

# HUMAN PLAGUE OUTBREAK IN TWO VILLAGES, YUNNAN PROVINCE, CHINA, 2005

JX Yin<sup>1,2</sup>, XQ Dong<sup>1</sup>, Y Liang<sup>1</sup>, P Wang<sup>1</sup>, P Siriarayaporn<sup>2</sup> and L Thaikruea<sup>3</sup>

<sup>1</sup>Yunnan Institute of Endemic Disease Control and Prevention, Yunnan Province, PR China;

<sup>2</sup>International Field Epidemiology Training Program, Ministry of Public Health, Thailand;

<sup>3</sup>Department of Community Medicine, Faculty of Medicine, Chiang Mai University, Thailand

**Abstract.** Plague is still a serious public health problem in Asia. On July 5, 2005, a suspected outbreak of human plague in two Chinese villages was reported to Yunnan Institute of Endemic Disease Control and Prevention (YIEDC). Active case finding, laboratory investigation, environmental inspection, and control measures were conducted by provincial and local health authorities. A suspected case was an individual who resided in one of the two villages and developed fever and painful swollen lymph nodes in the groin, axilla, and neck between June 26 and July 11, 2005. Confirmation was by indirect hemagglutination test (IHA) for plague F1 antibody. A confirmed animal plague case was an animal that tested positive for one of the following tests: IHA, reverse indirect hemagglutination, or bacterial culture. There were three confirmed and one suspected case of human plague. Of nine retrieved rats, three were confirmed cases. Most surveyed houses had poor sanitation, and there was a history of dead rats observed in the villages. After control measures were implemented, the rat density and flea index decreased to acceptable levels and no new cases occurred. The cause of this outbreak was likely due to rat die off in the villages, such that rat flea populations migrated to humans under environmentally favorable conditions. The outbreak was controlled after implementing environmental and educational control measures.

## INTRODUCTION

Plague is an infectious disease of animals and humans caused by the bacterium *Yersinia pestis* (*Y. pestis*). It has been one of the most feared diseases in history, and the third pandemic can be regarded as still ongoing since *Y. pestis* sporadically re-emerges from its reservoir of wild rodents (Thullier *et al*, 2003). Pneumonic plague epidemics in China early in the 20th century killed tens of thousands of persons (Wu *et al*, 1936). Although plague

patients are rare compared with other communicable diseases, there are still a few patients annually in China (Zhang and Yu, 2005).

Plague has historically been an important public health problem in Yunnan Province, China. For 30 years, from 1955 through 1985, no cases were reported in the province. However, from 1986 to 2003, there were 503 cases reported in Yunnan Province, accounting for approximately 50% of all reported cases in China during this period. Although there were no human cases reported in 2004, plague continued to be found in animals every year from 2000 to 2005 (Ma, 2005).

On July 5, 2005, a suspected outbreak of human bubonic plague in two villages was reported to Yunnan Institute of Endemic Disease Control and Prevention (YIEDC). YIEDC conducted an epidemiologic investigation to

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Correspondence: Yin Jiaxiang, Yunnan Institute of Endemic Disease Control and Prevention (YIEDC), 33 Wenhua Road, Dali City, Yunnan Province, 671000, PR China.

Tel: 86-872-2125196; Fax: 86-872-2196165 or 2125437

E-mail: chinayjx@gmail.com; chinayjx@hotmail.com

determine the cause of the outbreak, to assist local public health authorities in controlling the plague epidemic, and to evaluate the control measures implemented by local public health authorities.

## MATERIALS AND METHODS

### Setting

The investigation was conducted in County M, which is located in the southeastern plains of the province. The county is rural, predominantly agricultural, and has a predominantly (57%) ethnic minority population. The total estimated population in 2004 was 320,000 (Administrative Services Center of Mengzhi County, 2006). The two villages from which cases had been reported had populations of 1,284 and 1,700. The region in which the villages are located is served by a regional hospital and six health clinics.

### Epidemiologic and environmental investigations

A suspected outbreak-associated case of plague was defined as an individual who resided in one of the two villages and developed fever with painful swollen lymph nodes in the inguinal region, axilla, or neck between June 26 and July 11, 2005. A confirmed case was defined as an individual who met the definition of suspected plague and had a positive indirect hemagglutinin antibody (IHA) test for plague F1 antibody.

Medical records of the cases at the hospital and health clinics were reviewed. All patients with suspected plague were interviewed and had blood drawn for confirmatory testing. The family members of the index patients were interviewed regarding observed dead rats in the affected villages. Nine rats from the two villages and surrounding area were collected for plague testing. Collection sites were categorized into three groups depending on their distance from an index case (plague foci type I, II, and III). To evaluate flea and rat control, the density indices of these two groups of animals were as-

essed on the nights of July 6 and 23, 2005, indicating the pre- and post- control status. Rat captures were done both indoors and outdoors around the houses of the three plague foci using baited cages. Dissociated fleas were captured indoors only, using adhesive flypaper. Houses selected for indoor captures were the index houses and their nearest neighbors. Each study house was evaluated with 5 cages and 10-15 pieces of flypaper around 6:00 PM and harvesting was done at 8:00 AM the next morning. For each plague focus, a total of 150 cages and 150 pieces of flypaper were used for each capture. Rat density was calculated as the number of rats captured per 100 cages and flea index as the number of fleas captured by dividing 150 flypapers (Department of Disease Control and Prevention, 2002).

### Control measures

Clinical measures included isolating patients in the hospital or in their households and treatment with parenteral penicillin and streptomycin. Environmental measures included improvement of sanitation (indoors and outdoors), trapping and baiting for rats with Diphacinone sodium salt, and flea control by application of Decamethrin K-othrin Decis Deltamethrin to possible rat habitats and to villager's homes.

### Laboratory methods

Human sera were tested by IHA for plague F1 antibody using standard methods and serial dilutions. We reported the reciprocals of the least concentrated positive dilution and considered specimens positive that were greater than 1:20 (for a single serum) or if two serum specimens (at a ten day interval) demonstrated a four-fold increase. Reverse IHA (RIHA) was used to examine rats for plague F1 antigen and considered these specimens positive if greater than 1:160. Standard bacteriological culture methods was used to isolate *Y. pestis* from rats (Department of Disease Control and Prevention, 2002). All tests

were conducted at the county's Center for Disease Control (CDC).

### RESULTS

There were 723 households with a total population of 2,984 in the two villages with suspected plague cases. The investigation team went to all 723 households to interview family members to find suspected cases. Three confirmed and one suspected case of bubonic plague were identified. Clinical manifestations and laboratory results for the four cases were shown in Table 1. The attack rates were 23.36 (3/1284x10,000) and 5.88 (1/1700x10,000) in village A and village B, respectively.

The cases occurred in two nearby villages, A and B, which are separated by a road. The three patients with confirmed infection (P1, P2, and P3) were from two households situated approximately 100 m apart in Village A. P1 and P2 were sisters living in the index household. P4, a suspected plague case, came from a nearby township, however, he had been working and sleeping in Village B. All four patients recovered within 7-15 days after treatment and no new human plague cases were reported after control measures were implemented.

Nine rats from Type I and II plague foci were collected; of these, 8 were dead. All were *Rattus norvegicus*. Plague was confirmed in three rats using RIHA, and in two of these, bacterial cultures were positive for *Y. pestis*.

Environmental inspection revealed poor sanitation around the homes with multiple food sources for rodents. Debris was abundant both indoors and outdoors. The interiors of the homes were easily accessible to rodent entry and exit, with close proximity and open access to fields. Rat density and flea index decreased after control measures were implemented (Table 2).

### DISCUSSION

In this investigation, we found three confirmed human plague cases and one suspected case in two villages in Yunnan Province. All four patients recovered after treatment and no new human plague cases were reported after control measures were implemented.

Our findings suggest that there was an animal plague outbreak in these two villages leading to a human outbreak with three laboratory-confirmed cases during July 2005. Previous studies also found this type of pattern (Li and Gao, 2002; Zhang *et al*, 2004; Li *et al*,

Table 1  
Clinical manifestations and laboratory results, human bubonic plague outbreak, Yunnan Province, China 2005.

Case	Age	Sex	Date of onset	Village of residence	Household code	Symptoms		Lab	Lymph node		
						Fever (Celsius degree)	Cough	IHA	Pain	Swelling [width x length (cm)]	Groin
P1	11	F	July 2	A	SWR	38.8	-	Positive	+	0.5x0.6	Right
P2	10	F	July 2	A	SWR	37.9	-	Positive	+	3.0x3.0	Right
P3	4	M	July 5	A	SWX	38.5	+	Positive	+	0.3x0.3, 1.0x3.0	Right and Left
P4	23	M	July 3	B	CYL	38.1	-	Negative	+	2.5x2.5	Left

Table 2

Number of rats and dissociated fleas captured from 150 cages/pieces of flypaper on the nights of July 6 and July 23, 2005 (Rat density and flea index are in brackets).

Plague foci	Indoors				Outdoors	
	No. of rats captured (Rat density) <sup>a</sup>		No. of fleas captured (Flea index) <sup>b</sup>		No. of rats captured (Rat density) <sup>a</sup>	
	Before (July 6)	After (July 23)	Before (July 6)	After (July 23)	Before (July 6)	After (July 23)
I	5 (3.3)	0 (0)	6 (0.04)	0 (0)	1 (0.7)	0 (0)
II	3 (2)	1 (0.7)	61(0.41)	0 (0)	1 (0.7)	0 (0)
III	12 (8)	2 (1.3)	9 (0.06)	0 (0)	0 (0)	2 (1.3)

<sup>a</sup>Rat density is the percentage of sentinel cages (n=150) found with rats over one night, either outdoors or indoors.

<sup>b</sup>Flea index is calculated by dividing the total number of sentinel flypaper samples (n=150) by the number found with fleas over one night in the household.

2005). The fourth suspected case, with negative IHA, might have simply had a low titer for F1 antibody. There was no history of plague (animal or human plague) previously in these villages. Poor environmental sanitation, overcrowding, and high numbers of rodents are conditions that enhance urban plague transmission (CDC, 2006). In Yunnan, May to August is the rainy season, and rapid plant growth may have contributed to propagation of rat and flea populations and thus plague transmission (Gregory *et al*, 2001; Lang, 2004; Li *et al*, 2004). This is also the planting season for farmers, and thus, they may not attend to environmental sanitation as diligently. In addition, many families have cats to control rats and guard dogs, thus increasing potential flea carriers and risk for flea bites within households. Plague is a flea-borne disease that may cause large epizootics among the rodent population ("rat fall" phenomenon), and humans living in close contact with these rodents may acquire bubonic plague following infective flea bites (Perry and Fetherson, 1997; Adler *et al*, 2001; Lang, 2004). In this outbreak, we believe the fleas moved from dead animals to seek other sources of blood, possibly from humans who were in close proximity to rat populations. Ill cats can also pose a risk of

direct transmission to humans, although there is no evidence that occurred in this outbreak.

Implementing timely control measures is crucial to preventing plague epidemics. In this outbreak, the local government, local public health department, and local hospital collaborated to effectively control a small human and animal plague outbreak. After control measures were implemented, the reduced rat density (both indoors and outdoors) and improved flea index suggested the efficacy of these measures.

There were at least three limitations in our outbreak investigation. First, other animal carriers were not sampled or tested (serology testing or bacterial cultures). Second, no other fleas were collected for testing besides those from rats, and the confirmed rat cases that we collected might not be the same rats that caused the outbreak. Third, the rat density (indoors and outdoors) and flea index at the actual time of the outbreak are not available. However, according to villagers' reports and the environmental inspection, it is likely that these were high at the time of the reported outbreak.

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