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Outbreak of *Salmonella* Serotype Enteritidis Infections Associated with Raw Almonds — United States and Canada, 2003–2004

On May 12, 2004, the Oregon State Public Health Laboratory identified a cluster of five patients infected with *Salmonella enterica* serotype Enteritidis (SE) isolates that were matched by using two-enzyme pulsed-field gel electrophoresis (PFGE). The five patients were from four Oregon counties; their onsets of illness occurred during February–April 2004. A subsequent investigation, still ongoing, has identified a total of 29 patients in 12 states and Canada with matching SE isolates, since at least September 2003. Seven patients have been hospitalized; no one has died. Raw almonds distributed throughout the United States and internationally have been implicated as the source of the SE infections. As of May 21, approximately 13 million pounds of raw almonds had been recalled by the producer.

Routine interviews of the initial five patients with salmonellosis had not indicated a common exposure. However, prompted by the May 12 laboratory data, the patients were reinterviewed by using a standard hypothesis-generating questionnaire that included questions about consumption of approximately 400 specific food items and their shopping and eating venues during the 5 days before illness onset. Using binomial distribution, consumption rates for selected foods were compared with background rates estimated from a 2002–2003 population-based survey of residents of Oregon (1).

The initial five patients from Oregon all reported consuming Kirkland Signature brand raw almonds, purchased at Costco warehouse stores. Survey data (1) indicated that an estimated 9% of Oregon residents (86 of 921 surveyed) consumed raw almonds from any source in the preceding week. Even assuming that 20% of all Oregon residents ate Kirkland Signature brand raw almonds each week, the binomial probability of finding five of five sporadic cases with that history is <0.001. No other foods or food sources were associated with illness.

After determining that the raw almonds were distributed widely, U.S. and Canadian epidemiologists and state and federal regulatory agencies were notified on May 13 via electronic information networks. Through PulseNet, the national

molecular subtyping network (2), laboratories were queried for reports of isolates matching the outbreak PFGE patterns (*Xba*I: JEGX01.0049; *Bln*I: JEGA26.0008 or JEGA26.0009, reflecting minor variation later observed with the second enzyme). Laboratories that did not routinely screen SE isolates by using PFGE were encouraged to do so for isolates collected since February 1, 2004. Phage typing was performed by standard methods. As additional PFGE-matching isolates were identified, a brief, customized questionnaire was used in interviews with persons about their nut consumption.

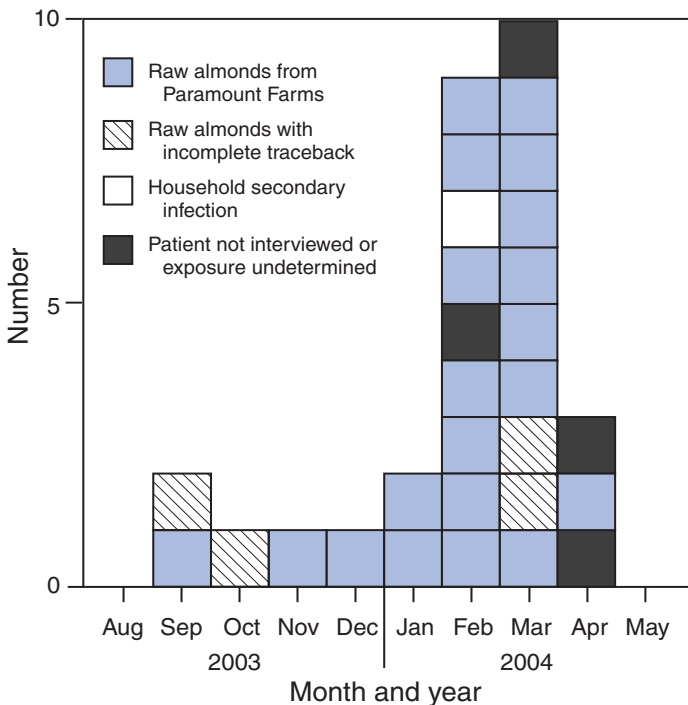
Raw almonds from an opened package recovered from one patient's household were tested for *Salmonella* by enzyme immunoassay. Unopened packages of nuts from the supplier's warehouse and environmental samples collected at the almond processor and at huller-shellers supplying the processor were tested for *Salmonella* by using standard microbiologic methods.

As of June 2, a total of 29 patients with SE infections matching both *Xba*I and *Bln*I PFGE patterns had been identified in 12 states and one Canadian province. Symptom onsets ranged from September 2003 to April 2004 (Figure). Patients ranged in age from 11 months to 91 years (median: 40 years); 17 (59%) were female. Seven patients were hospitalized; no one died. Multiple other cases with matching PFGE patterns and onsets earlier in 2003 remain under review. To date, nine isolates from the current outbreak have been phage typed; all are type 9c, which is uncommon.

Among 26 patients interviewed, 24 recalled eating raw almonds during the week before illness onset; 20 patients identified brands packaged or supplied by Paramount Farms (Lost Hills, California). One infant patient was presumed secondarily infected. Through retailer computer records linked to membership cards or customer receipts, dates and places of almond purchase were verified for 10 households of patients. The dates of verified almond purchases ranged from November 3, 2003, to January 28, 2004.

Efforts to identify specific production lots associated with illness, based on almond purchase dates and locations and store inventory data, are ongoing. On May 18, Paramount

FIGURE. Number* of PFGE[†]-matched cases of salmonellosis associated with raw almonds, by date of illness onset and mode of exposure — United States and Canada, September 2003–April 2004



* N = 29.

[†] Pulsed-field gel electrophoresis.

announced a nationwide recall* of all raw almonds sold under the Kirkland Signature, Trader Joe's, and Sunkist labels. Costco mailed 1,107,552 letters to members known to have purchased the recalled product in the United States. The recall was expanded subsequently to include nuts sold in bulk to approximately 50 other commercial customers, some of whom repackaged almonds for sale under other brand names. In addition to sales in the United States, almonds were exported to France, Italy, Japan, Korea, Malaysia, Mexico, Taiwan, the United Kingdom. The majority of the recalled almonds likely were consumed months ago; however, raw almonds have a shelf life of >1 year, and consumers might still have the implicated products.

Tests of raw almonds recovered from a patient's household and samples collected at Paramount were negative for *Salmonella*; however, *Salmonella* was isolated from one environmental sample collected at Paramount and from three samples from two huller-shellers that supplied Paramount during the period of interest. Serotype and PFGE analyses of these isolates have not been completed, and additional sampling continues.

*Notice available at <http://www.fda.gov/oc/po/firmrecalls/almonds.html>.

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Editorial Note: The only previously recognized outbreak of salmonellosis associated with tree nuts was identified in 2001, when raw almonds were linked to an outbreak of SE infections, mostly in Canada, during a 6-month period (3). The SE isolates from that 2000–2001 outbreak had different PFGE patterns and a different phage type (PT30) than those in the current investigation. The almonds in the previous outbreak were traced to three California orchards that were all contaminated with SE of identical phage and PFGE patterns; SE also was isolated from unopened packages of nuts. Since that outbreak, almonds from the implicated orchards reportedly have been diverted for use in processed foods only.

Approximately 1 billion pounds of California almonds were produced in 2003 (4), of which 5% were sold for raw consumption. Almonds are California's largest agricultural crop, with an annual value of \$1.5 billion; California produces approximately 80% of the world's almonds and almost 100% of the almonds sold in the United States (4).

California and federal regulatory agencies are continuing to investigate how almonds become contaminated with *Salmonella*; the mechanisms are poorly understood. Typical harvesting, drying, and hulling-shelling practices readily enable cross-contamination. Raw nuts can be treated with dry heat, steam, propylene oxide, or other methods to reduce the risk for bacterial contamination; at least one almond processor has been treating all raw almonds since the 2001 outbreak. No evidence has been presented that roasted, blanched, or otherwise heat-processed nuts pose any risk for *Salmonella* contamination.

Fewer than 5% of *Salmonella* infections are ever reported in the United States (5). More cases in the current outbreak are being identified as more SE isolates are screened by PFGE. Screening has focused on isolates submitted since February 1, although sales of the almonds in the recalled lots date back to the summer of 2003.

Although declining in incidence (6), SE remains the second most common *Salmonella* serotype (*Salmonella* Typhimurium is the most common) isolated from salmonellosis patients in the United States; nationwide, 5,116 (15.8%) of 32,308 isolates serotyped in 2002 were SE (7). Shell eggs and poultry have been identified as the most common vehicles for both outbreaks and sporadic infections attributed to SE (8), but multiple other sources also have been identified, including raw milk, meat, and sprouts (8–10).

The current outbreak continued for months, and possibly for more than 1 year, without being detected. Although serotyping is an invaluable epidemiologic tool, the added distinguishing power of phage typing or molecular techniques (e.g., PFGE) can be critical to separating outbreak cases from background cases, especially for common *Salmonella* serotypes such as Typhimurium, Enteritidis, Heidelberg, or Newport. Outbreaks caused by products with long shelf lives, wide distribution, and low attack rates might not cause notable spikes in serotype-specific incidence locally or even nationally. To identify these outbreaks, isolates must be screened rapidly by additional methods (e.g., PFGE), and those results must be pooled rapidly over networks such as PulseNet. Appropriate epidemiologic follow-up and coordinated use of standardized hypothesis-generating questionnaires across multiple jurisdictional lines often are necessary to identify sources of infection. At present, certain state health departments do not have the resources to subtype all *Salmonella* isolates as they are identified. In the United States, all state public health laboratories can perform PFGE and participate in PulseNet; however, phage typing is available only on a limited basis at CDC.

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