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Environmental Health Investigations: Conducting Environmental Health Assessments

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Imagine that you're whipping up a batch of your famous chocolate chip cookies. As you take them steaming hot out of the oven, you can't help but sample one.... Ugh! They just don't taste right! What's wrong with those cookies? As you go back over every step, every ingredient, and every measurement, you discover your mistake. You added salt instead of sugar!

In the same way that you went back over every step to find the source of your cooking mishap, an environmental health assessment goes back over events to help to identify the possible cause of an outbreak.

In the last issue of FOCUS, we explored traceback investigations. Tracebacks are used to find the point at which an item implicated in an outbreak may have become contaminated. Remember that a traceback does not identify the source of the problem; it just tells investigators where to look.

Once you've identified *where* the contamination occurred, the environmental health assessment 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.

What is an Environmental Health Assessment?

An environmental health assessment is a systematic, detailed, science-based evaluation of environmental factors that contributed to the transmission of a particular disease in an outbreak. An environmental health assessment is not a general inspection of operating procedures or sanitary conditions like that used for licensing an assisted living facility or a restaurant. Rather, an environmental health assessment focuses on the problem at hand and considers how the causative agent, host factors, and environmental conditions interacted to result in the problem.

The environmental health assessment often focuses on a vehicle implicated in an outbreak investigation such as a contaminated food item, cosmetic, blood product, or medicine. In some instances, when a specific vehicle has not been implicated, the assessment focuses on the setting in which the problem occurred or is thought to have occurred. For example, the investigation might focus on the kitchen in which a meal associated with a foodborne disease outbreak was prepared or an operating room that was linked to an increased risk of surgical wound infections. The goals of an environmental health assessment are to identify:

- possible points of contamination with the causative agent (i.e., a microbe or toxin);
- determine whether the causative agent could have survived or not been inactivated; and
- determine whether the conditions were conducive to subsequent growth or toxin production by the causative agent.

"Contamination" involves factors that introduce or permit the introduction of pathogenic microorganisms, natural toxins, or other poisonous substances. Sources of the problem may include contaminated raw materials, an infected person, cross-contamination from another contaminated item, and unclean equipment. Factors influencing contamination include breaks in packaging and poor storage practices.

"Survival" involves factors that allow the survival of pathogenic microorganisms or fail to inactivate heat-labile toxins already present. Factors supporting survival include inadequate sterilization or heat-processing of an item, inadequate reheating, or inadequate use of preservatives.

"Growth" involves factors that allow pathogenic bacteria and fungi present to multiply to numbers sufficient to cause illness or allow toxigenic bacteria and molds to elaborate toxins. (Note: viruses and parasites do not replicate in vehicles but require hosts to "grow.") Conditions that support growth include inadequate refrigeration, inadequate hot-holding, prolonged storage (so that preservatives break down and are no longer active), anaerobic packaging, and inadequate fermentation.

There are two important points to remember.

First, the presence of factors that lead to contamination, survival, and growth of the causative agent may not be sufficient to cause a health problem. If subsequent steps in the production and/or use of the vehicle control the problem introduced by the factor (i.e., eliminate it or reduce it below a critical level), the factor will no longer create a problem. Let's use the example of contamination of a food item through bare-handed contact by an infected food worker to illustrate this point.

- If the food is not cooked after this contact (let's say it is tuna salad), the bare-handed contact may cause a problem. The pathogen could survive and multiply sufficiently to cause illness in someone who consumes the food.
- If the food item is cooked after contact (let's say it is raw chicken), the bare-handed contact will probably not be a problem. Proper cooking will destroy pathogens introduced into the food.
- This is referred to as a "critical control point" in the food safety world. Critical control points are steps in the preparation of a food item where action can be taken to prevent or eliminate a food safety problem. Control of the problem at the critical control point is necessary because it will not be addressed in subsequent steps in the preparation of the food.

Second, although the primary goals of an environmental health assessment are to identify possible points of contamination, survival, and growth, to be most valuable, the investigation needs to identify "antecedents" that resulted in these conditions. "Antecedents" are the circumstances behind the problem. They include things like inadequate worker education, behavioral risk factors, management decisions, and social and cultural beliefs. Only by identifying the problem behind the problem will investigators be able to develop effective interventions to prevent future occurrences of the problem.

Here is a fairly typical example: An outbreak of salmonellosis in a small community was linked to potato salad served at a local restaurant. The environmental health assessment determined that the potato salad was probably contaminated with *Salmonella* from chicken that was thawing above the potato salad ingredients in the refrigerator.

The root of the problem, however, was deeper. To save money, the manager had begun hiring more part-time workers (whom he could pay less) rather than full-time employees (to whom he would have to provide benefits). Although the part-time workers had taken a food safety course from the local health department, they lacked experience and did not always make good decisions on foodhandling practices. And the workers were not closely supervised. So correcting the problem required not only education of the workers on the proper handling of raw chicken but general education on good food handling techniques and ongoing oversight of the foodhandling activities by a knowledgeable and experienced person.

How Should the Environmental Health Assessment Be Conducted?

Sources of information for an environmental health assessment include product information (e.g., chemical and physical characteristics and source); written policies or procedures; direct observations and measurements; interviews with employees and managers; and lab testing of suspect vehicles, ingredients, and environmental surfaces.

Sources of Information for an Environmental Health Assessment

- **Product information**
- **Written policies and procedures**
- **Direct observations and measurements**
- **Interviews with employees and managers**
- **Lab testing of suspect vehicles, ingredients, or environmental surfaces**
- **Lab testing of employees or others in contact with the suspect vehicle or environment**

On occasion, clinical specimens may be collected from people in contact with the suspect vehicle (e.g., foodhandlers, factory-line workers) or the environment in which it was produced or used.

The specific activities included in an environmental health assessment differ depending on the causative agent, the suspect vehicle, and the setting. Let's use the environmental health assessment of a food implicated in a foodborne disease outbreak as an example of the kind of activities that might be undertaken.

Environmental Health Assessment of Food Implicated in Outbreak

- **Describe the implicated food**
- **Observe procedures used to make food**
- **Talk with foodhandlers and managers**
- **Take measurements**
- **Collect specimens**
- **Collect documents on the source of the food**

In the environmental health assessment of a food item, the investigator first **describes the implicated item** and obtains the recipe for the item, in writing if possible. He or she determines the quantity prepared and sources of the ingredients. The investigator then considers the intrinsic chemical and physical characteristics of the food (including the expected microbial/toxin content, pH, water content, and sugar content) and determines whether the food is likely to allow survival and growth of the causative agent.

The investigator then **observes the procedures used to make the implicated food**. This includes all steps from receipt of raw ingredients to finished product. The investigator examines how the ingredients were cleaned and stored. He or she observes how foods were thawed, cooked, cooled, reheated, served, and transported. The investigator determines what equipment was used in the preparation of the suspect food and the condition of that equipment. The investigator considers the floor design of the facility and employee traffic patterns, and determines whether there was adequate separation between food preparation activities to prevent cross-contamination.

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The investigator **talks with foodhandlers and managers** familiar with the food preparation process and facility. He or she determines the food preparation schedule (including the date and time of preparation) and the person(s) who prepared the implicated food. The investigator also collects information about the foodhandlers themselves, including use of gloves, handwashing practices, and recent illnesses. The investigator also asks about standard operating procedures, including sick foodhandler policies and routine food safety education of employees.

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The investigator **measures** the time and temperature conditions to which the food and/or its ingredients were exposed during storage and preparation. The investigator tries to determine the weight/volume of food prepared and the depth of containers used to store the food. If not already known, he or she may also measure water activity, sugar content, and pH of the suspect food to determine if the causative agent could survive/grow in the food.

The investigator then **collects leftover samples** of the implicated food and all its ingredients, and where appropriate, swabs food preparation surfaces or equipment for cultures or other tests.

Finally, the investigator **reviews the available records and collects identifying information** about the implicated item and its ingredients. Available records may include the results of past inspections or complaints, worker logs or time cards, and monitoring logs (e.g., temperatures in walk-in refrigerators). Identifying information about the implicated food item will include brand name; producer; distributor; batch and lot number; dates produced, shipped, and received; and quantities received. This information is collected to determine the exact source of the food item (and to facilitate traceback of the item, if appropriate).

The activities described above are very specific to a food item implicated in an outbreak, but you can easily see how many of the same activities might be used in the investigation of non-food vehicles. For example, think about the environmental health assessment for an intravenous medicine implicated in an outbreak of sepsis at a hospital.

What steps might you go through to explore where/how the problem occurred? What product information would you collect? What activities would you observe? With whom would you talk? What records would you examine?

To summarize information gained through an environmental health assessment, investigators often draw a flow diagram showing each step in the production and use of the vehicle. Flow diagrams clearly display the flow of operations, and they can be used to verify production activities as different workers/managers are consulted. They can also help identify possible points of contamination or microbial survival and growth.

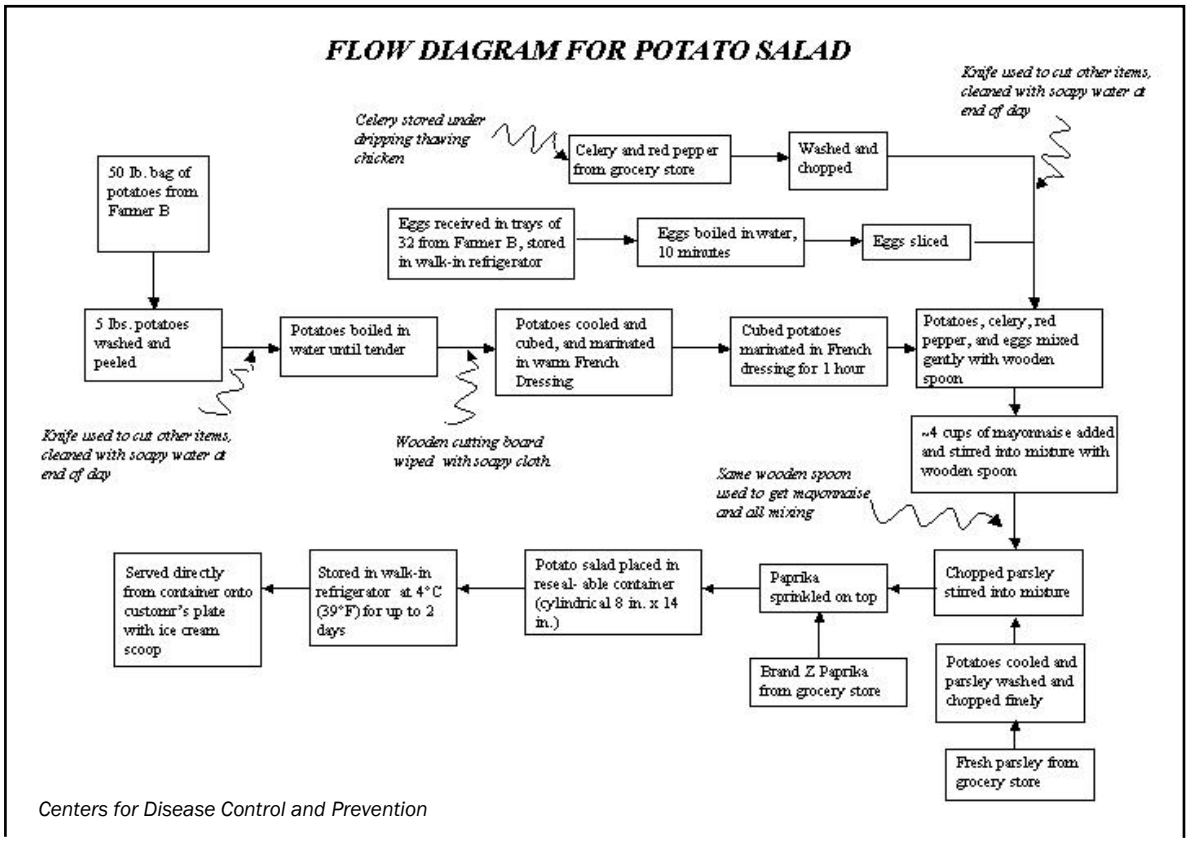
In these flow diagrams, each operation is represented by a rectangle. (NOTE: an "operation" is very narrowly defined. As you can see in this example on making potato salad, each operation is like one step in a very detailed recipe.) Arrows indicate the direction of flow of the process. The investigator notes other important information directly on the diagram, including measurements (e.g., temperature, duration of operation) and the name of the person(s) performing the operation.

Who Should Conduct an Environmental Health Assessment?

To recognize opportunities for contamination, survival, and growth in an environmental health assessment, the investigator needs a good understanding of:

- the causative agent (e.g., likely sources, optimum growth conditions, inhibitory substances, means of inactivation);
- factors necessary to cause illness (e.g., infectious dose, portal of entry); and
- the implicated vehicle (e.g., physical and chemical characteristics of the vehicle that might facilitate or inhibit growth, methods of production, processing, and preparation).

With a good grasp of this information the investigator can home in on the likely source of the problem and the ways in which the causative agent, host factors, and environmental conditions interacted. The volume of knowledge needed typically requires someone with special training in this field of investigation, such as a sanitarian or environmental health specialist. Circumstances may also require consultation with a person who has special knowledge of or experience with a particular causative agent or vehicle.



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Where Should an Environmental Health Assessment be Conducted?

An environmental health assessment should take place where the problem leading to the outbreak (or other health problem) occurred. This might be where the suspect vehicle was produced, processed, stored, or used or the means by which it was transported. The investigation may need to focus on several of these places.

The decision about where to focus the assessment will be based largely on clues to where the source of the problem lies. This may be obvious from information available at the outset of the outbreak investigation. For instance, if an outbreak is associated with a meal served at a banquet, the assessment is likely to be conducted in the kitchen in which the meal was prepared. But if the outbreak involves cases across a state or country (or across the globe), it might not be so clear where to start. Investigators may need to collect information to determine where the problem most probably occurred. This usually takes the form of a traceback investigation, as discussed in the last issue.

When Should the Environmental Health Assessment be Conducted?

The timing of an environmental health assessment depends on the specifics of the outbreak and the information available. Early investigation and early collection of specimens are most likely to uncover the conditions at the time of the outbreak and indicate where things went wrong. In situations where cases are clearly associated with a particular meal or setting, environmental studies can be initiated quickly (even before a specific food is implicated through an epidemiologic study). In fact, it is important to act as quickly as possible! Vehicles such as foods can be discarded or grow old. Individuals/groups involved in the production, processing, storage, transportation, or preparation of an item can change their practices and procedures, becoming more conscious about their activities as a result of the outbreak.

Example: The Burrito Blunder

From October 1997 through October 1998, 16 outbreaks of gastrointestinal illness occurred in Florida, Georgia, Illinois, Indiana, Kansas, North Dakota, and Pennsylvania. All but one outbreak occurred in a school, and approximately 1,700 persons were affected. The predominant symptoms were abdominal cramps (88%), vomiting (62%), headache (62%), and nausea (39%), with a short incubation period. An etiologic agent was not isolated. Epidemiologic investigations implicated burritos as the source. However, by the time the investigators had pinpointed the likely source in one outbreak, the school cafeteria had discarded the leftover burritos and garbage pick-up had already occurred. Anxious to identify the causative agent, investigators scurried down to the dump. They used a forklift to find the burritos under a huge pile of garbage. And as you can imagine, the burritos were not in very good shape. (By the way, to this day, they have not determined the cause of the burrito-associated risk factor.) (1)

Of course, if you have no clues on the source, it is very difficult (and even wasteful) to initiate an environmental health assessment. So you may need to wait until the causative agent has been isolated, results from descriptive epidemiologic studies or hypothesis-generating interviews are available, or analytic epidemiologic studies have implicated a specific vehicle.

Glossary

Contamination: The introduction of pathogenic microorganisms, natural toxins, or other poisonous substances.

Critical control point: Step in the preparation of a food item where action can be taken to prevent or eliminate a food safety problem that will not be addressed in a later step in the preparation of the item.

Growth: Pathogenic bacteria and fungi present multiply to numbers sufficient to cause illness or toxigenic bacteria, or molds produce toxins.

Survival: Pathogenic microorganisms are not killed, or heat-labile toxins already present are not inactivated.

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Conclusion

Environmental health assessments provide invaluable insights into an outbreak by identifying breakdowns in techniques, system design and/or operation, or just plain "human error" that led to the problem underlying the outbreak. An environmental health assessment allows you to identify points where you can intervene to stop the problem and prevent future occurrences. Combining the information from epidemiologic, laboratory, and environmental health studies helps us complete the picture of an outbreak or other public health problem by putting the characteristics of the agent, host, and environment together. With this picture, control measures can be implemented more quickly and they are more likely to be effective. And that's a good thing!

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REFERENCES:

1. CDC. Outbreaks of gastrointestinal illness of unknown etiology associated with eating burritos—United States, October 1997-October 1998. *MMWR Morb Mortal Wkly Rep*. 1999;48:210-213.

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