SHORT REPORT
Added value of a household-level study during an outbreak investigation of *Salmonella* serotype Saintpaul infections, New Mexico 2008

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SUMMARY

In 2008, nationwide investigations of a *Salmonella* serotype Saintpaul outbreak led first to consumer warnings for Roma and red round tomatoes, then later for jalapeño and serrano peppers. In New Mexico, where there were a large number of cases but no restaurant-based clusters, the NM Department of Health and the Indian Health Service participated with CDC in individual-level and household-level case-control studies of infections in New Mexico and the Navajo Nation. No food item was associated in the individual-level study. In the household-level study, households with an ill member were more likely to have had jalapeño peppers present during the exposure period and to have reported ever having serrano peppers in the household. This report illustrates the complexity of this investigation, the limitations of traditional individual-level case-control studies when vehicles of infection are ingredients or commonly eaten with other foods, and the added value of a household-level study.

Key words: Epidemiology, foodborne infections, investigation, *Salmonella*, salmonellosis.

Salmonella is a common foodborne pathogen in the USA, accounting for 110 reported foodborne outbreaks with confirmed aetiology in 2008 [1]. Of the more than 2500 known *Salmonella* serotypes, serotype Saintpaul is the 11th most commonly reported among US residents, with 588 cases reported in 2006 [2].

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All state public health laboratories are requested to perform serotyping and pulsed-field gel electrophoresis (PFGE) subtyping on human isolates of *Salmonella*, and to submit the subtype pattern to PulseNet, the national molecular subtyping network for foodborne disease surveillance [3]. In New Mexico, clinical laboratories are required to submit all *Salmonella* isolates to the New Mexico Department of Health (NMDOH) Scientific Laboratory Division for serotyping and PFGE. On 22 May 2008, the NMDOH notified the Centers for Disease Control and Prevention (CDC) of a cluster of four human cases of *Salmonella* serotype Saintpaul infections with

matching PFGE patterns. This cluster would grow to become the largest foodborne outbreak in the USA in over a decade, with a total of some 1500 laboratory-confirmed infections reported in 43 states, the District of Columbia and Canada [4, 5].

Early cases were concentrated in Texas and New Mexico, and in a case-control study in those states in May 2008, illness was associated with eating raw tomatoes. A subsequent national case-control study in June implicated Mexican-style foods and eating pico de gallo, corn tortillas, and freshly prepared salsa. In analyses of clusters associated with restaurants or events, jalapeño peppers were implicated in all three clusters with implicated ingredients, and jalapeño or serrano peppers were an ingredient in an implicated item in another three clusters. Raw tomatoes were an ingredient in an implicated item in three clusters. Tracebacks of tomatoes did not converge on any one geographical location, grower, or supplier. Jalapeño pepper tracebacks led to isolation of the outbreak strain from jalapeño peppers collected in Texas and in agricultural water and serrano peppers on a Mexican farm [5, 6].

While additional details of the findings of the investigation have been published elsewhere [5, 7], here we describe the New Mexico, Indian Health Service (IHS), and Navajo Nation experience during this outbreak. In addition to reporting the first cases and being the site of the first case-control study for the outbreak, New Mexico also had the highest overall incidence rate and many of the cases were from the Navajo Nation. Most importantly, unlike in other states involved in this outbreak, no restaurant-associated clusters were identified in New Mexico or the Navajo Nation. Restaurant-based studies were key in identifying jalapeño and serrano peppers as vehicles of infection in the latter part of this nationwide outbreak [7]. The New Mexico experience allows us to illustrate how, in the absence of restaurant-associated clusters, traditional population-based case-control studies may fall short and how the simple addition of a household-level study can assist in outbreak investigation.

In June 2008, we conducted a case-control study in New Mexico and the Navajo Nation to collect Mexican-style food exposure information. The goal was to discern specific ingredients linked to illness through the use of in-person interviews and visual aids, as well as to increase the representation of the Navajo population that is generally more difficult to reach by telephone.

For this outbreak, a confirmed case was defined as a laboratory-confirmed *Salmonella* serotype Saintpaul infection with PFGE *Xba*I pattern indistinguishable from the outbreak strain (JN6X01.0048). The case-control study included residents of New Mexico or the Navajo Nation who met the definition for a confirmed case and who had illness onset on or after 30 May 2008. A case-patient whose illness began after a culture-confirmed illness in another household member was defined as a secondary case and was excluded, as were case-patients who had travelled outside of New Mexico and the Navajo Nation during the duration of their exposure period. Controls were defined as residents of New Mexico or the Navajo Nation within the same age group as the matched case (<18, 18–49, ⩾50 years) who belonged to a household in which no household member had reported diarrhea since 1 May 2008.

The CDC National Center for Emerging and Zoonotic Infectious Diseases determined that the investigations in this outbreak were for the primary purpose of identifying and controlling disease in response to an immediate public health threat. As such, these investigations did not meet the definition of research as described by the Common Rule 45 CFR 46 and IRB review was not required. All participants were read an explanation of the background and purpose of the investigations and provided oral consent for their voluntary participation. Interviews were conducted in person. Respondents were asked whether they had consumed specific food items in the 7 days before illness began for the case-patient; controls were asked about the same time period as their matched case. A photo booklet with pictures of food items was used to aid recall and identification.

Controls were neighborhood-matched to cases by approaching the third household counter-clockwise of the case household and continuing with each sequential household until up to three controls were enrolled. If more than one eligible person in a household was willing to serve as a control, the person nearest in age to the case-patient was enrolled.

A household-level case-control study was conducted simultaneously with the individual-level case-control study, enrolling households of respondents from New Mexico or the Navajo Nation. The goal was to identify not only foods eaten by the case-patients, but also foods that were present in the home. The primary food preparer was enrolled and others present in the household with knowledge of food purchasing and handling practices were invited to

Table 1. *Association between cases of* Salmonella *serotype Saintpaul infection and selected foods consumed by residents of New Mexico or the Navajo Nation with illness onset from 30 May 2008 to 15 June 2008*

Food consumed	Cases (N=41) n (%)	Controls (N=107) n (%)	Adjusted mOR (95% CI)*
Jalapeño peppers	19 (46)	35 (33)	1·7 (0·6–5·0)†
Serrano peppers	4 (10)	7 (7)	0·5 (0·1–3·1)†
Any chili peppers	23 (56)	44 (42)	1·6 (0·6–4·4)
Red round tomato	13 (33)	32 (32)	1·0 (0·3–2·8)
Roma tomato	6 (15)	10 (10)	1·2 (0·2–6·2)
Any tomatoes	27 (66)	50 (49)	1·9 (0·6–6·1)
Cilantro	6 (15)	17 (16)	0·6 (0·2–2·3)
Fresh salsa	11 (28)	27 (26)	0·9 (0·3–2·9)
Pico de gallo	4 (10)	3 (3)	1·8 (0·2–22·0)
Guacamole	7 (18)	17 (17)	1·0 (0·3–3·4)

* Matched odds ratio with 95% confidence intervals, exact conditional logistic regression. Cases and controls were matched for general age group (<18, 18–49, $\geqslant 50$ years); age and sex were controlled for in the model.
† Data included in a previously published summary paper [5].

assist the primary food preparer in the interview. If the primary food preparer was not available in a control household, the household was excluded from the individual-level and household-level study.

Respondents in the household-level study were asked about purchase, preparation, and consumption of suspect food items in the 7 days before illness onset for the case-patient; controls were asked about the same exposure period as their matched case. Participants were also asked about having the suspected food items in their household since Memorial Day (26 May) or ever before. Food items assessed included items suspected based on prior investigations, including red round and Roma tomatoes, jalapeño and serrano peppers, and cilantro; respondents were shown fresh samples of these items to aid in recall and identification.

Data were entered into Microsoft Access databases. Statistical analyses were performed using SAS version 9.1 (SAS Institute Inc., USA). Matched odds ratios (mOR) and 95% confidence intervals (CI) were calculated using exact conditional logistic regression models that controlled for age and sex. Exact confidence intervals were used; a *P* value of $\leqslant 0\cdot05$ was considered statistically significant.

From 1 June to 27 July, 62 persons with a laboratory-confirmed *Salmonella* infection matching the outbreak strain were reported in New Mexico and the Navajo Nation. Of these, seven secondary cases and three cases that had travelled outside of New Mexico and the Navajo Nation during their exposure period were excluded. An additional four cases that lived on American Indian reservation land where permission for the study had not been obtained were also excluded. Of the 48 cases remaining, four could not be reached and three refused to participate. The remaining 41 cases were enrolled. There were no significant differences in demographics for those enrolled and the 21 not enrolled; mean age of those not enrolled was 29 years ($P=0\cdot12$ compared to those enrolled), 57% were female ($P=0\cdot18$), and 52% were Navajo ($P=0\cdot27$).

Of the 41 case-patients enrolled, 27 were residents of the Navajo Nation and 14 were residents of New Mexico. The most commonly reported symptoms of enrolled patients were diarrhoea (98%), abdominal cramps (90%), and fever (90%). Seven patients had been hospitalized, with ages ranging from 1 to 82 years (median 50 years), all seven were American Indians. There were no deaths. Illness onset dates ranged from 30 May 2008 to 15 July 2008.

In the individual-level study, no food item was significantly associated with illness among residents of New Mexico and the Navajo nation (Table 1), which was consistent with results from a national case-control study conducted earlier in the outbreak [5]. Among persons enrolled, 66% of case-patients reported eating tomatoes at home or in a restaurant in

the week before illness onset compared to 49% of controls (adjusted mOR 1·9, 95% CI 0·6–6·1). Forty-six percent of case-patients reported eating jalapeño peppers at home or in a restaurant in the week before illness onset, compared to 33% of controls (adjusted mOR 1·7, 95% CI 0·6–5·0). There was also no significant difference in the proportions of case-patients reporting eating serrano peppers, other chili peppers, salsa, pico de gallo, or guacamole in the week before illness onset compared to controls. Ninety percent of case-patients and 89% of controls had heard of the tomato advisories; controlling for knowledge of the tomato advisories did not affect the association of illness with tomato consumption.

For the household-level study, the household size was not statistically different for the 41 case-households (median 3, range 1–9 persons) and 107 control households (median 3, range 1–12 persons). More than one household member responded to the interview in 29% of case households and 23% of control households. The person responding to the individual-level case-control study also participated in the household-level study in 88% of case and 85% of control households, and was the sole respondent for both studies in 61% of case and 69% of control households.

Case households were significantly more likely than control households to report having jalapeño peppers in the home during the exposure week (mOR 2·9, 95% CI 1·2–7·6) (Table 2). The strength of the association increased as the exposure period increased: 78% of case households and 45% of control households reported having jalapeño peppers in the household since Memorial Day (mOR 5·8, 95% CI 2·1–20·0), and 95% of case households and 65% of control households reported ever having jalapeño peppers in the household (mOR 11·0, 95% CI 2·4–98·0). Twenty-two percent of case-households and 8% of control households reported having serrano peppers in the household during the exposure period (mOR 3·0, 95% CI 0·9–10·0). This increased to 27% of case households and 12% of control households reporting having serrano peppers since Memorial Day (mOR 2·5, 95% CI 0·9–7·2), and 44% of case households and 24% of control households reporting ever having serrano peppers in the household (mOR 2·5, 95% CI 1·1–6·1). Illness was not associated with the presence of cilantro, tomatoes, salsa, pico de gallo, or guacamole in the household in any time-frame (during the exposure period, since Memorial Day, or ever).

The findings from these studies in New Mexico illustrate the challenges and limitations of current investigative techniques when dealing with food vehicles that are novel, complex, or used as ingredients where they may be missed or mistaken. The investigations were part of a nationwide effort to stem the outbreak, but were unique in that no restaurant-associated clusters of illness were identified.

An initial case-control study in New Mexico showed a strong association between illness and consumption of raw tomatoes. Subsequent epidemiological studies of cases not linked to restaurant clusters and involving persons who became ill later in the outbreak than those in this initial study, including the analysis presented here of just residents of New Mexico and the Navajo nation, showed no association between illness and consumption of any food item in the week before illness [5]. However, the household-level study, conducted by in-home interviews of the primary household food preparers using samples of suspect food items to aid recall and identification, found an association between the presence of jalapeño or serrano peppers in the household and illness in a household member.

Foodborne outbreak investigations rely first and foremost on patient recall of food items eaten. Standard hypothesis-generating questionnaires ask open-ended questions about all foods eaten and also include questions on some 200 or more specific food items. As these questionnaires are typically administrated weeks or even months after the subject was exposed, recall is an obvious challenge. In addition, these questionnaires necessarily focus on common food items and foods previously implicated in outbreaks, although it has become increasingly clear that practically any food item may be contaminated with *Salmonella*. No previous outbreaks have identified jalapeño or serrano peppers as a likely vehicle, although experimental evidence supports the idea that *Salmonella* can persist and grow on peppers [8, 9].

Identifying a contaminated food that is commonly used as an ingredient or eaten together with certain other foods can be challenging. Patients in the outbreak who consumed hot salsa, and investigators inquiring about that item, for example, may not have considered whether the salsa contained fresh hot peppers. The case-control study presented here was initiated to tease apart several food items identified in prior investigations in the outbreak that were all commonly part of Mexican-style foods. In-person interviews and a picture book of food were added to

Table 2. *Association between selected household exposures and cases of* Salmonella *serotype Saintpaul infection within the household among households of respondents enrolled in the individual-level case-control study, by time period* (*household-level case-control study*)

Food in household	Case households (N=41) n (%)	Control households (N=107) n (%)	mOR	(95% CI)*
Jalapeño peppers				
During exposure week	26 (63)	42 (40)	2·9	(1·2–7·6)†
Since Memorial Day	32 (78)	48 (45)	5·8	(2·1–20·0)
Ever	39 (95)	69 (65)	11·0	(2·4–98·0)
Serrano peppers				
During exposure week	9 (22)	9 (8)	3·0	(0·9–10·0)†
Since Memorial Day	11 (27)	13 (12)	2·5	(0·9–7·2)
Ever	18 (44)	26 (24)	2·5	(1·1–6·1)
Jalapeño or serrano peppers				
During exposure week	28 (68)	45 (42)	3·1	(1·3–8·0)
Since Memorial Day	33 (80)	52 (49)	6·3	(2·1–26·0)
Ever	40 (98)	73 (69)	19·0	(2·9–829·0)
Red round tomatoes				
During exposure week	16 (39)	31 (29)	1·5	(0·6–3·8)
Since Memorial Day	21 (51)	45 (42)	1·3	(0·6–3·0)
Ever	33 (80)	84 (80)	0·9	(0·3–2·9)
Roma tomatoes				
During exposure week	5 (12)	9 (8)	1·4	(0·3–5·5)
Since Memorial Day	7 (17)	15 (14)	1·2	(0·3–4·1)
Ever	20 (49)	37 (35)	1·7	(0·7–4·4)
Red round or Roma tomatoes				
During exposure week	20 (49)	35 (33)	1·8	(0·8–4·6)
Since Memorial Day	25 (61)	52 (49)	1·6	(0·7–3·8)
Ever	36 (88)	88 (83)	1·5	(0·4–6·8)
Cilantro				
During exposure week	2 (5)	12 (11)	0·4	(0·04–1·9)
Since Memorial Day	5 (12)	18 (17)	0·6	(0·2–2·3)
Ever	15 (37)	30 (28)	1·6	(0·6–4·0)
Homemade salsa, pico de gallo, or guacamole				
During exposure week	9 (22)	21 (20)	1·1	(0·4–3·1)
Since Memorial Day	15 (37)	30 (28)	1·5	(0·6–3·8)
Ever	22 (54)	51 (49)	1·3	(0·5–3·5)

* Matched odds ratio with 95% confidence intervals, exact conditional logistic regression. Cases and controls were matched for general age group (<18, 18–49, $\geqslant 50$ years).
† Data included in a previously published summary paper [5].

strengthen respondent recall to the extent possible. Because the suspect food items in this investigation were those commonly used as ingredients in other foods and may be eaten without being identified by the consumer, the household-level study was also conducted. This study queried the primary food preparer whether food items had been in the house at all, regardless of whether or not they were consumed.

While the individual-level study showed no association between illness and the consumption of any food item included on the questionnaire, the household-level study revealed an association between illness and the presence of jalapeño and serrano peppers

in the household. It is possible that this disparity is due to patients having eaten jalapeño peppers as an ingredient in a food dish prepared at home without being aware that the peppers were present. It is also possible that patients do not consider or recall component ingredients of foods they may have consumed, and that foods such as salsa and other sauces may not be easily recalled during hypothesis-generating interviews. Last, it is also possible that other food items in the home were contaminated, either by direct contact with peppers or via cross-contamination. Although the individual-level case-control study asked only about consumption of *raw* jalapeño peppers, a number of respondents reported anecdotally that they always boil or fry their peppers before consumption. All such individuals would have responded to the individual-level case-control study that they did not consume raw jalapeño peppers, while the household-level study revealed that peppers were nonetheless present in their homes and could have contaminated other food items or the person's hands, or have been insufficiently cooked.

Microbiological sampling conducted by FDA found that jalapeño and serrano peppers originating from Mexico were contaminated with the outbreak strain of *Salmonella* [5, 6], consistent with the finding from the household-level study despite the fact that the traditional individual-level study found no association between illness and any food item. When feasible, interviews with food preparers can reveal food items present in the house and possibly consumed by case-patients without having been noticed or reported by the case-patient. Interviews that question respondents only if they ate the food item raw are standard, although following up with a question on whether respondents ate the food item at all, or whether the suspected food item was in the house even if it was not consumed, could help account for possibilities of cross-contamination in the home or insufficient cooking of contaminated items.

Restaurant-based clusters of cases provide the advantage of recipe-level information of ingredients that might have otherwise gone unidentified by patients' recall [7]; however, New Mexico had no restaurant-associated clusters of illnesses during this outbreak. Future investigations of foodborne outbreaks not associated with a specific venue or event may benefit from enhanced investigational techniques such as household-level studies and questioning of food preparers, as well consideration of novel food items or multiple food items as vehicles for infection.

DECLARATION OF INTEREST

None.

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