"Texarkana:" Epidemic Measles in a Divided City

This case study is based on a 1990 EIS Summer Preparation course (authors unknown). It was modified and adapted for use with *Epidemiology Kept Simple*, 2/e (2003, Wiley) by B. Gerstman.

Objectives

At the completion of this exercise the student should be able to:

1. Describe the epidemiologic objectives of investigating an outbreak of a vaccine-preventable disease
2. State the advantages and disadvantages of using a sensitive or specific case definition in an epidemiologic investigation
3. Calculate and interpret rates in populations, and estimate vaccine efficacy from the data
4. Discuss the advantages and disadvantages of selecting a given age for administering vaccinations.

Part I

On Tuesday, Nov. 3, 1970, the Texas State Health Department's weekly telegram to the Centers for Disease Control reported 319 cases of measles in all of the Texas-Arkansas state line. Texarkana, Texas (Bowie County), had a population of 29,393 in the 1960 census; the population has been stable during the decade. Texarkana, Arkansas (Miller County) has a population of 21,088.

Although Texarkana is divided by the state line, it is a single town economically and socially. There are many opportunities for contact among the residents on both sides of town.

Churches, physicians, offices, movie theaters, and stores draw people from both the Arkansas and Texas sides of town. People cross the state line to attend social functions such as football games and school dances. Many families have relatives who visit back and forth on both sides of town. Private nurseries and kindergartens receive children from both sides of town. The two sides of Texarkana, however, do have separate public school systems and separate public health departments.

QUESTION 1A: What are the reasons you might want to investigate this outbreak?[1]

QUESTION 1B: What would be the objectives of the initial phase of your investigation?[2]

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[1] See *Epi Kept Simple* pp. 352–353 for reasons to investigate outbreaks and the goals of outbreak investigation. Which of these apply?

[2] See *Epi Kept Simple* pp. 353–355, esp. item 1 in Table 20.1.

Part II

The Investigation

In this investigation, names of cases were obtained from health departments, from physicians, from school and nursery records, from a door-to-door survey, and by asking families of cases for name of other cases. Methods of case findings and of epidemiologic investigation were similar on both sides of town.

Clinical Picture

The illness was clinically compatible with measles. Typically, the patients had a 4- to 5-day prodrome with high fever, coryza, couch, and conjunctivitis followed by appearance of a bright maculopapular rash.[3] The temperature usually returned to normal 2 to 3 days after appearance of the rash; the rash usually persisted 5-7 days.

QUESTION 2A: How might you define a case for the purpose of this investigation?[4]

QUESTION 2B: What is the difference between a *sensitive* case definition and a *specific* case definition?[5] What are the advantages and disadvantages of each? Provide an example of a situation where each would be useful.

QUESTION 2C: In this investigation a case was defined by the investigators as "an illness which is clinically compatible with measles" [occurring in Texarkana from June 1970 to January 1971]. Would you use this as your case definition?

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[3] See a medical dictionary for definitions of terms when necessary. See the online Merck Manual or other reliable text sources for full clinical description of measles.

[4] Case definitions for outbreak investigations are based on clinical and "person, place, and time" criteria. See *Epi Kept Simple*, p. 355 and pp. 111–115.

[5] A *sensitive* case definition is one that will uncover most cases but will identify false positives. A *specific* case definition is one that will fail to find all cases but will exclude false positives. Chapter 4 discusses test sensitivity and specificity and its relation to the predictive value of a given test.

The Outbreak

Six hundred thirty-three cases of measles were reported in Texarkana from June 1970 through January 1971. Dates of onset were determined for 535 cases. An epidemic curve for the outbreak is:
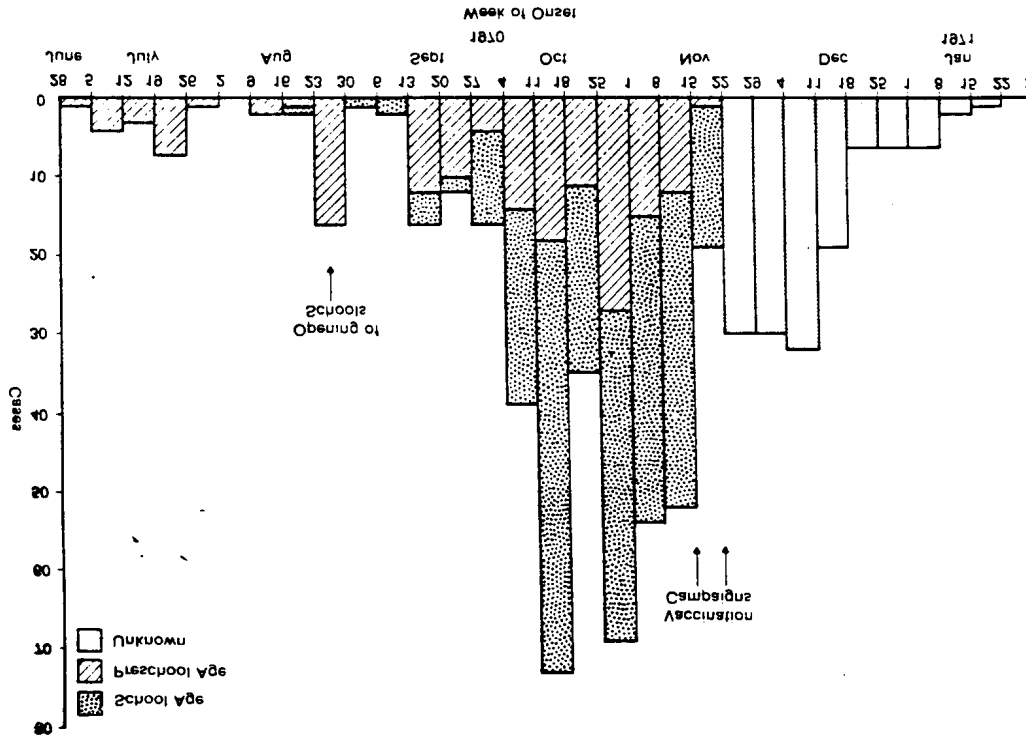
QUESTION 3: Discuss the key features of the epidemic learned from this epidemic curve.

Though infants, adolescents, and adults were involved in the epidemic, the majority of cases occurred in children 1 to 9 years of age. Measles cases were not evenly distributed in the two counties. The table below displays the number of measles cases and population size by age for Bowie County, Texas and Miller County, Arkansas.

TABLE. Measles cases and population (1960 census) by age group and county, Texarkana outbreak, 1970

Residence	Urban/rural	Age group (yrs)	Cases	Population	Rate (per 1000)
Bowie Co., TX	Rural	1–4	47	2452	_____
		5–9	178	3242	_____
		1–9	_____	_____	_____
	Urban	1–4	195	2481	_____
		5–9	73	3010	_____
		1–9	_____	_____	_____
	Total	1–4	_____	_____	_____
		5–9	_____	_____	_____
		1–9	_____	_____	_____
Miller, Co., AR	Total	1–4	19	2671	_____
		5–9	6	3345	_____
		1–9	_____	_____	_____

QUESTION 4A: Fill in the above table by calculating the rates (and summing number of cases and population sizes when necessary).

Notes:

(1) Rates are calculated as (no. of cases) ÷ (population size). To report the rate "per 1000," as requested, multiply the calculated value by 1000. Thus, the rate per 1000 = (no. of cases) ÷ (population size) × 1000.

(2) The rates calculated above are incidence rates. The population is open population and assumed to be stationary. A stationary population is one of constant size and age distribution. For details concerning rates in open populations see *Epidemiology Kept Simple* pp. 130–131.

QUESTION 4B: Compare the rates for the Texas and Arkansas counties, for the rural and urban counties, and for preschoolers and school-aged children.

Part III

Measles in Previously Vaccinated Children

Before this outbreak, the proportion of children vaccinated against measles in Miller County, Arkansas was much higher than the proportion vaccinated in Bowie County, Texas. In Texarkana, Texas there had never been a community or school vaccination campaign for measles. In contrast, Texarkana, Arkansas had mass vaccination programs for school and pre-school children in 1968 and 1969.

Based on health department and physician records, over 99% of children aged 1–9 years of age in Miller County, Arkansas had received measles vaccination prior to the outbreak. The overall vaccination level in Bowie County, Texas was approximately 57%.

During the outbreak, 27 of the measles cases in Bowie County (TX) and all 25 cases in Miller County (AR) gave a history of prior vaccination with modified live measles virus vaccine. Parental history of vaccination was corroborated for all cases using clinic and physician records. Local health officials in both counties were concerned that children who had previously received measles vaccine had become cases anyway.

QUESTION 5: Calculate the rate of measles in the vaccinate populations in both counties and comment on your findings.

Vaccine Efficacy

The ability of a vaccine to prevent disease depends on its efficacy, its proper administration, and the ability of the host to respond immunologically. The success of a vaccination campaign conducted under field conditions may be measured epidemiologically. The epidemiologic measurement of vaccine effectivness has the advantage of not requiring laboratory support and can be useful when the occurrence of disease in a population leads to doubts about vaccine effectiveness.[6]

Vaccine effectiveness is defined as the percent reduction in incidence in vaccinated people relative to unvaccinated people. The greater the reduction in illness, the greater the vaccine effectiveness. Let:

VE represent vaccine effectiveness,
R_1 represent the rate of disease in the unvaccinated population, and
R_0 represent the rate of disease in the vaccinated population.

The formula is $VE = \dfrac{R_1 - R_0}{R_1}$. Notice that the numerator of this formula is the absolute difference in the rates

in the unvaccinated and vaccinated populations. The denominator is the rate in the unvaccinated population. Thus, vaccine effectiveness is a form of the attributable fraction in the exposed (formula 8.14 on p. 167).

QUESTION 6A: Using the formula, calculate vaccine effectiveness in Bowie County (TX).

QUESTION 6B: Was the vaccine effective? Was vaccine ineffectiveness responsible the outbreak?

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[6] See *Epi Kept Simple* pp. 186–186 for a discussion of effectiveness versus efficacy. Briefly, effectiveness refers to the extent to which an intervention produces its intended results in a real-world setting. Efficacy is the extent to which the intervention produces its effect under optimal conditions.

QUESTION 7: What are possible causes of vaccine failure?
Part IV

In vaccinated children (ages 1–9 years) in Bowie County (TX), the rate of measles was 4.2 per 1000. The rate in unvaccinated children was 96.9 per 1000. Thus, the vaccine efficacy was 95.7% (see prior page). This is a minimum figure since we have assume all 27 cases were vaccinated properly and all cases in vaccinated children represent vaccine failures.

In actuality, some of the cases probably did not receive vaccine under proper conditions. Eight of the 27 vaccinated cases had been vaccinated by nurses from the Bowie County Health Unit at the nursery. The vaccine for these eight children had been carried back and forth to the nursery from the Health Unit in a cooler in a car os three separate occassions. It is possible lapses in technique allowed warming of the vaccine, which would have compromised vaccine potency.

An additional seven patients had been vaccinated when they were under 1 year of age. It has since been learned that vaccine failure rates are high when vaccination occurs in children under 1. (Vaccine failure rates of 20% may accompany vaccination at 9 months of age.)

TABLE. Rates of measles in children 1–9 by vaccination status, Bowie County (TX), June 1970–1971

	Children	Cases	Rate (per 1000)
Vaccinated	6375	27	4.2
Non-vaccinated	4810	466	96.9
Total	11,185	493	44.1

QUESTION 8: Go the WHO website and determine current recommended ages for measles vaccination in developing countries. What factors account for this recommendation?