



FOCUS on Field Epidemiology

Environmental Health Investigations: Conducting Traceback Investigations

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Think back to being a kid, on a day when you would sit at the table by yourself or with friends or siblings, and dump out a box of puzzle pieces (like the one of Miss Piggy™ on a motorcycle riding through a glass window). You would carefully turn all the pieces picture-side up. Then maybe you separated the outside pieces from the inside pieces and combed through everything sorting groups by color (glass-color, pig-color, background). You would work on fitting pieces of the same color together until a section of the picture started growing.

After many hours of labor, Miss Piggy™ would be nearly together in all her valiant splendor... except, where was the piece that completed her snout? Even though the entire puzzle was done, the missing snout piece was a glaring defect – the puzzle would never be complete without it. Funny how one missing piece can prevent closure after all that work.

In this issue of FOCUS, we touch on a key piece of the outbreak investigation puzzle: environmental health investigations. Epidemiologic or microbiologic investigations may implicate a vehicle* in an outbreak; environmental health investigations can help to determine *why* the implicated vehicle was the source.

The information gained from environmental health studies can be critical in controlling the outbreak or health problem and preventing it from happening again.

Environmental health is an extensive area of study including topics like air

pollution, food and waterborne diseases, radiation, toxic substances, and natural disasters, to name but a few. Environmental health investigations, therefore, cover a wide territory.

In this issue, we consider one specific type of environmental health investigation: the traceback investigation of a vehicle implicated as the source of an outbreak. This type of investigation is common in the practice of public health, so it is likely that you will come across some in the future, and you could be called upon to assist in one of them.

What is a Traceback?

A traceback investigation is the process used to determine the production and distribution chain of a vehicle implicated during the investigation of an outbreak or other public health problem. Tracebacks also help determine whether (and where) you conduct an environmental health assessment, which we will discuss in the next issue of FOCUS.

Traceback investigations are used to clarify the point at which the implicated vehicle may have become contaminated.

A traceback investigation identifies

- places where the implicated vehi-

***Vehicle:** A vehicle is an inanimate intermediary involved in the transmission of a pathogen—it carries the pathogen from a reservoir to a susceptible host. Food, cosmetics, and medicines are all examples of vehicles.



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cle has been (farms, factories, warehouses, stores, restaurants), and

- whether the vehicles to which different cases have been exposed had places in common (were produced at the same plant, transported in the same truck).

Identification of a common place (or places) where the vehicles used by different cases in an outbreak have been found is a strong indicator that contamination of the vehicle occurred at or before that point in the production and distribution of the vehicle. The traceback does not, however, identify the source of the problem. It just tells investigators where to look. Further investigation and inspection of these places is necessary to identify the practices or conditions that may have resulted in the problem, and to implement control measures to prevent the problem from happening again.

Here’s an example. In 1994, a nationwide outbreak of *Salmonella* Enteritidis was associated with a particular brand of ice cream. Cases in 41 states obtained the implicated ice cream through home deliveries from multiple warehouses across the country. The ice cream eaten by cases, however, was ALL prepared in one plant in Minnesota, which then shipped the ice cream to the different warehouses. The implicated plant obtained ice cream pre-mix from two suppliers. Tanker trucks from a contracted trucking company transported the pre-mix from the supplier to the ice cream plant. Identification of the plant that supplied all the ice cream suggested that contamination of the ice cream with *S. Enteritidis* occurred at or before that point in the production of the ice cream (at the plant, in the tanker trucks, or at the suppliers of the pre-mix.) Follow-up investigations focused on these areas. (1)

An environmental health assessment of the ice cream plant identified no food safety problems. Assessments of the two pre-mix suppliers also revealed no problems. Investigation of the trucking company, however, determined that the tanker trucks used to transport the ice cream pre-mix were also used to carry non-pasteurized eggs from egg-breaking plants. Although there were protocols for cleaning and sanitizing the tanker trailers, some were not cleaned and some were cleaned inadequately. (1)

The traceback investigation allowed investigators to zero in on the place the problem was likely to have occurred (the trucks). But other investigations were necessary to identify the problem with the trucks.

A traceback investigation begins with information from cases about the implicated vehicle and extends backward in time. All points in

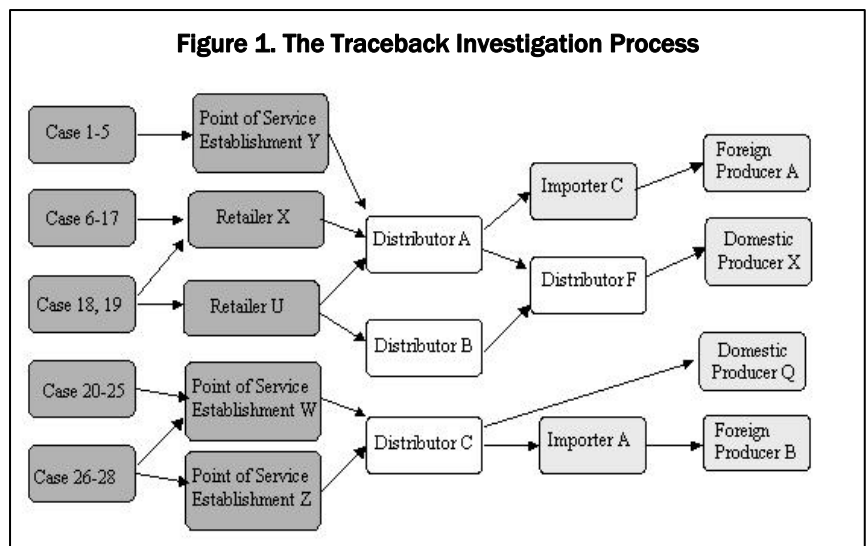
the production and use of the vehicle are considered, including retailers, point of service establishments (e.g., restaurants), distributors, importers, and producers. A typical traceback investigation is illustrated in Figure 1 below.

Each vehicle will have its own unique pattern of distribution – and distribution patterns can be very complex! For example, retailers may obtain the vehicle from more than one distributor and may change distributors over time. Distributors may have multiple sources and may supply to other distributors. Producers may be domestic or foreign.

Let’s look at an outbreak of *E. coli* O157:H7 in Michigan in 1997 for another example of a traceback investigation. Investigators conducted a case-control study and found that being a case was strongly associated with eating alfalfa sprouts. To initiate the traceback process, investigators reviewed information collected from the Michigan cases during the case-control study. They made a list of the stores and restaurants where the cases had purchased (or eaten) the sprouts and noted the locations of these establishments and the dates of purchase (or consumption). (2)

The investigators then met with managers of the stores and restaurants where the implicated sprouts had been purchased. Using store and restaurant records, the investigators identified the likely sprouting facilities for the implicated sprouts. For 16 patients, the source of the sprouts could be traced to Facility A in Michigan (15 patients) or either Facility A or Facility B in Michigan (1 patient). Although Facility A could possibly have accounted for all 16 of the cases, the investigators decided to examine both Facility A and Facility B in subsequent investigations. (2)

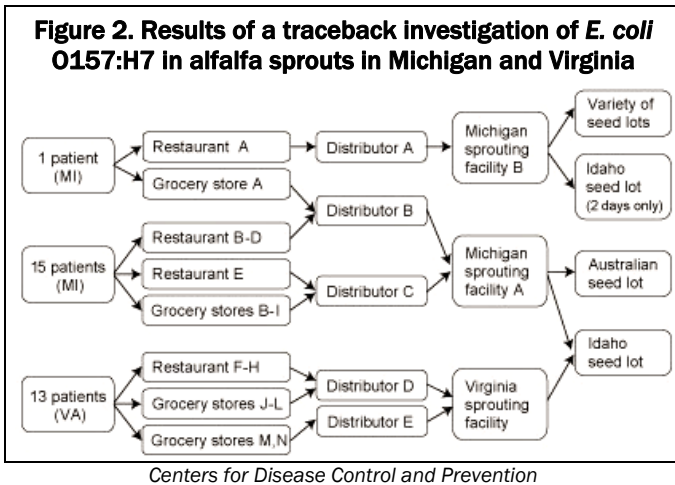
Inventory records at the sprouting facilities identified the source(s) of the seeds germinated at each facility around the time of the *E. coli* O157:H7 outbreak. Sprouts grown



by Facility A prior to the outbreak came from two lots of seed: one from Idaho and one from Australia. Facility B had used a large number of different seed lots prior to the outbreak. (2)

At this point, investigators became aware of a concurrent outbreak of *E. coli* O157:H7 infection in Virginia that was also linked to alfalfa sprouts. The source of the sprouts could be traced for 13 patients to one sprouting facility in Virginia. The Virginia facility was using a single lot of seed harvested in Idaho – the same lot used by Facility A in Michigan. (2)

Investigators re-examined the sources of the sprouts in Michigan and discovered that Facility B had also sprouted a small number of seeds from this Idaho seed lot during the outbreak period, but had used these seeds for sprouting on only 2 days (see Figure 2). (2)



Since the sprouts eaten by cases involved multiple home kitchens, restaurants, and grocery stores and three sprouting facilities in two states, it is likely that the problem lay in the lot of seeds from Idaho rather than in any of these intermediary sources. (2)

Of course, in a traceback investigation, the exact source of the problem (the alfalfa farm, equipment used to harvest the seed, storage canisters, transport trucks, or seed warehouse) cannot be identified. That requires a detailed environmental health assessment.

What's in a Name?

The ability to clearly identify the product implicated in an outbreak is essential to a traceback investigation. For commercially packaged commodities (as opposed to things like fresh fruits and vegetables), the brand name would seem like a perfect means of identification. But is it? First, collecting the information is not as easy as it sounds. If the package is not available, consumers often do not remember the exact name of the product. This is

particularly true for lesser-known brands (NOT Coke® or Pepsi®!) and products for which the consumer commonly switches sources or brands. Furthermore, in today's economy, with conglomerates and global marketing agreements one product may be repackaged and distributed under several different (or slightly different) names.

For example, in April and May of 1998, 49 cases of *Salmonella* Agona (an uncommon serotype of *Salmonella*) were reported to the Illinois State Health department. Serotype-specific surveillance confirmed that nine other states also had increases in *S. Agona* infections. Pulsed field gel electrophoresis (PFGE) subtyping indicated that many of the *S. Agona* in those states had the same pattern, suggesting that the cases could have a common origin. A matched case-control study linked the *S. Agona* infections with consumption of cereal. However, at first glance, no common brands were noted. (3)

A traceback investigation revealed that the implicated cereal was produced by a Minnesota company, Malt-O-Meal, under the brand name Toasty O's®. HOWEVER, the cereal was also sold as Toasted Oats® in 39 grocery store chains under the individual grocery stores' in-house label and package (see Figure 3). Thus, although it did not appear that the cases had consumed a common cereal, they actually had! (3)

Finally, even with a brand name (and even reading the fine print to determine which brand names are related), the brand name is not enough to home in on a problem. Most outbreaks result from a temporary problem in the production of the vehicle (i.e., a particular batch or lot prepared at

Figure 3. Stores Selling Toasted Oats®/Toasty O's® Under Store Name

America's Choice	Bi-Lo
Tops	Janet Lee (Albertson's)
Millville (Aldi)	Acme
Jewel	Lucky
Value Wise	IGA
Signature (FSA)	Hannaford Brothers
Harris-Teeter	Hill Country Fare (HEB)
Laura Lynn (Ingles)	Kroger
Our Family	Pathmark
Safeway	Shaw's
Stater Brothers	Cub
Flavorite	Foodland
Natures Best	Shop N Save
Sweetlife	Delchamps
Eagle	Finast
Food Club	Fry's
Kingston	Meijer
Schnucks	Smith's
Weis	Western Family

a specific time on a specific day).

Therefore, to identify the exact vehicle during a traceback, much more detail is needed. In addition to the brand name, information such as the item description, date and place of purchase, the manufacturer, supplier, and lot number are needed (see box). Furthermore, to determine where the vehicle has been, you will also need to know the locations of farms and production facilities, supplier information and delivery schedules, and wholesale customer information.

Useful Information in a Traceback Investigation

- Name
- Names of customers
- Where purchased
- When purchased
- Grade
- Color
- Quantity/size/weight
- Manufacturer
- Supplier
- Lot or batch number
- Date produced
- Date shipped
- Dates/time/quantity of deliveries
- Locations of production facilities
- Sell-by date or code
- Use-by date or code

How Do You Get Started?

Where do you get all of this information? In a traceback investigation, information is collected from

- cases
- retailers or point of service establishments
- distributors/importers
- producers/processors.

A traceback begins with the information available from interviews of the cases (ill persons) about the time and

Sample Product Label

Annotations on the label:

- Bar code identifying product
- Product description
- Sell-by date
- Quantity
- Meat packing facility

from National Environmental Health Association Epi-Ready Course

place of purchase of the implicated food item. Original packaging and labels (see the sample below) with identifying features, such as lot numbers or the name of the manufacturer, make the traceback investigation much faster and simpler.

The investigation then continues at the place where the case obtained the item, such as a retail store or point of service establishment, and expands to encompass distributors. Distributors usually store and/or transport the product or work with other entities to accomplish these activities. Distributors include brokers and importers and may involve multiple levels. Business documentation can be useful at this level, including invoices, inventory records, air bills (for air transport), bills of lading (for trucking, see sample below), and importation documents (e.g., Customs Form 3461), among others. Just looking at a few of these documents can make you cross-eyed. Can you imagine what it must be like to examine dozens of these?

Sample Bill of Lading

No. Packages	DESCRIPTION OF ARTICLES AND SPECIAL MARKS	UNIT PRICE	TOTAL AMOUNT
432	REG 8X16OZ C/U-		
192	REG 12X6OZ RASP-		
60	REG 8X8OZ STEM C/U-		
6	TECTROL		
1	RECORDER - RYAN UTI		

from the CDC

A traceback is completed when the firms that supplied, processed, and produced the implicated product are identified. The investigation may include a visit to the source to verify the information already collected, the production dates, and the location of farms or production facilities.

The validity of a traceback is highly dependent on proper documentation. Receipts and labels are essential. Sadly, documentation is often incomplete or difficult to interpret. And that makes the investigator's job very difficult.

To Trace or Not to Trace?

As you can imagine, tracebacks can be time-consuming and can result in many dead ends (which equate with a waste of resources). Therefore, although traceback investigations can be important in controlling an outbreak and preventing it from happening again, they should be undertaken selectively. Before starting, investigators must make sure that the vehicle in question is truly implicated in the outbreak AND that the source of the contamination is within the production chain (i.e., is not due to contamination by the consumer, retailer, or point-of-service establishment).

To begin a traceback, investigators should be able to answer the following questions affirmatively:

- Is there solid epidemiologic evidence linking the outbreak and the implicated product(s)?
- Is there historical precedent for the product being contaminated with this organism (or a similar organism)?
- Is there microbiologic evidence linking the outbreak and the implicated product(s)?
- Does the vehicle have chemical and physical characteristics conducive to the survival and growth of the causative agent?
- Has mishandling or environmental contamination of the product by the consumer, retailer, or point of service establishment (e.g., restaurant) been ruled out?
- Could the product be commercially distributed in a way that is consistent with the outbreak?

Investigators also need to consider the likelihood of success before deciding to undertake a traceback. Traceback investigations are most successful when the implicated vehicle is commercially packaged (it has an identifying label), is unusual (salami), or has a long shelf-life (frozen hamburger patties). Traceback investigations of products with a short shelf-life (fresh fruits and vegetables) and those derived from many sources (blood clotting factor derived from thousands of donors) are often unproductive.

Finally, investigators must weigh the benefits of the investigation against its costs. How serious is the disease? Is it



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likely to lead to death, hospitalization, or permanent disability? Is exposure likely to be ongoing? Are vulnerable populations at risk (e.g., infants, the elderly, immunocompromised individuals)? Answering “yes” to any or all of these questions will provide the justification to undertake a traceback investigation.

Successful tracebacks require collaboration among many players. In most cases, traceback investigations are conducted by local, state, or federal regulatory agencies including the U.S. Department of Agriculture (USDA) and the Food and Drug Administration (FDA). Epidemiologists, however, can play a critical role. Traceback investigations rely on good, solid epidemiological data. Information obtained from cases about the vehicle during the epidemiological investigation is often the first step in the traceback. Furthermore, a poorly executed epidemiologic study might implicate the wrong vehicle and misdirect subsequent investigations. So good epidemiologic work is the basis for a successful traceback investigation.

Conclusion

To find the source of an outbreak or other public health problem, you need to look back in time and figure out what went wrong. Using a traceback investigation as the first step, you can determine where problems may have occurred in the chain of production of an implicated vehicle. With this information, you can focus on the areas with the problem to identify practices or conditions that may have resulted in the problem. That is the next step - the environmental health assessment.

Useful resource for traceback investigations:

- Guide to Traceback of Fresh Fruits and Vegetables implicated in Epidemiological Investigations http://www.fda.gov/ora/inspect_ref/igs/epigde/epigde.html

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REFERENCES:

1. Hennessy TW, Hedberg CW, Slutsker L, et al. A national outbreak of *Salmonella* Enteritidis infections from ice cream. *N Engl J Med*. 1996;334:1281-1286.
2. Breuer T, Benkel DH, Shapiro RL, et al. A multistate outbreak of *Escherichia coli* O157:H57 linked to alfalfa sprouts grown from contaminated seeds. *Emerg Infect Dis*. 2001;7:977-982.
3. CDC. Multistate outbreak of *Salmonella* Serotype Agona infections linked to Toasted Oats cereal—United States, April-May, 1998. *MMWR Morb Mortal Wkly Rep*. 1998;47:462-464.

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