

AN OUTBREAK OF HEMORRHAGIC ESCHERICHIOSIS TRACED TO SPINACH

There is no just ground, therefore, for the charge brought against me by certain ignoramuses—that I have never written a moral tale, or, in more precise words, a tale with a moral.¹

IT WAS A Friday evening: 6:08 pm. We were working the swing shift in Acute & Communicable Disease Prevention. The phone rang. It was J—, a microbiologist at the Oregon Public Health Lab. The conversation was brief, but her terse message would set in motion a chain of events that would dominate domestic news for weeks, bring a large segment of the agro-industrial complex to its knees, and strike fear into salad eaters everywhere.

The spinach investigation was underway.

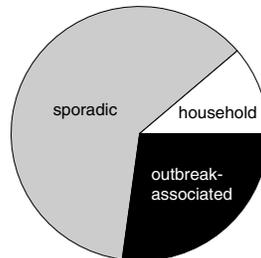
What was that message? What was its real meaning? How did the investigation proceed? Where did it lead? Why did this outbreak occur? Was it a fluke, or does it really speak to the safety of produce in general and spinach in particular? In today's installment of the *CD Summary*, we'll explore some of these issues, separating the myth from the hype.

In this country, the Four Horsemen of bacterial gastroenteritis are *Campylobacter*, *Salmonella*, *Shigella*, and Shiga-toxigenic *Escherichia coli* (STEC²). Although now eclipsed as causes of morbidity and mortality by diabetes, cancer, and even heart disease, these infections continue to capture the attention of patients and clinicians, not to mention public health and regulatory agencies, the media, and the food industry (*sensu lato*). All are spread by the fecal-oral route: what John Waters might call Divine retribution. Some of that is direct (e.g., subsequent to immediate animal contact) and some is indirect (e.g., via contaminated food and water).

By far the most commonly identified STEC pathogen identified in the United

States is *E. coli* O157:H7 ("O157"), not least because it is pretty much the only one ever tested for, and its epidemiology is more or less³ typical of the lot. Since 1990, when they became reportable in Oregon, 1,992 O157 infections have been reported. Most of them (62%) were what we call "sporadic"—not known to be epidemiologically linked to any other cases (see figure). About 27% were part of recognized multi-household outbreaks, and the balance were part of intra-household clusters (two siblings, parent and child, etc.) But while explaining only around one-quarter of reported cases, outbreaks are of disproportionate importance in terms of public health significance.

Epi Links of Reported O157 Cases, Oregon, 1990-2006



But we digress. It was [still] Friday evening—September 8th, to be specific. The report was that we had 3 "PFGE-matching" O157 cases, one from Linn County, one from Marion, and one from Cowlitz (Washington).⁴ PFGE is the acronym for pulsed-field gel electrophoresis, a restriction fragment length polymorphism-based subtyping method. While often referred to as a "molecular fingerprinting" method, it is important to realize that "molecular blood typing" might be a more apt metaphor. These kinds of matches are reported frequently, and it is relatively uncommon for common sources to be identified. Indeed, some PFGE patterns are common, appearing year-in, year-out in a context not suggestive of any ongoing common source. That said, suspicious matches always deserve a

second look, particularly when they match, not only in the lab but cluster in space and time, as these did.

This investigation unfolded rapidly. Routine interviews had already been conducted with these 3 cases by local health department nurses in Oregon and Washington. While sometimes a hot prospect jumps out from even those basic interviews (e.g., everyone visiting the same county fair, swimming hole, or restaurant; or everyone reporting consumption of a high-risk food such as alfalfa sprouts or unpasteurized cider), more often the clues are harder to read. That was the story this time, unfortunately—but for the tantalizing fact that one of the Oregon cases had been in Idaho for the 2 weeks before onset. With an incubation period of 1–10 days (and usually in the 2–7 day range), that almost certainly meant an exposure in Idaho. So right off the bat we knew that these cases had been exposed in Idaho, Washington, and Oregon, respectively. But did they really have a common source?

By Monday we were able to confirm that there were no other matching cases in the Northwest, California, or British Columbia.⁵ Tuesday was quiet until again around 6 pm, when our lab reported 3 more matching isolates: these from Multnomah and Benton Counties. Other than the observation that 5 of 6 were adult women we still had little to go on. At this point we began to reinterview these cases with our "shotgun" questionnaire⁶—a brute tour-de-force to find something (*anything*) that people may have eaten in common. We asked about over 300 specific food items, as well as questions to jog people's memories about places they may have eaten in the week or so before they became ill. In addition to the obvious, people are reminded to think about food they may have eaten at bars, airports, at sporting events or concerts; foods from street vendors or handed out as free samples, at

¹ from an essay by E. A. Poe (1841). Never bet the Devil your head: a tale with a moral.

² Two syllables; rhymes with the capital of Kyrgyzstan. Well, not really rhymes, but similar, sort of.

³ Unfortunately, we don't know which.

⁴ Isolates from residents of other states frequently turn up at the OSPHL. All formal reporting and almost all investigations are based on state of residence, however.

⁵ Unfortunately, a computer glitch kept us from learning that there were matching cases in Wisconsin.

⁶ Available at <http://oregon.gov/DHS/ph/acd/keene.shtml>



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ice cream shoppes, gas stations, and on and on.

Interviews continued until almost 10 pm Tuesday night, and resumed Wednesday morning. By mid-morning, the word was spinach: 4 of 5 recalled eating pre-washed, ready-to-eat bagged spinach. Given background rates of (any) spinach consumption in a given week of 15–25%⁷, finding this 80% proportion was highly suspicious.⁸ Moreover, spinach and similar produce (e.g., bagged lettuce and other salad mixes) were certainly plausible vehicles, having been previously implicated in outbreaks of O157 infections and salmonellosis. The Oregon interviews did not suggest a common brand, however, but discussions with California health officials confirmed suspicions that multiple brands were often packaged by a single processor.

There was still no word of similar cases in neighboring states. When we notified CDC that afternoon (September 13) about the cluster and our evidence pointing at spinach, however, we learned for the first time that Wisconsin epidemiologists were investigating a large cluster of cases (~18 at that moment) that they thought were due to some kind of produce item, and that there were matching cases in New Mexico and Utah at least. A hastily arranged conference call confirmed that indeed we were all working on the same outbreak, and that the cause was bagged spinach. New Mexico officials were already collecting leftover spinach packages for lab testing—testing that days later would corroborate the epidemiological findings.

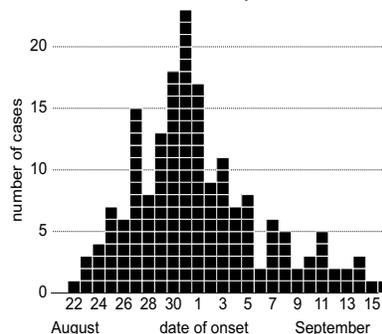
The rest, as they say, is history. The

⁷ This from ongoing FoodNet-sponsored population surveys.

⁸ With a binomial model and a background consumption rate of 15–25%, the probability of getting 4 or more consumers out of a random sample of 5 would be 0.2–1.6%.

FDA announced a public recall, initially of all spinach products. Additional cases were quickly identified in state after state—eventually 194 lab-confirmed cases in at least 25 states⁹ (see figure), with at least 98 hospitalized and 3 deaths. Evidence collected over the next several weeks would narrow the spotlight of suspicion to product packaged at only one California facility on

Epidemic Curve of Spinach-Associated O157 Cases, U.S.



August 15, 2006—product that for the most part would have long since either been consumed or slimed by the time of the September 14 recall. A vast investigation conducted by public health agencies in California has identified similar O157 isolates in cattle-grazed areas and wild pigs in close proximity to implicated spinach fields, suggesting that wind- or waterborne runoff from livestock or direct contamination by wild animals could have been the proximate source of contamination. At this writing, lab comparison of those isolates with the outbreak isolates is incomplete.

Microbial contamination of produce is a vexing problem. While a higher proportion of raw meat and poultry packages at the grocery store may be contaminated with O157, *Salmonella*, *Campylobacter*, or other pathogens, the kill steps including in commercial processing methods and just plain

⁹ and 1 in Canada.

thorough cooking offer pre-prandial opportunities to ameliorate those risks. With uncooked fruits and vegetables, however, there may be little the consumer can do of great effect. Refrigerating produce to minimize bacterial growth and hand washing to reduce cross-contamination are worthwhile practices—and we recommend them—but don't kid yourself; probability theory is the consumer's main line of defense for uncooked produce. Washing loose spinach is an effective way to reduce the amount of rocks and dirt, but has limited effect on bacterial loads. Re-washing commercially washed produce is probably a waste of time and water. Effective control will have to occur further "upstream"—in the fields and packing houses.

Although a meal of chicken nuggets and freedom fries does pose little risk of an enteric infection, these risks must be kept in perspective—especially during an obesity epidemic. Fruits and vegetables, including spinach, are well-recognized pillars of a healthy diet. Grease and salt are not.¹⁰ Regulatory agencies, produce buyers, packers, growers, and litigators are now working to identify practical ways to minimize the future risk of infection. We close with the hackneyed observation that this outbreak again demonstrates the utility of disease surveillance. Without appropriate diagnostic testing and disease reporting by clinicians and laboratories, this outbreak would have gone unnoticed. And while that might be a Good Thing for some in the short term, in the long run it would be a Bad Thing for the public's health.

¹⁰ Indeed, pillars of salt have distinctly unhealthy connotations that have been long recognized.