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ABSTRACT: Plague is widespread among rodents and their fleas in the western United States, but most human cases occur in several definable, ecologically unique, and geographically limited high risk areas in the Southwest and Pacific Coast states. Control strategies to prevent human cases in high risk areas must vary from one epizootic focus to another, depending on such basic ecological factors as rodent/flea species involved; their distribution, abundance, seasonality, and relationship with the plague organism; climatic factors that affect transmission; the lifestyles of human residents; and others. This paper briefly summarizes preliminary results of a long-term program to define human risk and develop effective surveillance and control measures against plague in a north-central New Mexico plague focus.

INTRODUCTION

Plague (Yersinia pestis infection) is known to be widespread among wild rodent populations in 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 located in California, Oregon, and western Nevada (Barnes 1982). Outside these regions, animal plague activity has been detected frequently from the Pacific Coast to about the 97th meridian and from Mexico north to Canada, but human cases have been scattered and few (Figure 1).

The overwhelming majority of human cases in the two high-risk regions have originated from the bite(s) of infective vector fleas and have involved only a few host-flea associations or complexes. Of these, Spermophilus variegatus (in the southwest) and S. beecheyi (in the Pacific region), along with their shared flea species, Diamanus montanus, have been shown to be involved with over 50% of the human cases in the United States from 1974 to 1980 (Barnes 1982). More recent Centers for Disease Control (CDC) data indicate that this continues to be the case (Barnes and Poland 1983, 1984; and Barnes et al. 1985). Chipmunks (Eutamias spp.) and their fleas (Monopsyllus eumolpi) also have been implicated in transmission to humans (Nelson 1980) as have antelope ground squirrels and their fleas, Thrassis bacchi (Barnes et al. 1985), and various other sciurid species.

Areas of high risk to humans might be defined as places or foci where plague, people, and abundant populations of reservoir animals and vector fleas come together under conditions suitable for transmission. Since such foci vary substantially, it follows that strategies for preventive control of human plague should begin with the identification and characterization of high-risk areas, followed by the design and implementation of control measures designed to suit the landscape, animal populations, human lifestyles, seasonal aspect of the disease, and the host-flea complexes involved. The following represents a preliminary report on results of a longitudinal and continuing program designed to characterize a north-central New Mexico plague focus and develop effective surveillance and control strategies to prevent human cases.

BACKGROUND

Since 1965, more human plague cases have occurred in New Mexico than the total in the remaining western states (Figure 1). The New Mexico cases have been concentrated in two distinct regions: the northwestern part of the state, a rural, thinly populated region which includes the Navajo Reservation and is devoted primarily to grazing livestock and extractive industries, and the north-central part of the state from Albuquerque, Bernalillo County, northward through counties flanking the Upper Rio Grande. The greater part of New Mexico's human population live in the latter area which includes Albuquerque, the largest city, and Santa Fe, the state capitol.

Epidemiological investigations, surveillance, and field studies during the 1960s and 1970s (Barnes 1982) proved that most of the human cases emanating from the region occurred in people living in rural areas or among persons who moved into new areas where plague was endemic. A substantial majority of cases were acquired at or near the patient's home environments. The majority of cases investigated were associated epidemiologically with ongoing epizootic plague among the rock squirrel (S. variegatus) and its flea, D. montanus, though in some cases infective fleas appeared to have been brought home by pet dogs or cats (Weber 1977), or the direct source of infection proved to be an intermediate species such as wild rabbits (Von Reyn et al. 1976) or domestic cats (Kaufmann et al. 1981).

One of the focal areas for the increase in plague and plague cases which began in 1974 (Von Reyn et al. 1977) was the Sandia Mountain area of Bernalillo County, immediately north and east of the City

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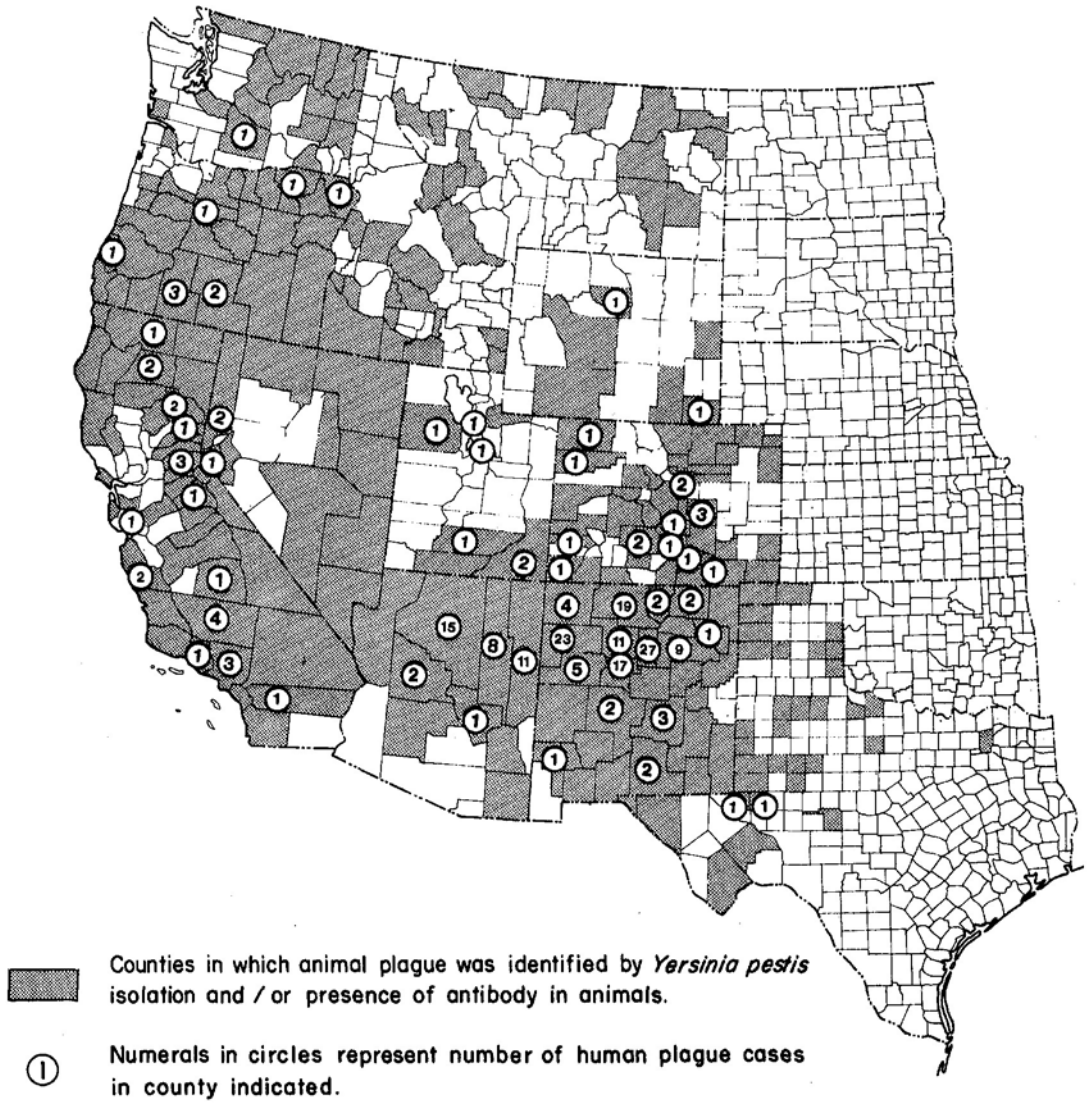

Figure 1. Geographic distribution of human and animal plague in the United States by county of origin, 1970-1984.

of Albuquerque, where rapid development of new subdivisions took place during the 1970s and into the 1980s. From 1970 through 1978, 13 cases were identified in the area.

Sandia Mountain rises sharply to over 3300 m immediately northeast of Albuquerque and is separated from the Manzanito Mountains to the south by Tijeras Canyon and Interstate 40. A foothill area extends to the east with sharply cut canyons and slopes. Habitat in the area ranges from desert scrub at the base of the mountain to pinon-juniper woodland on intermediate slopes and foothills, through a ponderosa pine belt, mixed coniferous forest, and eventually to alpine at the crest. During the past 15 years, Albuquerque has expanded to the western base of Sandia Mountain, and substantial population growth has occurred in Tijeras Canyon and the eastern foothills, particularly in areas served by NM Highway 14. Much of the growth has been on larger lots or tracts where people have attempted to retain "natural" habitat rather than traditional landscaping. As pointed out by Barnes (1982), such growth actually enhances rock squirrel habitat and increases the risk of plague for residents.

In 1979, a comprehensive surveillance and control program was initiated in the Sandia Mountain area by the City of Albuquerque Department of Health, Energy, and Environment, the New Mexico Health and Environmental Department, and the Centers for Disease Control, with the objective of testing approaches to plague surveillance and control and to reduce or eliminate human cases.

MATERIALS AND METHODS

Surveillance

Description of study area. The study area consisted of the eastern third of Bernalillo County and included that portion of the City of Albuquerque which had been built along the western base of the Sandia and Manzanito Mountains, the east slope of the Sandia Mountains, Tijeras Canyon, and the residential and recreational areas 14 miles south along NM 14 in the Manzanito Mountains. The extreme southeast corner of Bernalillo County was not included in the study area because of its low human population density and the wish of most residents for virtually total privacy.

Surveys were conducted in the study area during April each spring to assess rodent and vector populations. Visual observations were an important part of the surveillance program. Rodents and fleas were collected in suspect areas and tested for plague. During the first years of the program, the submission and testing of dog sera for plague antibodies was an important aspect but, as the dynamics of the focus became better known, dog serologies proved to be less valuable than rodent/vector surveys and were discontinued.

An informal surveillance network involving other public agencies and, most importantly, private citizens was developed. The press, TV, and radio news media cooperated by carrying news of plague-positive areas and by encouraging the cooperation of citizens. Flyers were developed, informing citizens on how to report abundant rodent populations, sudden disappearance of rodents, and animals found dead. Citizen groups were reached through schools, homeowner associations, water-well associations, and developers. Handouts were distributed through fire and ranger stations, the Welcome Wagon Organization, stores, veterinary clinics and, in areas deemed to be at immediate risk, door-to-door by volunteers and health agency personnel.

Citizen reports were screened, and credible situations were investigated immediately. The premises of the reporting party and neighboring areas were examined for evidence of rodents or recent rodent disappearance. Animals found sick or dead were collected as were fleas from rodent burrows, all to be tested for the presence of *Y. pestis* or its F1 antigen. When present, rock squirrels and other rodents were trapped, bled for serologic studies, and their fleas removed for *Y. pestis* isolation attempts. Tissues from trapped animals were not examined unless the animal became ill or died in the live-traps used. These surveys extended to whole neighborhoods until the scope of the hazard to people was identified and the need for control determined.

Control

In response to positive evidence of plague in animals and/or fleas, rock squirrel burrows were identified and treated with 5% carbaryl dust at a rate of 1 to 2 ounces per burrow. Where burrows were not readily found because of the habitat or terrain, bait stations with 5% carbaryl dust were used. Where animal populations had disappeared and burrows still had fleas, all identifiable burrows were treated. Plague-positive areas were posted and, in some cases, recreation areas were closed. Notices of plague-positive areas were published in newspapers and announced on radio and TV.

People were encouraged to clean up trash, dilapidated buildings, rock piles, and other situations that encourage the presence of rock squirrels. The lining of ditch banks and arroyos with concrete rip-rap on city property was discontinued and approval required prior to lining of ditch banks on private property. The practice of using large rocks as road-fill and landscaping material was eliminated or discouraged. Recently, agreement was reached with developers of new subdivisions to eliminate large rocks from new road cuts, clean up brush piles, prevent trash and masonry dumping, and to write and enforce covenants to limit rock landscaping, provide for proper storage and disposal of trash and garbage, and to store livestock feed in rodent-proof containers.

The success of control versus no control was measured by comparing the number of human cases from the study area prior to 1979 versus the number from the study area after 1979, and by comparing the number of cases from the study area to cases in populations at risk in other Upper Rio Grande counties and other parts of Bernalillo County, where no comparable surveillance and control programs existed.

RESULTS AND DISCUSSION

During the 7-year period from 1979 to 1985, plague in animals and fleas in the general study area continued at a rate at least equal to that of previous years (Table 1). Surveillance activities produced 88 plague isolations from flea pools and 44 positive animal carcasses. Of the 132 positives, 79 (60%) came from the yards of residents; 88 of the 132 (67%) were found as a direct result of citizens' reports.

Table 2 shows the number of human cases in each year versus the yearly estimated population at risk in Bernalillo County and each of four adjacent counties having closely similar plague histories. From 1970 to 1978, Bernalillo County led all other New Mexico counties in human cases. From 1979 to 1983, no human cases occurred in the Bernalillo County study area, while cases continued to occur and actually increased in the other Upper Rio Grande counties. Single cases occurred in the study area in each of 1984 and 1985, while in the same years, 11 and 8 cases, respectively, occurred in the four neighboring counties observed. It must be noted that in 1983 one human case occurred in the southeast corner of Bernalillo County not included in the study area, and in 1984 two more cases were acquired in the same location.

Table 1. Recognized human and animal plague before and after implementation of a comprehensive surveillance and control program in a Bernalillo County, New Mexico, study area.

Years	No. of human cases	No. of animals found pos.	No. of flea pools pos.
1970	3	2	0[1]
1971-72	0	0	0
1974	1	0	0[1]
1975	2	1	0[1]
1976	3	8	21[1]
1977	0	0	0
1978	4	2	3[1]
TOTAL	13	13	24
1979[2]	0	0	0
1980	0	9	24[1]
1981	0	2	24[1]
1982	0	5	4[1]
1983	0	2	0
1984	1[3]	16	21[1]
1985	1[3]	20	18[1]
TOTAL	2	54	81

[1]Epizootic years.

[2]Year program began.

[3]The 1984 and 1985 cases each occurred in a person naive to the problem of plague in New Mexico--one a visitor to a mountain recreation area, the other a new arrival.

Even though the program appears to have had obvious success, it is lacking in several respects. The methods used are labor-intensive and repetitive, and plague remains a continuing problem. Efforts to encourage people to clean up the environment to reduce rodent harborage have not been totally successful, although the inclusion of harborage-reducing measures in planning of new developments is promising.

No program currently exists to reduce rodent populations in anticipation of plague problems, an approach very likely to be successful now that populations at risk have been identified. The current program in Los Angeles County (Madon et al. 1986) is an example in hand. In the New Mexico focus, where plague is more widespread than in the Los Angeles area, rodent control might better be conducted by property owners than by public program. We currently are working on cholecalciferol (vitamin D,) as a candidate rodenticide that could possibly be licensed for sale to the public and used effectively in plague areas. Laboratory trials against rock squirrels and several other rodent species have been encouraging, and field trials are planned in New Mexico during 1986. With the tools and methods available plus an effective rodenticide, we hope to be able to reduce the number of human plague cases in the region.

Table 2. Populations at risk[1] and number of human plague cases acquired in five northern New Mexico counties, 1970-1983.

	Bernalillo		Santa Fe		Sandoval		San Miguel		Rio Arriba	
Year	Cases	Pop. at risk	Cases	Pop. at risk	Cases	Pop. at risk	Cases	Pop. at risk	Cases	Pop. at risk
1970	3	23,881	1	29,680	1	17,492	0	21,951	2	25,170
1971	0	26,269	0	31,543	0	19,223	0	22,031	0	25,581
1972	0	28,657	0	33,406	0	20,954	0	22,111	0	25,992
1973	0	31,045	0	35,269	0	22,685	0	22,191	0	26,403
1974	1	33,433	2	37,132	0	24,416	0	22,271	1	26,814
1975	2	35,821	2	38,995	2	26,147	2	22,351	3	27,225
1976	3	38,209	0	40,858	1	27,878	1	22,431	3	27,636
1977	0	40,597	1	42,721	0	29,609	0	22,511	2	28,049
1978	4	42,985	0	44,584	0	31,340	0	22,591	0	28,458
1979[2]	0	45,373	1	46,447	0	33,071	1	22,671	0	28,869
1980[2]	0	47,761	6	48,306	1	34,799	1	22,751	2	29,282
1981[2]	0	50,149	0	50,173	4	36,533	0	22,831	0	29,691
1982[2]	0	52,537	2	52,036	1	38,264	0	22,911	1	30,102
1983[2]	0[3]	54,925	7	53,899	0	39,995	2	22,991	2	30,513
TOTAL	13		22		10		7		16	

[1]Populations at risk estimated as the number of people residing in proven endemic areas of each county calculated from 1970 and 1980 census bureau figures.

[2]In 1979, Bernalillo County and City of Albuquerque Environmental Health Department initiated a comprehensive plague surveillance and control program which has been in operation each year through 1983.

[3]In 1984, one human plague case was acquired by a resident in the extreme southeast corner of Bernalillo County. This portion of the county was not included in the study area.

LITERATURE CITED

BARNES, A. M. 1982. Surveillance and control of bubonic plague in the United States. Symp. Zool. Soc. London 50:237-270.

BARNES, A. M., and J. D. POLAND. 1983. Plague in the United States, 1982. CDC Surveillance Summaries 32(3):19-24.

BARNES, A. M., and J. D. POLAND. 1984. Plague in the United States, 1983. CDC Surveillance Summaries 33(1SS):15-21.

BARNES, A. M., T. J. QUAN, and J. D. POLAND. 1985. Plague in the United States, 1984. CDC Surveillance Summaries 34(2SS):9-14.

KAUFMANN, A. F., J. M. MANN, T. M. GARDINER, F. HEATON, J. D. POLAND, A. M. BARNES, and G. O. MAUPIN. 1981. Public health implications of plague in domestic cats. J.A.V.M.A. 179(9):875-878.

MADON, M., B. C. NELSON, and A. TILZER. 1986. The complexities at the interface amongst domestic/wild rodents, fleas, pets, and man in urban plague ecology in Los Angeles County, California. Proc. Vertebrate Pest Conf. Univ. of California, Davis. (In press).

VON REYN, C. F., A. M. BARNES, N. S. WEBER, and U. G. HODGIN. 1976. Bubonic plague from exposure to a rabbit: A documented case in the United States. Am. J. Epidemiol. 104:81-87.

VON REYN, C. F., N. WEBER, B. TEMPEST, A. BARNES, J. POLAND, J. BOYCE, and V. ZALMA. 1977. Epidemiologic and clinical features of an outbreak of bubonic plague in New Mexico. J. Infect. Dis. 136(4):489-494.

WEBER, N. S. 1977. Plague in New Mexico. (A special publication of the New Mexico Environmental Improvement Agency).