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PLAGUE IN THE U.S.: PRESENT AND FUTURE

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ABSTRACT: An increasing trend in the frequency of human bubonic plague cases in the United States, the principal sources of human infection, and emerging control techniques are described. Development of an integrated control program involving public health education, citizen participation in plague surveillance, and insecticidal control of flea vectors in response to evidence of plague and potential human exposure substantially reduced human plague cases in a Bernalillo County, New Mexico, hyperendemic plague area. Permethrin 0.5% dust (Pyraperm 455) applied at a rate of 7 g per burrow was found to provide effective control of flea vectors for at least 6 weeks.

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INTRODUCTION

Bubonic plague (*Yersinia pestis* infection) is widespread among an array of rodent hosts and flea vectors in the western United States from the Pacific Coast eastward to about the 97th Meridian (Fig. 1). The disease also has been recorded (from animals) in Alberta (Brown 1944) and British Columbia, Canada (unpubl. data, British Columbia Ministry of Health and CDC records), and from the northern State of Coahuila, Mexico (Verela and Vasques 1954).

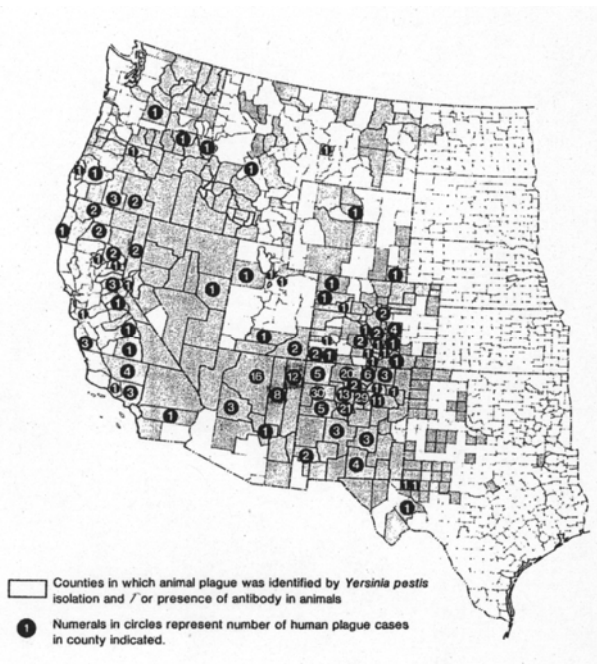


Figure 1. Geographic distribution of human and animal plague in the United States by county of origin 1970-1988.

From 1925 (following the last urban plague epidemic in the United States) until 1965, human cases—all from wild rodent sources—averaged fewer than two per year. With an outbreak of seven cases on the Navajo Reservation in northwestern New Mexico in 1965, the number of cases per year began an increase that continued into the 1980s with peaks about every 5 to 8 years, reaching highs of 40 cases in

1983 and 31 in 1984 (Fig. 2). Following the 1983-84 outbreaks in New Mexico and northern Arizona, the number of cases gradually diminished, reaching a low of four cases in 1989.

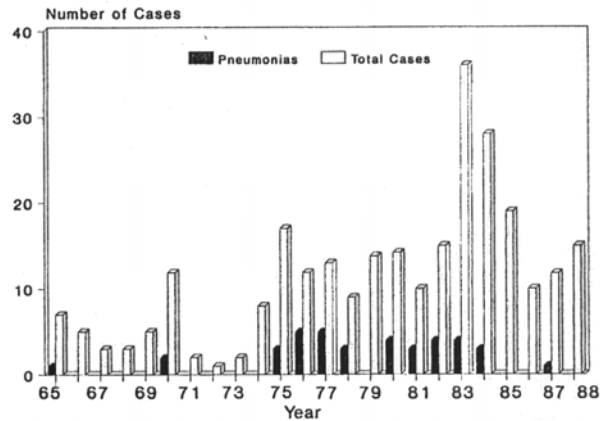


Figure 2. Human plague and plague pneumonia cases in United State 1965-1988.

DISTRIBUTION

Rodent plague has been reported frequently from much of western North America, but human cases have been concentrated in two principal regions: 1) a southwestern region, which includes New Mexico, northeastern Arizona, southern Colorado, and southernmost Utah; and 2) a Pacific Coast region, which includes California, southern Oregon, and western Nevada. Outside these regions, human cases have been scattered and few (Fig. 1). From 1965 to 1989, 57.4% of the 308 plague cases reported from the United States occurred in New Mexico, followed by Arizona (14.1%), Colorado (9.4%), and California (9.4%). Although animal plague was frequently detected in outlying states, only 9.5% of the 308 cases occurred in the eight other western states that reported cases (Fig. 3). The New Mexico cases were concentrated in two distinct regions: the northwestern part of the state, a rural, thinly populated region, which includes the Navajo Reservation; and the northcentral part of the state from Albuquerque, Bernalillo County, northward through counties along the Upper Rio Grande. The greater part of New Mexico's human population lives in the latter region. Studies and epidemiological investigations during the 1970s and 80s found that most of the cases acquired in this region

occurred in residents of rural areas, or among persons who had moved into new suburban developments where plague is enzootic or frequently epizootic (Barnes 1982, Montman et al. 1986, CDC, unpubl. records). Most of the cases were acquired from animal/flea sources in or near the patient's home environment (Montman et al. 1986).

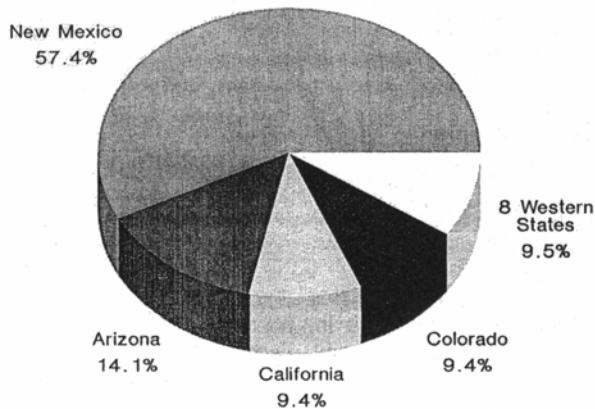


Figure 3. Percentage of human plague cases by state of occurrence 1965-1989.

SOURCES OF HUMAN INFECTION

The overwhelming majority of human cases in the two major foci have resulted from the bite(s) of infective vector fleas and have been associated epidemiologically with ongoing plague epizootics among *Spermophilus variegatus* (southwest focus) or *S. beecheyi* (Pacific focus) and their shared flea species, *Oropsylla (Diamanus) montana*. These two host/flea complexes were shown to be involved with approximately 50% of all human cases in the United States from 1974 to 1986 (Montman et al. 1986) and more recent Centers for Disease Control data (Figure 4) indicate that this continues to be the case.

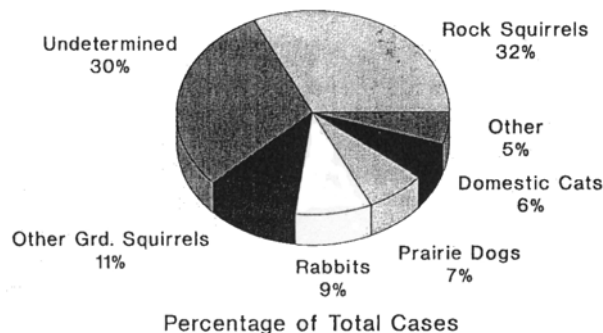


Figure 4. Animal sources of human plague infection United States 1981-1988 based on 157 cases.

Many other rodent species are subject to plague infection and epizootics, and many of their flea species are good rodent-to-rodent vectors, but relatively few human cases result from such sources. When cases are acquired from them, they most often occur as a result of direct contact with infective tissues of a sick or dead animal rather than flea bite, the usual means of transmission. In the southwestern focus, at least two cases have been attributed to antelope ground

squirrels, (*Ammospermophilus leucurus*) and their fleas, *Oropsylla (Thrassis) bacchi*. Relatively few cases have been attributed to prairie dogs and their fleas, despite the fact that prairie dogs are abundant in the southwest focus, are highly susceptible to plague, and are subject to sweeping epizootics. Cases acquired in areas peripheral to the two major foci are invariably the result of direct contact with infective animal tissues rather than flea bite. Such cases may be acquired from a variety of nonrodent and therefore nontypical sources.

SURVEILLANCE AND CONTROL PROGRAM

One of the focal areas for the increase of human plague cases which began in the 1970s is the Sandia Mountains area of Bernalillo County, New Mexico, immediately north and east of the City of Albuquerque, where rapid development of subdivisions took place in the 1970s and continued into the 1980s. From 1970 to 1978, 13 human cases were identified in the relatively small area.

In 1979, a long-term comprehensive surveillance and control program was initiated in the Sandia Mountains area by the City of Albuquerque Department of Health, Energy, and Environment, the New Mexico Health and Environment Department, and the Centers for Disease Control, with the objective of developing a model integrated plague surveillance and control program to reduce or eliminate human cases in hyperendemic plague areas. A description of the program and results through 1985 were presented by Montman et al. (1986). In brief, animal and flea populations were surveyed for evidence of plague activity each year before the usual onset of epizootic plague activity. An informal plague surveillance network with strong citizen participation was developed, using the press, TV, and radio news media. Citizens were asked to report unusual numbers of animals, sudden disappearances, and sick or dead animals. Citizen reports were screened and credible situations investigated immediately. Animals found sick or dead and fleas from rodent burrows were collected and tested for plague. Surveys were extended to whole neighborhoods until the scope of the hazard to people was identified and the need for control was determined.

CONTROL MEASURES

In response to positive evidence of plague in animals and fleas, rock squirrel burrows were identified and treated with 5% carbaryl dust. Where burrows could not be found readily because of the habitat or terrain, bait stations with the same insecticide were used. People were encouraged to manage the environment to eliminate rock squirrel harborage as described in detail by Montman et al. (1986). Plague-positive areas were posted and surveillance notices published in newspapers and announced on radio and TV.

Although the program as reported above was successful in reducing human cases in the Sandia Mountains study area, it was extremely labor intensive and therefore expensive. Carbaryl dust (5%) was used for wild rodent flea control through 1987. Applied as described, it quickly and effectively reduced the vector flea population; however, its effects were short-lived. Successful treatment early in the season often had to be repeated as the insecticide lost its effectiveness and the treated area was reinvaded by plague from untreated areas. The Environmental Protection Agency registration label for carbaryl dust for control of fleas on wild rodents was not renewed in 1985.

Following laboratory and field trials conducted during 1986-1987 (Maupin et al. in prep.), carbaryl dust was replaced by 0.5% permethrin dust (Pyraperm 455), now labeled under special local needs permits in several states. Pyraperm 455 dust applied to burrows at a rate of 7 g per burrow achieved the same quick knockdown of vector fleas as carbaryl and maintained control for at least 6 weeks (Fig. 5). In recent operational treatments in Colorado (CDC, unpubl. data), dusting of prairie dog burrows with Pyraperm 455 appears to have reduced flea populations for at least 3 months.

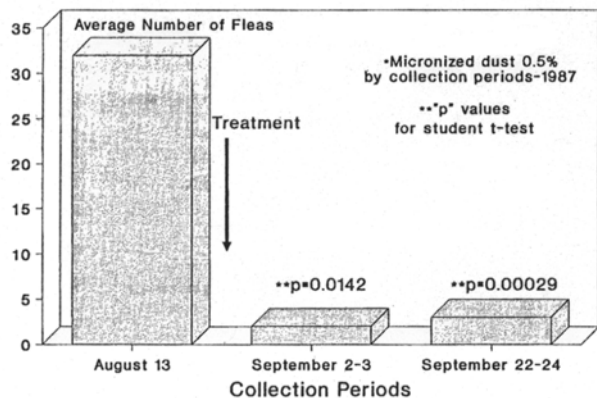


Figure 5. Average flea load of *S. variegatus* pre and post burrow dusting with Permethrin*.

RESULTS AND DISCUSSION

Plague was isolated from animals and fleas in the study area in every year during the period 1979 to 1989 (Table 1), reaffirming the Sandia Mountains as a hyperendemic area. Surveillance activities during the study period produced 180 plague isolates from animal carcasses and flea pools. Most of the 180 positives were collected as a result of citizens reports. Twenty-one of the isolates were from domestic cats and were reported by cooperating veterinarians.

Table 1. Human plague cases and case rates in suburban and rural areas of two New Mexico counties in the 1970s and 1980s.

County	1970s	1980s
<u>Number of Cases</u>		
Bernalillo	13 cases	4 cases ^a (control area)
Santa Fe	7 cases	23 cases ^b (non control areas)
<u>Case Rates</u>		
Bernalillo	3.75 cs/100,000/yr	0.8 cs/100,000/yr ^c
Santa Fe	1.84 cs/100,000/yr	4.58 cs/100,000/yr

^a(99% Poisson CI = 5.58 - 25.50)

^b(99% Poisson CI = 2.04 - 17.13)

^cPopulation at risk in control areas

Ultimately, the success of a plague control program can be measured only in terms of reduction of human cases. In this study, the success of control versus no control was measured by comparing the number of human cases in the study area before the onset of the program in 1979 to the number of cases that occurred after 1979, and by comparing the number of cases from Bernalillo County (study area) with the number of cases among populations at risk in adjacent Santa Fe County where no comparable surveillance and control programs existed. Populations at risk were defined as those populations living in rural and suburban census tracts of each county each year as compiled by the Bureau of the Census, Washington, D.C., and reestimated annually through the 1980s by the Bureau of Business and Economic Research, University of New Mexico.

Table 1 shows the number of cases and case rates per 100,000 per year in human populations at risk in Bernalillo and Santa Fe counties for the 1970s (before the program) and the 1980s. During the 1970s there were 13 cases among populations at risk in Bernalillo County (3.75 cases per 100,000 persons per year) as compared to 7 cases in Santa Fe County (1.84 cases per year per 100,000). Following the implementation of the program from 1979 through 1989, 4 cases (0.8 per 100,000 per year) occurred in Bernalillo County as compared to 23 cases (4.58 cases per 100,000) in Santa Fe County.

The program appears to have had obvious success in reducing human plague cases in the Sandia Mountains hyperendemic area and the approaches and materials used might also be adapted to other foci. The methods used to date remain labor-intensive and repetitive, although the use of Pyraperm 455 is expected to reduce the number of treatments necessary to maintain vector flea control.

In recent field trials (Beard et al. 1988), cholecalciferol (Vitamin D₃) (Quintox[®]) 0.075% grain bait was found to be highly effective (>95%) against rock squirrels (*S. variegatus*) when applied in bait stations in a suburban residential setting. A special local needs exemption (24c) has been issued for its use in New Mexico by licensed pest control operators and public health personnel. We plan field trials in 1990 that will test the effectiveness of cholecalciferol in combination with flea vector control and the other elements of an integrated program, including surveillance, public education and citizen involvement, and environmental management. With the tools and strategies available, we expect to be able to increase the cost-effectiveness of the program and maintain its success in reducing human cases.

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