

# PRINCIPLES OF EPIDEMIOLOGY

Self-Study Course 3030-G

Investigation of Disease Outbreaks

## EPIDEMIOLOGIC EXERCISE AN UNUSUAL EPISODE IN MUDVILLE, U.S.A.

A Supplement to Lesson 6



**SELF-STUDY**

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES

10/88:4R

PUBLIC HEALTH SERVICE

Centers for Disease Control

Training and Laboratory Program Office

Division of Training

Atlanta, Georgia 30333

Lesson 6 - Supplement

EPIDEMIOLOGIC EXERCISE

This exercise, "An Unusual Episode in Mudville, U.S.A.," is a part of Lesson 6

- . It is a practical exercise in the investigation of an outbreak of an unknown disease.
- . It requires you to apply what you have learned in the previous lessons to the solution of an outbreak.
- . It is an open book exercise and you can use any resource available--except another person.

The necessary information is provided on pages 1 through 3.

The assignment, starting on page 4, consists of:

	<u>Pages</u>
I. Disease Surveillance	4
II. Characterization of the Epidemic by time, place, and person	4-8
III. Analysis and Conclusions	9-14
IV. Hypothesis Formulation	15-17
V. Hypothesis Testing	17-20

Following each question--adequate space has been provided for your answer. The work should be neat and legible. If you prefer to type the answers--this workbook can be separated and restapled.

# PRINCIPLES OF EPIDEMIOLOGY

## Self-Study Course 3030-G

### An Unusual Episode in Mudville, U.S.A.--An Epidemic Problem

Attached is a list of cases of illness occurring among persons living in the small town of Mudville. Neither the signs and symptoms of the cases nor the diagnoses will be provided. From epidemiological information alone you will attempt to solve this epidemic. On the basis of the epidemiologic data provided, you are to characterize the epidemic by the variables of time, place, and person; you should develop a hypothesis concerning the disease involved, the source, the mode of transmission, and the probable period of exposure to the source of the agent.

An investigation was initiated which revealed the following:

1. A total of 30 cases was discovered among residents of the city. This total represents more cases than has occurred in the community in the past several years.
2. Case investigations were conducted and information acquired for each of the cases. Included among the data acquired was each case's age, sex, address, place of employment/occupation or school and grade attended, and the date of onset of illness. This information is provided in a line listing of cases on page 2.
3. Milk consumed by the cases was from various sources but all came from approved dairies.
4. Of the four schools available to Mudville residents all had separate cafeterias and sources of food. No illnesses were detected in students attending these schools from other areas.
5. There was a city water system from which all persons in town obtained their drinking water.
6. All homes in Mudville are connected to the city sewage system.
7. None of the cases had any visitors from outside the town for a period of two months prior to this epidemic who were ill at the time of their visit.
8. The sister of case #21 and her family (consisting of herself, her husband, and four children) had visited the home of case #21 on February 5 and 6. This visiting family had come from a neighboring state. At the time that case #21 became ill she learned that her sister and two of her children had become ill two days previously with an illness similar to hers.

SELECTED CHARACTERISTICS OF CASES IN THE MUDVILLE EPISODE

<u>NO.</u>	<u>CASE</u>	<u>AGE</u>	<u>SEX</u>	<u>ONSET</u>	<u>ADDRESS</u>	<u>PLACE EMPLOYED/OCCUPATION</u>
1.	R.D.	22	M	2/21/75	220 Main	Service Station #1
2.	J.S.	5	F	2/22/75	318 Court	Mudville Ele. School (K)
3.	R.B.	30	F	2/22/75	316 Main	Housewife
4.	S.S.	15	M	2/22/75	330 Court	Mudville High School
5.	R.J.	18	M	2/23/75	402 Oxford	Service Station #2
6.	M.M.	33	F	2/23/75	315 Oxford	Teacher, Mudville Ele. Sch. (Grade 7)
7.	T.R.	8	F	2/24/75	230 Oxford	Mudville Ele. Sch. (Gr. 3)
8.	J.R.	6	M	2/25/75	230 Oxford	Mudville Ele. Sch. (Gr. 1)
9.	A.S.	27	F	2/26/75	230 Main	Bank
10.	H.A.	35	M	2/26/75	330 Main	Farm in country
11.	I.M.	34	F	2/27/75	422 Main	Housewife
12.	G.S.	9	F	2/27/75	318 Main	Parochial School
13.	C.M.	11	M	2/28/75	402 Court	Mudville Ele. Sch. (Gr. 6)
14.	K.C.	25	F	2/28/75	229 Court	Memorial Hosp. (nurse's aide)
15.	J.E.	7	M	2/28/75	220 - 3rd E.	Parochial School
16.	D.F.	14	F	3/2/75	230 - 4th E.	Mudville Jr. High Sch.
17.	D.P.	12	M	3/2/75	401 Oxford	Mudville Ele. Sch. (Gr. 6)
18.	J.A.	10	F	3/3/75	115 - 4th E.	Mudville Ele. Sch. (Gr. 5)
19.	D.H.	14	M	3/3/75	115 - 4th E.	Mudville Jr. High Sch.
20.	J.V.	22	M	3/4/75	220 - 4th E.	Unemployed
21.	D.T.	43	F	3/5/75	308 Oxford	Housewife
22.	V.K.	8	F	3/5/75	216 Court	Parochial School
23.	J.C.	11	M	3/5/75	116 - 3rd E.	Mudville Jr. High Sch.
24.	G.A.	30	M	3/5/75	320 - 4th E.	Hardware Store
25.	L.C.	14	F	3/7/75	128 - 3rd E.	Mudville Jr. High Sch.
26.	M.E.	10	F	3/7/75	210 - 4th E.	Mudville Jr. High Sch.
27.	G.W.	11	M	3/9/75	230 - 3rd E.	Mudville Jr. High Sch.
28.	B.R.	13	F	3/11/75	318 Main	Mudville High School
29.	C.H.	15	M	3/12/75	230 Court	Mudville High School
30.	B.E.	8	M	3/15/75	222 - 3rd E.	Mudville Ele. Sch. (Gr. 3)

Population of Mudville, by Age-Group

Age Group	Number in Each Group
0 - 4	1,000
5 - 9	2,000
10 - 14	2,500
15 - 19	1,500
20+	7,000
Total	14,000

**INCUBATION PERIODS OF SELECTED DISEASES**

Disease/ Etiologic Agent	Incubation Period		Maximum expected duration of a point-source epidemic*
	Average	Minimum/Maximum	
Amebic dysentery	14-28 days	3 days-several mos. or years	8 days+
Anthrax	2-5 days	2-7 days	6 days
Brucellosis	5-30 days	5 days - sev. mos.	17 days+
Diphtheria	2-5 days	2-5 days+	4 days+
Food poisoning: Staphylococcal	2-4 hours	1-6 hours	6 hours
<i>Clostridium</i> <i>perfringens</i>	10-12 hours	6-24 hours	19 hours
Hepatitis A	28-30 days	15-50 days	36 days
Leptospirosis	10 days	4-19 days	16 days
Measles	10 days	8-13 days	6 days
Poliomyelitis	7-14 days	3-35 days	33 days
Rabies	14-56 days	10-365 days	356 days
Rocky Mountain Spotted Fever	3-14 days	3-14 days	12 days
Salmonellosis	12-36 hours	6-72 hours	67 hours
Shigellosis	1-3 days	1-7 days	7 days
Syphilis	3 weeks	10 days - 10 weeks	61 days
Trichinosis	10-14 days	1-45 days	45 days
Typhoid Fever	14 days	7-21 days	14 days

Assuming simultaneous exposure of a large number of susceptibles and no subsequent transmission (based upon the minimum and maximum incubation periods).

ASSIGNMENT

I. DISEASE SURVEILLANCE. After reviewing the information provided on pages 1-3, what specific sources of information would be utilized in a search for additional epidemic-associated cases? List three.

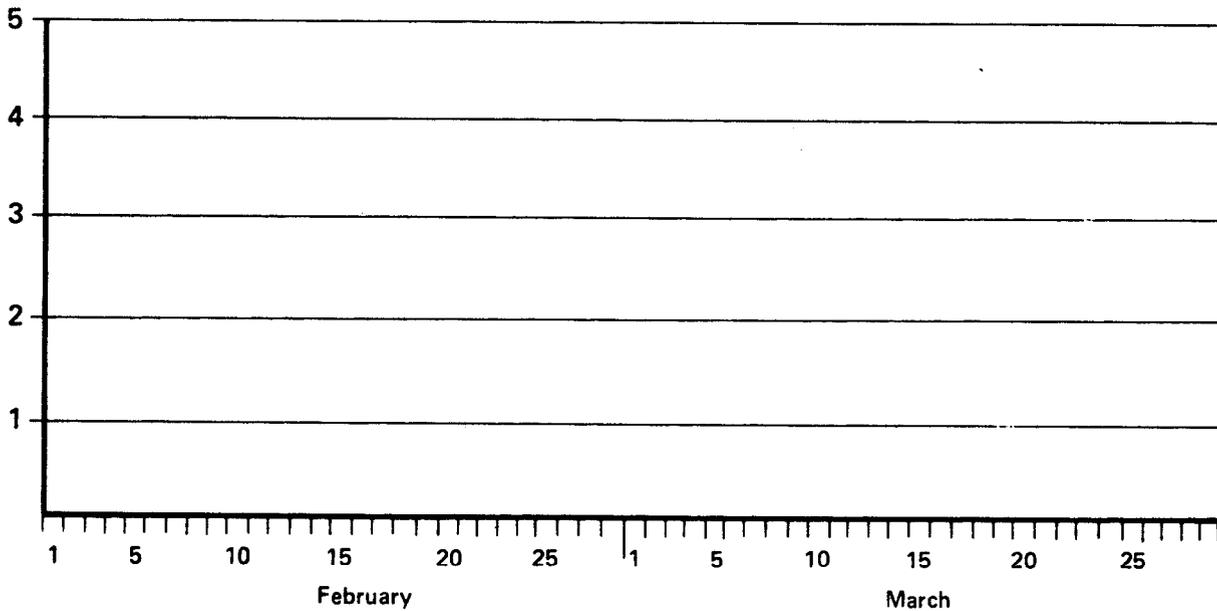
A. \_\_\_\_\_

B. \_\_\_\_\_

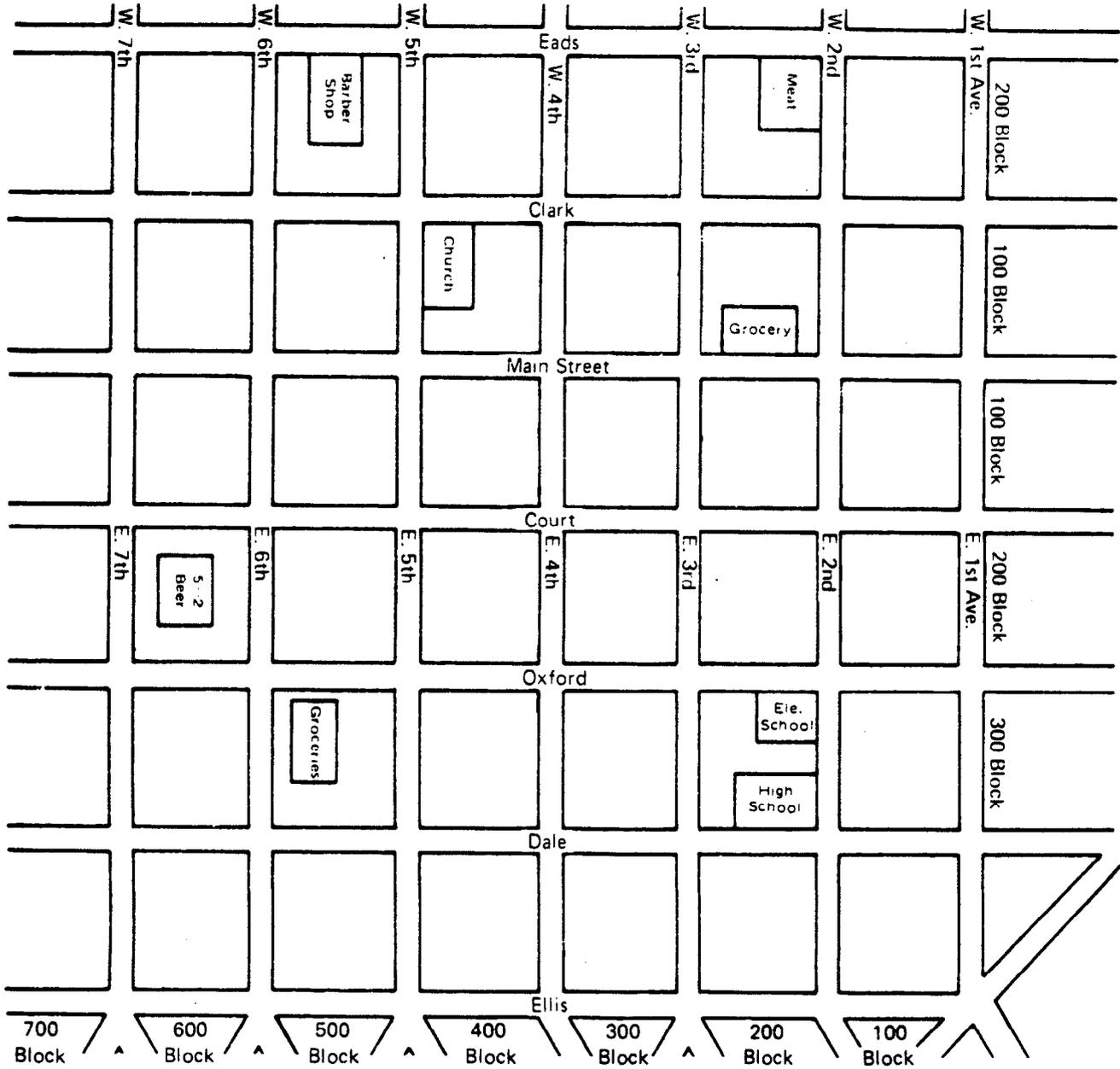
C. \_\_\_\_\_

II. CHARACTERIZATION OF THE EPIDEMIC BY TIME, PLACE, AND PERSON. Complete the following graph, spot map and tables. Provide each with an appropriate title, label, and legend. All calculations should be correctly rounded to one decimal place.

A. Construct an epidemic curve using a histogram with 1 day intervals.



B. Prepare a spot map showing the location of cases according to their block of residence.



NOTE: On East-West streets even-numbered addresses are on the north side; on the North-South streets even-numbered addresses are on the east side.



C. Complete this table showing (in descending order of frequency), the distribution of cases according to "place employed/occupation." Calculate and include in the table the percent of the total cases in each group.

PLACE EMPLOYED	NUMBER OF CASES	PERCENT

D. Complete this table by showing the number of cases by sex and age-group. Calculate and include in the table the appropriate age-group specific attack rates per 1,000 population.

AGE GROUP (YEARS)					ATTACK RATE
0 - 4					
5 - 9					
10 - 14					
15 - 19					
20+					
TOTAL					

E. Calculate the ratio of the attack rate in the age-group most affected to the attack rate in the remaining population of Mudville.

RATIO =

F. Explain the meaning of this ratio in a single sentence.

G. Calculate the mean and median ages of the cases by sex.

male mean age =

female mean age =

male median age =

female median age =

H. Using a ratio, compare the mean ages by sex.

### III. ANALYSIS AND CONCLUSIONS

Referring to the epidemic curve, spot map, and tables prepared in Part II "Characterization of the epidemic..." give a brief analysis of the occurrence and distribution of cases as reflected in each of the following:

A. Epidemic curve (temporal distribution of the cases):

1. Dates of the epidemic period: \_\_\_\_\_
2. Duration of the epidemic: \_\_\_\_\_
3. Number of cases: Mudville residents: \_\_\_\_\_; others \_\_\_\_\_; Total \_\_\_\_\_
4. Distribution of the cases during the outbreak: (complete either column "a" or "b"):

	Column "a" (Mud. res. only)	Column "b" (All cases)
-Date of the peak		
-Date of onset of illness of the median case		

5. Probable period of exposure of the cases to the source (Give three estimates, each based upon a separate method, and state the method used for each estimate).







D. Refer to the table of the cases by age group and sex.

1. Describe the distribution of the cases by age group and sex.

2. Specify three limitations to the interpretation of the data.

3. Using the mean and median ages and the ratios calculated, specify three meaningful observations of the distribution of cases.

4. State any conclusions that can be reached about this outbreak on the basis of the analysis of the data by age group and sex only.

#### IV. HYPOTHESIS FORMULATION

On the basis of the outbreak characterizations and analyses, prepare a written hypothesis in which you specify the most likely disease involved, nature of the source, mode of transmission of the agent, and the period of time during which the cases were most likely to have been exposed. For each of these elements also state the rationale supporting your conclusion. After you have done this, combine these statements into a one-sentence hypothesis.

A. Disease involved:

B. Nature of the source of the agent:

C. Mode of transmission of the agent:

D. Period of time during which the cases were most likely to have been exposed:

E. Summary hypothesis statement:

V. HYPOTHESIS TESTING

For each part of the hypothesis previously stated, specify one or more ways to test that part.

A. Disease involved:

B. Nature of the source of the agent:

C. Mode of transmission of the agent:

D. Probable period of exposure.

PRINCIPLES OF EPIDEMIOLOGY  
EPIDEMIOLOGICAL EXERCISE ANSWER KEY  
MUDVILLE, U.S.A.

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.

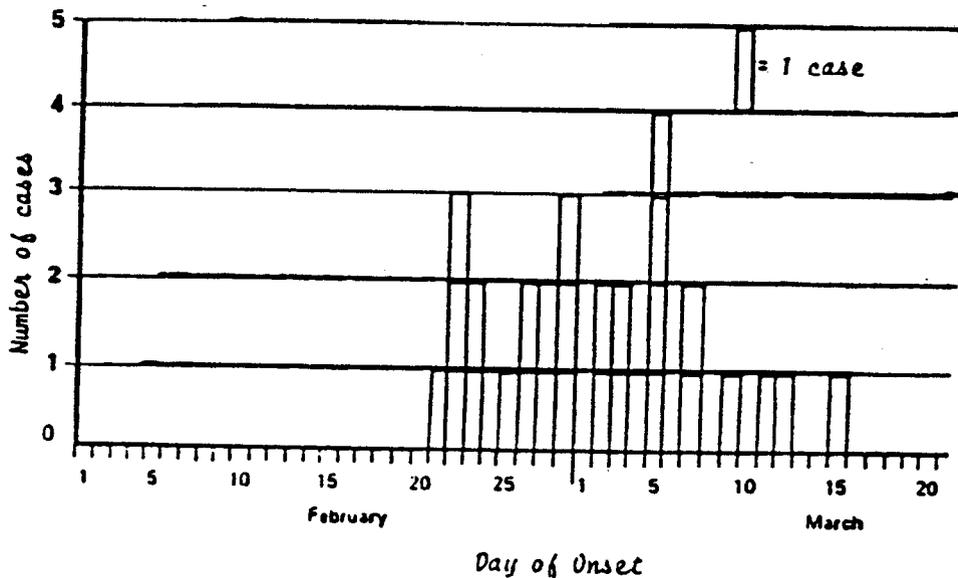
ANSWER KEY

I. DISEASE SURVEILLANCE.

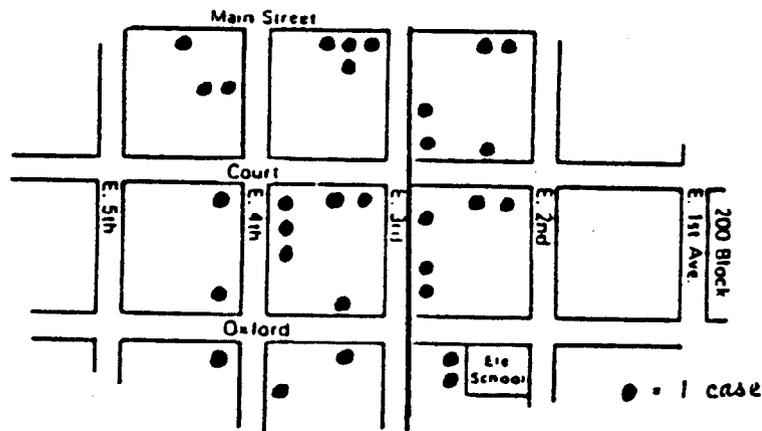
- A. Physicians
- B. Associates/contacts of cases discovered
- C. Laboratories/Hospitals/Clinics/Schools

II. CHARACTERIZATION OF THE EPIDEMIC BY TIME, PLACE, AND PERSON.

- A. (Distribution of Epidemic-Associated) Cases of an (Unknown) Disease By Day (Date) of Onset of Illness (Symptoms). Mudville (USA), February (21) - March (15), 1987.



- B. (Distribution of Epidemic-Associated) Cases of an (Unknown) Disease By Block of Residence, Mudville (USA), February (21) - March (15), 1987.



EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

C. (Distribution of Epidemic-Associated) Cases of an (Unknown) Disease and Percent of the Total (Cases) By Place Employed, Occupation, Mudville (USA), February (21) - March (15), 1987.

PLACE EMPLOYED / OCCUPATION	NUMBER OF CASES	PERCENT
Mudville Elementary School	3	26.7
Mudville Jr. High School	3	20.0
Mudville High School	3	10.0
Parochial School	3	10.0
Housewife	3	10.0
Service Station #1	1	3.3
Service Station #2	1	3.3
Bank	1	3.3
Farm	1	3.3
Hospital	1	3.3
Hardware Store	1	3.3
Unemployed	1	3.3
<b>TOTAL</b>	<b>30</b>	<b>99.3</b>

D. (Distribution of Epidemic-Associated) Cases of an (Unknown) Disease By Age Group and Sex and Attack Rates Per 1,000 Population By Age Group, Mudville (USA), February (21) - March (15), 1987.

AGE GROUP (YEARS)	Population	Number of Cases			ATTACK RATE
		Male	Female	Total	
0-4	1,000	0	0	0	0.0
5-9	2,000	3	4	7	3.5
10-14	2,500	5	5	10	4.0
15-19	1,500	3	0	3	2.0
20+	7,000	4	6	10	1.4
<b>TOTAL</b>	<b>14,000</b>	<b>15</b>	<b>15</b>	<b>30</b>	<b>2.1</b>

E. Attack rate in 10 - 14 year-olds = 4.0 cases/1,000 pop.

Attack rate in remaining pop.

$$= \frac{(30-10)}{14,000-2,500} \times 1,000 = \frac{20}{11,500} \times 1,000$$

Ratio = 4.0:1.7

= 1.7 cases/1,000 population

= 2.4:1.0

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

F. The attack rate (risk of acquiring illness) among 10-14 year-olds was 2.4 times (fold) greater than the attack rate (risk of acquiring illness) among the remaining population.

G. male median age = 14.0 years.

male mean age =  $\frac{237}{15} = 15.8$  years.

female median age = 14.0 years.

female mean age =  $\frac{283}{15} = 18.9$  years.

H. Female mean age: male mean age.  
18.9:15.8  
1.2:1.0

(The mean age of female cases was 1.2 times greater than the mean age of male cases).

III. ANALYSIS AND CONCLUSIONS.

- A. 1. : Began Feb. 21 and ended March 15, 1975  
2. : 23 day interval  
3. Mudville residents: 30; others 3; Total 33

4.

Column "a" (Mud. res. only)	Column "b" (All cases)
March 5 (4 cases).	March 3 (5 cases).
March 1.	March 2.

5. - Feb. 5 and/or 6 most likely (based on 3 non-resident cases).  
- Jan. 30 - Feb. 1 based upon the average incubation period of 28-30 days from median date of onset for 30 Mudville cases (Jan. 31-Feb. 2 if using median of March 2 with all 33 cases).  
- Jan. 24 - Feb. 6: minimum incubation period (15 days) from first case (Feb. 21) and maximum incubation period (50 days) from last case (March 15).

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

6. - The Mudville cases? 15 - 38 days
  - Case #21 27 - 28 days
  - Case #21's relatives 24 - 25 days
7. - Diagnosis of the cases lacking (etiology of the disease unknown).
  - Temporal distribution of similar cases which have occurred in earlier periods are unavailable for comparison.
8. - The temporal distribution of cases during a 23-day interval is consistent with a common source exposure during a brief period of time to hepatitis A virus. Assuming the non-resident cases were exposed to hepatitis A virus during their visit to Mudville on Feb. 5 and/or 6 and that exposure of the remaining cases occurred during this same interval, the incubation period of 15-38 days is also compatible with exposure to hepatitis A virus. Should this not be the case, exposure may have occurred any time in the interval from January 24 through February 6, 1975, and quite likely around the period January 30-February 1, 1987.
  - B. 1. - All cases resided in a square area comprising 9 blocks (9 square-block area/area 3-blocks square) bounded by Main Street, E. 2nd, Dale, and E. 5th.
    - Two-thirds (20/30 or 66.7%) of the cases occurred in a square area of 4 blocks bounded by Main Street, E. 2nd, Oxford and E. 4th.
  2. - Distribution of housing units in the affected area is unknown.
    - Populations by block of residence are not available to allow for a comparison of risk of disease among the affected blocks.
  3. Exposure resulting in acquisition of disease was apparently limited to residents of a 9 square block area and three non-resident visitors of the area. Such a distribution could be the result of a variety of circumstances:

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

- C. 1.
- Of the 30 cases, 29 were associated with 13 separate places of work or school. One case was unemployed.
  - Twenty of the cases or 66.7% were associated with 4 schools. Nineteen (63.3% of the cases) occurred in students. The other school-associated cases occurred in a 33-year old woman who was a teacher in Grade 7 of the Mudville Elementary School.
    - (a) Fourteen (46.7% of the 30 cases) occurred in the Mudville Elementary and Jr. High Schools.
    - (b) The 6 remaining school-associated cases were equally divided between the Mudville High School and the Parochial School.
- Of the remaining 10 cases (33.3%), 9 were associated with separate places of work and 1 was unemployed.
- 2.
- Lack of population (denominator) data by category of place employed/occupation, especially the schools.
  - Information concerning the total number of students attending Mudville schools who lived outside Mudville.
- 3.
- Association between schools and cases among Mudville residents.
  - Cluster of cases by place of residence regardless of place of work or school.
  - Association with schools may be indirect.
- D. 1.
- The overall attack rate for Mudville was 2.1 cases per 1,000 population.
  - The youngest case was 5 years old while the oldest was 43 years old. (The range was 38 years.)
  - Cases were distributed throughout all age groups with the exception of children under 5 years (0-4).
  - The attack rate among the affected age groupings (5-20+) was 2.3 cases per 1,000 population.

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

- The highest attack rate (4.0) occurred among the age group 10-14 with the next highest (3.5) in the age group 5-9.
  - The attack rate for the 5-14 year olds was 3.8 cases per 1,000 population.
  - The total number of cases was equally divided by sex.
- 2.
- Neither total nor age-specific attack rates by sex can be calculated due to lack of population data by both age and sex.
  - The small numerical differentials in attack rates among age groups should be subjected to statistical tests before firm conclusions can be drawn regarding true differentials in risk of disease acquisition.
  - The risk of illness among the population twenty years of age and older cannot be clearly established since all ten cases in the grouping occurred among individuals 22-43 years of age. The population 44 years of age and older was apparently not at risk of acquiring this disease.
- 3.
- The attack rate among persons 10-14 years old was 2.4 times greater than the attack rate among persons in the remaining population of Mudville.
  - The median age of both sexes was the same - 14.0 years.
  - The mean age of the female cases (18.9 years) was 1.2 times greater than the mean age of the male cases (15.8 years).
- 4.
- The disease affected persons from 5 to 43 years of age with the highest attack rate among 10-14 year olds. The attack rate among 10-14 year olds was 2.4 times greater than the attack rate among the remaining population. There was no apparent significant difference in the mean and median ages of the cases by sex.

Cases (total) were equally divided by sex although the risk of acquiring disease could not be established.

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

*The distribution of cases by age and sex and attack rates by age group are compatible with common source exposure to hepatitis A virus. Of the various potential sources, food, water and milk would seem most likely.*

IV. HYPOTHESIS FORMULATION.

A. *Hepatitis A is most likely disease involved. Based on data provided:*

- *Incubation periods are compatible given exposure on or about Feb. 5 or 6. Based on the data provided, incubation periods would range from 15 days to 38 days. Such a variation is consistent with the incubation period of 15-50 days of hepatitis A.*
- *The duration of the epidemic is compatible with brief exposure of a number of susceptibles to hepatitis A virus.*
- *The marked geographic cluster of cases by place of residence, the apparent school association probably indirectly associated with exposure, and the age and sex distribution are also compatible.*
- *The absence of cases in the 0-4 age group may reflect lack of exposure to the virus or inapparent infections which were not detected subsequent to exposure.*

B. *Common source of infection most likely*

- *The epidemic lasted 23 days which is consistent with exposure to a common source of infection over a brief period of time such as a day or two. If a large number of susceptibles were infected due to exposure to a common source over a period of one day, the resulting epidemic would be expected to last 36 days or less. The 23-day duration of this epidemic is consistent with exposure over an interval of a day or less.*
- *The information regarding relatives of case #21 (assuming the disease is the same and that exposure and resulting infection were related to their Mudville visit) would tend to indicate that exposure to the common source occurred on Feb. 5 and/or 6. As discussed above, the estimated minimum and maximum incubation periods are consistent with common source exposure.*

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

- C. - *Vehicle borne mode of transmission seems likely*
  - *Most probably infection from ingestion of contaminated food item (including milk and water) with appeal to 5-14 year-olds as well as adults available at a common gathering or point.*
  - *Food served at the schools seems unlikely since each school acquired foods from different sources and one might expect many more cases among students including non-resident students and school personnel assuming they consumed similar foods as the students.*
  
- D. *February 5th or 6th (based on information concerning relatives of Case #21).*
  - (a) *The illnesses are etiologically similar to those of the resident cases.*
  - (b) *Exposure and resulting infection occurred during their visit to Mudville.*
  
- *If the illnesses of the relatives of case #21 are unassociated, the most likely period during which exposure occurred would extend from January 24 through February 6.*
  
- E. *This epidemic of 33 cases is consistent with common source exposure to hepatitis A virus on or about February 5-6. Infection most likely resulted from ingestion of contaminated food or water.*

V. HYPOTHESIS TESTING.

- A. *Establish a diagnosis of the disease.*
  - *Acquire clinical and laboratory data for cases.*
    - (a) *Relatives of case #21*
    - (b) *Mudville residents.*
  
  - *Establish criteria to define an epidemic-associated case.*

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

B.

IF	THEN
Common gathering identified,	<ol style="list-style-type: none"><li>1. Determine persons present.</li><li>2. Search for additional cases among others present at the gathering.</li><li>3. Identify potential common sources of infection.</li><li>4. Compare exposure histories of the cases and a group of well persons to potential common sources.</li><li>5. Identify a common source of infection by showing a statistically significant difference in attack rates among those exposed and those not exposed to a potential source.</li><li>6. Search for a source of contamination and establish circumstances present to account for such contamination.</li><li>7. Ensure that the source of infection is no longer present.</li></ol>
Common gathering not associated with exposure,	<ol style="list-style-type: none"><li>1. Establish and compare exposure histories of relatives of case #21 and resident cases.</li><li>2. Perform steps 3-7 above.</li></ol>

If relatives of case #21 are considered epidemic-associated cases, focus on activities of February 5th and 6th and potential sources of infection common to cases among residents.

EPIDEMIOLOGIC EXERCISE -- MUDVILLE, U.S.A.  
(continued)

- C. - Identity of the specific vehicle involved and circumstances surrounding exposure to it would be necessary in order to determine if foodborne, milkborne, or waterborne.
- Person-to-person spread as through direct contact would depend upon excluding exposure to an identified common source and documentation of exposure to infected individuals.
- D. - Analyze exposure histories (including the period of time before and after the probable period of exposure) of cases as well as individuals selected for comparison ("controls").
- Identify cases and "controls" having only single events of exposure to the common source during this time span.
- Identify cases and "controls" having multiple events of exposure during time intervals of concern.
- Calculate attack rates for the specific intervals of concern.
- Compare attack rates between those exposed and not exposed during each interval of time.
- Identify specific times of exposure.

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7/88:4R