An Outbreak of *Salmonella* München in Germany Associated with Raw Pork Meat

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ABSTRACT

In summer 2001, an outbreak of *Salmonella* München occurred in Germany. We conducted descriptive epidemiology and hypothesis-generating interviews among case patients, two retrospective cohort studies, and a case-control study of suboutbreaks. We performed pulsed-field gel electrophoresis (PFGE) from selected patient isolates and a limited trace-back investigation for analytical purposes. Four states were consecutively affected: Saxonia (SX), Brandenburg (BB), Berlin (BE), and Baden-Württemberg (BW). Although hypothesis-generating interviews failed to identify a plausible food item, descriptive data and investigations of the suboutbreaks suggested pork meat as a probable source in three states (SX, BB, and BE) but not in BW. The PFGE profiles from isolates of case patients in the first three states were indistinguishable but differed from PFGE profiles of case patients in BW. Trace-back investigation suggested that contamination of pork meat occurred early in the rearing-production chain. This outbreak demonstrates how contamination early in the production process that can yield different end products may complicate multistate outbreaks. Investigation of suboutbreaks and use of the trace-back method as investigational tools may be useful adjuncts in solving the problem of multistate outbreaks.

In Germany, the most commonly reported foodborne bacterial illness is due to infections from nontyphoidal *Salmonella* serotypes. In 2001, 77,186 *Salmonella* infections (incidence, 94 per 100,000) were reported to the Robert Koch-Institute (RKI), the federal public health institute for infectious diseases (6). For the leading serotype, *Salmonella* Enteritidis, poultry and poultry products, particularly eggs, have been confirmed as the main reservoir (2, 5). For serotypes other than *Salmonella* Enteritidis, however, the individual reservoir may vary and is, if in existence, less well described or unknown for the more rare serovars.

In Germany, there are two institutions that collect data on patients with confirmed *Salmonella* infections: (i) the German National Reference Center for *Salmonella* and Other Bacterial Enteric Pathogens (NRC), which receives *Salmonella* isolates for serotyping and other typing methods, and (ii) the Center for Infectious Disease Epidemiology of the RKI, which obtains reports of notified *Salmonella* infections. According to German law, laboratories have to notify confirmed *Salmonella* infections to the local health department from which reports are transmitted first to state health departments and then to RKI. Time from symptom onset to receiving reports at the federal level lasts approximately 2 to 3 weeks.

In week 28, both of these databases identified an increase in isolates of *Salmonella* München (Figure 1). Although nationwide from week 1 to 25 only 12 cases of *Salmonella* München were reported to RKI, 17 cases were reported in week 26. After communication with the pertinent state health departments, RKI investigated the outbreak to identify the cause and introduce preventive measures if possible.

MATERIALS AND METHODS

We defined a laboratory-confirmed case patient as a person with *Salmonella* München reported to the national database for notifiable infectious diseases between weeks 26 and 36 in 2001 (the outbreak period). A clinically and epidemiologically confirmed case patient was a person who participated in the same event as a laboratory-confirmed case patient and had diarrhea within 3 days of the event. We focused in the beginning on the case patients of the states of Saxonia (SX), Brandenburg (BB), and Berlin (BE), because these three states reported the most numbers of patients. After obtaining permission from the state health departments, we contacted case patients directly and interviewed them at length with a detailed exploratory questionnaire that contained both open and closed questions with the goal to develop a hypothesis for the outbreak (Figure 1). Among other questions, we asked about every single meal in the 72 hours before symptom onset and where it was purchased or consumed. After we failed to see an obvious commonality among case patients, we conducted two retrospective cohort studies in defined, separate settings of suboutbreaks, one in BE and one in BB. Later, in week 32, an increase in *Salmonella* München cases occurred in a fourth state (Baden-Württemberg [BW]). Most cases in BW were confined to visitors to a single county who had gathered for a church party. We conducted a case-control study of this event. For statistical analyses of the three studies, we used Epi-Info, version

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6.03 (Centers for Disease Control and Prevention, Atlanta, Ga.). Categorical variables were evaluated with a $\chi^2$ test or Fisher’s exact test if expected cell values were less than 5.

We asked laboratories to send their isolates to the NRC for further typing by means of pulsed-field gel electrophoresis (PFGE). To understand the clonality of the Salmonella München isolates, the NRC compared PFGE profiles from strains isolated from cases in SX, BB, BE, and BW (during the outbreak period) and other strains from patients before the outbreak period (background strains). After we had identified pork meat as a likely cause of the outbreak, we conducted a trace-back investigation on a selected number of cases and one situation where the outbreak strain was identified in a quality control sample of a pork sausage.

RESULTS

Epidemiology. The number of reported cases increased sharply in week 26, had a second peak in week 32, and then decreased rapidly until week 36 (Figure 2). Between weeks 26 and 36, 198 cases were reported. A total of 154 (78%) of 198 reported cases occurred in the four states SX, BB, BE, and BW. The outbreaks in the three states SX (10 case patients), BB (41 case patients), and BE (36 case patients) preceded the outbreak in BW (67 case patients, Figure 3). Within the states, case patients resided in 3 counties in SX, 9 counties in BB, 13 counties in BE, and 6 counties in BW.

Male patients were more frequently affected in the three states of SX (8 [73%] of 11), BB (23 [56%] of 41), and BE (24 [67%] of 36), whereas in BW male patients were in the minority (27 [40%] of 67). Also, the age distribution differed among the three states of SX, BB, and BE compared with BW. In the first three states, 73% of case patients were younger than 50 years; in BW, 67% were 50 years or older.

In the exploratory interviews, we did not identify a specific food item common to most case patients. The first retrospective cohort study investigated an outbreak after a celebration (early lunch) at a company in BE (company A). Approximately 70 to 80 persons had participated in the festivity on 23 June 2001 (week 25). Although only one person was identified via the infectious disease reporting system, we identified retrospectively six more cases patients who became ill with gastroenteritis after the celebration (clinically and epidemiologically confirmed cases). We were able to interview 43 participants about the food they had consumed. Seven (35%) of 20 persons who had eaten raw minced and spiced pork meat became ill, but of 23 persons who had not eaten this food, no one became ill (risk ratio is infinite, $P = 0.002$). No other food or drink was statistically associated with illness. One week later, a sporadic, laboratory-confirmed case occurred in the same company not related to the festivity. The case patient had eaten minced pork meat from the company’s cafeteria within 72 h before symptom onset.

In a second, unrelated company in BB (company C), 16 persons had participated in a lunch that was provided by one of the workers. Three of them became ill afterward with gastroenteritis: one laboratory-confirmed case patient and two clinically or epidemiologically confirmed case patients. All three (100%) had eaten raw minced and spiced pork meat during the lunch. Overall, 3 (33%) of 9 persons who had eaten raw pork meat became ill but none of 5 who did not ($P = 0.26$).

After having conducted these two studies, we reexamined the exploratory questionnaires for the mentioning of pork consumption. Of 30 case patients, 23 (77%) stated that they had eaten pork meat, and 21 (70%) had eaten any
FIGURE 4. Results of the trace-back investigation of an outbreak of Salmonella München in July and August 2001. Case patients A, B, C, E, and F and food sample G shared a PFGE pattern. RET, retailer; D, distributor; MPC, meat processing company; A, abattoir; PF, pig farm. Dotted circles indicate links within A through G. Case patient D, although the pertaining isolate was not available for PFGE typing, was included in the graph because his illness could be epidemiologically linked to case patient C.

form of raw pork meat, such as raw minced meat or raw ham.

We identified a meat processing company (MPC) where three workers were also reported with illness due to Salmonella München. A sausage produced by the company that was sent for quality assurance also contained Salmonella München. We were unable to receive a list of distributors supplied by the MPC.

BW was chronologically the fourth state with an outbreak of Salmonella München. BW does not share a common border with any of the other three states, whereas SX, BB, and BE are contiguous to each other. The occurrence of outbreaks was associated with a church supper on 22 July 2001 (week 30). Among 170 persons estimated to have been present during the supper, we conducted a case-control study among 85 participants. The foods with the strongest association with disease were a potato salad (odds ratio, 2.7; 95% confidence interval, 0.8 to 8.6) and a mixed vegetable salad (odds ratio, 1.8; 95% confidence interval, 1.0 to 3.1). Both salads did not contain meat. Consumption of meat and sausage was investigated but was not associated with illness.

Molecular subtyping (PFGE). All PFGE patterns of 16 strains from SX, BB, and BE were indistinguishable (PFGE type 1). The PFGE patterns from strains from case patients in BW were also indistinguishable (PFGE type 2). However, the two PFGE types were different from each other. Three of 8 background strains had PFGE type 1, but the remaining five had neither PFGE type 1 nor PFGE type 2.

Trace-back investigation. For the trace-back investigation, we selected five case patients from BB and BE (patients A, B, C, E, and F) with PFGE type 1, a laboratory-confirmed case patient (patient D) who had purchased pork consumed within 3 days before onset of illness in the same store as case patient C, and one microbiological quality assurance sample (food sample G) from the sausage with a Salmonella München strain also with PFGE type 1 (Figure 4). Case patient A participated in the festivity in company A, and case patient C participated in the lunch in company C. The five case patients and the sausage sample were from four different counties in two different states (BE and BB). We connected case patients A and B to the same MPC (MPC 1), which in turn received pork from 10 different pig farms. Pork meat from companies C, D, and E could have come from the same distributor. This distributor was supplied by 15 pig farms, three of which also supplied pork to MPC 3, where case patient F worked and where sausage G came from. We did not succeed in finding a possible common source, such as one herd, for MPC 1 (with 10 possible pig farms) and the three pig farms (farms 23 to 25) common to MPC 2 and 3 (Figure 4).

DISCUSSION

We investigated a multistate outbreak of Salmonella München that was linked to pork meat distributed to at least three German states. This conclusion is supported by the following findings. First, pork meat was the only identified vehicle that was associated with cases in the outbreak in company A. Second, raw pork meat was eaten by all cases in company C, and it was more frequently eaten by cases than by noncases. Third, the MPC where at least three cases were identified had also sent a pork sausage for quality control purposes, which yielded Salmonella München as well. The PFGE pattern of this Salmonella München isolate was indistinguishable from the outbreak strain. Fourth, at least 77% of cases for whom a detailed food history was available had eaten pork meat before illness; 70% had eaten any form of raw pork meat. Fifth, although we were not
able to show the possible final link, the trace-back investigation showed that different types of pork meat from case patients in different counties could be linked at several stages and traced to only two sources, supplied by 13 different pig farms, that would explain all cases included in the trace-back investigation.

We failed to generate a hypothesis through exploratory interviews alone. However, the two suboutbreaks in companies A and C led to the strong hypothesis that some form of pork meat was associated with cases. Reassessment of exploratory interviews supported the association with pork or raw pork meat. Since pork meat is a frequent part of the diet in Germany, we did not deem it promising to conduct a case-control study testing the hypothesis of “consumption of pork meat.” Because several different forms of pork meat were mentioned by case patients, it was unlikely that a very defined type of pork meat from a single production batch close to the consumer’s level was the culprit of the outbreak. We postulated, therefore, that contamination had occurred early in the rearing-production-distribution chain. To examine this hypothesis, we conducted, for analytical purposes, a trace-back investigation with the goal of identifying common links in the production and distribution chain of selected cases. Indeed, the trace-back investigation demonstrated several common links of cases. If a common source existed, it must have been at the beginning of the rearing-production chain.

The outbreak in the fourth German state, BW, seemed to be different from the beginning and could be distinguished from the situation in the other three states by the combined results of descriptive epidemiology, analytical epidemiology, and molecular subtyping. Results of the epidemiological investigation and subtyping became evident approximately at the same time. Although description of case patients by age and sex already found a different pattern, the case-control study did not identify meat as a likely vehicle for the outbreak. Molecular epidemiology finally showed that the respective strains (PFGE types 1 versus 2) were different from each other.

Investigations of suboutbreaks can be a useful tool in settings where several regions or states are involved (1, 3, 10). They are usually logistically easier, can be conducted more rapidly, and involve fewer methodological problems. In addition, they may be an effective tool to develop a likely hypothesis for the outbreak and to distinguish coincidental outbreaks of the same agent caused by different sources. When trying to solve multistate outbreaks, one should therefore always attempt to identify such opportunities.

It has been pointed out that multistate or supraregional outbreaks have become more common due to the changing production and distribution methods and the increasing role of few large companies in the food industry (7, 8). The outbreak described herein underpins the difficulties in the investigation of multistate outbreaks when contamination of the food occurred at an early stage in the production process. The search for a specific type of food may not be possible, because, in the case of meat, it may be processed to different end products, such as raw minced meat, raw ham, or sausages. On the other hand, the consumption of the causative type of food, such as pork meat, may be so widespread in the population that consumption as such will likely not be different among cases compared with controls.

The role of pork meat for the incidence of human Salmonella infections other than Salmonella Enteritidis in Germany is believed to be important, but this is largely based on studies on pigs, the food processing chain, and pork meat itself. For example, 7.3% of pigs housed for fattening (9) between 1996 and 1999 and 3.8% of sampled pork at retail level in 2001 (4) in Germany tested positive for Salmonella. The link with human illness, however, is not well established. Outbreak reports, such as this one, may not only give an indication why this link is so difficult to make but are also crucial to build the evidence necessary to advocate stricter regulations with the aim of curbing foodborne Salmonella infections in Germany.

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