

## REVIEW

### SURAT PLAGUE OF 1994 RE-EXAMINED

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**Abstract.** A plague episode in Surat in 1994, and its spread to other cities in India, lasted only a little over 2 weeks, but it created an unprecedented panic that had global repercussions. At first, the Surat hospital doctors could not diagnose the disease, but when they did, immediate intervention, in the form of prevention and treatment (administration of antibodies) prevented the disease from spreading beyond Surat, Delhi, Calcutta, Bombay and their vicinities. Fewer than 1,200 people were diagnosed with plague. A DNA-based study in 2000 decisively concluded that the Surat episode was a plague, but the Indian isolates were genetically more heterogeneous compared to others in the world.

#### INTRODUCTION

Epidemiology traces the disease pattern in a population based on "probability of contact between an infectious agent and the susceptible host" (DeBevoise, 1995). This situation is modified over time, by place and environment. The Surat plague in 1994, occurred in this context but was influenced by other factors. The question is, how can a plague occur in a country like India at the end of the twentieth century, where the medical profession is well developed? Did spread of the plague follow established patterns: contact/expansion diffusion, relocation diffusion and hierarchic diffusion? These three paths of disease diffusion are well established in the literature (Gould, 1969; Hagerstrand, 1967; Haggett, 1972). In an age of fast transportation, such as with the developed railroad sys-

tem in India, does the diffusion pattern follow established paths? Are there any lessons to be drawn from the plague epidemic of Surat, India? These are the themes discussed in this paper.

#### WHAT HAPPENED IN SURAT?

On September 23, 1994, pneumonic plague deaths were reported in Surat (in the state of Gujarat, India). The type of plague reported was pneumonic, though there are two other types, bubonic and septicemic. The hospitals were crowded with patients. For the first few hours the disease was not diagnosed. Though newspapers chronicled 460 plague cases between September 20 and September 25 in Surat, suspected cases totaled 1,061 (Fig 1). When news of the plague became known to the public, one-fourth of Surat's population (0.7 million) fled the city. The people who fled took all types of transport and paid whatever necessary. Transport operators made an enormous profit. The panic stricken people took taxis, tempos (three wheelers), trains and

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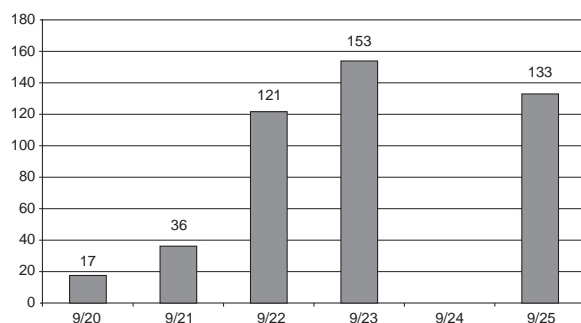


Fig 1—Reported number of plague cases in Surat (1994) from September 20 through September 25. The numbers are from newspaper reports.

buses to flee the city. The panic was wide spread; every person with swollen lymph-nodes was thought to have plague. The mass exodus occurred over long distances by railways and short distances by buses and other carriers. Surat does not have an airport for commercial flights. The train and bus stations were full of people struggling to make space for themselves and their family members, sitting, standing, hanging out the doors and windows and even on the roofs. The city of Surat consists of a large number of migrant workers who come not only from the state of Gujarat, but also from north-western and eastern India. Most of these migrants work in the silk and cotton textile mills, and diamond cutting and jewelry industries. Such migrants also come from the adjacent states of Maharashtra and Madhya Pradesh. These migrants tried to leave the city in order to get back to their home towns and villages, thinking that there they would find safe havens. While doing so, some infected migrants in the incubation stage, carried the disease with them.

The news coverage, aggravated the panic, locally, nationally and internationally. *India Today*, a prominent weekly magazine, described migration from Surat as reaching "biblical proportions". A German magazine described the exodus very vividly.

"The news spread like a fire in the city (Surat). First of all the richest industrialists fled away in their cars followed by private doctor practitioners, chemists, and many high officials. On Tuesday (September 20), there was a pay day in the diamond and textile industries. The moment the workers received their salary, they fled away on their bicycles, mini buses, trains etc. Vade (Beed), which was a chronic area, became almost uninhabited" (Anonymous, 1994a).

The international media dug-up false superstitions regarding the under-developed East and reminded Europeans of the black death of Europe and plague occurrences in England. A London tabloid described an *Air India* plane at Heathrow as a "plague plane". *The Times* called the plague in India as the "afflicted diaspora". *The Independent* branded it as "medieval scourge" while *the Times* news magazine designated the happenings as a "medieval horror show" (Madan, 1995).

Tourism was negatively affected. Tourists cancelled their flights to India and airplanes out of India were suspect. At some airports *Air India* planes were fumigated and the passengers questioned. Questioning also involved the Nobel Laureate, Mother Teresa, at the Rome airport.

#### WAS PLAGUE DIAGNOSED RIGHTLY IN SURAT?

September 20, 1994, Indian sources and media organizations from abroad confirmed there was a plague outbreak in India. The Journal of the American Medical Association (JAMA) reported that there were 5,150 suspected pneumonic and bubonic plague cases in India during the period August 26 through October 5. Diagnosis of pneumonic plague was confirmed on September 25 when *Yersinia pestis* was grown from specimens in 18 patients. Of the 53 reported deaths in India, 92.5% came from Surat (Anonymous, 1994).

In India, where medical research has a long tradition, it was confirmed that Surat was affected by pneumonic plague cases. Such information was confirmed by laboratory studies from the Haffkine Institute in Mumbai; the World Health Organization (WHO) collaborated in the study. The WHO confirmed that the lung infection of the patients in Surat was the result of pneumonic plague (Deodhar *et al*, 1998). After a visit by Russian and American epidemiologists, it was announced that by October 5<sup>th</sup> the plague epidemic was over in India.

The Surat plague, and its predecessor which took place a few weeks previously in Beed, Maharashtra, were questioned by many scientists as to whether they were truly the plague. Deodhar *et al* (1998) reviewed all the reports of Beed and Surat plagues and examined bacteriological and serological samples. They did not find *Y. pestis*. "In all these cases, fresh clinical samples of sputum from acutely ill patients, and lung tissue from autopsies, were negative for *Y. pestis* on repeated testing" (Deodhar *et al*, 1998). Kumar (1995) reported in the Lancet that even the Ministry of Health and National Institute for Communicable Diseases in India were skeptical about the diagnosis of plague because it was based only on serological evidence. There were no vigorous attempts to isolate the bacillus in pure form by the National Institute. Deodhar *et al* (1998) categorically concluded that the 1994 plague was incorrectly diagnosed and that the plague announcement was made based on inadequate and incorrect information. However, the scientists kept the door open for further confirmation by suggesting the desirability of an international confirmation.

Such a confirmation did come. In a DNA based study by Shivaji (2000). Cultures of 18 samples were positive for the "PLA" and "F1" genes, similar to those reported earlier for *Y. pestis*. Their research also concluded that the Indian isolates were genetically more heterogeneous compared to others in the world. They

found a great deal of genetic similarity among the 18 Indian isolates. The following is a quote from their paper:

"The present study establishes the identity of the causative organism of plague in India as *Y. pestis* based on the rRNA gene sequence gene analysis. It also demonstrates that the 18 isolates are genetically very similar within themselves, both based on 16s rDNA analysis and RAPD DNA fingerprinting, and further suggests that these may define a new ribotype but may not be clonal in origin. The results also indicate an epidemiological connection between rodents and man in the epidemic zone. Also, with the present study, the EMBL database entries on the rDNA sequences specific to *Y. pestis* isolates have gone up from 1 to 1 (EMBL Accession Number Z-75317, AJ232222 to AJ232223) (Shivaji *et al*, 2000).

One of the reasons, typical plague characteristics were absent in many patients in the two plague episodes in India of 1994 was that it was a different type of plague, more heterogeneous genetically. This is also the reason the WHO definition and criteria for identifying bubonic and pneumonic plague were not evident either in Surat or Beed. Genomic fingerprinting by Shivaji *et al* (2000) proved the Indian episode of 1994 was due to *Y. pestis*. It is more remarkable that such research was conducted in India and financed by the Indian Ministry of Health.

#### IS THERE A CONNECTION BETWEEN THE PLAGUE IN BEED AND THE PLAGUE WHICH OCCURRED IN SURAT?

India is no stranger to the plague. The history of plague in India can be divided into two distinct phases: Before the discovery of the plague bacillus in 1894, and after the discovery of the plague bacillus. The first known outbreak of plague occurred from 1500-600

BC as recorded in *Bhagvata Purana*. The plague was seen again in 1031 AD when the disease reached India from Central Asia following the invasion of Sultan Mahmud. In 1403 AD, Sultan Ahmed's Army was supposed to have been destroyed by a plague epidemic in Malwa. Plague was also reported in Berhampur (district Gangam, Andhra Pradesh) in 1707 AD. After the plague bacillus was discovered in 1894, the occurrences of plague in India were greatly reduced. The plague occurred in 1895, in Calcutta, where it was imported from Hong Kong. Not until after 1907 did the plague toll begin to decrease. The year 1907 marked the peak year of plague in India with 1.3 million deaths (Seal, 1987, unpublished data).

Although the plague was greatly feared in India in the first quarter of the century (and earlier), a significant decline was then noticed. This decline became quite dramatic after 1959. According to official statistics, the number of deaths due to plague between 1959 and 1966 were 211. No deaths were reported between 1967 and 1993. After the discovery of antibiotics and their use as a cure for plague, mortality declined in India. Several generations of medical personnel worked in India without ever encountering a plague patient. The plague was temporarily consigned to the textbooks. However, according to epidemiologists, the disease has not been eradicated in India, or any other country where it has been known to exist (Madan, 1995). It was reported in a Centers for Disease Control editorial note that there were 296 laboratory confirmed plague cases in the United States from 1970-1991 (Anonymous, 1994b).

For millions of years there has been a reservoir of *Yersinia pestis* in rodents living in warm, moist nests such as.

"The species of black rats that carried the plague in Europe appear to have lived originally in India. Rats of this species survive in a wild state in parts of the

Indian subcontinent, and they probably existed there long before learning to live as "weed species" in and around human houses. But as "weeds", rats were able to enter a new ecological niche that permitted them to spread far beyond their original homeland" (McNeill, 1976).

These wild rodent colonies will always be "plague reservoirs", ready to be stirred up by a sudden climatic or ecological change. Such an ecological change occurred in Beed, Maharashtra in the form of the 1993 earthquake.

#### SPREAD OF PLAGUE FROM SURAT

From 17 cases of plague in Surat on September 20, the number of cases increased at a rapid rate until September 25. Thereafter, the rate plateaued and by October 7 the total number had reached 581. By then the disease had started to spread to other parts of India. The first phase of the epidemic occurred in Surat and the surrounding areas, then spread by infected patients still in the incubation phase to Delhi by train, and then to Mumbai. It then spread to Calcutta (Kolkata) and the surrounding areas. During the next phase, patients carried the disease to Nasik in Maharashtra which lies between Surat and Bombay.

During the first phase of the epidemic, when the disease was confined to Surat and its adjacent areas, the disease took on a contiguous diffusion pattern (Fig 2). This "process follows the rules of distance decay at each step. Short-distance contacts are more likely than long-distance contacts, but over time the disease may have spread far from the original site" (Getis *et al*, 1996). During this stage the disease remained confined within a radius of 40 km around the city of Surat. This process is called expansion diffusion, in which the disease "often intensifies in the originating region" while "new areas are being added" (Haggett,

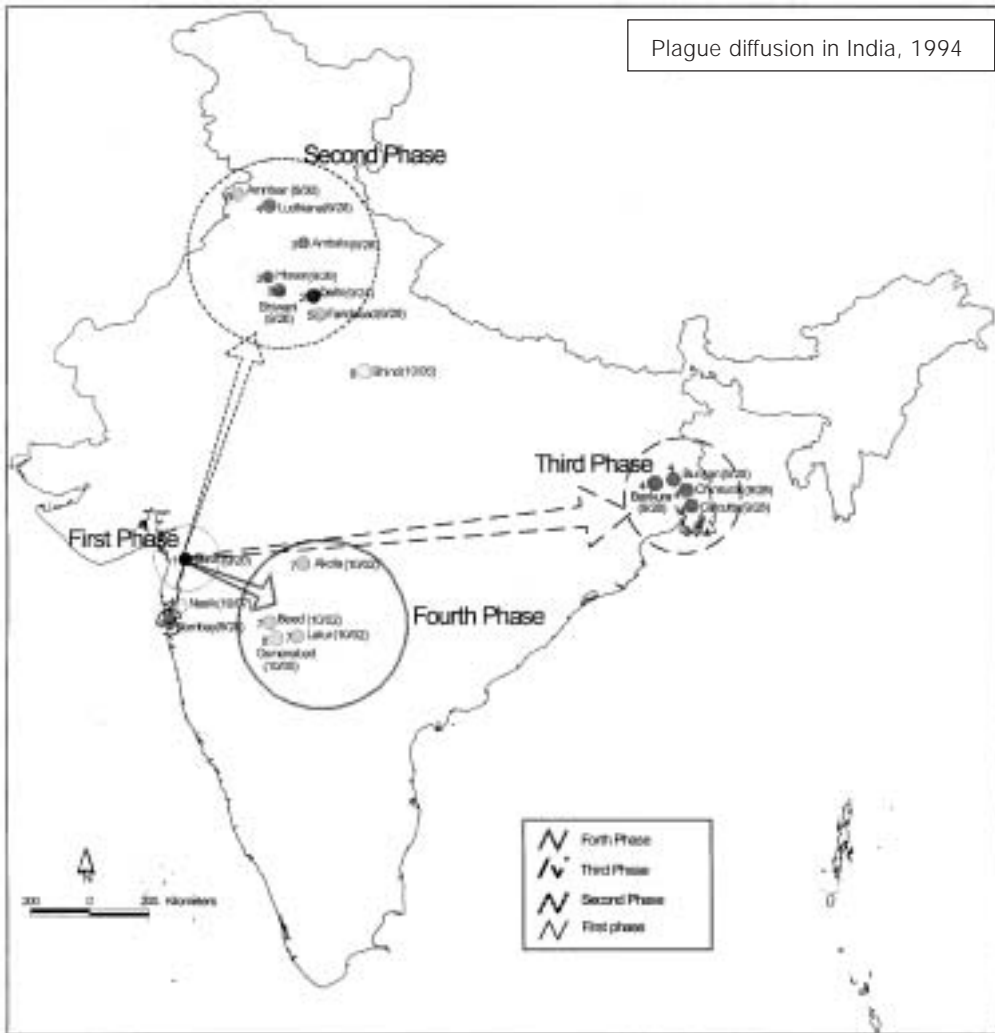


Fig 2—Four phases of plague diffusion in India (1994). The number in parenthesis by the side of the city indicates the first reported case of plague in that city, while the number to the left indicates the number of reported cases. The First Phases is the expansion diffusion in the Surat area. Second, Third and Fourth Phases occur by relocation diffusion, though there was a secondary relocation diffusion that occurred in Bombay when the disease spread to Nasik.

1972). It is remarkable the disease appeared such long distances from Surat, such as Delhi and Calcutta, which are 80 and 160 km from Surat, respectively. There was no occurrence of this disease between Surat and Delhi and between Surat and Calcutta. This happened because Surat's residents, who came from North and East India traveled home by trains. Some of them were infected. The disease in

Maharashtra and Bombay also spread by relocation diffusion. By the time new cases started to appear in Bombay, Calcutta and other parts of Maharashtra, the disease had already subsided in Surat. Haggett (1972) defined such a process in the following words. "In relocation diffusion, the things being diffused leave the areas where they originated as they move to new areas". Getis *et al*(1996)

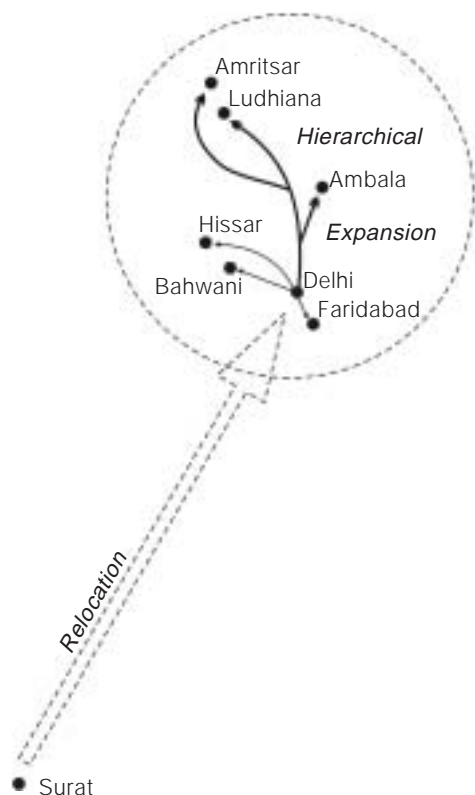


Fig 3—Diffusion pattern of plague (1994) in the Delhi Region. After relocation diffusion from Surat, the disease diffused by hierarchic form. The Delhi based plague spread to Faridabad, Bhiwani, and Hissar and eventually to Ambala, Ludhiana, and Amritsar.

declared when “diseases are transferred from one place to another through the migration of people, the process is called relocation diffusion”. The spread of the disease, after occurring in Delhi and Calcutta, took a hierarchic diffusion form. Gould (1969) defines this process of specify movement as either moving up or down a hierarchy. “Simple geographic distance is not always the strongest influence in a diffusion process, for some ideas and innovations seem to leap over many intervening people and places. Such leap-frogging usually characterizes processes of hierarchical diffusion, in which large places or important people tend to get the news first, trans-

mitting it to others lower down the hierarchy”. When the disease first surfaced in Delhi on September 24, it diffused in 2 ways. One route of diffusion occurred from Delhi to Faridabad, Bhiwani, and Hissar. The other was from Delhi to Ambala, Ludhiana and Amritsar, both taking the hierarchic diffusion path (Fig 3).

Thus, the plague diffusion process in India showed diffusion in three ways. First, was expansion diffusion, second, was relocation diffusion and third, was the hierarchic diffusion. Long distance migration of the disease was essentially the result of relocation. The disease was controlled in a short time because precautions and curative efforts were taken by health care providers and the government.

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