Centers for Disease Control and Prevention
Epidemiology Program Office
Case Studies in Applied Epidemiology
No. 941-903

Surveillance for *E. coli* O157:H7 - Information for Action

Instructor's Guide

Learning Objectives
After completing this case study, the participant should be able to:

- ☐ Discuss the process and criteria for placing a disease or condition on a state or national notifiable disease list;
- ☐ List the categories of information that should be included in a surveillance instrument;
- ☐ Summarize and interpret surveillance data;
- ☐ Recognize difficulties in balancing public health concerns with consumer and industry considerations in emerging issues.

This case study is based on surveillance and investigation activities of the Oregon Health Division between 1986 and 1995. The investigation described in the second half of the case study has been published in the following reference:

Keene WE, Hedberg K, Herriott DE, Hancock DD, et al. A prolonged outbreak of *Escherichia coli* O157:H7 infections caused by commercially distributed raw milk. J Infect Dis 1997;176:815-818.

This case study is largely derived from another study, "An Outbreak of *E. coli* O157:H7 Associated with Raw Milk," developed in 1994 by Julie R. Crom (Animal and Public Health Inspection Service US Department of Agriculture) and Richard C Dicker, MD, MSc (CDC). This case study was developed in 1998 by Richard C. Dicker. Substantial background information, reviews, and suggestions were provided to both case studies by:

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U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service

CENTERS FOR DISEASE CONTROL AND PREVENTION

PART I

Dateline: 1986. Infection with *Escherichia coli* O157:H7 was first recognized as a cause of human illness in 1982, when 26 persons in Oregon and 21 persons from Michigan developed bloody diarrhea after eating hamburgers contaminated with the organism. Both outbreaks were associated with restaurants of the same fast-food chain. In 1986 three patients in eastern Washington State were diagnosed with *E. coli* O157:H7 after being hospitalized with hemorrhagic colitis and subsequent thrombotic thrombocytopenic purpura.

An epidemiologic investigation linked these three cases and 37 others in the same community to a local restaurant that had served ground beef, the suspected vehicle of transmission. This outbreak was found to be part of a statewide increase in *E. coli* O157:H7 cases. Infections among nursing home residents and in patients with hemolytic uremic syndrome (HUS) were seen across the state, and an increase in sporadic cases of hemorrhagic colitis was noted at a Seattle health maintenance organization.

Question 1: Health departments use public health surveillance to keep track of diseases that affect the public's health. What is public health surveillance?

Answer 1:
Many definitions exist, but the common features are:
- ongoing, systematic
- collection
- analysis
- interpretation
- dissemination to "those who need to know"
- of public health data
- to help guide public health decision-making and action

Instructors' Note: Leave this list on the board or flip chart to facilitate answering the last question.

Question 2: What is the difference between *active* and *passive* surveillance systems? When might you use each?

Answer 2:
Passive surveillance = health care providers, hospitals, sometimes labs, etc. send reports to the health department based on a set of rules and regulations. Almost all ongoing surveillance systems rely on passive reporting.

Active surveillance = health department staff call or visit health care providers on a regular basis, e.g., weekly, to solicit case reports. Health departments may conduct active surveillance for brief periods of time under unusual circumstances, e.g., during an outbreak. Because it is resource-intensive, it is not a standard practice for most surveillance systems.

Each State has a list of diseases of public health importance that must be reported to the health department when diagnosed by a health care provider. Given the information on the previous page, public health officials in Washington and Oregon considered adding *E. coli* infection to their lists of notifiable diseases.

Question 3: What criteria would you use in deciding whether to add *E. coli* O157:H7 infection (or any other condition) to the reportable disease list in your State?

Answer 3:
The debate surrounding the addition of a new disease to the notifiable disease list usually pits the public health justification (see below) against the additional reporting burden placed on health care providers, laboratories, and others who are supposed to report.

Usually, a health agency justifies the addition of a new disease to the list by its need to:
1. take public health action as necessary / appropriate (e.g., if disease occurrence or distribution changes)
2. establish baseline incidence data if a new intervention is on the horizon (e.g., establish baseline incidence of *H. flu* or chickenpox and monitor impact of vaccination.)
3. learn more about the epidemiology and natural history/spectrum of illness of a new disease such as AIDS (in the early 1980s) or *E. coli* O157:H7.

In other words, the health agency justifies the need for surveillance to monitor the patterns of disease occurrence by risk group in order to carry out informed public health planning and action.

On the other hand, intended reporters (physicians, labs, etc.) express concern that too many diseases are already on the list, too much information is sought on the forms (which take too long to fill out and send in), and too little is done with the data that already are collected. The result is widespread under reporting of all but the most serious and rare conditions with clear public health implications (e.g., botulism, plague).

In 1992, a Canadian province developed the following criteria to prioritize conditions for their own notifiable disease list (0-5 points for each, no weighting)[1]:

1. World Health Organization interest
2. Agriculture Canada interest (USDA equivalent)
3. Incidence
4. Morbidity
5. Mortality
6. Case-fatality rate
7. Communicability
8. Potential for outbreaks
9. Socioeconomic impact
10. Public perception of risk
11. Vaccine preventability
12. Necessity for an immediate public health response

The addition of *E. coli* O157:H7 infection to the notifiable disease lists in Oregon and Washington may be justified because it is an emerging disease in those states, and knowledge of its epidemiology is evolving. The disease can be severe, causing substantial morbidity and, sometimes, death. There is a potential for epidemic spread which can be aborted if an outbreak is detected quickly.

Question 4: What is the process for making a disease reportable? What are the alternatives?

Answer 4:

Process: Each state has a morbidity reporting system that is based on state laws or regulations adopted by the state board or department of health. In most states, state health authorities are empowered by the state legislature to establish and modify reporting requirements. In a few states, the legislature keeps that authority. Politics may play a role in deciding whether to make a disease reportable.

Alternatives: Alternative methods to mandatory reporting could include: informal voluntary reporting, a network of sentinel physicians, active surveillance of labs and other sites by the health department, or analysis of existing data (e.g., hospital discharge data).

Question 5: Assuming you would like to make *E. coli* O157:H7 infection a reportable disease in Oregon, what information must you specify in the regulation or statute?

Answer 5:
What, Who, When, Where, [Why], How

What to report, i.e., case definition.
For *E. coli* O157:H7, you must decide whether to require reporting of:

- bloody diarrhea only if culture-positive for *E. coli*
- bloody diarrhea NOS ("not otherwise specified")
- hemolytic-uremic syndrome
- asymptomatic but culture-confirmed *E. coli* O157:H7 infection

Optionally, allow degrees of diagnostic certainty - confirmed vs. suspected, etc.
Also, **what** data to provide, including identifiers.

Who must report. Most States require reporting by physicians, hospitals, other health care providers. Historically, Oregon and some other states have relied heavily on reporting by laboratories. Other States, including neighboring Washington State, have never relied on laboratory reporting. Obviously, labs in states that have a history of lab reporting will be more accepting of a new reporting condition than labs in states with no such history.

When, i.e., within how many days of seeing or diagnosing a case must the report be sent? (For conditions that may represent a public health emergency, such as foodborne botulism or meningococcal meningitis, reporting should be immediate, often before the diagnosis is confirmed. For other diseases, reporting may be required within a week of diagnosis.)

Where should the report be sent (usually county, sometimes directly to State)

Why - optionally, you can include a justification for adding this condition, to help clinicians understand why it is important for them to report this disease

How to report, e.g., phone, mail - standard card or special form, etc.

Instructor's Note: Appendix 2 contains the case definition for Enterohemorrhagic *Escherichia coli* last updated in 2000.

Question 6: Assuming that you will add it to the reportable disease list in your state, what categories of information would you collect on an initial one-page disease report form?

Answer 6:
Since *E. coli* O157:H7 is generally a laboratory-based diagnosis, states that require laboratories to report would get most case reports from those laboratories. In other states, initial reporting from physicians or nurses may be on standard disease report card. A specific *E. coli* O157:H7 follow-up report form would be used to collect more specific information, especially on clinical features (to characterize spectrum/severity of illness) and risk factors.

A new form would create the opportunity to collect more information about a relatively new disease, which would provide more knowledge about risk factors and other epidemiology issues. Information on a standard form might be limited to the data collected for transmission to CDC.

Instructor's Note: Break the class into groups of about 4, and have each group list the types of information they'd want.

All surveillance instruments should include the following categories of information:
- **Patient identifying information** (name, address, phone number) - allows call backs, check for duplicate records, etc.
- **Demographic information** (date of birth or age, sex, race) - allows characterization of populations at risk
- **Clinical information** (date of onset, signs/symptoms, lab results, met case definition?, hospitalized, died?) - allows verification of case definition, characterization of spectrum and course of disease, impact on resources, etc.
- **Risk factors** (occupation, household contacts, travel, immunization status, possible exposures such as food, water, swimming, animals) - to help generate or evaluate hypotheses during an investigation, targeting of prevention and/or control measures
- **Reporter identifying information** (name, address, phone number, date of report) - allows follow-up, feedback

Some surveillance instruments also include:
- **Follow-up actions**
- **Contacts**, i.e., whom the case may have exposed (STDs, rabies, et al.)

Guidelines for reporting should be addressed. What is the case definition? Should reporting be delayed until laboratory confirmation? How often should the information be reported? In what situations should an immediate telephone call be made to the State Health Department? Must known outbreak-associated cases be reported, or only cases not associated with a known outbreak?

Instructor's Note: In Oregon, local health departments use one form for two different purposes -- to collect routine surveillance information and as a worksheet to document public health action to be taken (family contact information, need for home visit, work restrictions, vaccine history, etc. As worksheets at the local level, they are not used at the State Health Department.

PART II

Dateline: 1/1/93. By 1993, *E. coli* O157:H7 (O157) has been recognized as an important foodborne pathogen that can cause serious illness. Numerous outbreaks across the country have been attributed to ground beef, roast beef, water, apple cider, and unpasteurized milk. Human infection occurs primarily through ingestion of food or water contaminated with bovine fecal material, but person-to-person transmission also occurs. The organism can survive for extended periods in water, meat stored at subfreezing temperatures, soil, and acidic environments, but can be destroyed by thorough cooking or pasteurization.

Patients infected with O157 typically present with severe abdominal cramps, bloody diarrhea, and low grade fever. Children and the elderly are at greatest risk for complications such as hemorrhagic colitis, hemolytic uremic syndrome, and death.

In 1990, Oregon added *E. coli* O157:H7 to its reportable disease list. Oregon requires reporting by health care providers, health care facilities, and laboratories. The Laboratories must also send isolates to the State Laboratory.

Question 7: What attributes characterize a good surveillance system?

Answer 7
Among the attributes of a good surveillance system are:
- Addresses a health event with substantial public health importance
- Has clear objectives
- Is feasible (logistically and resource-wise)
- Is useful
- Is cost-effective
- Has as many of the following attributes as possible:
  - **Simplicity** - the ease of operation of the system as a whole and each of its components
  - **Flexibility** - ability to accommodate changes in operating conditions or information needs
  - **Data Quality** - completeness and validity of the data collected and reported
  - **Acceptability** - willingness of individuals and organizations to participate in the system
  - **Sensitivity** - ability to detect the cases or health events or outbreaks it is intended to detect
  - **Predictive Value Positive** - mostly affected by the system's specificity, PVP is the proportion of reported cases (or outbreaks) which truly are cases (or outbreaks)
  - **Representativeness** - extent to which the system accurately portrays the incidence of the health event in a population by time, place, and person
  - **Timeliness** - availability of data in time for appropriate action
  - **Stability** - reliability and availability of the system (operates properly and without failures)

You are an epidemiologist assigned to the Oregon Health Division, and are responsible for reviewing surveillance data on a regular basis.

Question 8: What basic descriptive epidemiology would you like to see to characterize the occurrence of *E. coli* O157:H7 in Oregon?

Answer 8
Descriptive epidemiology includes what (diagnosis / clinical), when (time), (where) place, (who) person.
Clinical - number / percent lab confirmed vs. clinical; percent hospitalized or died
Time - number of cases by week or month
Place - number and rate of cases by county
Person - number and rate of cases by age group and sex

PART III

Following are several tables of *E. coli* O157:H7 surveillance data collected in Oregon from August 1990 through December 1992.

Table A: *E. coli* O157:H7 cases by year (ONSETYY) and month (ONSETMM) of onset, Oregon, 1990 - 1992

ONSETMM	ONSETYY 90	91	92	Total
1	-	2	1	3
2	-	2	2	4
3	-	2	7	9
4	-	5	5	10
5	-	1	12	13
6	-	10	25	35
7	2	26	41	69
8	14	28	17	59
9	19	15	19	53
10	12	13	7	32
11	5	6	9	20
12	7	1	11	19
Total	59	111	156	326

Question 9: Using a separate piece of graph paper, graph the data in Table A and interpret.

Answer 9:
See figure below.

Increased number of cases over time? Note reporting started August 1990. When comparing August through December only, the numbers are: 1990=57, 1991=63, 1992=63

Seasonal - 50% cases occurred July-September

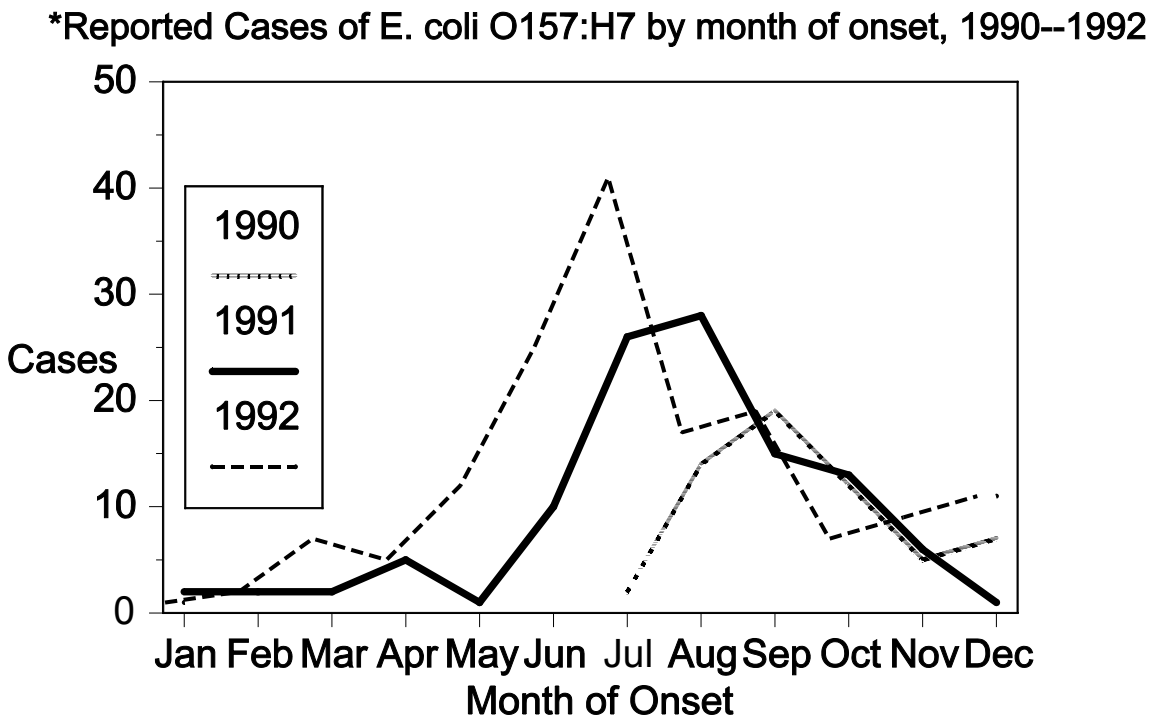
*Reported Cases of E. coli O157:H7 by month of onset, 1990--1992
50
40
30
20
10
0
Cases
1990
1991
1992
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec
Month of Onset

Table B: *E. coli* O157:H7 cases by year of onset and county, Oregon, 1990 - 1992

	ONSETYY			
COUNTY	90	91	92	Total
BAKER	0	1	0	1
BENTON	1	4	11	16
CLACKAMAS	7	11	21	39
COLUMBIA	1	2	5	8
COOS	0	0	1	1
DESCHUTES	2	0	0	2
DOUGLAS	2	4	4	10
GRANT	0	0	2	2
JACKSON	1	0	4	5
JEFFERSON	0	0	2	2
JOSEPHINE	0	0	1	1
LANE	6	9	16	31
LINCOLN	2	1	1	4
LINN	4	4	5	13
MALHEUR	3	0	1	4
MARION	9	8	10	27
MULTNOMAH	11	36	41	88
POLK	1	1	3	5
UMATILLA	1	0	3	4
WASCO-SHER	0	2	1	3
WASHINGTON	7	26	19	52
YAMHILL	1	2	5	8
Total	59	111	156	326

Question 10: Summarize the data in Table B and interpret.

Answer 10
The number of cases increased by about 50 each year, and this increase was consistent across counties. Most cases occurred in Multnomah, Washington, and Clackamas Counties. These numbers are important from the point of view of impact and resource allocation. However, we would **need denominators** to calculate risks or rates. In addition, comparisons among counties may be misleading because of variations in awareness and reporting.

Table C: *E. coli* O157:H7 cases by year of onset and 10-year age group, Oregon, 1990 - 1992

AGE10	ONSETYY 90	91	92	Total
0 TO 9	10	35	39	84
10 TO 19	10	11	31	52
20 TO 29	8	19	20	47
30 TO 39	7	14	10	31
40 TO 49	5	8	13	26
50 TO 59	6	8	14	28
60 TO 69	4	8	15	27
70 TO 79	6	5	8	19
80 TO 89	2	3	3	8
90 TO 99	0	0	3	3
Unknown	1	0	0	1
Total	59	111	156	326

Table D: *E. coli* O157:H7 cases by sex and 10-year age group, Oregon, 1990 - 1992

AGE10	SEX F	M	Total
0 TO 9	42	42	84
10 TO 19	24	28	52
20 TO 29	22	25	47
30 TO 39	15	16	31
40 TO 49	17	9	26
50 TO 59	15	13	28
60 TO 69	11	16	27
70 TO 79	8	11	19
80 TO 89	2	6	8
90 TO 99	2	1	3
Unknown	1	0	1
Total	159	167	326

Table E: *E. coli* O157:H7 cases by year of onset and single year of age for those under age 11 years, Oregon, 1990 - 1992

AGE	ONSETYY 90	91	92	Total
0	1	0	2	3
1	3	6	6	15
2	2	6	6	14
3	3	5	4	12
4	0	6	6	12
5	1	3	3	7
6	0	3	4	7
7	0	2	5	7
8	0	0	2	2
9	0	4	1	5
10	1	0	7	8
Total	11	35	46	92

Table F: Population of all ages, all races, both sexes by age, Oregon, 1990 (n=2,842,321)

Age (yrs)	Population	% of N
0-4	205,649	7.23
5-9	208,902	7.34
10-14	200,742	7.06
15-19	191,070	6.72
20-24	189,859	6.67
25-29	212,127	7.46
30-34	239,715	8.43
35-39	250,218	8.80
40-44	223,537	7.86
45-49	165,811	5.83
50-54	128,860	4.53
55-59	115,362	4.05
60-64	120,704	4.24
65-69	122,332	4.30
70-74	101,583	3.57
75-79	78,200	2.75
80-84	49,383	1.73
85+	38,267	1.34

Table G: Population of all ages, all races, both sexes by county, Oregon, 1990 (n=2,842,321)

	County	Population	% of N		County	Population	% of N
1	MULTNOMAH	583,887	20.54	19	CLATSOP	33,301	1.17
2	WASHINGTON	311,554	10.96	20	MALHEUR	26,038	0.91
3	LANE	282,912	9.95	21	UNION	23,598	0.83
4	CLACKAMAS	278,850	9.81	22	WASCO	21,683	0.76
5	MARION	228,483	8.03	23	TILLAMOOK	21,570	0.75
6	JACKSON	146,389	5.15	24	CURRY	19,327	0.67
7	DOUGLAS	94,649	3.32	25	HOOD RIVER	16,903	0.59
8	LINN	91,227	3.20	26	BAKER	15,317	0.53
9	DESCHUTES	74,958	2.63	27	CROOK	14,111	0.49
10	BENTON	70,811	2.49	28	JEFFERSON	13,676	0.48
11	YAMHILL	65,551	2.30	29	GRANT	7,853	0.27
12	JOSEPHINE	62,649	2.20	30	MORROW	7,625	0.26
13	COOS	60,273	2.12	31	LAKE	7,186	0.25
14	UMATILLA	59,249	2.08	32	HARNEY	7,060	0.24
15	KLAMATH	57,702	2.03	33	WALLOWA	6,911	0.24
16	POLK	49,541	1.74	34	SHERMAN	1,918	0.06
17	LINCOLN	38,889	1.36	35	GILLIAM	1,717	0.06
18	COLUMBIA	37,557	1.32	36	WHEELER	1,396	0.04

Question 11: Summarize these data by place.

Answer 11:
INSTRUCTOR NOTE 1: If you wish, you can have half of the class answer Question 10, and half answer Question 11. Break class into groups of 3-4 people, and assign one task per group. Give instructions based on how much time you wish to allocate for this section.

INSTRUCTOR NOTE 2: Suggest that the class can ignore 1990 data, when the system was just getting established.

INSTRUCTOR NOTE 3: Tell the class that, although the population of Oregon may have grown from 1990 to 1992, they should use the 1990 census data for denominators, since no other data is available.

Students should (split the counties up):
1. Calculate county-specific rates by year, 1991 and 1992.
2. Calculate 1991-1992 average county-specific rates by summing the number of cases over the 2 years, dividing by the population, then dividing by 2.
3. Use same method to calculate state-wide annual and average statewide rates.

PLACE: See county-specific rates (per 100,000) below. Caveat: surveillance and awareness may be more aggressive/higher in some counties. Some counties with high rates are rather small, with few cases (e.g., Grant).

County	Population	1990	1991	1992	3-yr Avg	2-Yr Avg
Baker	15,317		6.53		2.18	3.26
Benton	70,811	1.41	5.65	15.53	7.53	10.59
Clackamas	278,850	2.51	3.94	7.53	4.66	5.74
Columbia	37,557	2.66	5.33	13.31	7.10	9.32
Coos	60,273			1.66	0.55	0.83
Deschutes	74,958	2.67			0.89	0.00
Douglas	94,649	2.11	4.23	4.23	3.52	4.23
Grant	7,853			25.47	8.49	12.73
Jackson	146,389	0.68		2.73	1.14	1.37
Jefferson	13,676			14.62	4.87	7.31
Josephine	62,649			1.60	0.53	0.80
Lane	282,912	2.12	3.18	5.66	3.65	4.42
Lincoln	38,889	5.14	2.57	2.57	3.43	2.57
Linn	91,227	4.38	4.38	5.48	4.75	4.93
Malheur	26,038	11.52		3.84	5.12	1.92
Marion	228,483	3.94	3.50	4.38	3.94	3.94
Multnomah	583,887	1.88	6.17	7.02	5.02	6.59
Polk	49,541	2.02	2.02	6.06	3.36	4.04
Umatilla	59,249	1.69		5.06	2.25	2.53
Washington	311,554	2.25	8.35	6.10	5.56	6.92
Yamhill	65,551	1.53	3.05	7.63	4.07	7.22
Wasco-Sherman	23,601		8.47	4.24	4.24	5.34
Statewide	**2,842,321**	**2.08**	**3.91**	**5.49**	**3.82**	**4.70**

Question 12: Summarize these data by person.

Answer 12:
PERSON: Highest rate (per 100,000) in youngsters. No apparent gender differences. Otherwise, surprisingly uniform.

Age Group	Population	1990	1991	1992	3-yr Avg	2-Yr Avg
0 to 4 years	205,649	4.38	11.18	11.67	9.08	11.43
5 to 9	208,902	0.48	5.74	7.18	4.47	6.46
10 to 19	391,812	2.55	2.81	7.91	4.42	5.36
20 to 29	401,986	1.99	4.73	4.98	3.90	4.85
30 to 39	489,933	1.43	2.86	2.04	2.11	2.45
40 to 49	389,348	1.28	2.05	3.34	2.23	2.70
50 to 59	244,222	2.46	3.28	5.73	3.82	4.50
60 to 69	243,036	1.65	3.29	6.17	3.70	4.73
70 to 79	179,783	3.34	2.78	4.45	3.52	3.62
80+	87,650	2.28	3.42	6.85	4.18	5.13
Total	2,842,321	2.08	3.91	5.49	3.82	4.70

Dateline: 4/19/93. All *E. coli* O157:H7 case reports in Oregon are investigated by county health department nurse-epidemiologists. The investigation includes an interview about recognized sources for *E. coli* O157:H7 infection. Nurses at the Multnomah County (which includes the city of Portland) health department noted that three recent cases had reported drinking raw milk within the nine days prior to disease onset. Suspecting a possible outbreak, they immediately notified the state epidemiologist.

Question 13: Calculate the expected number of cases in Multnomah County in April. (Hint: Should you use 1990 data?)

Answer 13:
Instructor's note: Ask, "How do you estimate the expected number of cases?" or "What is the expected number based on?" Answer - usually use historical data, i.e., number of cases in previous year(s).

The expected number is usually based on the numbers reported in previous years, which would be available at the State or Multnomah County Health Department. We do not have monthly data for Multnomah County, but one might assume that the seasonal pattern observed for Oregon applies to Multnomah County as well.

Based on Table A 1991 and 1992 data, the percent of cases statewide seen in April is:

(5 + 5) / (111 + 156) = 10 / 267 = 3.7%.

Based on Table B 1991 and 1992 data, the number of cases expected in Multnomah Co. in April is:

3.7% x (36 + 41)/2 = 3.7% x 38.5 = 1.4.

Alternatively, Entire state of Oregon had 5 cases each April in past two years. Multnomah has had (36+41)/(111+156) = 77/267 = 28.8% of Oregon's cases. 5 x .288 = 1.44 expected cases.

Question 14: What can account for an increase in the number of cases reported to a surveillance system?

Answer 14:
The increase may be due to a **true** increase in incidence or to **artifact**.

A **true** increase may result from:
- change in the agent (virulent strain or antigenic shift away from vaccine type)
- change in host, including
  - increase in the size of the susceptible population (births, immigration, low vaccine coverage for a vaccine-preventable disease, etc.)
  - increased individual susceptibility (low resistance, vaccine failure [primary = no immunity induced; secondary = waning immunity] for a vaccine-preventable disease
- increased exposure / increased agent-host interaction (increase in agent, change in behavior leading to increased transmission, etc.)

Artifactual reasons include:
- changes in local reporting procedures (e.g., easier reporting procedure like active rather than passive)
- changes in case definition (cf: AIDS)
- increased interest because of local or national awareness
- improvements in diagnostic procedures
- new health care worker(s) or facilities - may see more referred cases, may make the diagnosis more often, may report more reliably
- outbreak of similar disease, misdiagnosed as disease of interest
- duplicate reports

Depending on perspective, can be considered “real” or artifactual:
- change in denominator - influx of tourists (Cape Cod), refugees, migrant farmers, etc.

PART IV

Epidemiologists at the State Health Department reviewed all 1992 and 1993 *E. coli* O157:H7 case reports and identified three more of 13 sporadic cases (not related to any recognized outbreak) in persons who reported drinking Dairy A raw milk in the days before their onsets. These three persons did not appear to share any other common exposures. All lived in the greater Portland area. Thus a total of 6 out of 13 sporadic cases reported drinking Dairy A brand raw milk, the only brand of raw milk sold in the Portland area. Additional (presumptive) cases were also reported among raw milk-drinking household members. The following table summarizes the 6 cases confirmed to date associated with Dairy A:

CITY	COUNTY	AGE	SEX	ONSET
Portland	Multnomah	61	F	12/19/92
Sandy	Clackamas	3	M	03/21/93
Portland	Multnomah	43	M	04/03/93
Sherwood	Washington	9	M	04/07/93
Portland	Multnomah	34	M	04/11/93
Portland	Multnomah	38	F	04/14/93

To determine whether the relatively high proportion of raw milk consumption was limited to the *E. coli* cases or simply reflected an increase in raw milk consumption overall, investigators reviewed all cases of salmonellosis in the Portland area 1992 and 1993. Raw milk consumption was not reported for any of these cases.

Question 15: In addition to the state and local health departments, what other agencies should be involved, and what are their roles? Who are the stakeholders in this situation? What concerns are they likely to raise?

Answer 15:

Agencies

State Health Dept:	Public Health
State Agriculture Dept:	License and inspect dairies, authority to issue recall
USDA, APHIS*:	No official jurisdiction, but notification would be helpful. Can provide assistance and advice.
FDA:	Food products that are interstate (raw milk is banned interstate)
Others?	(Students may have additional suggestions)

Stakeholders

Dairy Owner:	Financial concerns, survival of business, liability
Distributors, Markets	Loss of income, liability
Raw Milk Consumers	Likely to be adamant about keeping raw milk available

In general, agriculture agencies tend to support farmers' interests. In general, public health agencies attempt to protect the public's health with little regard for the economic impact to business.

* U.S. Department of Agriculture, Animal and Plant Health Inspection Service

PART V

Consultation with officials at the Food and Dairy Division of the Oregon Department of Agriculture (ODA) and with the USDA Animal and Plant Health Inspection Service (APHIS) Area Epidemiologist provided the following information:

The ODA Food and Dairy Division licenses raw milk dairies. There are five licensed cow dairies and one goat dairy in the state. In 1987, the FDA banned the distribution and sale of unpasteurized milk outside of the state in which it was produced. An FDA survey showed that intrastate raw milk sales were permitted in 27 states and raw milk was sold in at least 18 states in 1992. The 111 raw milk dairies in the U.S. constituted 0.06 percent of all dairies. It was estimated that raw milk sold to consumers constituted approximately 0.02 percent of the total milk production in the U.S.

Unpasteurized milk has been frequently implicated as a vehicle for many enteric infections, including campylobacteriosis and salmonellosis as well as O157 infection. Health food enthusiasts claim benefits result from drinking raw milk such as higher nutritive value and enhanced resistance to disease. While pasteurization does cause trivial decreases in thiamine, vitamin B_{12}, and vitamin C contents, human nutrition studies have shown no advantage of raw milk over pasteurized milk. No evidence exists in support of claims for disease resistance.

Dairy A has 132 cattle and produces 350 gallons of milk per day that is distributed through 35 retail outlets, including major supermarkets and numerous health food stores. It is the only supplier of bovine raw milk in the Portland area. In the early 1980s Dairy A was the apparent source of a small outbreak of campylobacteriosis, but this finding was not made public at the time.

The ODA inspects all dairies in Oregon six times per year and collects bulk milk samples approximately every six weeks. Herds are also required to be tested for brucellosis and tuberculosis once each year by an accredited veterinarian. Samples from the bulk tanks are tested for total bacterial count, *Salmonella*, milk fat percentage, added water, etc. In raw milk dairies, additional testing is done for fecal coliforms, but a maximum standard is not established and the numbers are strictly informational.

The mechanism by which raw milk becomes contaminated with O157 has not been documented; however fecal contamination associated with milking is presumed. Pathogen sources may include the farm environment, contaminated equipment used for milking, filtering, cooling, storing, and milk distribution, or infected farm workers. Preliminary evidence suggests that cattle transiently or sporadically shed O157 in their feces and that the excretion period ranges from hours to weeks. O157 is not known to cause clinical disease in cattle under natural conditions. Currently, not enough is known about the ecology of O157 in cattle to implement prudent, on-farm intervention measures to prevent future contamination.

Dateline: 4/20/93. Two epidemiologists including the Public Health Veterinarian from the Oregon Health Division and a sanitarian from the ODA Food and Dairy Division went to the dairy to inform the owner of the outbreak. While there, they collected swabs for culture from 30 manure piles near the milking area. Six raw milk samples were collected from the dairy and from several local distributors for testing and culture. Results from these preliminary tests will not be available for several days. Plans were made to do a complete herd test as soon as logistically possible.

Staff at the Oregon Health Division calculated the probability of finding by chance alone that at least six of the thirteen cases would have consumed raw milk, assuming that no more than 1% of the population in the area are raw milk drinkers. They reported the result in their epidemiology newsletter as follows: "The probability that at least six out of thirteen cases would be brand A drinkers by chance alone, given a 1% exposure prevalence, is 0.00000000162. (Or less than one in five-hundred million)."

Question 16a: List the lines of evidence that suggest that raw milk from Dairy A is the source of this *E. coli* O157:H7 outbreak.

Answer 16a

In favor

- Biologic plausibility: raw milk is a known source of enteric pathogens.
- Dairy A is the only supplier of raw milk in the area.
- Very strong statistical association, plus no other known shared exposures
- Dairy A has a history (was apparent source of campylobacter outbreak in early 1980s)

Against

- No lab confirmation
- Raw milk cannot account for all (or even almost all) of the 13 cases

Question 16b: After reviewing the lines of evidence you listed above, do you believe Dairy A's raw milk is the source (or at least a source) of *E. coli*?

Answer 16b

No right answer. Reasonable people may disagree on how much information is enough. Also, "where you stand (on an issue) often depends on where you sit (in an organization or community)."

Question 16c: What actions might you take next (e.g., issue warning about raw milk, pull raw milk off shelves, require pasteurization of raw milk, close Dairy A, do more investigation, wait for lab results, etc.)?

Answer 16c:
Matter of opinion, and obviously depends on one's answer to Question 16b. Some may want laboratory proof -- identifying the organism in the milk (or at least the same strain from the manure piles or cows themselves). However, that is not always possible, and additional people could get sick while you wait for the lab results. In addition, what do you do if the results come back negative?

The decision process must balance the potential risk to the public if there is a danger and it is not reported versus the potential damage to the producer if it is not a true danger and financial loss results from the actions taken. Is the potential risk to other raw milk drinkers so great that you had better announce your findings immediately? On the other hand, even if you believe that raw milk is the culprit, or that you should err on the side of protecting the public's health when you don't have all the information you'd like, can you defend your position to your superiors, to the public, perhaps to the court? It often can be a "damned if you do and damned if you don't" type decision. The credibility of the public health department is at stake.

The health department did indeed go public (see next section). They treated the review of case reports for raw milk consumption on 1992 O157 cases and 1993 salmonellosis cases as "quick and dirty control groups". There might be biases, but in the direction of the "null".

Why go public now? Raw milk is a continually produced commercial product, and this outbreak is current (i.e. not like a batch of food served at a restaurant 3 weeks ago). Going public could prevent more cases, and this may be just the beginning of a very large outbreak. Publicity may also help identify other ill persons who had not sought medical attention.

Possible methods to release information: Press conference, press release, leak, state newsletter that the media can get access to. Conduct a "live" tv or radio interview (which cannot be edited).

This may also be an opportunity to achieve collateral goals (i.e. education about the dangers of unpasteurized milk), or to justify the need for funding for the county health department (prevention of major outbreaks by doing superb surveillance).

Type I error (unjustly implicating Dairy A) -loss of credibility when HD has to admit error; may be sued for loss of income and reputation, etc.

Type 2 error (failing to implicate Dairy A when they should) - more people get sick ("preventable cases"); HD accused of covering up or being ineffective or uncaring.

PART VI

Dateline: 4/21/93. The Oregon Health Division went public. They issued a press release announcing that a cluster of six confirmed cases of *E. coli* O157:H7 in Portland area residents were linked to consumption of raw (unpasteurized) milk produced by Dairy A. At the same time, the Oregon Dept. of Agriculture announced a recall on Dairy A raw milk and arranged for the dairy's milk to be diverted temporarily to a nearby creamery for pasteurization.

Dateline: 4/26/93. Results from the fecal and milk sample tests all came back negative for O157. The Oregon Department of Agriculture lifted the recall.

The investigation became a hot topic in the local press.

Question 17: What would be your "SOCO" (Single Overriding Communication Objective) to the media? What other "spin" might the local media put on this story?

Answer 17:
Matter of opinion whether SOCO should focus on general public health measures regardless of the source of the outbreak, or should focus on not drinking raw milk, particularly raw milk from this dairy. The latter SOCO would be that a contaminated product is on the market, that although legal is every bit as dangerous as Jack-in-the-Box hamburgers and other sources of *E. coli* O157:H7. Although no one has died yet, the next case just might be the fatal one. We need to act decisively to protect the health of our public.

In some outbreaks, the media portrays the situation as "potentially more sick/dead children (with the health dept. trying to prevent more cases) versus uncaring, profit-oriented big business." In this particular outbreak, the situation was portrayed as "small businessman trying to make a living by selling a niche product to informed and loyal consumers versus The Government/Big Brother making unreasonable demands and trying to drive him out of business."

PART VII

Dateline: 5/93. The media portrayed the situation as the Government bullying a local businessman trying to make a living by selling a local product to informed local consumers. Letters to the Editor supported the dairy.

Meanwhile, a case was reported in a 73-year old man whose illness began on April 21. He had consumed raw milk form Dairy A.

Dateline: 6/93. Two sisters, one age 3 and the other age 9 months, were diagnosed with *E. coli* O157:H7 within a week of each other. The 3-year-old had consumed raw milk from Dairy A while visiting her grandmother on June 11 and 12. The 9-month-old had not consumed the milk, but was exposed to her sister. Samples of the implicated milk were tested at three separate labs but were found to be negative for O157.

After these new cases came to light, a meeting was convene with representatives of the Oregon Department of Agriculture, the Oregon Health Division, and the dairy's attorney. The parties agreed to test the milk every 2 weeks and perform 2 prevalence surveys of the herd. They also agreed that if the milk tested positive, a recall would be issued and pasteurization would be instituted. Animals testing positive for O157 would be removed from milk production.

Dateline: 7/19/93. A herd test was conducted on all 132 cattle on the premises. The testing found four animals in the milking herd positive for O157 (3% prevalence). The isolates from the positive animals matched the sub-typing on four of the previous human cases associated with the dairy.

Dateline: 8/24/93. Dairy A refused to allow a second herd test. No subsequent herd tests for O157 were permitted.

Oregon enacted an administrative rule requiring all unpasteurized milk to carry a warning label: *"This product has not been pasteurized... may contain disease-producing organisms"*.

Dateline: Spring 1994. A new cluster of O157 occurred involving three confirmed and four presumptive cases in three different families. As a result, ODA conducted a second herd test (by fecal swabs) at Dairy A. Two different subtypes isolated from the cases matched subtypes from at least two of the animals in the herd. The Oregon Health Division took the Dairy to court using a consumer protection statute that states "...cannot willfully spread an infectious disease." The court issued a restraining order preventing the dairy from selling raw milk.

Question 18: Consider the steps of a surveillance system (data collection, analysis, etc.) Which steps, if any, are traditionally the "weak links" in the system? How has the Oregon Health Division performed?

Answer 18:

• ongoing, systematic	- usually routine for notifiable diseases
• collection	- widely acknowledged gross under reporting for many notifiable diseases
• analysis	- sometimes weak, depending on health department's capacity and time availability
• interpretation	- usually adequate if data are looked at!
• dissemination	- often the "weak link"
• to help guide public health decision-making and action	- sometimes weak, depending on disease local politics, etc.

Oregon Health Division has generally performed well in accomplishing all of these steps.

PART VIII - CONCLUSION

The Dairy sued to vacate the restraining order, arguing that the subtyping results came back three weeks after the people became ill so there is no evidence of "ongoing public health threat." Further, the sale of raw milk was legal in Oregon and the health department had not come up with standards that the Dairy could meet to be able to market their product.

The restraining order was not lifted. Nevertheless, the dairy continued to sell raw milk surreptitiously until October 1995, when a Department of Agriculture "sting" operation uncovered the sales. The dairy owner was fined and jailed for contempt of court. No Dairy-A-associated cases have been reported since June 1994.

Dateline: 1995. In response to this and another outbreak, legislation to outlaw the retail sale of raw milk in Oregon was introduced in 1995. It died in committee.

Dateline: 1997. The owner closed the dairy and sold the property to a developer for a substantial sum.

REFERENCES

Surveillance

1. Carter AO. Setting priorities: The Canadian experience in communicable disease surveillance. MMWR Supplement 1992;41:79-84.

2. Centers for Disease Control and Prevention. Updated guidelines for evaluating public health surveillance systems. *MMWR* 2001;50(No. RR-13):11-24.

3. Teutsch SM, Churchill RE, eds. Principles and practice of public health surveillance, 2nd ed. New York: Oxford University Press, 2000.

***E. coli* O157:H7**

4. Keene WE, Hedberg K, Herriott DE, Hancock DD, et al. A prolonged outbreak of *Escherichia Coli* O157:H7 infections caused by commercially distributed raw milk. J Infect Dis 1997;176:815-818.

5. CDC. Update: Multistate outbreak of *Escherichia coli* O157:H7 infections from hamburgers - Western United States, 1992-1993. MMWR 1993;42:258-263.

6. Griffin PM, Tauxe RV. The epidemiology of infections caused by *Escherichia coli* O157:H7, other enterohemorrhagic *E. coli*, and the associated hemolytic uremic syndrome. Am J Epidemiol 1991;13:60-98.

Raw Milk

7. Potter ME; Kaufmann AF; Blake PA et al. Unpasteurized milk - the hazards of a health fetish. JAMA 1984; 252:2048-52.

Discussion of Taking Public Health Action Based on Incomplete Information

8. Hennessy TW, Hedberg CW, Slutsker L, et al. A national outbreak of *Salmonella enteriditis* infections from ice cream. N Engl J Med 1996;334:1281-4.

Appendix 1 - Solution to Binomial Problem

$$\sum_{x=i}^{N} \left(\frac{N!}{x!\,(N-x)!} \right) p^{x} (1-p)^{N-x}$$

where N = total number of observations (13)
x = i = all possible values from 0 to N
p = prevalence in population

To determine probability of at least 6 out of 13, add the probabilities for x $ 6.

Prob (x=0)	=	$13!/0!13! \times 0.01^{0} \times 0.99^{13}$	=	1×0.877521	=	0.878
Prob (x=1)	=	$13!/1!12! \times 0.01^{1} \times 0.99^{12}$	=	13×0.008863	=	0.115
Prob (x=2)	=	$13!/2!11! \times 0.01^{2} \times 0.99^{11}$	=	78×0.000089	=	0.00698
Prob (x=3)	=	$13!/3!10! \times 0.01^{3} \times 0.99^{10}$	=	$286 \times 9.0 \times 10^{-7}$	=	2.59×10^{-4}
Prob (x=4)	=	$13!/4!9! \times 0.01^{4} \times 0.99^{9}$	=	$715 \times 9.1 \times 10^{-9}$	=	6.53×10^{-6}
Prob (x=5)	=	$13!/5!8! \times 0.01^{5} \times 0.99^{8}$	=	$1287 \times 9.2 \times 10^{-11}$	=	1.19×10^{-7}
Prob (x=6)	**=**	$\mathbf{13!/6!7! \times 0.01^{6} \times 0.99^{7}}$	**=**	$\mathbf{1716 \times 9.3 \times 10^{-13}}$	**=**	$\mathbf{1.60 \times 10^{-9}}$
Prob (x=7)	**=**	$\mathbf{13!/7!6! \times 0.01^{7} \times 0.99^{6}}$	**=**	$\mathbf{1716 \times 9.4 \times 10^{-15}}$	**=**	$\mathbf{1.62 \times 10^{-11}}$
Prob (x=8)	**=**	$\mathbf{13!/8!5! \times 0.01^{8} \times 0.99^{5}}$	**=**	$\mathbf{1287 \times 9.5 \times 10^{-17}}$	**=**	$\mathbf{1.22 \times 10^{-13}}$
Prob (x=9)	**=**	$\mathbf{13!/9!4! \times 0.01^{9} \times 0.99^{4}}$	**=**	$\mathbf{715 \times 9.6 \times 10^{-19}}$	**=**	$\mathbf{6.87 \times 10^{-16}}$
Prob (x=10)	**=**	$\mathbf{13!/10!3! \times 0.01^{10} \times 0.99^{3}}$	**=**	$\mathbf{286 \times 9.7 \times 10^{-21}}$	**=**	$\mathbf{2.78 \times 10^{-18}}$
Prob (x=11)	**=**	$\mathbf{13!/11!2! \times 0.01^{11} \times 0.99^{2}}$	**=**	$\mathbf{78 \times 9.8 \times 10^{-23}}$	**=**	$\mathbf{7.64 \times 10^{-21}}$
Prob (x=12)	**=**	$\mathbf{13!/12!1! \times 0.01^{12} \times 0.99^{1}}$	**=**	$\mathbf{13 \times 9.9 \times 10^{-25}}$	**=**	$\mathbf{1.29 \times 10^{-23}}$
Prob (x=13)	**=**	$\mathbf{13!/13!0! \times 0.01^{13} \times 0.99^{0}}$	**=**	$\mathbf{1 \times 1.0 \times 10^{-26}}$	**=**	$\mathbf{1.00 \times 10^{-26}}$

The sum of probabilities for x = 6 through x = 13 = 1.62×10^{-9}, or 0.00000000162.

Note that, with an expected value of 1 in 100, the probability of x=0 (0.878) plus the probability of x=1 (0.115) add up to 0.99. Therefore, any observed value of 2 or greater has a p-value less than 0.01.

Appendix 2 - Case Definitions Used in Public Health Surveillance

Escherichia coli O157:H7
(2000 Case Definition)

Clinical description
An infection of variable severity characterized by diarrhea (often bloody) and abdominal cramps. Illness may be complicated by hemolytic uremic syndrome (HUS) or thrombotic thrombocytopenic purpura (TTP); asymptomatic infections also may occur.

Laboratory criteria for diagnosis
- Isolation of *Escherichia coli* O157:H7 from a specimen, or
- Isolation of Shiga toxin-producing *E. coli* from a clinical specimen

Case classification

Suspected: A case of postdiarrheal HUS or TTP (see HUS case definition)

Probable:
- A case with isolation of *E. coli* O157 from a clinical specimen, pending confirmation of H7 or Shiga toxin or
- A clinically compatible case that is epidemiologically linked to a confirmed or probable case
- Identification of Shiga toxin in a specimen from a clinically compatible case, or
- Definitive evidence of an elevated antibody titer to a known EHEC serotype from a clinically compatible case

Confirmed: A case that meets the laboratory criteria for diagnosis.

Comment
Laboratory-confirmed isolates are reported via the Public Health Laboratory Information System (PHLIS), which is managed by the Foodborne and Diarrheal Diseases Branch, Division of Bacterial and Mycotic Diseases, National Center for Infectious Diseases, CDC. Both probable and confirmed cases are reported to the National Notifiable Diseases Surveillance System (NNDSS), but only confirmed cases are reported to PHLIS. Confirmation is based primarily on laboratory findings.

Hemolytic Uremic Syndrome, Postdiarrheal **(Revised September 1996)**

Clinical description
Hemolytic uremic syndrome (HUS) is characterized by the acute onset of microangiopathic hemolytic anemia, renal injury, and low platelet count. Thrombotic thrombocytopenic purpura (TTP) also is characterized by these features but can include central nervous system (CNS) involvement and fever and may have a more gradual onset. Most cases of HUS (but few cases of TTP) occur after an acute gastrointestinal illness (usually diarrheal).

Laboratory criteria for diagnosis
The following are both present at some time during the illness:
- Anemia (acute onset) with microangiopathic changes (i.e., schistocytes, burr cells, or helmet cells) on peripheral blood smear and
- Renal injury (acute onset) evidenced by either hematuria, proteinuria, or elevated creatinine level (i.e., greater than or equal to 1.0 mg/dL in a child aged less than 13 years or greater than or equal to 1.5 mg/dL in a person aged greater than or equal to 13 years, or greater than or equal to 50% increase over baseline)

Note: A low platelet count can usually, but not always, be detected early in the illness, but it may then become normal or even high. If a platelet count obtained within 7 days after onset of the acute gastrointestinal illness is not less than 150,000/mm3, other diagnoses should be considered.

Case Classification

Probable:
- An acute illness diagnosed as HUS or TTP that meets the laboratory criteria in a patient who does not have a clear history of acute or bloody diarrhea in preceding 3 weeks or
- An acute illness diagnosed as HUS or TTP, that a) has onset within 3 weeks after onset of an acute or bloody diarrhea and b) meets the laboratory criteria except that microangiopathic changes are not confirmed

Confirmed: an acute illness diagnosed as HUS or TTP that both meets the laboratory criteria and began within 3 weeks after onset of an episode of acute or bloody diarrhea

Comment
Some investigators consider HUS and TTP to be part of a continuum of disease. Therefore, criteria for diagnosing TTP on the basis of CNS involvement and fever are not provided because cases diagnosed clinically as postdiarrheal TTP also should meet the criteria for HUS. These cases are reported as postdiarrheal HUS.