so closer interpretation of possible clusters of the same strains by laboratory personnel and/or surveillance staff would be feasible and may be warranted. Newly available laboratory techniques (e.g. PFGE) can identify strains as being identical and thus justify a cluster investigation. Few states were doing this in 1998. If data about identical strains were linked with findings from different states [28, 29], small clusters of geographically widespread disease might be more promptly detected leading to the appropriate remedies in production plants.

Estimating how many cases of gastroenteritis may have been caused by this product is difficult. At 50–200 c.f.u./g, contamination of the product (if not cooked further) was clearly high enough to cause illness in humans; infectious doses as low as 4–45 cells have been observed in previous outbreaks [30, 31]. Human illness likely occurred given a conservative estimate of approximately 180000 pounds of contaminated product being distributed in the 2 months before the recall – and positive rice dressing samples dated back even earlier than 14 July, 1998. It is also known that 95–99% of salmonella infections occurring in the population are never diagnosed or reported to health departments [32]. However, cases of gastroenteritis occurring from consumption of the rice-dressing mix may have been limited, because most individual food preparers may have properly cooked the product so that the bacteria were destroyed before consumption. In conclusion, it is perhaps not surprising that only a very limited number of patients

with *Salmonella* Infantis infections were reported to health departments.

As a result of the outbreak, the production plant began soaking parts of the equipment in iodine overnight in addition to the routine cleaning with soap and water and implemented daily environmental bacteriological testing of equipment and bimonthly bacteriological testing of cooked products. No positive samples have been detected since implementation of these measures.

It is the combined responsibility of production plants, regulating agencies, and health departments to ensure distribution and consumption of safe products through safe food production, regular food testing, and consumer education. HACCP-based production safety plans should be implemented in combination with periodic microbiologic monitoring of cooked products (particularly of processed meat products like the implicated rice-dressing mix) for enteric pathogens before distribution to retail stores. In addition, although handling labels on raw or partially cooked meat products do not ensure safe foodhandling practices by the consumer [5, 33], guidelines for labels of cooked products should be reconsidered. Consumers should be alerted to the need to reheat food products to proper temperatures before consumption, and to maintain foods at either hot or cold temperatures.

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