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A History of Plague In the United States of America

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Foreword

Measured in terms of morbidity and mortality, plague has never been a major public health problem in the United States, but, in terms of latent danger and the total cost of suppressive measures during the past 50 years, it cannot be placed in a minor classification. This disease, which has been one of the world's greatest killers, has forced the spending of large amounts of money on efforts to keep it out of this country, to suppress the epidemics which did gain a foothold, and to control or eradicate epizootics in domestic and wild rodents. Modern methods of rodent and ectoparasite control, together with almost specific therapeutic drugs, have decreased the potential danger from plague. Arrival at this turning point makes it particularly fitting to review the accomplishments of the past five decades, to summarize the cooperative efforts of the Public Health Service and the State health departments, and to emphasize specific contributions by individuals of the Public Health Service.

THEODORE J. BAUER,
Medical Officer in Charge,
Communicable Disease Center.

June 1954.

Acknowledgment

The preparation of this history was suggested in 1949 by the late Assistant Surgeon General Joseph W. Mountin. To assist the author, Dr. Mountin appointed an advisory board of seven Public Health Service officers, whose helpful assistance is acknowledged. Members of this board were: Medical Directors R. H. Creel, C. R. Eskey, W. T. Harrison, B. J. Lloyd, and N. E. Wayson, and Assistant Surgeon General C. L. Williams, all retired, and Medical Director G. W. McCoy, deceased.

Acknowledgment is made to the following sources for permission to reproduce illustrations:

Time, Inc., page 22, column 2; pages 33–35, 37–39, 41.

Los Angeles City Health Department, pages 58–63.

Territory of Hawaii Department of Health, pages 73–75.

Union of South Africa Plague Laboratory, page 87.

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Introduction

Historically, bubonic plague has been responsible for a number of notable pandemics. The disease appears to have a strong, long-term, cyclic tendency. It flares up on a global scale and then slowly retreats to smoulder in endemic centers. During the last 15 centuries, four important pandemics have been recorded: the pandemic of 542 to 600 A. D., which began during the reign of the Emperor Justinian and involved the whole Roman world; the "Black Death" of the 14th century, some of which was certainly plague, and which caused an estimated loss of 25 million lives, one-fourth of the entire population of Europe alone; the pandemic of the 15th, 16th, and 17th centuries, which culminated in the "Great Plague of London," 1664 to 1665; and the present pandemic, which began in 1894 and is now receding. Between pandemics, notable epidemics have been recorded in countries all over the world. There is also reason to believe that there are endemic centers in portions of Africa and Asia, which represent the points of origin of all pandemics (*1*).

The most recent pandemic of plague probably began in the Chinese province of Yunnan on the Tibetan border in the middle of the 19th century, reached Canton and Hong Kong in 1894, and Calcutta and Bombay in 1896. In a few years it had spread to Singapore, the Philippine Islands, Arabia, Persia, Turkey, Egypt, Africa, and Russia, and to parts of Europe, North and South America, Central America, the West Indies, and Mexico (*1*). Every continent in the world was soon involved. Numerous instances were reported of human beings on board ships who were sick with plague. It is not surprising, therefore, that the first recorded cases of plague within the borders of the United States were aboard ships arriving at San Francisco, Calif.; Port Townsend, Wash.; and New York, N. Y.

On June 27, 1899, the Japanese S. S. *Nippon Maru* arrived at San Francisco with a record of two cases of human plague on board between Hong Kong and Honolulu. Although no illnesses or suspicious symptoms were noted in either passengers or crew on arrival, because of the history of recent human plague on board, the vessel was placed in quarantine. When the crew and steerage passengers were inspected on the afternoon of June 27, 11 Japanese stowaways were found. When the crew was transferred to Angel Island the next day two of the stowaways were missing. Their bodies, bearing life preservers from the *Nippon Maru*, were recovered later from the bay. Post-mortem examinations made by the San Francisco Health Department showed plague bacilli in smears and cultures from enlarged glands (*2*).

On November 17, 1899, the British S. S. *J. W. Taylor* arrived at New York with plague on board. The ship had sailed from Santos, Brazil, on October 24, 5 days after plague had been officially declared to exist there. While in port at Santos, the steward had been treated at a local hospital for eczema of the face and lips, but had been discharged in time to sail with his ship. He became seriously ill on November 1 and died on November 7. On the day he died, the captain and the cook became ill. On arrival in New York, they were both convalescent, but each exhibited an ulceration on the foot and an inguinal bubo. Pus from the buboes contained plague bacilli. However, no further spread of the disease occurred (*2*, *3*).

On January 30, 1900, the Japanese S. S. *Nanyo Maru* arrived at Port Townsend with a history of illness en route. One person, with all the symptoms of beriberi, died at the quarantine station. However, because of the patient's general glandular enlargement, the quarantine officer was unwilling to accept this

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diagnosis and held the vessel and passengers to await bacteriological examination of tissues from the victim's body. The result of this examination confirmed the quarantine officer's suspicion of plague. Altogether, there were 17 cases of plague and 3 deaths among the crew and passengers of the *Nanyo Maru* (*4*).

These three instances all antedated the first case of plague in the San Francisco epidemic of 1900. It will never be known whether they had anything to do with the epidemics which later occurred in the ports of San Francisco and Seattle. However, they do suggest that the cases were probably associated with infected rats on ships and that there probably was ample opportunity in the last years of the 19th century and the early years of the 20th century for rats to leave ships in United States ports and start epizootics of plague.

The First San Francisco Epidemic

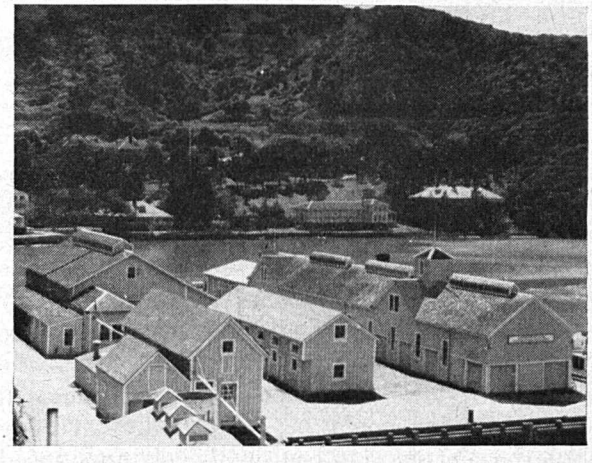
On March 6, 1900, the body of a Chinese man was removed from the basement of the Globe Hotel in San Francisco and taken to a Chinese undertaker. The body was autopsied because, before granting of a burial permit, the board of health required a death certificate from a Caucasian physician and a necropsy on the body of every person who died unattended. The assistant city physician, Dr. Frank P. Wilson, reported the case as suspicious of plague to the city health officer, Dr. A. P. O'Brien. The bacteriologist for the San Francisco Board of Health, Dr. W. H. Kellogg, made smears from an enlarged lymph node from the body of the man and demonstrated organisms having the size, shape, and staining characteristics peculiar to the plague bacillus. The glands were then submitted to Surgeon J. J. Kinyoun, of the United States Marine-Hospital Service, Federal quarantine officer for San Francisco. Dr. Kinyoun innoculated rats, guinea pigs, and a monkey with the suspected material on March 8. Three days later, one rat and two guinea pigs died. The monkey became very ill and died on March 13. The pathological diagnosis on the dead animals was plague and was later confirmed by bacteriological studies done by Dr. Kinyoun at the United States Quarantine Station, Angel Island, Calif.

On March 7, the city authorities placed a cordon around 12 blocks of Chinatown. It was estimated that 25,000 persons lived in this 12-block area. The dead man's dwelling and the undertaker's shop were disinfected with formaldehyde. On March 8, Dr. Walter Wyman, Surgeon General of the United States Marine-Hospital Service, suggested by telegram that the following recommendations be made to the local board of health:

1. Antipest serum to all persons known to have been exposed to plague.
2. Haffkine's vaccine to all other residents of Chinatown.
3. Disinfection of premises with sulfur rather than with formaldehyde.

On March 9, Chinatown was released from quarantine. However, guards were placed at each point of exit from the city by rail and by water to examine all Chinese attempting to leave the city and to detain every person with symptoms suspicious of plague. At the same time, 14 men began a house-to-house inspection. Within 5 days, 30 men were inspecting Chinatown and ordering inhabitants to clean up their premises. In another week, 30 medical inspectors and 120 lay inspectors were making house-to-house inspections and ordering a general cleanup. Sewers and dwellings were being disinfected with sulfur dioxide and bichloride of mercury.

On March 21, an Associated Press dispatch stated that there were four cases of bubonic plague in San Francisco, and that the news was being suppressed by the authorities, who wished to be positive of the diagnosis before



United States Quarantine Station, Angel Island, Calif.

making any announcement. The next day, Dr. John M. Williamson, president of the San Francisco Board of Health, issued a statement to the effect that the Chinese quarter was infected with plague, that the Chinese were concealing cases of the disease, and that local newspapers were endeavoring to suppress news of plague in spite of the fact that Dr. D. W. Montgomery of the medical department of the University of California and Dr. William Ophuls of Cooper Medical College, San Francisco, had concurred in the diagnosis after examining material from the body of one of the victims (*2*).

On April 1, the State of Texas instituted quarantine measures which, while not naming California specifically, were directed against that State (*5*).

House-to-house inspection continued until April 10, principally in Chinatown, but also in the Latin quarter, which was inhabited chiefly by Italian fishermen. Because of the continued occurrence of cases of plague, on May 15 a joint meeting was proposed between the San Francisco Board of Health, the Editor's Association, and the Merchants' Association. Surgeon General Wyman telegraphed the following suggestions:

1. One man in supreme charge.
2. Cordon of the suspected area.
3. Guards at railroads and ferries with reference to Chinese.
4. House-to-house inspection and administration of Haffkine inoculation.
5. Pest hospital in Chinatown.
6. Isolation of persons suspected of having plague.
7. A disinfecting corps.
8. Destruction of rats.
9. Inspection of railroads and outside territory.

The main features of these recommendations were adopted by the board of health on May 17. However, the board of health and the Merchants' Association requested that the recommendations be kept secret until financial arrangements could be completed. On May 19, the city board of health officially announced the existence of plague in San Francisco and requested the State board of health to act. Resumption of house-to-house inspection was begun the same day by 40 inspectors and a few policemen. This time, however, there was preconcerted resistance to inspection on the part of the Chinese. All houses and shops were locked up and access to them was impossible for several days.

On May 21, Surgeon General Wyman requested authority from President William McKinley to formulate regulations to prevent the spread of the disease. Authority was granted, and on May 22, the following regulations were adopted:

1. Transportation by common carrier was forbidden to Asiatics or members of other races particularly liable to the disease.
2. Common carriers were not to accept for transportation persons or things liable to convey the risk of plague contagion.
3. Bodies of persons dying of plague were to be cremated or transported in hermetically sealed coffins.

On May 24, the secretary of the Chinese Six Companies applied for a restraining order on the basis that the Federal Government had exceeded its authority. In the meantime, guards were on duty at all points of exit from the city and were inspecting railroad trains leaving the State. Asiatics attempting to enter the city without permits from the United States Marine-Hospital Service were turned back. To prevent an exodus from the city, launches were used at night to patrol the San Francisco water front and, because threats were made to run down and destroy these launches, an appeal was made to the Navy for protection (*2*).

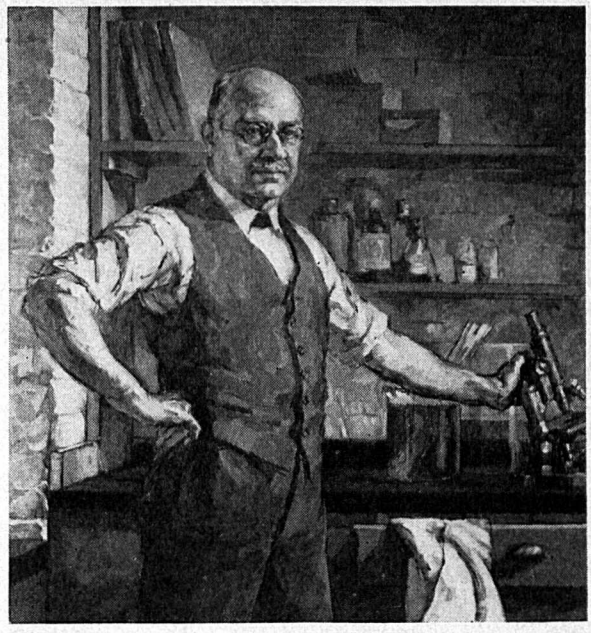
On May 28, Colorado instituted quarantine against the State of California. The same day the California Board of Health demanded another quarantine of Chinatown, and Judge William W. Morrow, Judge of the United States Circuit Court, granted a restraining order based on the opinion that the regulations issued by the United States Marine-Hospital Service were class legislation and denied equal legal protection to Asiatics, that President McKinley's order was general and did not declare plague to exist in California, and that the proper local

authorities (board of supervisors of San Francisco) had not declared plague to exist. The following day, the board of supervisors declared that plague did exist in San Francisco and passed an ordinance requiring the board of health to quarantine, to take such measures as were necessary for the prevention of and against the spread of epidemic disease, and to establish immediately an absolute cordon around Chinatown. The board of health was afraid to act, in view of the injunction issued by the United States Circuit Court, but strengthened the cordon and kept up a desultory house-to-house inspection. An appeal was made by the State board of health to the Governor, who declined to aid or to cooperate with the city authorities.

Plans were then made to institute a detention camp where Asiatics could be housed; but on June 7, Judge Morrow enjoined the board of health from removing Chinese to such a camp. The board of health had hardly passed a resolution to raise the quarantine, 20 days after the last ascertained case of plague had been reported, when, on June 15, the Federal court ordered the quarantine raised. The next day, Dr. Kinyoun was served with an order to show why he should not be punished for contempt of court by restricting travel in spite of the court order. Two days later, all inspectors at the State border were withdrawn and all inspection ceased. On July 3, Dr. Kinyoun was held not to be in contempt of court (*2*).

Dr. Kinyoun's role in the early phases of this controversy was exemplary. He had the courage to face what amounted to the most severe personal criticism, almost approaching martyrdom. The campaign of vilification launched against him and others who contended that bubonic plague was present in San Francisco has never been equaled in its unexampled bitterness and unfairness.

That Dr. Kinyoun was included in this vituperation is most difficult to understand in view of his background and training. He was particularly fitted for his role as an expert on plague. He had received postgraduate training in Europe in the best laboratories of that continent, including study under Louis Pasteur in France and Robert Koch in Germany. In 1886, he began to apply the techniques he had learned by setting up a laboratory at the Marine Hospital in Stapleton, N.Y. This laboratory became the Hygenic Laboratory which later developed into the National Institutes of Health. Dr. Kinyoun was the first of a long line of distinguished directors. Among his many accomplishments was the Kinyoun-Francis sterilizer, a shipboard disinfecting apparatus used in the quarantine service.



Surgeon Joseph J. Kinyoun

Dr. Kinyoun's ability was unquestionable. In spite of this, he became entangled in the political controversy over plague. Every attempt was made to discredit his findings, but history has supported his stand (*6*).

Few cases of plague occurred during the summer and fall of 1900, but by December of that year, the continued occurrence of cases of the disease and the unsatisfactory situation in general prompted the assignment to San Francisco of Surgeon J. H. White, chief of the Division of Domestic Quarantine, United States Marine-Hospital Service. On January 10, 1901, after studying the problem, Dr. White suggested that the testimony of the best bacteriologists in America was needed to confirm or deny the diagnosis of plague, since that was the major point of difference between Federal and local authorities.

On January 19, Secretary L. J. Gage of the Treasury Department appointed a commission

of experts consisting of Professors Simon Flexner of the University of Pennsylvania, F. G. Novy of the University of Michigan, and L. F. Barker of the University of Chicago. The commission proceeded to San Francisco.

The Governor of California, Henry T. Gage, was notified about the commission on January 25. He immediately sent a telegram to the President, in which he expressed the hope that no discourtesy was intended by the Secretary of the Treasury in appointing a commission without consulting State authorities, and suggested that local scientists and possibly scientists from other countries be appointed to the commission.

In reply to Governor Gage's telegram to the President, Secretary Gage stated that members of the commission had been selected wholly because of their knowledge of, and experience with, plague and that they had been directed to pay their respects to the Governor and acquaint him with their work. The commission, the Secretary explained, was to work independently without creating undue publicity and was to be unhampered by detailed instructions from any source. No discourtesy was intended. On January 31, a bill was introduced in the California Legislature to stop the work of the commission, but the bill never passed.

The commission met in San Francisco on January 27 and decided to examine rats until human cases of plague should occur, to request of university authorities the privilege of using bacteriological laboratory space, and to open temporary offices which would permit interviews with local citizens. A private room was made available in the University of California Medical Department by Professor A. E. Taylor. This action was later countermanded by the president of the university. The city authorities then made suitable space available to the commission.

On January 29, the commission requested an appointment with Governor Gage in order to pay its respects. The Governor's secretary replied that the Governor would be pleased to receive the members at any time they deemed proper. An appointment was requested on February 12. The Governor arranged to be in San Francisco on February 16. In the meantime, the commission had had an opportunity to examine six cases of plague between February 5 and 13 and was ready to make its report after seeing the Governor.

On February 17, Governor Gage again protested to the President that the State had been denied any opportunity to participate in the plague investigation, that Dr. Kinyoun, who was considered to be prejudiced, had been actively assisting the commission, and that a report by the commission that plague existed in San Francisco would be regarded as the result of an unfair and unjust investigation. The Governor suggested that a reinvestigation be made by a commission of three members appointed by the Federal Government, three by the State, and a seventh to be chosen by the other six in case their opinions were equally divided. If such a new commission could not be appointed, the Governor requested that California have an opportunity to discuss the commission's report before it was made public and before any action was taken. Secretary Gage accepted the latter suggestion.

On February 25, the Governor requested the Federal Government to assume responsibility for all plague-control work in San Francisco, and on February 27, he appointed a commission to go to Washington to confer with the Secretary of the Treasury on arrangements. The conference was held in Washington on March 9. John P. Young, Fremont Older, W. F. Herrin, H. T. Scott, and T. T. Williams represented the Governor, and it was agreed that plague-control measures would be adopted in San Francisco, the work to be done with the advice and cooperation of Surgeon J. H. White of the Marine-Hospital Service.

The report of the commission of expert diagnosticians was made available immediately to the Governor of California, the mayor of San Francisco, and several State health officers. A synopsis of the report was published in the March 29, 1901, issue of *Public Health Reports* (p. 636), and the entire report (7) was printed in the April 19 issue (pp. 801–816).

An interesting sequel to the commission's work occurred when Dr. Novy took cultures of plague bacilli back to Ann Arbor with him. A medical student (C. B. H.) employed to prepare Haffkine's vaccine and Lustig's serum under Dr. Novy's direction contracted pneu-

monic plague on April 3, 1901, and plague bacilli were recovered from his sputum. The student recovered and later practiced medicine for many years in California. His was the first laboratory infection, the first and only case of plague ever reported in Michigan, the first case in the United States outside of California, the first reported recovery from plague, and the first reported pneumonic plague recovery in the country (*8*).

On March 31, agreement was reached by the Governor of California, the mayor of San Francisco, the committee sent to Washington by the Governor, and Dr. White of the Marine-Hospital Service to raise funds for disinfecting all plague-infected houses, and for providing hospitals for suspects, detention houses for contacts, and a morgue. It was agreed that:

1. The Chinese were to make every concession toward a daily inspection of all sick and dead.
2. The sick whose illnesses were deemed to be at all suspicious of plague by the inspectors were to be removed to a hospital designated for the purpose, where they could be under constant observation.
3. The dead were to be removed to a morgue in Chinatown for necropsy. After necropsy, bodies were to be placed in lime in hermetically sealed coffins, buried immediately in a separate area, and not disinterred for a year.
4. All contacts of plague patients were to be detained under observation for 2 weeks.
5. Houses were to be fumigated for 48 hours with 5-percent sulfur dioxide (5 lb. per 1,000 cu. ft.).
6. Textiles were to be subjected to steam at 215° F. for 20 minutes.
7. Other goods were to be soaked in 1/1,000 bichloride of mercury solution or 5-percent carbolic acid solution.
8. Other articles were to be burned.
9. Walls were to be scraped, floors were to be soaked and scrubbed with saturated lye solution and then with plain water. Then walls and floors were to be washed with a 1/1,000 solution of bichloride of mercury and, after drying, were to be whitewashed.

On April 8, 1901, inspecting, cleaning, and disinfecting of houses were begun. Two days later, the city auditor declared that the appropriation made by the board of supervisors for cleaning Chinatown and erecting a hospital was illegal. However, the work in Chinatown continued until it was completed on June 21, 1901.

The district bounded on the north by Broadway, on the east by Kearny Street, on the south by Bush Street, and on the west by Powell Street, and commonly known as Chinatown, had been cleaned in a more effectual manner than ever before. Every house in this district except those inhabitated by the wealthy, and usually clean, Chinese was washed from garret to cellar with a solution of caustic potash, followed by spraying with a bichloride of mercury solution. Household goods were removed and aired from 1 to 3 days, and the rooms were then either reoccupied as they were or, if dark, were whitewashed thoroughly. This latter treatment was applied to all cellars and basements. Houses where plague had occurred at any time within the year not only were given this treatment but were also exposed to a 5-percent volume of sulfur dioxide for 24 hours. When plague had occurred in cellars contiguous to silk warehouses, formaldehyde fumes were generated by autoclaves and a 6-percent volume, 24-hour exposure was given. These methods were applied to 1,180 houses and 14,117 rooms (*7*).

Surgeon J. H. White was ordered to Washington on June 7 and Passed Assistant Surgeon Rupert Blue was left in charge of the plague eradication work.

After June 21, the Service maintained a laboratory at 641 Merchant Street to continue inspection of premises and to do such autopsies as were required. Plague continued to be reported, and toward the end of 1902 nearly 100 cases had been seen.

Opposition to all control efforts was steadily manifested by the Governor and the State board of health, who consistently refused to allow inspection of other California cities where plague was rumored to exist. San Francisco was embarrassed by lack of funds and by a new mayor who tried to remove members of the city board of health. He was prevented from doing so by an injunction. In October 1902, Surgeon A. H. Glennan was ordered from Cuba to assume charge of the Federal group. Dr. Glennan called on Governor Gage who, in

Passed Assistant Surgeon Rupert Blue
(In charge of plague control during first San Francisco epidemic, 1901–5.)

spite of the plague commission findings, stated that he still believed the illnesses were not caused by plague but were due to a syphilitic septicemia or pseudoplague (*9*).

In October 1902, a conference of representatives of State boards of health was held in New Haven, Conn. The plague situation in San Francisco was discussed and resolutions were passed which greatly disturbed the executive officials of the city of San Francisco because they feared that California might be quarantined. The acting mayor called a conference on November 3 with the secretary of the State board of health, the senior United States Senator from California, and others. Another conference was held on November 6, and an agreement was reached to submit the following proposals to Governor Gage and Surgeon General Wyman:

1. Surveys of suspected cities in California.
2. House-to-house inspections if necessary.
3. Adoption of German plague prevention measures modified to fit the situation in San Francisco.
4. Legislative action to regulate living accommodations (*11*).

On November 8, the city board of health, employing 3 men and 50 traps, began to trap rats in Chinatown (*10a*).

On November 20, Governor Gage appointed Dr. Matthew Gardner, chief surgeon of the Southern Pacific Railroad, to accompany Dr. Glennan on the inspection of other cities in California. Oakland, Berkeley, Alameda, San Jose, Sacramento, Davisville, Stockton, Fresno, and Bakersfield were inspected, but no present nor past plague was discovered.

Early in 1903, a new Governor of California, George C. Pardee, M.D., was inaugurated. Dr. Pardee was a practicing physician and a former member of the Oakland Board of Health. One of his first acts was to appoint Dr. Gardner as the official California representative to a conference in Washington on January 19. This conference had been requested by seven States for the purpose of discussing the plague situation in California. Representatives were present from 20 States or Territories and the District of Columbia. The resolution passed by this conference (*11*) is summarized below:

SINCE the presence of plague in California is established beyond debate,
AND the presence of plague in any community where proper precautions are not taken to prevent its spread is an injury to the best interests of that community,
AND the present danger to California and to the United States lies primarily in the persistence of a definite nidus of plague infection in that part of San Francisco known as Chinatown,
IT IS RESOLVED, That the Surgeon General of the Public Health and Marine-Hospital Service be requested to inform the various State boards of health at least 2 weeks before the annual meeting of the Public Health and Marine-Hospital Service and the State health officers to what extent the sanitary recommendations this day made to control and prevent the existence of plague in California have been carried out, to the end that they may then be prepared to take further action that may be necessary.

On January 19, Governor Pardee issued the following statement to the press:

Whatever the Marine-Hospital Service desires me to do in the way of public health preservation shall be done. If Surgeon General Wyman and his conferees decide that the safety of the country or any part of it would be enhanced by a more stringent adherence to the laws of sanitation in California, their decision will be respected by me and carried out in accordance therewith to the best of my ability and the State's available resources.

Again, on January 22, the Governor stated:

I want to say that I propose to act in complete harmony with the Federal authorities. They must be satisfied so as to restore public confidence and my plans therefore will be made to fit with theirs. The medical authorities have emphatically declared that plague has existed and does exist in San Francisco, and that settles it as far as I am concerned. It matters not what one's belief may be as to the existence or nonexistence of this disease. Medical men say it exists and there is no going behind the returns. Consequently, I stand ready to do what the Federal authorities desire. What we want to do is to put an end to the suspicion with which California is regarded outside the State's limits.

On February 2, 1903, Governor Pardee; Dr. Matthew Gardner, representing the State board of health, and Dr. A. P. O'Brien, health officer of San Francisco; E. E. Schmitz, Mayor of San Francisco; Surgeon A. H. Glennan, of the Public Health and Marine-Hospital Service; A. R. Briggs, vice-president of the California State Board of Trade; A. A. Watkins, president of the San Francisco Board of Trade; G. A. Newhall, president of the San Francisco Chamber of Commerce; F. J. Symmes, president, Merchants' Association of San Francisco; G. W. McNear, president, Merchants' Exchange of San Francisco; A. Sbarbora, of the Manufacturers and Producers Association of California; and P. P. Jennings of the California Promotion Committee, signed the following official statement:

Whereas competent medical authority has declared that bubonic pest has existed to a limited extent in the restricted area known as Chinatown in San Francisco, the last case having been reported December 11, 1902, and although the health authorities have exercised sanitary supervision over the section in the past, nevertheless this undersigned joint official statement is promulgated in accordance with the resolutions adopted at the conference of State health officers, held at Washington, D. C., January 19, 1903, as an assurance that there is no present or future danger from that disease, inasmuch as complete and harmonious action by all the health authorities concerned is hereby assured and will be maintained.

The following plan was then agreed upon by Dr. Gardner, Dr. O'Brien, and Passed Assistant Surgeon Blue (*10b*):

1. Dr. Matthew Gardner, representing the State, will pay three medical inspectors, two sanitary inspectors, and two Chinese interpreters.

2. The city board of health will begin immediately the extermination of rats by means of traps and poison, employing three sewer men for the purpose. Fifty additional traps will be supplied for this work. The city agrees also to disinfect immediately all infected places, and will cause the renovation of such habitations in a manner satisfactory to the health authorities.

3. The city further agrees to have the streets of the Chinese district thoroughly swept at least three times a week and the same flushed with water once a week. A per capita price will be paid for rats found in Chinatown. An extra effort will be made for the removal of garbage and the sanitation of back areas.

4. The United States Public Health and Marine-Hospital Service will exercise immediate supervision over this work in conjunction with State and city authorities, and will furnish for the prosecution of the work, a bacteriologist and laboratory, three medical officers (more if needed), and two Chinese interpreters.

Finally, it is agreed that all cases shall be reported to the proper authorities; that all inspectors shall report daily at 641 Merchant Street, United States Plague Laboratory, for instructions; that inspectors shall be required to make daily reports of their observation and the number of sick and dead seen by them; that the Chinese make every concession toward a thorough inspection of all the sick and dead in Chinatown; that the above work will be continued for at least 1 year from date of adoption of the plan; that the city board of health agrees to recommend to the board of public works and to the board of supervisors that Dupont Street be paved from California Street to Broadway Street; that the city board of health will immediately request the board of supervisors to provide sufficient funds for the purpose of carrying out the obligations assured by it herein.

The city board of health approved the plan, as outlined, on February 9, but because the action was not fully understood in other States, Colorado reimposed its original quarantine order of May 28, 1900. On February 21, Frank J. Symmes, chairman of the Mercantile Joint Committee of San Francisco, telegraphed Surgeon General Wyman to see if he could help lift the quarantine against San Francisco which Ecuador and Mexico had imposed, and this was accomplished. A similar request was made on March 10 in regard to the restrictions placed on San Francisco by Sydney, Australia. In March 1903, although 3 months had elapsed without a human case of plague, Mexico again instituted quarantine against San Francisco at her Pacific ports.

On April 2, representatives from the State board of health visited the United States Public Health and Marine-Hospital Service laboratory, inspected the work in progress, and heartily endorsed the program. On May 11, at the meet-

ing of the State board of health in Sacramento, a resolution was passed recommending that Chinatown be moved en masse to a new location and that temporary housing be given to Chinese in the meantime. This was never done.

On May 12, Ecuador again instituted quarantine against California. This quarantine was finally lifted on June 16. On May 30, Surgeon A. H. Glennan was transferred to Washington and the direction of activities again was turned over to Passed Assistant Surgeon Rupert Blue (*11*).

The plan of action agreed upon by Dr. Gardner, Dr. O'Brien, and Dr. Blue and approved by the city board of health on February 9, 1903, was to have continued for at least a year. A year later, on February 6, 1904, following the appointment of a new city board of health, a meeting was called of Federal, State, and city health authorities, the finance committee of the board of supervisors, and representatives of mercantile organizations. The following resolutions were passed:

RESOLVED, That it is the sense of this meeting that the sanitary measures adopted by the city, State, and Federal health authorities in February 1903, for the eradication of contagious diseases in Chinatown be continued for so long a time as may be considered necessary; that the city board of health be requested to recommend to the board of supervisors additional measures for the wholesale destruction of rats.

RESOLVED, That all cellars, basements, and underground places in the district between California and Pacific, Stockton, and Kearny, be condemned as places of abode and the same be destroyed; that in case of reconstruction, the owners be required to remove surface soil and to concrete the area thus exposed solidly from wall to wall.

RESOLVED, That the work be done under the direction and supervision of the Public Health and Marine-Hospital Service and that a meeting of the representatives of the Public Health and Marine-Hospital Service, the city board of health, and the State board of health be held once every 2 weeks for consultation.

MARTIN REGENSBURGER,
President State Board of Health.
RUPERT BLUE,
Passed Assistant Surgeon U. S. P. H. and M. H. S.
JAMES W. WARD, M. D.,
President San Francisco Board of Health.
N. K. FOSTER,
Secretary State Board of Health.
A. A. D'ANCONA,
Member Hospital and Finance Committees, Board of Supervisors.
WM. C. HASSLER, M. D.
Chief Inspecting Physician.

SAN FRANCISCO, *February 6, 1904.*

This is apparently the first record of a resolution recommending ratproofing as an antiplague activity. Under the authority granted, many insanitary structures were demolished and removed, and in 22 city blocks, all wooden floors in basements were destroyed. By the end of June 1904, the following recapitulation was made of this ratproofing activity:

Activity	*Number*
Basements and cellars torn out	155
Basements and cellars cemented	139
Rear areas torn out	173
Rear areas rebuilt	113
Buildings totally destroyed	7
Buildings refitted with new plumbing	71
New toilets erected	72

Thus, the art of ratproofing was born even before the role of the rat in the transmission of plague was accepted generally (*12*).

Altogether, there were 121 cases of plague with 118 deaths during the first San Francisco epidemic. Fourteen of the cases were diagnosed clinically; 107 diagnoses were confirmed by laboratory methods. Two cases were not classified as to type, but 4 were septicemic, 5 were pneumonic, and 110 were bubonic. The last case of human plague in this outbreak was reported on February 29, 1904, but certain phases of plague control continued until the laboratory was discontinued on April 13, 1905.

The first epidemic was over. It had existed for nearly 4 years and, during the first 3 years, there was constant warfare between those who knew the disease was plague and those who insisted it was something else. Even after the Plague Commission made its report early in 1901, which proved the existence of plague beyond the slightest doubt, there were those who would not accept the truth. The Governor of California was adamant in his stand, and it was not until a new governor was inaugurated in 1903 and other States in the Union began to exert steady pressure that any real progress was made in controlling the disease.

Noteworthy also in the first San Francisco epidemic was the general belief that Asiatics were more susceptible to plague infection than other races. It is true that there was a predominance of Chinese and a few Japanese in the list of cases; however, this was not because

of their greater susceptibility to plague, but rather because of their environmental situation.

It is interesting to note that, although the Plague Commission in February 1901 stated that they wanted to obtain and examine rats, it apparently was not until November 8, 1902, that rats were actually trapped and examined for plague. Surgeon General Walter Wyman had recommended measures for the destruction of rats on May 15, 1900, but there is nothing to indicate that antirat activities actually were initiated until 1902. During the calendar years 1902, 1903, and 1904, there were found 16, 12, and 10 plague-infected rats, respectively.

Emphasis during the first epidemic was placed on fumigation and disinfection of infected premises or premises suspected of being infected rather than on antirat activities. This is not surprising, because the role of the rat and its ectoparasites in the transmission of plague had not yet been proved. Ogata (*13*), in 1897, crushed fleas from rats which had died of plague and injected them into two mice, one of which died of plague after 3 days. Ogata suggested, from epidemiological considerations, that plague was usually conveyed by suctorial insects. However, the rat-flea theory was not universally accepted until after the work of the Commission for the Investigation of Plague in India in 1905–16 (*14*).

Chapter III

The Second San Francisco Epidemic, Including Other Bay Area Cities

A death from plague in San Francisco was reported in May 1907, a little more than 3 years after the last case in the first epidemic. The patient, a sailor from the tugboat *Wizard*, was examined at the United States Marine Hospital. He had slept on board the *Wizard* continuously for 5 or 6 weeks prior to falling ill, but at intervals had taken his meals at a lodging house at 247 Steuart Street near the San Francisco waterfront. Immediately after sending the patient to the hospital, the *Wizard* sailed for Oregon ports, struck a rock 4 days later, and sank at sea. Her crew returned to San Francisco on a rescue ship and arrived at the city on June 7. They were given a thorough examination at quarantine, found free from glandular enlargement and without a rise in temperature, and all were released.

No other cases of plague occurred until August 8, when a sailor on the S. S. *Samoa* fell ill. This man, with the exception of about 45 minutes, had not left the vessel for any purpose for more than 6 weeks. The ship was given a thorough fumigation for the destruction of vermin at the United States Quarantine Station at San Francisco, and her crew were bathed and held for 7 days. The sailor died on August 12 at the United States Marine Hospital.

On August 14, a case of plague occurred in San Francisco in the block bounded by Stockton, Du Pont, Francisco, and Bay Streets, and this was quickly followed by other cases in localities throughout the city. Efforts were made by local and State authorities, assisted by officers of the United States Public Health and Marine-Hospital Service, to control the disease. On September 4, 1907, a telegram was addressed to the President of the United States by the mayor of San Francisco, requesting the Federal Government to take immediate charge of plague control work. Passed Assistant Surgeon Rupert Blue was assigned immediately to take charge of plague-suppressive measures in San Francisco and vicinity. On his arrival he found that the disease was widespread, that cases had occurred in all parts of the city, and that the difficulties of the situation were increased by the disorganized and ruined condition of the city consequent to the earthquake and conflagration of April 1906.

San Francisco was undergoing a period of reconstruction. The streets in the burned districts were littered with all kinds of debris, and in certain sections of the city many persons were living under most insanitary conditions. Some districts were very much congested because of the sudden influx of refugees and the lack of legal restrictions regarding the placing of frame cottages and the building of stables. Thousands of refugees had established temporary houses in the vacant and sparsely settled portions of the city, some of which were scattered, some clustered in small groups. Most of these abodes were without any of the ordinary sanitary conveniences.

Several large refugee camps were in operation under the direction of the Red Cross. These were usually maintained in good sanitary condition. However, in some locations speculators had built large, irregular camps covering an area of one or two blocks. In these, sewer connections and toilet accommodations were often most inadequate. The camps themselves were filthy in the extreme, and in some the conditions were deplorable. Uncovered holes in the earth, from which flies rose in clouds, served as latrines. Washwater and slops ran under and between the

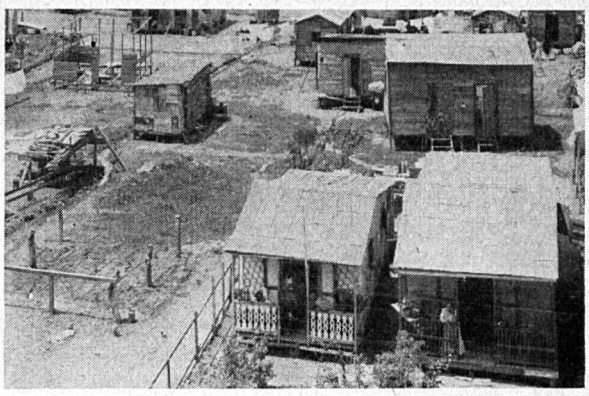
shacks, garbage was promiscuously scattered, and rubbish of all sorts littered the premises. The shacks themselves were nondescript affairs, constructed of scraps of sheet iron and bits of old lumber. Because they were close to the ground they afforded excellent rat harborage.

Garbage was almost universally kept in wooden boxes, barrels, and old boilers, and in many cases, it was taken to the nearest vacant lot and dumped. The scavenger service of the city was performed by private individuals, who removed the garbage for a stated sum per week. One of the most objectionable features of this system was the fact that the garbage cans, which the scavenger was supposed to furnish the householder, were, without exception, nondescript containers of the most insanitary pattern and without covers.

The majority of the stables in the city were hastily constructed buildings without any sanitary arrangements whatever. Grain was kept on the floor in sacks or in open wooden bins, no care was taken to prevent the entrance of rats, and very few stables were provided with suitable manure bins. There were numerous chickenyards throughout the city, and the unconsumed food therein furnished a ready source of food for rats. From one end of the city to the other there were innumerable rodent harborages. Stables with wooden floors close to the ground, planked yards, debris in the vacant lots, defective basements, and cellars all afforded a safe shelter for rats. The combination of these convenient breeding and nesting places plus a plentiful food supply made possible a large rat population. Coincident with this condition, fleas were unusually prevalent *(15)*.

This was the general picture of the city of San Francisco at the beginning of the second plague epidemic in 1907. These conditions could not start a plague epidemic, but once the seed was planted, it had very fertile soil in which to grow. This was the problem with which Passed Assistant Surgeon Blue had to contend when he arrived in San Francisco.

Experience in Manila, P. I., suggested that when the number of infected rats secured by general trapping reached 1 percent of those examined the situation was dangerous, and when the figure reached 2 percent, it usually meant a serious outbreak of human plague. The percentage of plague-infected rats in San Francisco climbed to 1½ percent in December 1907. Dr. Blue felt that an emergency existed and was convinced that the public must be aroused and that they should go to work fighting rats instead of fighting the city board of health *(16)*.



Refugees from fire-swept areas, living in squatters' shacks, San Francisco, 1907.

Early in January 1908, at Dr. Blue's suggestion, Dr. George H. Evans, president of the California State Medical Society, sent 600 invitations to leading business and professional men asking them to meet and consider the situation. Only 60 appeared. However although lacking in numbers, they were not lacking in spirit. They passed a resolution calling on Edward R. Taylor, mayor of San Francisco, to appoint a committee of 25 citizens to secure the cooperation of the public with the health authorities. The resolution received the active attention of the officers of the commercial organizations, who issued a call to their members and to the general public for a mass meeting on the floor of the Merchants' Exchange on January 28. Thus was launched a popular movement which was to become an example of civic cooperation and of what can be accomplished when community energy is directed against a common enemy.

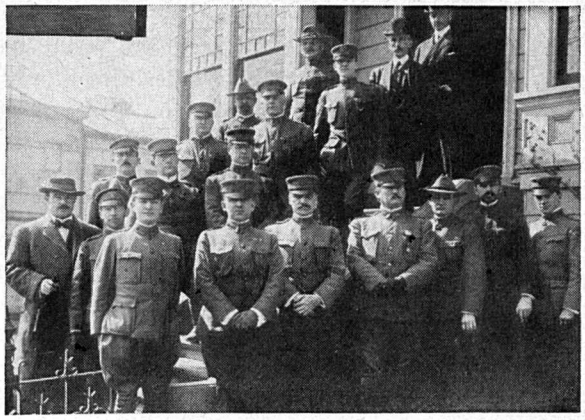
The January mass meeting was much better attended than the meeting of business and professional men, because people were getting a better idea of what was wrong. The meeting was addressed by Dr. Blue, who presented a report on what had been done already and told the meeting why he was so concerned about the plague-positive rats reaching 1½ percent of those examined. The infection, he explained, was so widespread that the difficulties were be-

coming greater than the health department could cope with. It had become necessary for householders to cooperate with the health authorities, clean up their premises, shut off the rats' food supply by keeping all garbage in tightly covered metal cans, and make rats homeless by destroying their nests.

The meeting was also addressed by Dr. Martin Regensburger, president of the State board of health; Governor James Norris Gillett; Dr. William Ophuls, president of the San Francisco board of health; Passed Assistant Surgeon W. C. Hobdy, quarantine officer for San Francisco; and Edward R. Taylor, mayor of San Francisco, who announced the names of members of the Citizens' Health Committee:

Homer S. King, president, San Francisco Clearing House Association
Charles C. Moore, president, Chamber of Commerce of San Francisco
Frank J. Symmes, president, Merchants' Association of San Francisco
A. W. Scott, Jr., president, Civic League
T. C. Friedlander, secretary, Merchants' Exchange
L. M. King, secretary, Merchants' Association of San Francisco
H. W. Goodall, Shipowners' Association
E. H. Rixford, San Francisco Bar Association
Gustave Brenner, San Francisco Credit Men's Association
H. H. Sherwood, San Francisco Board of Trade
R. H. Wayne, Shipowners' Association
James McNab, Draymen's Association
Walter Macarthur, organized labor
Martin Regensberger, M.D., president, State board of health
N. K. Foster, M.D., secretary, State board of health.
James H. Parkinson, M.D., California State Medical Society
Philip Mill Jones, M.D., editor, California State Journal of Medicine
John Gallwey, M.D.
Charles G. Levison, M.D.
Langley Porter, M.D.
Harry M. Sherman, M.D.
H. C. Moffitt, M.D.
E. N. Ewer, M.D., health officer, Oakland, Calif. (later replaced by F. D. Tait, M.D.)

Beginning on January 30, 1908, the Citizens' Health Committee held 9 meetings of the general body and 66 meetings of its executive committee. The committee collected $177,412.38 and disbursed $138,943.65. In addition to the force maintained by the board of health and the Federal Government, the health committee kept 400 paid inspectors and laborers in the field for several months, trapping and poisoning rats, and put to work a large force of volunteer inspectors. It purchased nearly $15,000 worth of rat traps and poisons and paid $12,375 in rat bounties. It printed and distributed 700,000 circulars and other pieces of literature.



United States Public Health and Marine-Hospital Service officers and members of San Francisco Citizens' Committee.

Front row (left to right): **Assistant Surgeon Joseph R. Hurley, Passed Assistant Surgeons William Colby Rucker, Charles W. Vogel, Rupert Blue, Halstead A. Stansfield, Carroll Fox, and Richard H. Creel.**

Second row (left to right): **Dr. Gunn (city health officer), Acting Assistant Surgeons Louis L. Schmitt, Bruce F. Ffoulkes, George M. Converse, Philip M. Thomas, and Chester H. Woolsey, and L. M. King (secretary, Citizens' Health Committee).**

Back row (left to right): **Acting Assistant Surgeons Howard H. Hopkins, Joseph L. Howard, and G. A. Weyer, and Medical Inspector Arthur D. Prentice.**

This tremendous accomplishment was brought about by a good organization, which worked through subcommittees. The executive committee was composed of Charles C. Moore, chairman, Frank J. Symmes, Walter Macarthur, Gustave Brenner, and Dr. George H. Evans. A. W. Scott, Jr., later took Mr. Symmes' place. The executive committee was charged with the appointment of subcommittees of citizens in all lines of business and social activities and, with Dr. Blue, was given full charge of work under the auspices of the Citizens' Health Committee, with power to

make contracts and disbursements according to its own judgment.

Nine special committees and 45 subcommittees were appointed; 224 men and women served on these committees. In addition, the president of the Bar Association, with the approval of the district attorney, appointed 4 committees of 5 lawyers each to take charge of the prosecution of health cases in police court (*16*).

Legal authorization was provided for the work in a series of 11 city ordinances:

Ordinance No. 384. Required the concreting of all floors and ratproofing of all coops and houses in which chickens, rabbits, geese, ducks, pigeons, etc., were kept within certain limits of the city and county of San Francisco.

Ordinance No. 369. Required the ratproofing of all buildings and basements, the maintenance of rat traps in slaughterhouses, docks, warehouses, etc., prevented the dumping of garbage, offal, manure, etc., on any land or water within the limits of the city and county of San Francisco, and required the keeping of all buildings in a sanitary condition.

Ordinance No. 357. Required every residence or other building where food was kept for human consumption to be provided with garbage can and scavenger service.

Ordinance No. 13. Required the screening of all bakeries, restaurants, and other places where human food was kept.

Ordinance No. 1409. Required that no more than two cows be kept within certain limits of the city and county of San Francisco.

Ordinance No. 1410. Required that swine be kept only for the purpose of loading, unloading, and slaughtering; and only within the limits of Butchertown reservation.

Ordinances Nos. 65–1029. Required vehicles used for transportation of garbage, swill, and manure to be approved by the board of health.

Ordinance No. 138. Prohibited human occupation of insanitary structures or cellars.

Ordinance No. 162. Prohibited the selling of herbs or vegetables grown within 1,000 feet of a sewer outlet.

Ordinance No. 193. Required all unsafe and insanitary stables condemned by the board of health to be vacated.

Ordinance No. 328. Required all unsafe and insanitary structures unfit for human habitation condemned by the board of health to be vacated (*15*).

The Committee on Sanitary Regulations made these recommendations as a sort of preliminary plan:

1. The employment of sanitary inspectors sufficient to cover the entire city at least once every 48 hours.

2. The appointment of inspectors as special police officers and deputies to the health department.

3. The prosecution of offenders by the Bar Association.

4. The collection of $500,000.

5. Full charge of all work to be shared by the executive committee and Dr. Blue.

The subcommittees were the most effective agency in the work that followed. Through them an attempt was made to reach every housewife by exerting influence on the man of the house. Employers were made responsible for interesting every employee in cleaning up his premises and in killing rats. For several months San Francisco was a city of meetings; 162 were held in 6 weeks.

To collect funds to carry on plague-control activities a system of calling together persons engaged in different trades was adopted. Forty-two meetings were held, and committees were appointed from each trade. These committees went actively to work gathering the necessary money. An executive finance committee and an advisory finance committee assessed firms and individuals in proportion to their estimated assets. Everybody was given a chance to contribute, and the sums received ranged from $30,000 from the Southern Pacific Railway to 50 cents from an individual. The original goal of $500,000 was never reached, but the tremendous effort put forth by the individual citizens themselves made this amount of money unnecessary. As a matter of fact, a 19-percent refund was later returned to all contributors to the original fund.

The San Francisco clergy played an important part in getting people interested in the antiplague work. At least once a month, every minister in the city was supposed to devote a sermon to the subject.

The women of the city contributed a great deal to the success of the campaign. The movement among the women was started by the Citizens' Health Committee, through the California Club. A committee of nine women was appointed and a mass meeting of all the women's clubs in the city was called, at which 60 organizations and 45 churches were represented. The work was divided into sections corresponding to the city's 13 sanitary districts.

Acting Assistant Surgeon G. A. Weyer and staff. (In front of District 7 headquarters, San Francisco.)

Committees were appointed to function in each district and 5 special committees were appointed for 5 other areas. The organization was known as the Women's Sanitation Committee and, after the Citizens' Health Committee disbanded, it became a permanent organization with the name of Women's Public Health Association of California.

Dr. Blue detailed officers to address public meetings called by the Citizens' Health Committee, and in a short time there were comparatively few people in the city and county who were not thoroughly instructed as to the history, nature, and mode of spread of plague and the necessity for placing the entire city in a sanitary condition (*16*).

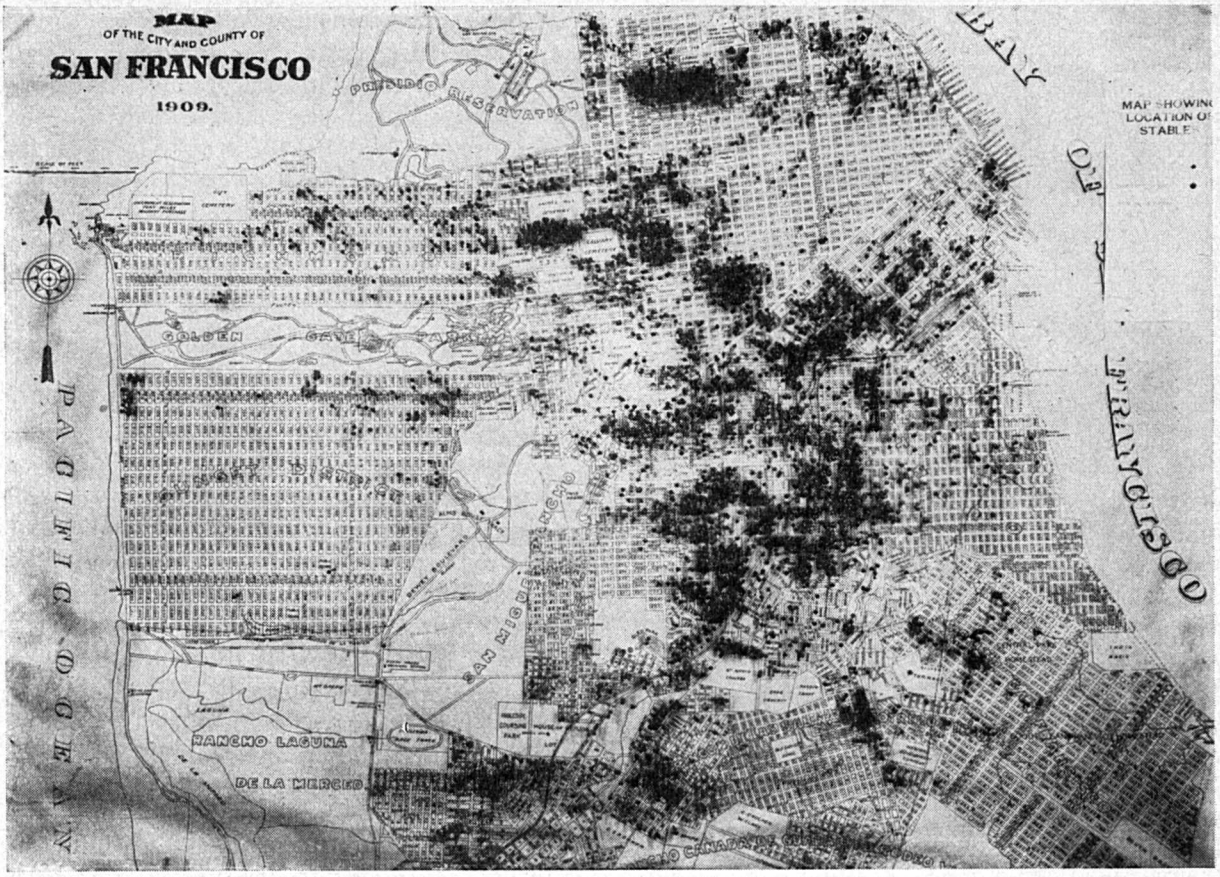
Up to June 30, 1908, 1,680 sick persons suspected of being infected with plague were examined, 3,973 inspections of the dead were made, and 5,320 houses were disinfected. A total of 203,642 rats were trapped and 90,720 were examined. In the Public Health and Marine-Hospital Service laboratory, 60,300 rats were examined and 306 were found infected with plague. Over 7 million pieces of poisoned bait for the destruction of rats were put out.

The work at Committee headquarters at 401 Fillmore Street was divided into three divisions: statistics, personnel, and laboratory. The divisions of statistics and personnel were under the direction of the executive officer, Passed Assistant Surgeon W. C. Rucker, who was responsible for organization and discipline in the districts. The division of laboratory investigation was under the direction of Passed Assistant Surgeon H. A. Stansfield until March 23, 1908, after which date the work was in charge of Passed Assistant Surgeon Carroll Fox in association with Passed Assistant Surgeon G. W. McCoy.

The work of the laboratory was divided into four parts: examination of rats, attendance at and performance of autopsies, examination of persons with illness suggestive of plague, and general laboratory work. The work was carried out along the lines laid down by the Commission for the Investigation of Plague in India. Diagnosis was made on the basis of gross lesions rather than on microscopic findings alone. Careful search was made for lesions of the cervical, axillary, inguinal, pelvic, and mesenteric glands. The condition of the liver, spleen, and lungs was noted. The diagnosis was confirmed by bacteriological procedures and animal inoculation in all cases in which plague was suspected.

When the Service took charge of plague-suppressive measures in San Francisco, the city had already been divided into sanitary districts by the city health officer, and an active campaign to eradicate plague and to destroy rats had been started, with a small force of men under the direction of local physicians working in each district. For the most part, district boundaries were not changed and most of the physicians were retained by the Service as acting assistant surgeons. Ten commissioned officers and 13 acting assistant surgeons of the Public Health and Marine-Hospital Service were assigned to duty in San Francisco, and 31 inspectors, 56 assistant inspectors, 102 foremen, and 534 laborers were employed. Each district had its field office, with a medical officer in charge and a corps of inspectors, assistant in-

Personnel of District 6, San Francisco, 1908.



Stables remaining in San Francisco after nearly 1,400 were vacated or destroyed, 1909.

spectors, foremen, and laborers. Headquarters were established for the districts and a laboratory was installed (*15*).

The city and county of San Francisco appropriated $11,000 a month to pay for labor and supplies, and Service officers directed the work. This system was continued until November 25, 1908, when, in response to a request from the finance committee of the board of supervisors of the city and county of San Francisco, the Service assumed payment of the salaries of all personnel.

An office was furnished each medical officer in charge in a central portion of his district; telephone connections were installed; and sufficient supplies to begin the work were issued. The inspectors conducted the sanitary reconnaissance of the district, including house-to-house and garbage-can inspection, followup of nuisance complaints, direction of foremen, serving of warrants, and compilation of data. The laborers were divided into gangs of five men each and were employed in trapping and poisoning rats and in fumigating and disinfecting premises. Five laborers and a foreman constituted a squad. For every two squads, there was one assistant inspector. For every two assistant inspectors, or four squads, there was one inspector.

Each district was divided into subdistricts, and an attempt was made to keep the same personnel in the subdistricts so that they could become familiar with the people and the buildings.

Each inspector was required to visit all the premises in his subdistrict. He spent about 20 minutes inspecting each premises, gave written notices to abate all nuisances, described in detail the nature of the corrective measures required, and noted the length of time to be allowed to complete the work. At the expiration of the allotted time, he returned for a reinspection. If conditions had not been corrected the owner of the premises was served with a notice to

Tagging morning's catch of rats, San Francisco.

appear at the district office and show cause why he should not be prosecuted. As a result, following issuance of 82,554 abatement-of-nuisance notices, it was necessary to make only 370 arrests and to assess only $587 in fines.

One interesting result of the sanitary inspections was the installation of 49,046 new garbage cans, or practically 1 for every home in San Francisco. Another was the work done on stables. Owners of nearly 4,000 stables complied with ordinance No. 193 by laying almost a million square feet of concrete. Nearly 1,000 stables were vacated and 371 were destroyed. An interesting innovation in ratproofing was the development of methods of elevation. Because so many buildings were built flat on the ground, they afforded good rat harborage. When these buildings were elevated 18 inches above the ground, rat infestation materially decreased.

The following figures (*16*) show the volume of work done on houses: condemned, 493; destroyed, 1,713; disinfected, 11,342.

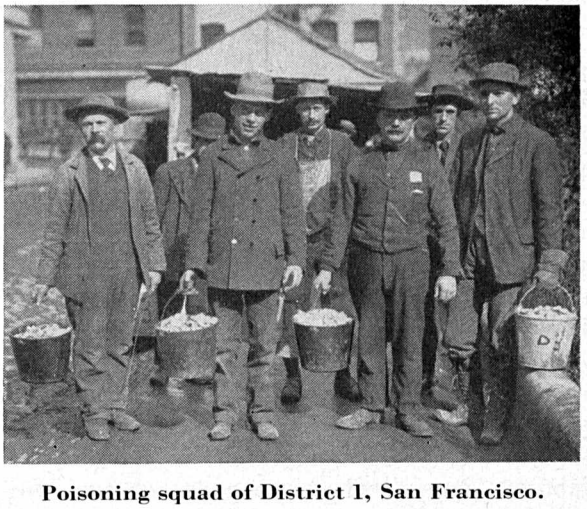
There were 276,000 square feet of concrete poured for sidewalks and over 4 million square feet of concrete laid down for basements and floors. Including the work done in stables and chickenyards, a grand total of nearly 6½ million square feet of concrete was laid.

A survey was made of the city's sewer system, which was found to be in a deplorable condition. In certain localities, the line and grade of the sewers had been dislodged by the earthquake and the main pipes had broken in places, allowing sewage to seep into the surrounding soil. In many places, the gradient of individual leads from occupied premises was insufficient or the leads were too small for the area to be drained. The corner catch basins were generally obstructed with sand and street sweepings, and rat runs and other signs of rat infestation were in evidence in the main and lateral sewers. In a few instances, the sewers were simply boxes constructed of redwood, while others were practically open creeks.

As a result of the survey, the supervisors of the city of San Francisco made an allotment in a new bond issue for rebuilding the entire sewer system and installing sewers in districts then unsupplied. Since the sewers were convenient highways for rodents, this measure proved to be important in the permanent eradication of plague from the city.

Schools were conducted to give special instruction to men performing plague control work. Classes were held in all district headquarters on fumigation, disinfection, poisoning, ratproofing, city ordinances, and bubonic plague in rats and in humans. Separate lectures were given to inspectors and assistant inspectors, and to foremen and laborers. Men who served in the campaign for 3 months or longer were given certificates of honorable discharge, showing the character of the work performed and the way in which it was done.

The trapping of rats constituted a very important measure of the usefulness of the cam-



Poisoning squad of District 1, San Francisco.

Laboratory examination of rats, San Francisco.

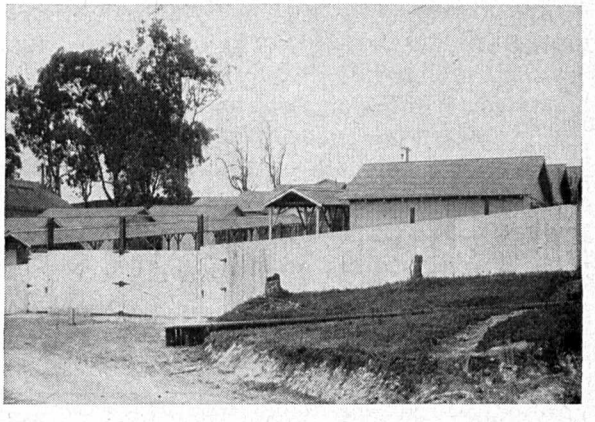
paign and was pursued uninterruptedly from the time the force was organized. A squad was provided with traps, and each foreman was assigned a number of blocks. In addition to the daily wage of $2.50, a bounty of 10 cents per rat was paid to the rat catchers. Large cage traps and spring traps were used. The cage traps were found more effective in stables and warehouses where rats were plentiful, while the spring traps were chiefly used around dwellings. Each laborer had about 35 cage and 30 spring traps. All types of baits were used, including cheese, meats, fruits, and vegetables. Rats were brought into district headquarters at 11:30 a. m. and at 5 p. m. Dead rats were carried in metal receptacles with tight covers. Live rats were transported in the cage in which they were captured, which was covered with a sack soaked in kerosene. As soon as they were caught, the rats were tagged to show where, when, and by whom they had been captured. If the rats were sick or had been found dead, this was noted on the tag. In the district headquarters, the rats were placed in large metal cans with tight-fitting lids and were transported to the laboratory at the general headquarters.

Danysz's virus was tried as a rat poison with no apparent success. The best results were obtained with arsenic and phosphorus paste placed on bits of bread. It was estimated that 700,000 rats were killed by this method, although no data are given to support the figure.

Whenever a case of rodent plague was discovered, the same measures were applied as for human cases. Every known means was employed to destroy rats and fleas, and in no instance did human plague occur on premises which had been thoroughly treated following the removal of plague-infected rats. Persons working or living in premises from which infected rats were taken were kept under observation for 8 days.

When the Service took charge in San Francisco, plague patients were being cared for in the contagious pavilion of the city and county hospital. The hospital was a large wooden building, poorly constructed, and swarming with rats. Several cases of plague had been contracted there. A plague compound, enclosing about 2 acres of ground, was therefore built at Army and De Haro Streets. This was surrounded by a galvanized iron fence 8 feet high, which rested on a concrete base sunk 3 feet into the ground. On the inner side of the fence was placed an inverted metal trough to make the escape of rats impossible should any be brought within the enclosure. The patients were treated in cottages and were provided with all the necessary comforts. The treatment of patients was in charge of Dr. A. A. O'Neil, assisted by a corps of nurses (*15*).

The routine followed in a human case of plague was as follows: As soon as a sick person whose illness in any way resembled plague was discovered, the case was reported to the board of health by the attending physician and then reported to the officer in charge of the district in which the case occurred. That officer then visited the patient and if, in his opinion, the illness was suspicious of plague, the sick person



Compound where plague patients were isolated, San Francisco, 1908.

was sent to the isolation camp. If doubt existed regarding the diagnosis, an expert was sent from headquarters to pass upon the case. After the patient was admitted to the camp, the diagnosis was confirmed by bacteriological and clinical examination by representatives of the Service and of both the State and city boards of health. During the period May 1907 through October 1908 (see table 1) 167 cases of plague occurred, with 89 deaths. Of the 167 cases, 112 were verified bacteriologically and 55 clinically. Of the total cases, 152 were bubonic, 6 were pneumonic, 3 were septicemic, and 6 were not classified as to type.

If clinical examination showed the case to be plague, a rapid sanitary survey was made of the premises from which the patient was taken. In the block in which the patient lived and in the blocks immediately adjacent, particular cognizance was taken of rat harborage, rat food, violation of regulations, and violations of ordinances requiring that the premises of stables, feed stores, and grocery stores be kept rat free.

The infected house was then carefully rendered gastight with strips of paper and was fumigated with 4 pounds of sulfur per 1,000 cubic feet of initial air space. All of the patient's bedding and wearing apparel which could not be thoroughly disinfected was burned. The house was kept sealed for 6 hours after the ignition of the last pot of sulfur and then was opened and aired. Curtains and carpets were thoroughly beaten in the sun, and then were sprayed with a strong solution of carbolic acid. The furniture was also sprayed with the carbolic acid solution. The floors were swept, the dust was burned, and the floors were scrubbed with a disinfectant. A thorough search was made for ratholes and rat harboring places. Decayed wood floorings, defective floor boards, and hollow wood partitions were removed and opened. Dead rats were frequently found in these places in numbers. Ratholes in floors and sidewalks were filled with broken glass, covered with sheet metal, or closed with cement. Rat poison was then spread in the infected and contiguous blocks, and all neighboring householders were notified that they must maintain their premises in a clean condition.

Table 1. Seasonal distribution of human cases of plague and corresponding distribution of plague-positive rats, May 1907–October 1908

Date	Human cases	Infected rats
1907		
May	1	0
August	20	0
September	61	4
October	31	23
November	41	37
December	11	43
1908		
January	1	64
February	0	89
March	1	62
April	0	36
May	0	20
June	0	3
July	0	1
August	0	1
September	0	0
October	0	2
Total	167	385

Preparing for sulfur fumigation of infected building, San Francisco, 1908.

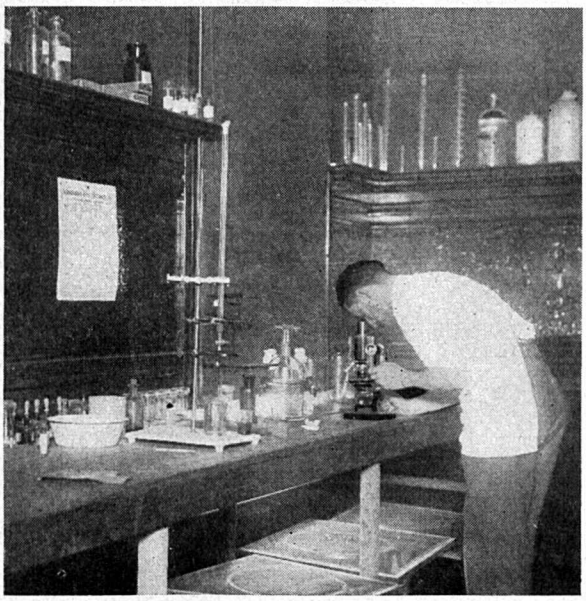
A portion of all rats brought in alive were chloroformed and their ectoparasites were combed off, placed in a small vial of alcohol, and several thousand specimens were forwarded to the Hygienic Laboratory (now the National Institutes of Health) for identification. Other specimens were identified by Passed Assistant Surgeon Carroll Fox, with the assistance of R. W. Doane of Leland Stanford, Jr., University, and M. B. Mitzmain of the University of California. Among the fleas recovered, there

was a preponderance of *Nosopsyllus fasciatus* (Bosc). The percentages of various species among 10,972 fleas examined from all districts were:

Species of fleas	*Percent*
Nosopsyllus fasciatus (Bosc)	68. 07
Xenopsylla cheopis (Rothschild)	21. 36
Pulex irritans Linnaeus	5. 57
Leptopsylla segnis (Schönherr)	4. 48
Ctenocephalides canis (Curtis)	. 52

Although the city as a whole showed an overwhelming majority of *N. fasciatus*, some districts showed a preponderance of *X. cheopis* while others had more *P. irritans*. Sickly and very young rats were flea-infested in an extreme degree. The highest indexes of flea infestation were noted in September and October, with a diminution from then until April (*15*).

On August 26, 1907, the quarantine officer of San Francisco was ordered to fumigate all vessels leaving for ports in Canada, Mexico, Hawaii, or the United States. By June 30, 1908, 2,796 vessels had been disinfected. Sulfur was generally used, and 620,000 pounds were burnt. Over 4,000 gallons of alcohol were used. One ship produced over 500 rats; another, over 300 rats. Usually, subsequent fumigations produced fewer rats, and after the third or fourth fumigation, a ship was generally rat-free



Passed Assistant Surgeon Carroll Fox
(In Plague Headquarters laboratory, San Francisco.)

Pulicidal solution sprayer used to control fleas, San Francisco, 1908.

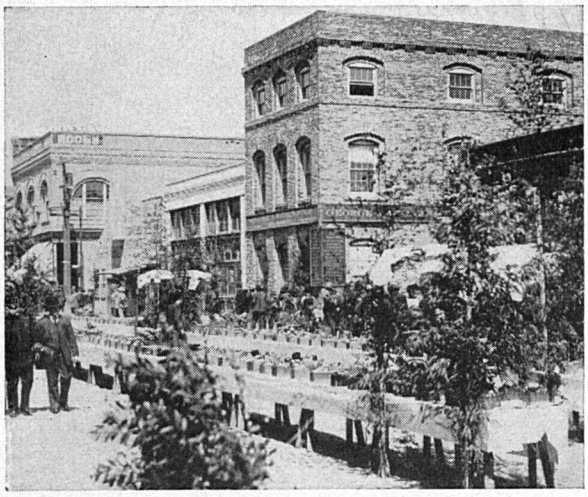
(*15*). In June 1910, one plague-infected rat was found on the Japanese S. S. *Nippon Maru* after fumigation (*17*). This was the first plague-positive rat ever found on board a ship in this country, and the only plague-positive rat ever found on board ship at San Francisco. In brief, the plague-suppressive measures instituted by the Service in San Francisco included:

1. Widespread and intensive trapping and poisoning of rats, and examination of rats to determine the delineation of the epizootic.
2. The treatment of rodent foci by disinfection of premises with a pulicidal solution, the destruction of rodent harborage by a "wrecking crew," and the installation of ratproof construction in as short a time as possible.
3. Widespread ratproofing of buildings, both old and new construction, throughout the city.

The effectiveness of these measures was attested by the fact that the last human case of plague occurred 4 months after the adoption of control measures, and there ensued a rapid subsidence of rodent cases within 6 months. Rodent plague was practically eradicated within 8 months.

4. Effective maritime quarantine procedures on incoming as well as outgoing ships.

The second epidemic of plague in San Francisco was in decided contrast to the first. There were no ideas that Asiatics were particu-



Banquet in the Streets, San Francisco, 1909.

(The Produce and Commission House District celebrated the conclusion of the plague campaign in this manner.)

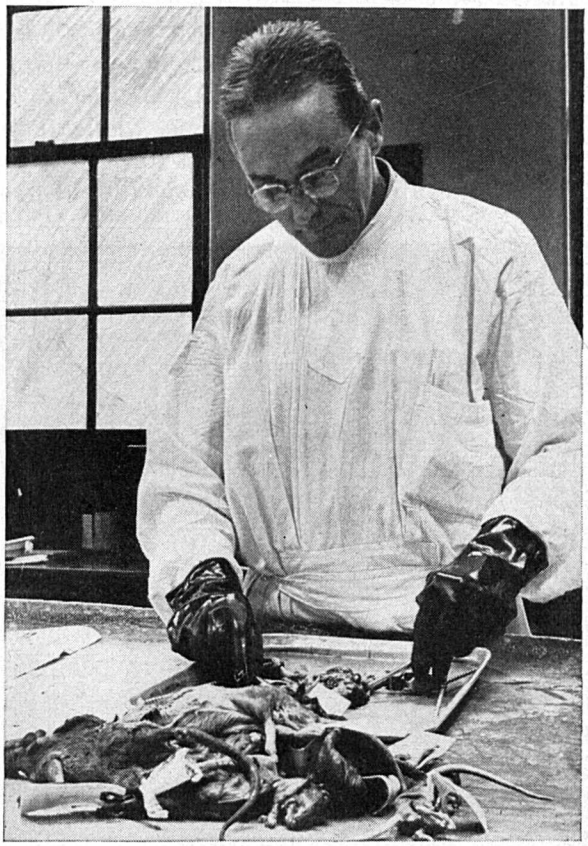
larly susceptible to the disease and, as a matter of fact, very few of the patients were of Asiatic origin. The rat and its fleas were accepted as the host and the vector of the infection. There were no attempts to conceal cases of plague or to deny that plague existed in the city and, without exception, all officials concerned were completely cooperative. There existed a fear that, unless adequate measures were taken, the entire State of California might be quarantined, with a considerable loss of commerce. The gratifying response of civic organizations and their leaders and the influence which they ultimately wielded will be impressed upon anyone who cares to go over the record. Unquestionably, the duration of plague was considerably shortened by the cooperation of the public-minded citizens of the city.

About February 1, 1909, the original force of workers was considerably reduced. The work, however, continued along similar lines, and rats have been examined for plague ever since. The last plague-positive rat was found in 1941.

On March 31, 1909, at the Fairmont Hotel in San Francisco, a banquet was given in honor of Dr. Blue. The mayor of the city presented him with a gold watch and each Public Health and Marine-Hospital Service officer who had participated in the plague-eradication campaign was given a medal.

In the fall of 1907, cases of plague were reported in Point Richmond, Oakland, and Berkeley. On September 18, 1907, on the invitation of Dr. N. K. Foster, secretary of the State board of health, Dr. Blue met with the city officials of Oakland and neighboring cities. As a result of this consultation, Oakland, Berkeley, Point Richmond, and Alameda decided to appropriate funds for a defensive campaign against the disease.

The city council of Oakland allotted $10,000 per month for the prosecution of plague-control work and requested the detail of an experienced Service officer to take charge. Passed Assistant Surgeon John D. Long was assigned to this duty under Dr. Blue's direction. The work was planned along the same lines as the work in San Francisco and consisted of trapping, poisoning, ratproofing, improvement of garbage collection and disposal, destruction of rat harborage, inspection of sick persons, disinfection of houses, and laboratory work. In



Examining rats in the plague laboratory, San Francisco.

the fall of 1907, 3 plague-positive rats were found, and during the calendar year 1908, 122 rats were proved to be plague-positive (*15*). In 1908 the Service set up a branch laboratory in Oakland and maintained it until November 1910. After that date captured rodents were sent to the San Francisco laboratory for examination (*20*). Trapping was finally discontinued in April 1914, more than 5 years after the last plague-positive rat was obtained (*23*). During the period 1907–11, 21 human cases of plague with 11 deaths occurred in Oakland (see table 2).

The last case of and death from human plague in Oakland occurred in June 1922, making a total of 36 cases with 25 deaths, including the 14 cases with 13 deaths in the 1919 epidemic (*25*). In December 1924, rodent plague was again found in Oakland, and an intensive rodent control program was instituted. Between December 1924 and March 1925, 21 plague-positive rats were found. Plague control was continued until March 1926 (*38, 39*).

The citizens of Berkeley raised $10,000 in 1907 to be used in plague-suppressive measures. A force of inspectors and laborers was employed under Dr. Long's direction and conducted operations in Berkeley until early in 1908 (*15*). In February 1910, plague-infected squirrels were found near the Berkeley city limits and rat trapping was again instituted (*19*). This was continued until April 1914, when the work in the east bay cities was stopped (*23*). During the above period, no cases of rodent plague were found in Berkeley, although one human case occurred in November 1907 (*15*).

Table 2. Human plague in Oakland, Calif., 1907–11

Year	Cases	Deaths
1907	16	9
1908	3	2
1909	1	0
1910	0	0
1911	1	0
Total	21	11

Similar work was carried on in Richmond, Point Richmond, and Emeryville during fiscal years 1908 and 1909. No plague-infected rats were found in these communities, but three human cases of plague with two deaths occurred in Richmond and Point Richmond during the fall of 1907 (*15, 18*).

Alameda never carried on any antiplague activities, although some rat trapping was done there by Federal employees during the fiscal year 1912 (*21*). One human case was reported in Alameda in June 1909.

During the period 1908–27, 10 cases of plague with 8 deaths occurred in residents of rural Contra Costa and Alameda Counties, making a total of 14 cases with 12 deaths for these two counties, all presumably contracted from wild animals.

Chapter IV

Plague in Seattle, Washington

In Seattle, plague first occurred in the fall of 1907. Although most official records show only three proved fatal cases, presumptive evidence indicates that there were seven deaths in 1907 and one in 1913. In his "Review of Plague in Seattle" (*26*), Medical Director L. D. Fricks gives the details of these deaths, which are summarized in table 3.

E. C. O. was a policeman whose beat included that part of downtown Seattle where L. S. lived. E. C. O. was nursed by his sister, L. M. O. The attending physician stated later that L. M. O.'s symptoms were identical to those of A. O., another sister, and that he was convinced in retrospect that L. M. O. also had had pneumonic plague. C. O. E. was a helper to the undertaker who embalmed E. C. O. M. E. O. was E. C. O's sister-in-law. The epidemiological evidence supporting the inclusion of cases 1, 2, and 3 as presumptive cases of plague is self-explanatory. However, no reason is given by Dr. Fricks for the inclusion of J. S. in the series except that this Chinese man's death occurred about the same time as the others (*26*).

An eighth Seattle case (L. W.) occurred in December 1913 (see appendix, p. 97), but was never proved to be plague. The body of the victim was autopsied after being embalmed, and organisms similar to *Pasteurella pestis* were observed, but could not be cultured. A board of four Public Health Service officers made a diagnosis of probable septicemic plague (*27*).

As soon as the diagnosis of L. S. was confirmed in October 1907, the Service was requested by the Governor of the State of Washington and the mayor of the city of Seattle to assume the direction of antiplague activities. Passed Assistant Surgeon L. E. Cofer was detailed to this job and work was begun on November 9 (*15*).

Two city ordinances were enacted in November 1907, for the purpose of improving the sanitary conditions in the city and thereby combating plague. The first was a nuisance ordinance (No. 15957) prohibiting the dumping of garbage, human excrement, butcher's offal, or dead animals, particularly fish, on premises within the city limits. The second ordinance (No. 17391) provided for the protection of buildings from invasion by rats. This ordinance was one of the first ratproofing ordinances in the United States enacted as a plague control measure (*26*).

The Service was responsible for medical supervision of plague-control activities, laboratory facilities, and ship disinfection; the city of Seattle provided the men and material for municipal sanitation. A central office was located in a six-room building especially constructed for this purpose on the corner of Jackson and Maynard Streets. Space was provided there for executive and clerical workers, bacteriology laboratory, morgue and autopsy room, animal house, and manufacture of poison.

A survey was made and it was found that the bulk of the sanitary work could be confined to 218 city blocks. However, rat extermination was to be carried on in the entire city. The city was divided into 6 sections, which were further subdivided into regularly defined districts comprising 9 to 20 blocks each. Each section was under the direction of an acting assistant surgeon with from 6 to 9 assistants.

It was the duty of the medical officer and his assistants to make a detailed inspection of the sanitary condition of each house. Reports of these inspections included notes on the method of garbage disposal, whether or not metal cans were used as garbage containers, rubbish which should be hauled away, plumbing irregularities,

Table 3. Deaths from human plague in Seattle, Wash., 1907

Case No.	Initials	Date of onset	Date of death	Diagnosis
1	E. C. O.	Oct. 7	Oct. 13	Typhoid and endocarditis.
2	L. M. O.	Oct. 15	Oct. 19	Double lobar pneumonia.
3	C. O. E.	Oct. 16	Oct. 18	Do.
4 [1]	L. S.	Oct. 16	Oct. 19	Bubonic plague.
5	J. S.	?	Oct. 17	Aortic stenosis.
6 [1]	A. O.	Oct. 21	Oct. 24	Pneumonic plague.
7 [1]	M. E. O.	Oct. 25	Oct. 31	Do.

[1] Plague proved by microscopic, bacteriological, and animal inoculation.

and places where rat poison should be distributed. Every landlord was given a written order to comply with the recommendations made, and failure to do so resulted in a special report to the chief of police. A detailed map of each block was drawn up and filed in a book, where it was easily accessible for reference. The districts were inspected repeatedly at regular intervals. Inspections included house-to-house inspection of the occupants in a search for illness suspicious of plague.

The collection and disposal of garbage was one of the most serious difficulties encountered in cleaning up the city and in depriving rats of food. Garbage was collected by a draying and trucking corporation, which charged each householder a monthly fee. Failure to pay resulted in garbage being left on the premises. In some sections of the city, garbage was not collected at all, but was merely disposed of on vacant lots or thrown into the streets. In 2 months' time, after each household was required to use a metal garbage container, and after the collection system was improved, the total amount of garbage collected increased about 50 percent. Disposal of rubbish, elimination of rat harborage, and ratproofing of food depots accompanied the general program of carrying out sanitary measures.

In addition to the regular rat trappers, the public was encouraged to bring in rats by the payment of a bounty of 10 cents for every rat delivered at the laboratory. Rats were also killed by the extensive use of poison. A pharmacist was employed whose full-time job was the manufacture of poisoned baits. Phosphorus, barium, and arsenic were used in regular rotation. Between November 6, 1907, and January 22, 1908, 128,800 pieces of poisoned bait were distributed.

The laboratory was under the direction of Passed Assistant Surgeon M. J. White. Each rat was tagged to show where it was caught. Fleas were removed for identification and the rats were then dissected. If appearances were suggestive of bubonic plague, smears were made of the spleen, liver, and lymph nodes, followed by culture and animal inoculation. From November 6, 1907, to January 22, 1908, 15,475 rats were examined and 4 were proved to be plague-infected. Table 4 shows the number of rats found plague-positive in the 10-year period 1908–17.

Table 4. Number of rats examined and number found plague-positive, Seattle, Wash., fiscal years 1908–17

Fiscal year	Rats examined	Rats plague-positive
1908	40, 475	14
1909	48, 652	7
1910	25, 425	1
1911	49, 212	0
1912	45, 131	3
1913	45, 228	0
1914	25, 793	40
1915	15, 531	13
1916	12, 818	3
1917	12, 891	3
Total	321, 156	84

The number of plague-positive rats obtained decreased gradually during the fiscal years 1908–11, with a recurrence of positives in the fiscal year 1912. During this period, there was a marked decline in public interest in plague, and antiplague activities were carried on by the city health department on a modified basis.

There then followed a period of nearly 2 years in which no infected rats were found.

The disinfection of ships was under the direction of Passed Assistant Surgeon M. W. Glover. Seattle had an intensive trade with Alaska and British Columbia and with other parts of Washington, most of which was carried on by shipping. Routine fumigation of vessels with sulfur was done to kill rats and to keep plague from spreading to other areas (*15*).

On September 29, 1913, a rat was obtained which later proved to be plague-positive. As soon as the provisional diagnosis was made, the Surgeon General of the Public Health Service urged that prompt and efficient antiplague measures be instituted.

A committee of businessmen was formed to cooperate with the city health commissioner. On December 10, after a conference with the State health commissioner, a part of the antiplague work was placed under the direction of Surgeon B. J. Lloyd, who was appointed deputy State health commissioner (*23*). Dr. Lloyd instituted a new method of mass examination of all rats obtained. Previously, guinea pigs were inoculated only to confirm the autopsy findings in rats with pathology suggestive of plague. However, in order not to overlook the disease in any rat, Dr. Lloyd had the daily catch of rats divided into three or four lots. A small piece of spleen was taken from each rat of a given lot, ground up, and the whole mass inoculated subcutaneously into guinea pigs. Tissues from rats found dead, however, were not combined but were inoculated individually into the guinea pigs (*23*). Either there was a great deal of plague present in Seattle in 1914, or this new method assisted immensely in demonstrating that which was present.

The plague-suppressive force was soon increased to a total of 30 men, 25 of whom were paid by the city. A vigorous campaign against insanitary buildings was instituted, and about 3,000 buildings in the infected zone were ratproofed by individual property owners under instructions from the city health commissioner. In March 1914, the entire plague-suppressive work was placed under Public Health Service jurisdiction. Shortly afterward, the city council passed an ordinance (No. 32988) requiring ratproofing of all new buildings and of all buildings undergoing repairs to the value of 40 percent of the building. The methods specified included elevation, concrete foundation walls, and concrete floors (*26*).

Immediately after the passage of this ordinance, the plague-control work was reorganized with the following objectives:

1. Prevention of the introduction of plague from other ports.
2. Trapping and poisoning operations, including collection of dead rats.
3. Laboratory examination of rodents and of persons with illnesses suspicious of plague.
4. Educational work by means of lectures and circular letters to all persons making complaints about rats.
5. Intensive trapping of rats by residents in certain districts.
6. Trapping operations in cities outside of Seattle.
7. The extermination of existing foci in Seattle.
8. The ratproofing of buildings outside of Seattle.
9. The maintenance of full cooperation of State and local authorities.

This program was continued actively for about 7 years, after which the work was carried on with a reduced force.

During the fiscal years 1916, 1917, and 1918, over 10,000 rats were examined from Everett and Tacoma, Wash., without finding any evidence of plague. From July 1, 1917, to June 30, 1933, an additional 157,000 rats from Seattle were examined, with negative findings (*26*). The examination of rats has been continued along similar lines until the present time. No plague-infected rats have been discovered since 1917.

In November 1907, the city of Seattle appropriated $15,000 for municipal sanitation. It is estimated that the city spent more than $50,000 from the beginning of the outbreak until the beginning of the second campaign in 1913. Of the amount, $16,369.20 was paid out in rat bounties. After 1913, the city appropriated several thousand dollars a year for the salaries of trappers (*26*).

Chapter V

Plague in Wild Animals

The existence of a plague epizootic in rural Contra Costa County, Calif., was suspected as early as the summer of 1903. In August and September of that year, three human cases of plague occurred in widely separated sections of the county. The investigation which followed failed to connect any of the cases with a previous case of human plague. Although domestic rodents were not plentiful, two of the victims had been hunting ground squirrels and one had eaten ground squirrels prior to falling ill. The records show that efforts were made to collect sick and dead squirrels for examination, but there is no evidence as to how many were actually obtained (*16*).

These incidents were remembered by Dr. Blue when two human deaths from plague occurred in July 1908 in Contra Costa County, one near Concord and the other near Martinez. Although the two deaths were not associated, a force of trappers was immediately put to work collecting squirrels from ranches in the vicinity. A plague-infected squirrel was found on August 5 on the ranch where the first death had occurred. During the next 2 months, 3 more plague-positive specimens were obtained from a total of 423 squirrels.

At almost the same time, attention was called to a case of plague in Los Angeles which resulted when a boy was bitten by a ground squirrel on August 5. Subsequently, another squirrel was found dead in the same vicinity and was proved to be plague-infected. Although a considerable search was carried on for infected rodents for several months afterward, no more were found (*18*).

These instances provided the first evidence of the existence of plague infection in wild rodents in this country.

Dr. Blue stated in 1909 that the demonstration of natural plague in the California ground squirrel was perhaps the most important observation of the antiplague work of 1908. He then initiated a campaign which was directed at the eradication of what he thought would otherwise be a permanent focus of plague in the United States, and a constant menace not only to San Francisco, the bay cities, and the State of California, but also to the entire Nation (*16*). Thus began the concern over plague foci in wild animals, which was destined to continue for the next 40 years.

The ground squirrel, *Citellus beecheyi*, was known to have a wide distribution throughout California. Its various subspecies could be found in almost the entire State with the exception of the arid southeastern portion. From sea level, the infestation extended to a point at approximately 7,000 feet elevation in both the Coast Range and the Sierra Nevada Mountains. From California, there extended northward and eastward an unbroken chain of rodents which were capable of passing along the infection. The prevailing fleas on the *beecheyi* squirrel were *Diamanus montanus* (Baker) and *Hoplopsyllus anamolous* (Baker), both of which were known to bite other animals, including man (*19*).

In the year ending June 30, 1909, 3,826 ground squirrels were examined from Contra Costa County and 42 squirrels were found to be plague-infected. In the same year, 13,922 animals were examined from Los Angeles County: 4,722 ground squirrels (1 plague-positive), 8,288 gray rats, 564 black rats, 125 pocket rats, 96 mice, 69 white rats, 32 rabbits, 23 gophers, 2 skunks, and 1 wild rat. Eighteen ground squirrels were examined from Oakland and all proved to be negative for plague (*18*).

The finding of plague-positive squirrels in Contra Costa and Los Angeles Counties radically changed the nature of the antiplague work.

Ground squirrel burrows and runways, California

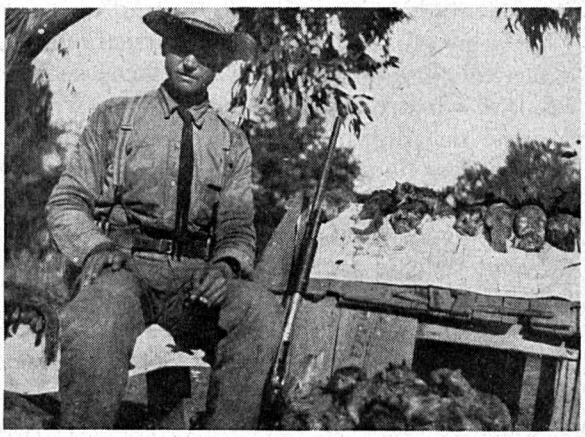
Previously, the measures had been confined to certain cities and adjoining territories, and consisted of destruction and examination of rats, cleaning of premises, removal of garbage, destruction of rat harbors, and ratproofing of premises. Subsequently, primary concern was with the nature and extent of the infected wild animals, especially the ground squirrel.

In April 1909, a well-organized campaign was inaugurated to determine the extent of plague infection among ground squirrels and to evolve, if possible, a plan for its complete eradication. Men were assigned to various parts of Contra Costa County and were provided with shotguns, gun oil, cleaning rods, knapsacks, canteens, squirrel tags, twine, chloroform, report blanks, stationery, and milk cans. They were directed to tag each squirrel individually, showing the name of the ranch on which the squirrel was found, its direction and distance from the nearest town, and the section, township, and range in which the ranch was located. At the end of the day's shooting, the squirrels were placed in the milk cans, a definite quantity of chloroform was added to destroy fleas, and the tops of the cans were tightly closed. The cans were then forwarded by express to the laboratory and a report of the day's operation was made to headquarters (*19*).

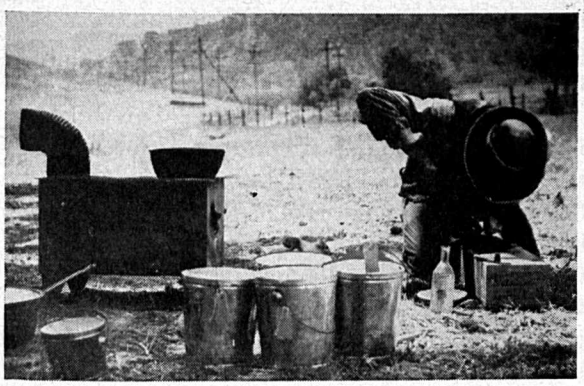
During the early part of the campaign, squirrel eradication activities were confined to the counties of Alameda and Contra Costa, which are contiguous to San Francisco Bay, but at the end of September 1909, the disease had been found to be so widespread that operations were extended farther south. In October, scouting parties were sent into Santa Clara, San Benito, San Joaquin, Merced, and Stanislaus Counties. On October 16, an infected squirrel was found in San Benito County, and on October 30, three infected squirrels were found in Santa Clara County. During the same month, hunters were sent north into Solano County; but since so few squirrels were found, the hunters were withdrawn at the end of the month. Shipments of squirrels from two other northern counties, Napa and Colusa, were received but nothing suspicious was recorded.

In Contra Costa County, the disease was found to be so prevalent among squirrels that an attempt was made in the latter part of October to institute a general eradicative campaign. It was thought that the most successful end could be reached by supplying individual landowners with free poison. Accordingly, orders for poisoned wheat and for bisulfide of carbon were taken; and during the months of October, November, and December, 32,770 pounds of poisoned wheat and 885 gallons of carbon bisulfide were distributed among 840 farmers for application over squirrel-infested territory.

In November, operations were extended even farther south to include Santa Cruz, Ventura, Tulare, Santa Barbara, San Luis Obispo, Monterey, Fresno, and Kern Counties. Hunt-



Squirrel hunter, California.



Preparing poisoned wheat for squirrel control in California.

ers were withdrawn from Alameda, Santa Clara, San Benito, and Stanislaus Counties for this purpose. On November 20, an infected squirrel was found in the southern part of Santa Cruz County. Early in December, hunters were sent into San Mateo and Mariposa Counties, but at the end of December, no further extension of the zone of infection had been found. Examinations had been made of 51,323 squirrels; 305 had been found infected:

County	*Number of infected squirrels*
Contra Costa	240
Alameda	54
Santa Clara	9
San Benito	1
Santa Cruz	1
Total	305

In January 1910, realizing the potential danger in foci of squirrel infection scattered immediately beyond the bay cities of Berkeley, Oakland, and Alameda, it was decided to create a squirrel-free zone around these cities. A squad of men in charge of an inspector and under the immediate supervision of a foreman began squirrel eradicative work on January 7. A point on the bay north of the city of Berkeley on the county line was selected and, following a line from there to a point just north of the town of Diamond (North Fruitvale) and southeast of Piedmont Heights, a belt averaging 1 mile in width was made practically squirrel-free by the thorough use of bisulfide of carbon and poisoned wheat. Shortly after this work was undertaken, two foci of infection were found within the limits of this zone, and during January, February, March, and April, a total of 22 plague-infected squirrels was found, the disease being present in both acute and chronic forms.

In the spring of 1910, after no infection had been found in Ventura, Fresno, Mariposa, and Santa Barbara Counties, the hunters were withdrawn from these counties. Hunting was then started in Stanislaus, Santa Clara, and San Benito Counties, and additional men were sent to Monterey, Santa Cruz, San Joaquin, and Merced Counties. The work previously done in San Joaquin, Stanislaus, and Merced Counties had been confined principally to the foothills and to that portion of the valley east of the Southern Pacific Railroad. The hunters were directed to limit operations to the foothills and the territory lying west of the railroad. As a result, 5 infected squirrels were found in San Joaquin County, 5 in Stanislaus County, and 2 in Merced County. During the latter part of May, plague infection in squirrels first was found in Monterey County, but only after the careful examination of over 12,000 animals. On June 1, the work of squirrel examination was extended to include a portion of southern California, and hunters there were shooting within the city and county of Los Angeles and in the adjacent counties of Orange, San Bernardino, and Riverside. Table 5 shows the work accomplished.

These 25 counties represent all except the northeastern and eastern range of the *beecheyi* squirrel in California. Of the squirrels obtained, 4,700 were not examined bacteriologically. Branch laboratories were maintained by the Public Health Service in Oakland and Los Angeles to facilitate laboratory investigations.

It was concluded at the end of the year that, while the danger of plague spreading to other portions of the United States might be more or less remote, it was nevertheless real. Operations planned for the next fiscal year included destruction of known foci of infection, determination of new foci, and general squirrel eradication. The first two objectives were to be handled by the Service alone, and the third by the Service with assistance from the State of California. The State was to be divided into northern, central, and southern districts. In areas outside the cities, five men were to work

Table 5. Results of examination of squirrels for plague infection in 25 California counties, fiscal year ending June 30, 1910

County	Number of squirrels examined	Number of squirrels plague-positive
Contra Costa	23, 800	212
Alameda	7, 457	81
San Mateo	2, 819	0
Santa Cruz	1, 402	3
Santa Clara	6, 813	22
San Benito	3, 894	19
Monterey	14, 635	4
San Luis Obispo	7, 589	1
San Joaquin	4, 239	5
Stanislaus	1, 976	5
Merced	8, 951	2
Mariposa	687	0
Madera	755	0
Fresno	11, 515	0
Tulare	6, 367	0
Kern	326	0
Santa Barbara	4, 651	0
Ventura	2, 189	0
Los Angeles	1, 809	0
Orange	526	0
San Bernardino	321	0
Riverside	597	0
Solano	216	0
Napa	11	0
Colusa	110	0
Total	113, 655	354

in each county. When plague-positive animals were found, the whole county was to be considered infected and the crew would then move to a new county to see whether infection also existed there. Scouting parties were to be sent into neighboring States. The work of creating squirrel-free zones around San Francisco, Oakland, Alameda, and Berkeley was to continue (*19*).

During the fiscal year 1911, the investigation for the detection of plague foci was extended to 45 of the 58 California counties, 3 counties in Nevada, and 1 county in Oregon, and to parts of Arizona, and it was believed that the extent of the infection had been determined. Infection was not found in any new county and was found in only 7 of the counties known to have been previously infected. These were Contra Costa, Alameda, San Joaquin, Stanislaus, Merced, Santa Clara, and San Benito Counties. In Merced and San Benito Counties, new foci were found which indicated an extension of the known infected areas in those counties.

It had been thought that the San Joaquin River was the eastern boundary of infection in the San Joaquin Valley, but at least two new foci were discovered east of the river in Stanislaus and San Joaquin Counties. This indicated the danger which might result from the infection spreading over the Sierra Nevada Mountains through passes which were low enough to harbor *C. beecheyi*. The western end of one of these passes was relatively near the new foci in Stanislaus and San Joaquin Counties, and so a squirrel-free zone was attempted in those areas.

The number of animals examined at the plague laboratory and the number found to be plague infected are shown in table 6 (*20*).

County boards of supervisors were urged to adopt a plan to enforce the State law requiring farmers to exterminate rodents, and much time and money were spent by farmers in poisoning squirrels. By June 1911, 185 men were employed as inspectors and hunters. These included 5 mobile crews of 6 men each provided with covered wagons, tents, kitchen utensils, and other equipment for living out of doors.

Table 6. Results of examination of animals at the Federal plague laboratory, fiscal year 1911

Animal	Number examined	Number plague-positive
Ground squirrels	124, 265	55
Rats	92, 923	----
Gophers	384	----
Rabbits	1, 778	----
Weasels	75	----
Chipmunks	75	----
Mice	94	----
Field mice	7	----
Kangaroo rats	36	----
Badgers	4	----
Moles	3	----
Wood rats	6	----
Wildcats	2	----
Tree squirrel	1	----
House cat	1	----
Coyote	1	----
Total	219, 655	55

These crews operated in remote sections of the State where living accommodations were hard to find.

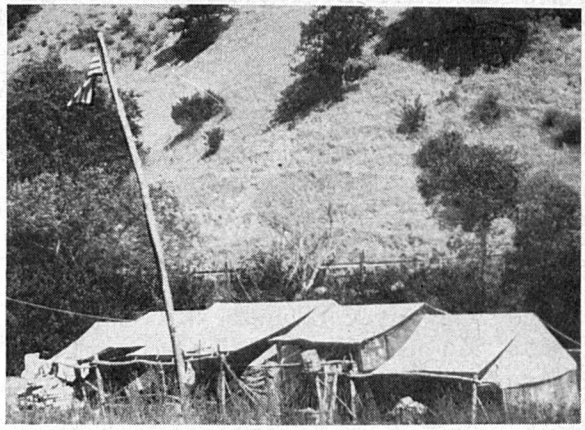
In June 1911, the year's work was summarized as follows:

1. Through maintenance of squirrel-free zones, the reinfection of cities had been prevented.
2. The area of infection was believed to have been definitely outlined.
3. Plague had apparently been eradicated from San Francisco, Los Angeles, and San Luis Obispo Counties.
4. Forty-five counties in California, one in Oregon, three in Nevada, and part of Arizona had been investigated.
5. The possible routes by which plague could spread to the east had been determined.
6. The sanitary condition of bay cities had been improved.
7. The destruction of squirrels on a large scale had resulted in economic benefits to farmers, ranchers, and landowners.

It was concluded that plague-suppressive measures would have to be continued in California for such period of time as would insure the eradication of the disease, and that for both public health and economic reasons the squirrel should be exterminated throughout the entire State. The effort to create a squirrel-free zone around the bay cities apparently was a major undertaking. The comment was made at the end of June 1911 that at the rate of progress then in effect it would require many years of intelligent labor to exterminate the ground squirrel. Either the job was bigger than had been originally planned or the squirrel was a difficult animal to eradicate.

Plans for the fiscal year 1912 included:

1. The maintenance of a squirrel-free zone around the bay cities.
2. The maintenance of squirrel-free zones in San Joaquin and Stanislaus Counties.
3. The destruction of all foci east of the San Joaquin River.
4. Squirrel extermination in all counties in which plague was known to exist.
5. Further reconnaissance in California, Oregon, Nevada, and Arizona (*20*).



Outdoor camp of squirrel hunters, California.

During the year ending June 30, 1912, work was continued on the squirrel-free zone surrounding the bay cities. Through the operation of movable camps in the area, a strip of territory 16 miles long and 1 to 2 miles wide was maintained practically free of squirrels. An area comprising 135,714 acres was poisoned with 24,684 pounds of poisoned grain and 710 gallons of carbon bisulfide. Eighty percent of the squirrels in 250 sections (160,000 acres) of Stanislaus and San Joaquin Counties were estimated to have been destroyed. Hunting operations were carried on in the above counties wherever reports of plague-positive squirrels were obtained. Special attention was given to Altamont Pass, in Alameda County, the natural gateway between that county and San Joaquin and Stanislaus Counties. Over 5,500 squirrels from this pass were examined; 128 were found to be infected.

Squirrel eradicative work was continued in San Joaquin, Calaveras, Stanislaus, Merced, Mariposa, Madera, Fresno, Kings, Tulare, and Kern Counties. It was estimated that on 60 percent of the land in the San Joaquin Valley (7,000,000 acres) the squirrel population had been reduced 50 to 80 percent and that squirrels had been eliminated from 7 percent (500,000 acres) of the valley. Similar work was carried on in Alameda, Contra Costa, Monterey, San Benito, Santa Clara, Santa Cruz, and San Luis Obispo Counties. By the end of 1911, the State had reduced its appropriation to allow squirrel eradication work only in the counties where known plague was most extensive, namely, Contra Costa, Alameda, Santa Clara, and San Joaquin Counties. Tulare, San Luis

Obispo, and Santa Cruz Counties continued to work with county employees, in cooperation with Federal inspectors assigned to the latter two counties.

Hunting operations were carried out until January 1, 1912, in Alameda, Amador, Butte, Calaveras, Colusa, Contra Costa, Eldorado, Fresno, Glenn, Imperial, Kern, Kings, Lake, Los Angeles, Madera, Mariposa, Mendocino, Merced, Monterey, Plumas, Riverside, San Benito, San Joaquin, San Luis Obispo, Shasta, Siskiyou, Sonoma, Stanislaus, Sutter, Tehama, Tuolumne, and Yolo Counties. The numbers of infected squirrels found in the following counties were: Alameda, 123; Contra Costa, 485; Fresno, 1; Merced, 1; and San Joaquin, 3. The laboratory examined 63,006 squirrels from these counties.

No infected animals were found among 1,670 squirrels from Ormsby, Douglas, and Washoe Counties in Nevada, nor among 382 squirrels from Jackson County, Oreg.

On June 30, 1912, the year's work was summarized as follows: Sanitary conditions in the bay cities had been improved; reinfection of the bay cities had been prevented by the squirrel-free zone; eastward extension of plague had been prevented by work in the San Joaquin Valley; and a renewed interest had been manifested in squirrel eradication (*21*).

The proposed plans for the fiscal year 1913 were almost identical with those of the previous year. They included continuation of the squirrel-free zone around the bay cities and in the San Joaquin Valley and squirrel eradication in known infected counties. The zone around the east bay cities was kept free of squirrels except for reinfestation around the edges. A total of 90,018 acres of land in this zone was treated, 67,172 acres with poisoned grain, and 22,846 acres with a squirrel destructor (*33*), using carbon bisulfide. The camp in the zone was used for training personnel.

Because no more plague-positive animals were found to the east of the San Joaquin River, squirrel eradication in San Joaquin and Stanislaus Counties was discontinued. Squirrel infestation was so low there that a hunter could only get one or two squirrels per day. The work in Altamont Pass was maintained until September 1912, because this was one of the worst infected spots in the State, because the work there was useful as a pilot study in cost accounting, and because it was a test in determining whether squirrels could be reduced to a point where plague infection would disappear.

Squirrel destructor apparatus for using carbon bisulfide.

The laboratory examined 30,408 squirrels, 96,005 rats, and 483 other animals, of which 680 squirrels were found infected. By June 30, 1913, a total of 135,146 acres in Contra Costa, San Benito, Santa Clara, Merced, Stanislaus, Alameda, San Joaquin, and Santa Cruz Counties was known to be infected. The conclusion was reached that: sanitary conditions in bay cities had been improved; a squirrel-free zone around bay cities had prevented reinfection in that area; plague had been eradicated among squirrels east of the San Joaquin River and in the Altamont district of Alameda County; and a satisfactory and economical means of squirrel eradication had been evolved (*22*).

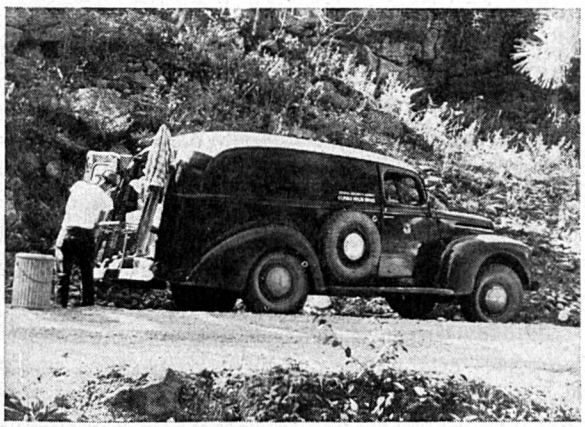
Plans for squirrel eradication in California during the next fiscal year were aided by an appropriation of $100,000 by the State legislature. Nine counties—Contra Costa, San Benito, Santa Clara, Merced, Stanislaus, Alameda, San Joaquin, Santa Cruz, and Monterey—were divided into districts of 40,000 acres each. Each county had a supervising inspector and each district had a field inspector. Field inspectors served notices on landowners to institute eradication measures. At the end of 10 days, reinspection was made, and if work had not been begun, the inspector requested the landowner to state the date when eradication meas-

ures would be started. If the owner did not do the work, a force of State employees destroyed the squirrels, and the expenses incurred were collected according to law, by claiming a lien on the property. Out of 33,350 inspections made, only 53 ranchers had to be prosecuted. An area of 5,722,438 acres was inspected, 6,903,307 acres were reinspected, and a total of 1,909,728 acres was treated by landowners.

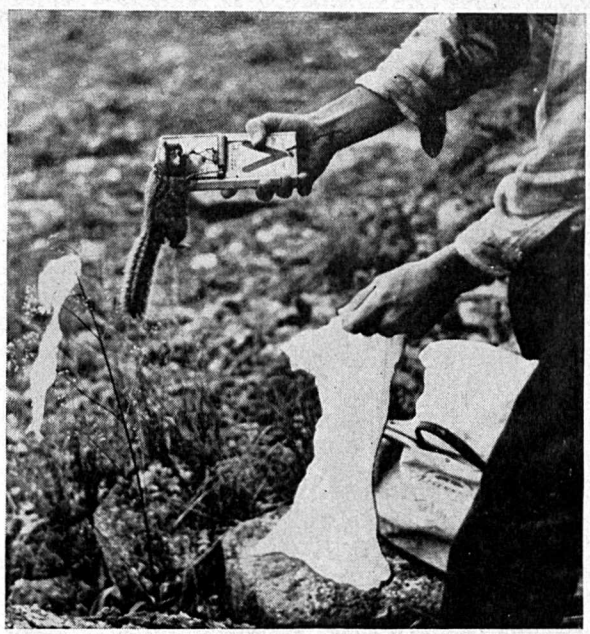
In addition to hunting squirrels and using squirrel destructors, a new method of using carbon bisulfide was developed. For this operation, a gang of seven laborers was necessary. Balls of waste were saturated with carbon bisulfide and ignited in the squirrel holes. One man placed the waste in the hole and marked it with a flag, two men ignited the balls, three men with mattocks covered the holes and removed the flags, and the seventh man supplied the others with materials. It was estimated that the cost of this operation was 2 cents per hole and that 400 to 500 holes could be treated per man-day. About 75 percent eradication of squirrels was obtained as compared with about 95 percent for the squirrel destructor.

Work on the squirrel-free zone around the bay cities was discontinued in December 1913. Squirrels were scarce and no plague-positive animals had been found in the zone for over 2 years. The laboratory examined 18,322 squirrels and 74,120 rats; 177 squirrels were found plague-positive.

On June 30, 1914, the year's work was summarized as follows: Bay city sanitation had been improved; reinfection of bay cities had been prevented; all but five known plague foci had been eradicated, and these were expected to be wiped out by August 1914; and it had been demonstrated that squirrels could be efficiently and economically eliminated.



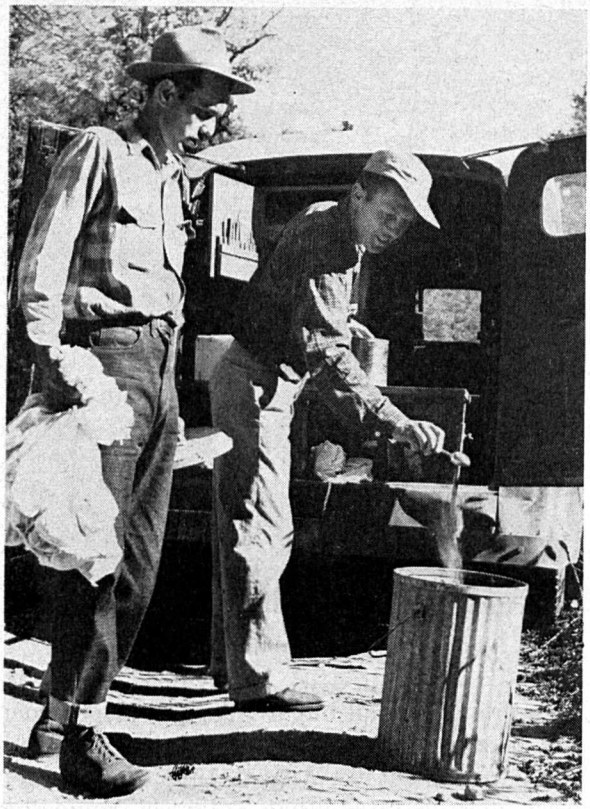
Mobile laboratory truck set up for operation.



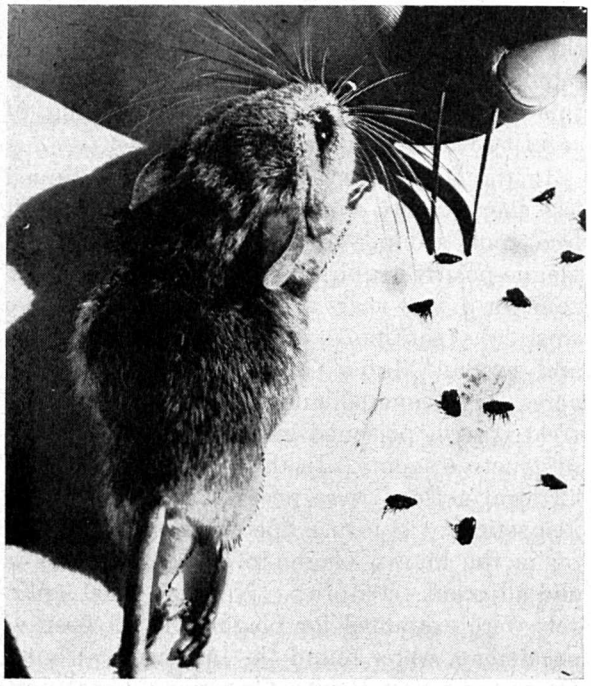
Placing trapped animal in cotton bag.

These conclusions led a Service officer to make the prediction that all discoverable plague in California would soon be eradicated and that the danger of its further spread had been removed. Subsequent events did not bear out this optimistic statement nor the feeling of security which resulted from it (*23*).

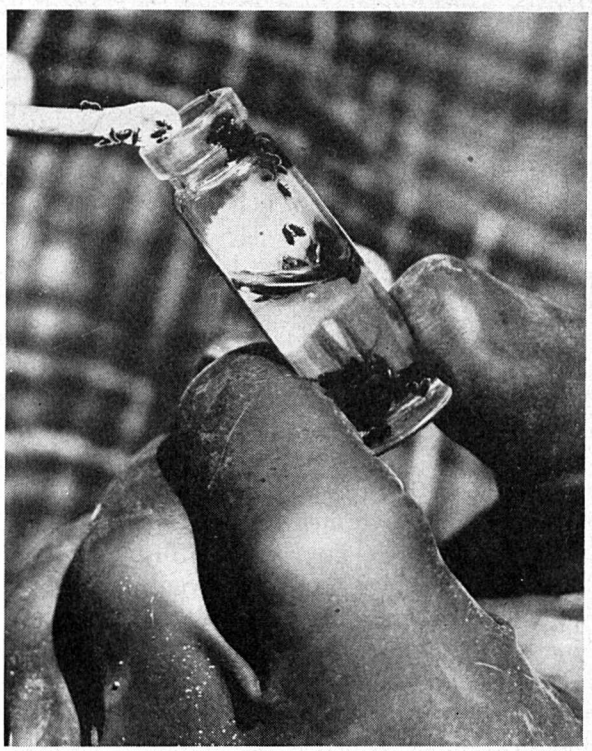
In the fiscal year 1915, work was continued less energetically on maintenance of a squirrel-free zone around the bay cities because no plague-positive squirrels had been found in the zone for over 3 years. The squirrel-eradicative work was continued in the nine-county area and in San Mateo County. Over 8 million acres were covered and 1,672,869 acres were treated with poisoned grain or other squirrel-destructive agents. In the 9-county area, only 42 legal actions were necessary out of 18,131 inspections. Hunting operations were carried on in the known plague-infected areas and in the adjacent territories. Nearly 30,000 squirrels were examined for plague and 39 positive specimens were found in Alameda, Contra Costa, and San Benito Counties. Local con-



Cyanide dusting of can in which bags are placed to kill ectoparasites.



Fleas picked from inside of bag.



Putting ectoparasites into vial for shipment.

tributions from county boards of supervisors ranging up to $500 per month were made by all counties except Contra Costa. These moneys were used to pay travel expenses of inspectors, to purchase supplies, and to rent office space for the supervising inspector in each county.

A more guarded statement was made at the end of this year's work, to the effect that, although it seemed that plague had been eradicated from all but two counties in California, it would be unwise to predict with certainty that the disease had been completely wiped out in any county. It was thought that another year or so of work would finish the job and that, should this be accomplished, it would demonstrate for all time what had at first seemed to be an impossibility—that given the requisite money, time, and men, plague among ground squirrels disseminated over a large terrain could be stamped out (*24*).

During the fiscal year 1916, a plague-infected squirrel was found east of Berkeley, seven squirrels were found near Richmond, and one near Hayward. This necessitated a vigorous reinstitution of intensive antisquirrel activities

Combing ectoparasites from wild rodent.

in the squirrel-free zone around the bay cities. The question of rat eradication in the nearby cities was also taken up with the local health officers and municipal councils, all of whom promised to carry out such activities.

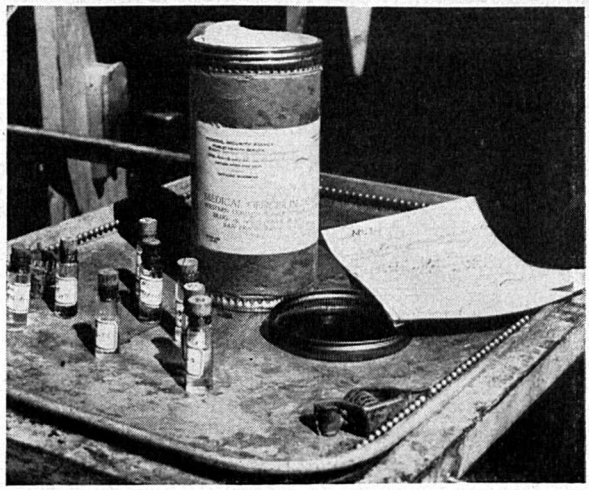
Squirrel eradication was pursued in Contra Costa, Alameda, San Benito, Monterey, and Stanislaus Counties. Contra Costa and San Benito Counties were the only recently infected counties at the beginning of the year, but plague-positive animals were obtained during the year in Alameda, Merced, Santa Clara, San Mateo, Santa Cruz, and Monterey Counties, as well as in Contra Costa and San Benito Counties. Out of 63,598 squirrels examined, 138 were plague-positive. The infection found in San Mateo County was the first ever recorded there. Hunting parties were sent to Modoc, Lassen, Mendocino, Sonoma, Lake, Kern, and Madera Counties, but no plague infection was found. The increase in positive findings during the year emphasized that the optimistic attitudes of the past 2 years had not been justified and pointed out that control of plague in any animal species existing in such large numbers over such an extensive territory is a large undertaking (*28*).

On May 21, 1917, an infected ground squirrel was shot in the County of San Francisco 1 mile north of the San Mateo line. This infection appeared to be an extension of the infection found in San Mateo County the previous year, but no involvement of domestic rats was noted. Hunting operations also disclosed 42 plague-positive animals in Alameda, Santa Cruz, San Benito, and San Mateo Counties. The laboratory examined only 4,174 squirrels (*29*).

On November 1, 1917, the Service delegated active charge of the squirrel eradication work in Merced, Stanislaus, San Benito, and Monterey Counties to the State Horticultural Commission. On June 5, 1918, intensive hunting operations were reinstituted in Contra Costa, Alameda, and San Mateo Counties for the protection of the bay cities. Nearly 10,000 squirrels were examined in the laboratory and 32 were found to be plague-positive (*30*).

In the fiscal year 1919, work was limited to Alameda, Contra Costa, and San Mateo Counties. Over 70,000 squirrels were obtained and 124 proved to be infected (*31*).

In California, until 1919, human cases of plague attributable to association with wild rodents had been single, widely scattered, and sporadic. On August 15, 1919, a man (V. D. B.) who lived in Oakland was taken sick. His physician found that he had a temperature of 101.5° F., a pain in his right side, and congestion of the lower lobe of the right lung. The physician made a diagnosis of influenza. Two days later, the patient developed a tender axillary swelling which was incised after a



Packing vials and data sheets into mailing tubes.

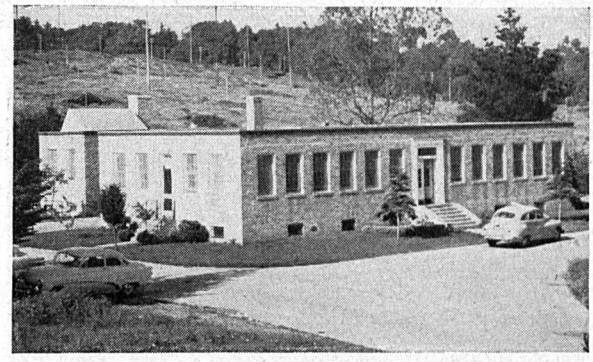
consultation with a second physician. The swelling was again opened the next day, but the patient died on the afternoon of August 20.

In quick succession there followed a series of illnesses which were first diagnosed as influenza with pneumonia. Four of these patients were contacts of V. D. B.: his landlord, his nurse, and two visitors. From three of these contacts, seven similar cases developed. The suspicions of the city health officer were aroused after a seventh death (G. A.) on September 7, and he ordered an autopsy on the body of that patient. Smears were made from the lungs, but plague organisms were not seen until a reexamination of the slides at a later date. An autopsy was performed on the next victim who died (G. O.), and bipolar ogranisms were observed which led to inoculation of a guinea pig with lung tissue from G. O. The diagnosis of plague was confirmed by the State health department laboratory and by the Federal plague laboratory. There were 14 cases of plague in the Oakland epidemic, 13 of which were fatal. Although the diagnosis of 12 cases had to be made in retrospect, the diagnoses are accepted as valid.

The original plague patient (V. D. B.) had hunted and shot squirrels in the foothills of Alameda County on August 11 and 13, and had brought them home, where they were prepared for eating. It is of interest to note that this epidemic was self-limited and had ended before the correct diagnosis was made. No control measures were put into effect, but a sampling survey of the rodent population of Oakland was made in order to be sure that rats were not infected (*25*).

During the fiscal year 1920, squirrel eradicative work was extended from the three bay counties of Alameda, Contra Costa, and San Mateo to Santa Clara, Santa Cruz, Monterey, San Benito, Merced, Stanislaus, and San Joaquin Counties. Hunting operations netted nearly 46,000 squirrels, of which 45,892 were examined at the laboratory. Of these, 185 were proved to be plague-infected. Plague positive animals were found in all 10 counties (*32*).

During the fiscal year 1921, operations were continued in the 10 infected counties with a considerably reduced force. Hunting operations were carried on intensively for a while in San Benito County in order to locate an infected focus from which a human case originated in February 1921. Of 614 squirrels shot, 8 were found infected (*34*).



Plague laboratory, San Francisco, 1950.

About this time, further budgetary restrictions limited both the hunting operations which located plague foci and the control work designed to eliminate the squirrel and to eradicate plague. The Service maintained a limited amount of control work in Contra Costa, Alameda, San Francisco, and San Mateo Counties, and cooperative efforts were made by the State Horticultural Commission in the first two counties named. The commission also worked in a number of other counties. Plague-positive animals were found as follows:

Fiscal year	*County*
1923	Contra Costa, Santa Cruz (*36*).
1924	San Luis Obispo, San Benito (*37*).
1925	San Luis Obispo, San Benito, Los Angeles (*38*).
1926	San Luis Obispo, San Benito (*39*).
1927	San Luis Obispo, San Benito (*40*).
1928	Contra Costa, Monterey, San Benito, Santa Cruz (*41*).
1929	Alameda, Contra Costa, Monterey, San Benito, San Luis Obispo, Ventura, Santa Barbara (*42*).
1930	Monterey, San Luis Obispo, Santa Clara (*43*).
1931	Monterey (*44*).
1932	San Benito (*45*).
1933	San Benito (*46*).

During the fiscal year 1934, plague was found in San Benito, Santa Clara, Kern, Tulare, and Modoc Counties. The epizootic in Kern and Tulare Counties was the largest outbreak noted in years. There were 199 plague-positive animals found in an area of 800,000 acres. One human case of plague occurred, and the fact

that there were no more was probably due to the sparse human population (*47*).

The finding of plague in Modoc County was a warning of what was to come. Modoc County was 250 miles north of the nearest previously known plague focus. About 25 animals were found infected. On May 21, 1934, a human death from plague occurred at Lakeview, Oreg., about 15 miles north of the California State line. It was the first case of plague outside of California which was attributable to association with plague in wild animals, and it was presumed that the Modoc County infection had extended northward into Oregon. Because the ground squirrels in that area go into estivation in July, the search for infected animals was postponed until the following year (*48*).

In April 1935, a mobile laboratory was put into the field to search for new foci of plague in Pacific coast and northwestern States. This field laboratory was equipped for hunting and trapping rodents and provided for dissecting rodents in the field, taking specimens of tissue from those found suspicious of plague, and forwarding the tissue in insulated refrigerated shipping cases to the San Francisco laboratory. Operations were begun in Modoc County, Calif., and then extended to Lake County, Oreg. Two foci were found, one 2 miles east and one 25 miles northeast of Lakeview, Oreg. A survey was also made in Washoe County, Nev., which is adjacent to both Modoc County, Calif., and Lake County, Oreg., but no plague-positive animals were found. In June 1935, a third focus was found in Oregon in Wallowa County, 5 miles northeast of Wallowa (*48*).

In July 1935, personnel of the Rocky Mountain Laboratory at Hamilton, Mont., found three plague-infected ground squirrels (*Citellus richardsonii*) near Dillon in Beaverhead County, Mont.

The mobile laboratory crew was kept busy in the fiscal year 1936. They made surveys in 28 counties in California, in 16 counties in Oregon, in 9 counties in Nevada, and ended the year in Idaho. Plague was found among ground squirrels in Lassen, Ventura, Modoc, and Santa Cruz Counties in California. Human cases occurred in Monterey and Sonoma Counties. The Sonoma case was the first evidence of plague in California north of San Francisco Bay and west of the Sacramento River. Plague was again found in wild rodents in Lake and Wallowa Counties, Oreg., and for the first time in Bonneville County, Idaho, and in Elko County, Nev. The Department of Public Welfare in Idaho provided a field laboratory truck for surveys in that State. Three more field laboratory trucks were ordered by the Service and preparations were made to widen the scope of field activities. The Service also turned over the squirrel-eradication program to the California State Board of Health on February 1, 1936, and proceeded to give its attention primarily to the search for new plague foci in other States rather than to the control of known foci in California (*49*).

In the early years of this century, the laboratory diagnosis of plague, either in domestic or wild rodents, had generally consisted of animal

Autopsying wild rodent.

Identifying ectoparasites in the laboratory.

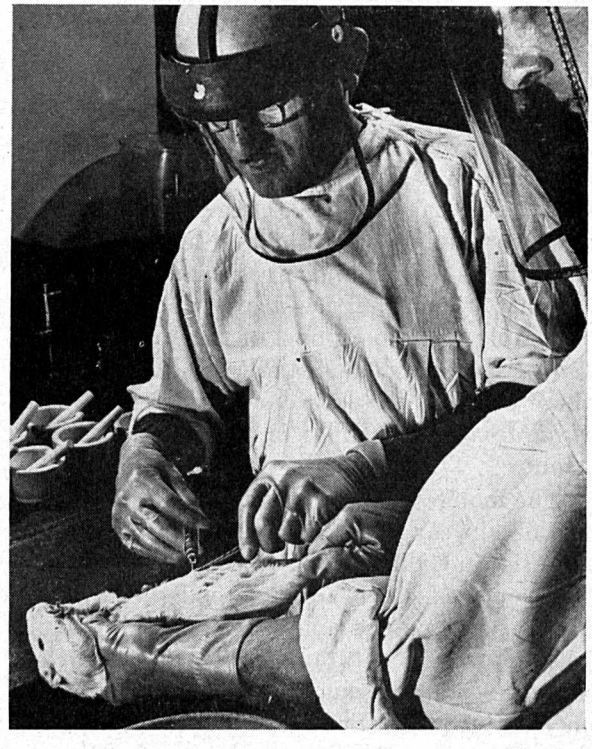
autopsy with confirmation of gross lesions by microscopic and cultural methods, using tissues from the suspected animals. Originally, bits of diseased spleens, livers, lungs, or lymph nodes had been inoculated into laboratory animals, using one guinea pig for each suspected animal. This method had been somewhat modified in 1914, when a system was devised in Seattle whereby plague in all autopsied animals could be determined by inoculating bits of their organs into guinea pigs whether or not the organs showed any gross pathology. This mass inoculation of pieces of tissue from many animals often gave positive results which otherwise would have been missed when only suspicious or obviously infected animals were further investigated (*23*).

In 1936, a still better method of locating plague foci was employed by Surgeon C. R. Eskey. Fleas were collected from animals in the field and shipped to the laboratory in salt solution. The fleas were then ground in a mortar and injected subcutaneously into a guinea pig or other laboratory animal (*49*).

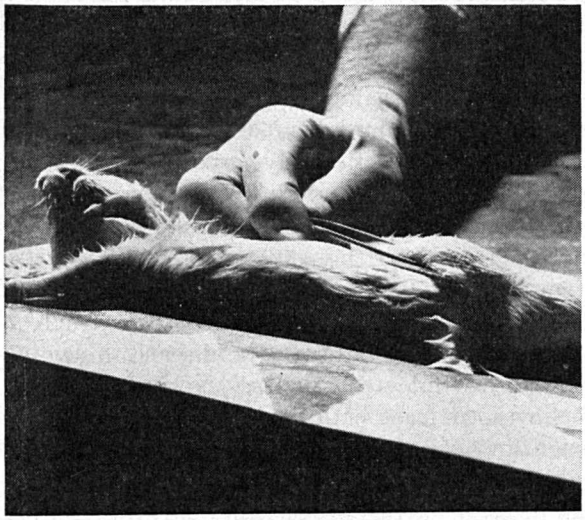
This was not a new idea, since Ogata (*13*), in 1897, had demonstrated that crushed fleas taken from a plague-infected rat would produce plague when injected into mice. Ogata noted that ectoparasites would leave rats which had died of plague and he suspected that fleas, because they were the most numerous of the ectoparasites, were probably the vectors of plague. His work was confirmed by Simond in Bombay in 1898 (*50*); a short time later, Thompson of Sydney also advocated the rat-flea theory (*51*).

In 1914 and 1915, Swellengrebel and Hoesen (*52*) had inoculated guinea pigs cutaneously with fleas alone and with fleas combined with tissue. They had gotten 18 positive results with the fleas alone and 37 positive results with the combined fleas and tissue. As stated above, this was not an original idea and the method had been used on at least one occasion for survey purposes; but its use by Dr. Eskey and his coworkers, beginning in 1936, was its first application on such a wide scale.

This method was doubtless the greatest im-



Injecting groundup ectoparasites into guinea pig.



Bubo in guinea pig visible through skin.

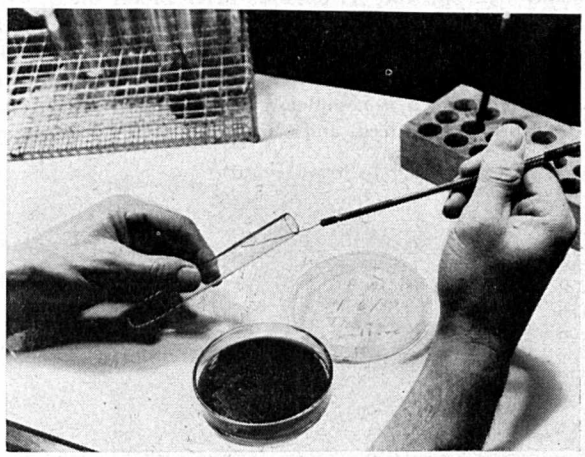
Dissected guinea pig, showing typical plague-infected spleen.

provement in the laboratory diagnosis of plague in 35 years. It was much simpler and quicker than doing autopsies in the field and was infinitely less troublesome than shipping tissues from the field to the laboratory. It has allowed field studies to be made in areas much farther removed from the laboratory than would otherwise have been possible.

The finding of plague-positive ectoparasites on a wild animal is not necessarily evidence that the host is a natural reservoir of plague, but it certainly throws suspicion on that species. Since the objective of the survey is to find where plague actually exists in wild animals, it is obviously less important at the moment to know just which animal is the primary host in a particular area.

At least two important modifications have been made since 1936 in the method of handling ectoparasites collected for inoculation. At first, chloroform was used to kill the ectoparasites before they were removed from the animals. Quite by accident it was discovered in the laboratory that chloroform tended to inhibit the growth of plague organisms. Since then, cyanide dust has been used as the ectoparasiticide. At first, fleas were placed in normal saline solution for shipment to the laboratory. Because putrefaction occurred in certain specimens, the concentration of salt was increased to 2 percent, with a consequent reduction of putrefaction. It was also noted that whenever dirt, hair, or other extraneous matter from the animals was included in the vial with the ectoparasites, putrefaction was increased. Field workers were advised to keep this contaminating material to a minimum.

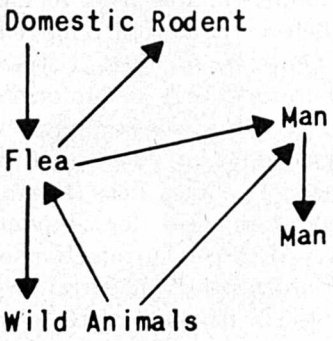
Since the first confirmation of wild rodent plague outside of California in 1935, the survey units of the Service have ranged far from the San Francisco headquarters. Plague has been found in wild rodents as far east as western Kansas, and surveys have been extended to a line drawn north and south through the center of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas. In the 17 States from that line to the Pacific coast, 611 counties have been surveyed. Plague has been



Transfer of 48-hour culture of *Pasteurella pestis* to confirming sugars.

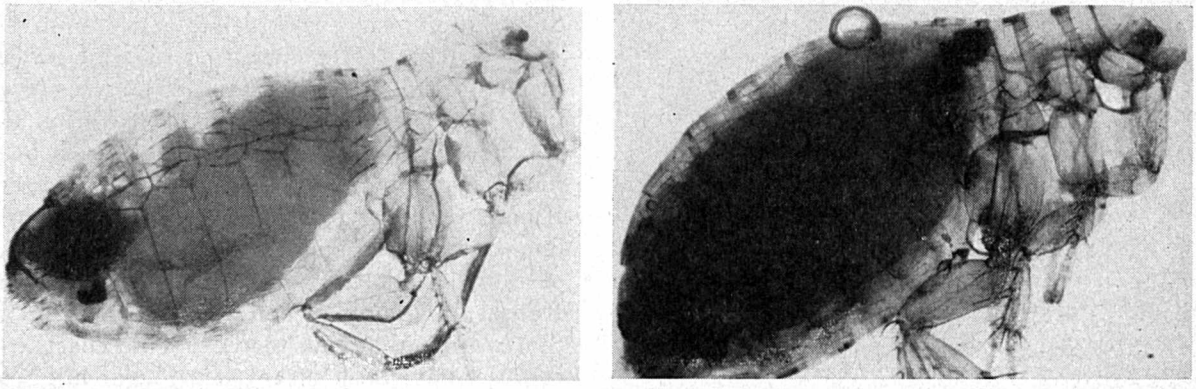
found in wild animals nearly 4,000 times in 129 counties in 15 of the 17 States.

The delineation of this vast area containing naturally infected wild rodents raises the question of what can be done about it. Certainly, with earlier control methods, the disease was never eradicated in the California ground squirrel. In recent years, the extensive use of sodium fluoroacetate (1080) as a poison for wild animals, particularly coyotes and prairie dogs, indicates that it might be possible to eliminate wild animal life in a circumscribed area. However, the experience with the attempt to eradicate plague in ground squirrels in California should have a deterrent effect on attempts to eradicate the disease in any of the known infected species. No one seriously believes, at least with present knowledge, that such an operation would be economically possible in a campaign which would have to cover millions of acres of territory in the known infected areas of today. Rather, it would seem that the best current method of approach to

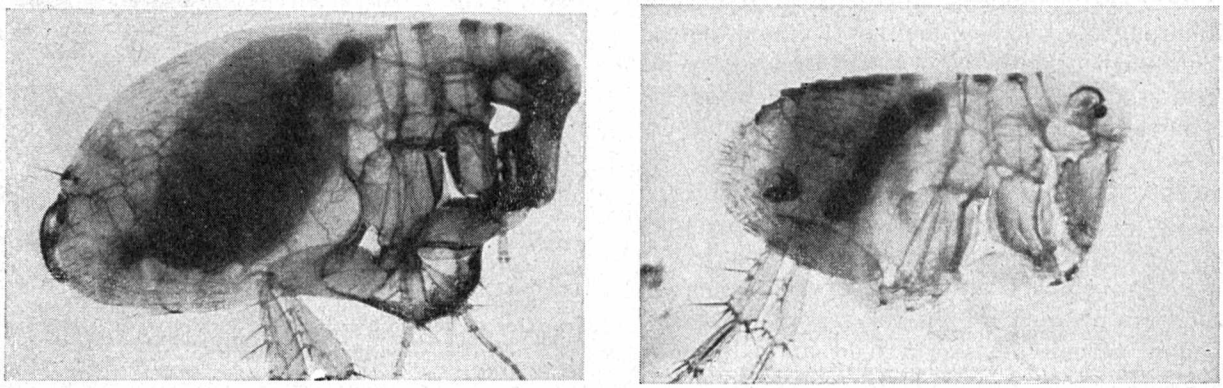


Infection chain in plague.

Normal *Xenopsylla cheopis* after blood meal and infected *X. cheopis* 6, 10, and 16 days after feeding on plague-infected mouse.



Upper left: **Normal *X. cheopis* after blood meal.** *Upper right:* **Infected *X. cheopis* 6 days after feeding on plague-infected mouse.** (Note mass of *Pasteurella pestis* beginning to form in proventriculus.) *Lower left:* **Infected *X. cheopis* 10 days after feeding on plague-infected mouse.** (Note that mass now extends into the stomach.) *Lower right:* **Infected *X. cheopis* 16 days after feeding on plague-infected mouse.** (Note that stomach is completely blocked by the mass and that no blood can enter. This causes the flea to attempt repeatedly to feed, and while doing so, *P. pestis* are carried by regurgitated blood into the bite wound.)



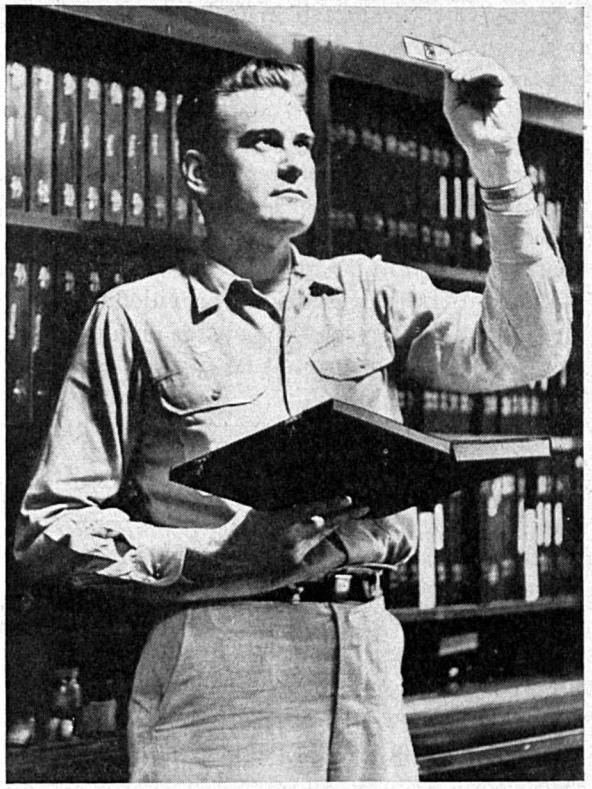
the control of plague would be to institute and maintain domestic rodent control in all communities located near areas where plague is known to exist. Thus, the infection could be prevented from extending to domestic rodents and creating a much more dangerous hazard to human populations. Cases of plague which can be shown to be associated with plague-infected wild animals will continue to be reported, but experience has shown that the danger is much greater when plague is seeded into domestic rodent populations and creates epizootics among them.

Although the Public Health Service has initiated and maintained a number of surveys in the search for wild rodent plague foci, 9 of the 15 western States in which plague has been known to be present have conducted their own surveys at one time or another, and 2 States have carried out their own laboratory procedures. The Public Health Service has done the work for the other 7 States.

The California State Department of Public Health has maintained an active interest in wild rodent plague since 1910, shortly after the discovery of the first focus in Contra Costa County in the summer of 1908. Until 1936, the work was conducted jointly by the Public Health Service and the State. Since 1936, California has maintained its own survey units and has performed all of the laboratory procedures necessary to carry out the diagnosis of plague on the suspected specimens obtained.

Following the realization in 1934 that plague-infected wild rodents no longer were confined to California, the Public Health Service shifted its attention to other States. In 1935, plague foci were demonstrated in Oregon and Montana, and in 1936, in Idaho, Nevada, Utah, and Wyoming. The interest of western State health departments was aroused, and as a result, certain States undertook to conduct surveys of their own territories.

In April 1936, the Washington State Department of Health began its own survey work, even before it was known that wild rodent plague existed in the State. It has maintained these surveys continuously since that time, and has made important contributions to the knowledge of plague, particularly in the matter of the importance of the pygmy vole (*Lagurus curtatus*) as a reservoir host.



Entomologist examining ectoparasite collection.

In June 1936, the Idaho Department of Public Health initiated its own survey unit, which operated until July 1938. It was reactivated during 1941 and 1942.

The Oregon State Board of Health began its plague surveys in August 1936. These have continued to the present time.

In April 1937, the Utah State Department of Health organized a survey unit, which continued working until July 1938.

The Montana State Board of Health initiated plague surveys in May 1937. These were continued until 1946.

Four States have carried on plague surveys with financial assistance from the Public Health Service's Communicable Disease Center. In 1946, following the first demonstration of wild rodent plague in Texas, the State department of health and the Communicable Disease Center set up a plague study with headquarters at Brownsfield. This study continued until June 30, 1949. During 1948 and 1949, plague

surveys were conducted in Colorado and Utah as a joint effort of the Communicable Disease Center and the health departments of those States. In 1950, following the occurrence of several cases of human plague, the New Mexico Department of Public Health, in cooperation with the Communicable Disease Center, established a survey unit which continued in operation until June 30, 1952.

Without the able assistance provided by these nine States, the present knowledge about plague foci in wild rodents would be far less complete than it is (*53*).

At the end of the survey season of the calendar year 1950, results of the plague surveys were reviewed, to determine the need for such surveys and to decide whether or not they should be continued. It was realized that surveys had been an essential part of defining the problem, and that no program of control of wild rodent plague could be devised or put into effect unless it was known where plague foci existed. On the other hand, it was apparent that surveys alone were not developing enough knowledge to implement control measures; they were merely providing additional data on where plague existed and not on how to control it.

A review of survey activities during the 5-year period 1946–50 revealed an interesting situation. It will be remembered that along the eastern margin of the known plague-infected territory, foci were found as follows: North Dakota, 1941; Oklahoma, 1944; Kansas, 1945; and Texas, 1946.

In North Dakota, plague-infected rodents have been found in only one county (Divide). In Oklahoma, Cimarron and Texas Counties have been incriminated. These counties are adjacent to and an integral part of known foci in New Mexico (Union County), Colorado (Baca County), Kansas (Morton County), and Texas (Dallam County). In six Kansas counties, with one exception (Morton County), the plague-infected counties (Cheyenne, Logan, Rawlins, Scott, and Thomas) are grouped together. Similarly, in Texas, the six counties in which plague-infected rodents have been found are divided into two groups: Cochrane, Dawson, Gaines, and Yoakum Counties, which are adjacent to the New Mexico focus in Lea County, N. Mex.; and Dallam and Hartley Counties, which are adjacent to the foci in Colorado, New Mexico, and Oklahoma.

None of the findings between the discovery of the plague in these four States and the 1950 survey represent much of an eastward spread of the disease. All of the counties implicated represent parts of well-defined foci. The question then arises as to how fast plague is spreading into the more densely populated Mississippi River Valley. The evidence cited does not indicate such a spread.

These two factors—that surveys alone do not provide knowledge of how to control wild rodent plague and that there has been no marked tendency in recent years for plague to spread eastward in North Dakota, Kansas, Oklahoma, and Texas—prompted the decision to discontinue the annual surveys and to use those funds to establish one field station to study the ecology of plague in wild rodents.

Such a study was initiated at Santa Fe, N. Mex., in July 1951. Its ultimate objective is to determine how wild-rodent plague can be controlled efficiently and economically. To accomplish this, it will be necessary to determine more precisely the ecologic factors of this disease, factors which are at the present time unknown or not well understood.

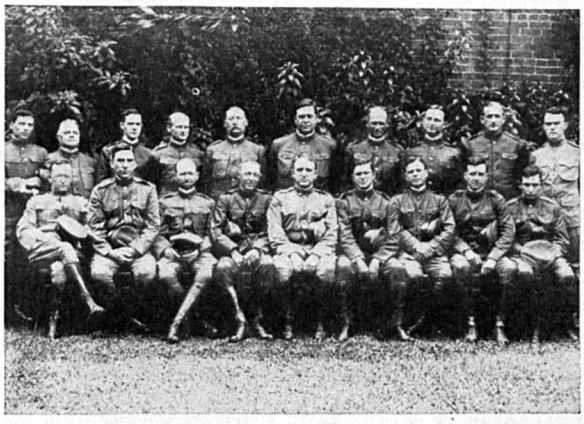
The New Orleans Epidemics

In the summer of 1912, plague struck Cuba and Puerto Rico. Because of the presence of the disease in those places, the Surgeon General of the United States Public Health Service urged the larger seaport cities of the United States to determine whether plague had spread to them (*21*). The suggestion was promptly accepted by the Louisiana State Department of Health and a rat-trapping campaign was instituted in New Orleans (*22*). Almost immediately, a rat trapped at Stuyvesant Docks on July 18 was reported to be plague-infected (*54*). In the ensuing 6 months, 7,265 more rats were captured and examined, but none was plague-positive (*55*). Thereafter, rat-trapping was carried on at a reduced scale.

On June 17, 1914, at Charity Hospital in New Orleans, an autopsy was performed on the body of T. B., an 18-year-old white man who had died of symptoms highly suggestive of bubonic plague. Although this was never actually counted as a case of plague, the fact that the victim had worked in what was later determined to be a plague-infected district, together with the symptoms and autopsy findings, makes it rather certain that his death was caused by plague. That there might have been earlier unrecognized cases of the disease in New Orleans is obviously open to speculation (*24*).

The first officially recognized case of plague was that of C. L., who fell ill on June 19 and died on June 28 in Charity Hospital. This was the first reported plague on the gulf coast. The case was officially reported on June 27, when Dr. Oscar Dowling, president of the Louisiana State Board of Health, sent a telegram to Surgeon General Rupert Blue. Dr. Blue immediately proceeded to New Orleans. In response to requests from many organizations, including the city and State boards of health, the Service was placed in charge of plague-eradicative measures. On July 3, Assistant Surgeon General W. C. Rucker arrived in New Orleans to assume charge of the work.

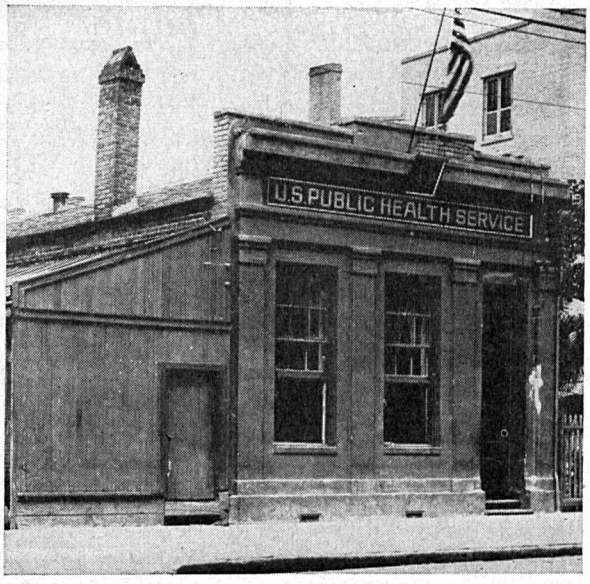
Headquarters were established at 163 Dryades Street. For administrative purposes, the city was divided into seven districts, each under a medical officer. Later on, because of the persistence of plague in two districts, the original seven districts were further subdivided into nine districts. Each district officer was provided with office space, clerical assistance.



Commanding officer and district commanders, New Orleans, 1914.

Front row (left to right): **Passed Assistant Surgeons James M. Gillespie, Hugh de Valin, and Norman Roberts; Surgeon Gustav M. Corput; Assistant Surgeon General William Colby Rucker (commanding officer); Surgeon Richard H. Creel; Passed Assistant Surgeons Friench Simpson and Richard Kearny; and Assistant Surgeon Charles L. Williams.**

Back row (left to right): **Assistant Surgeon Marion S. Lombard; Acting Assistant Surgeon F. Turney; Assistant Surgeon Francis A. Carmelia; Assistant Surgeons Thomas B. L. Layton, George McG. Stewart, H. King, and Mark D. Hollis; Pharmacist W. H. Keen; and Assistant Surgeons Harry F. White and Charles V. Akin.**



Plague headquarters, 163 Dryades Street, New Orleans.

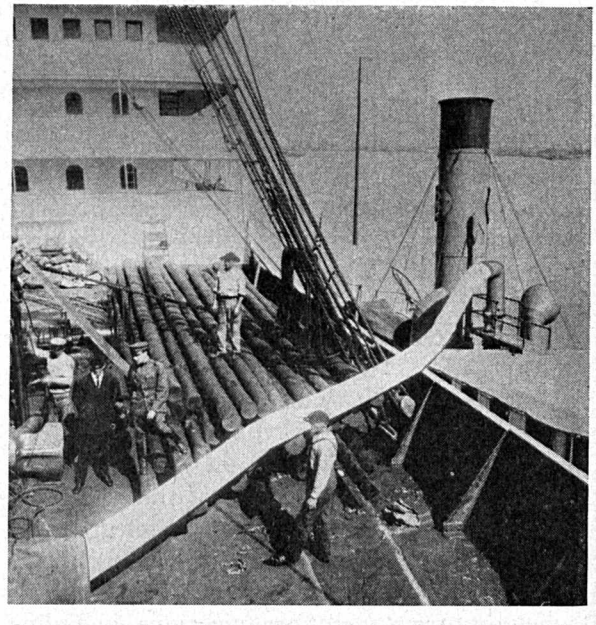
and means of transportation. Each district was assigned a trapping force, building inspectors, and a squad of men to fumigate and disinfect premises and to destroy rodent harborages.

From the beginning, certain difficulties presented themselves in New Orleans. The city was spread out over an area of 196 square miles, although the population was only 375,000. Because the city was one of the oldest in the country, there were many buildings which were in a poor state of repair and consequently furnished good rat harborage. For the most part, the buildings were of frame construction and were built close to the ground. The wharves along the Mississippi River presented an especially complex problem because they were State property, and at first, funds to ratproof them apparently could not be secured officially.

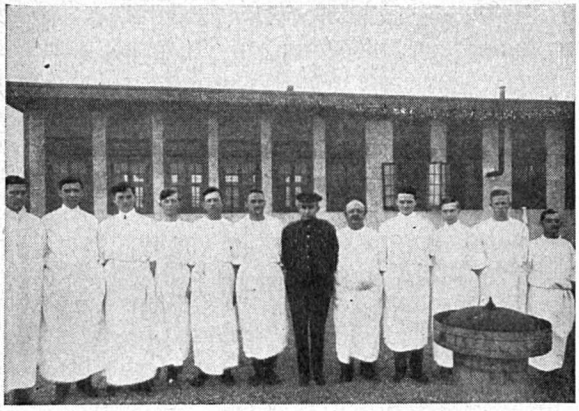
From the very start, the authorities and the press were quite frank about the existence of plague in the city, and hearty cooperation was received from all civic organizations. A citizens health committee was formed and gave invaluable assistance. Public health education was carried on at meetings, at which information was disseminated and the public was told how it could help. All in all, the frankness and publicity given to the epidemic and to the fact that every precaution was being taken saved the city from any burdensome restrictions and resulted in a relatively free and unrestricted commerce.

From the beginning of the epidemic, the strictest measures were enforced to prevent the spread of infection by vessels and freight cars. Ships were required to be properly rat-guarded and breasted off; gangways were raised at night; and prior to departure, most ships were fumigated to destroy rats. At first, sulfur was used as a fumigant; but later on, the quarantine tug *Neptune* was ordered from Philadelphia, and carbon monoxide was employed. All outward-bound freight cars were required to be ratproof. They were inspected at the time of loading to prevent the introduction of rodents and to see that they were properly sealed upon completion of the loading. No loading was allowed at night. From 40 to 85 inspectors were employed. During the first 4 or 5 months of the epidemic, certain restrictions were imposed by several foreign countries; for example, ships bound for Cuba had to be fumigated with hydrocyanic acid gas.

In the laboratory, rodents were dissected and examined, and records were kept of the location where each rodent was trapped. A flea survey was accomplished and the various procedures necessary for the confirmation of rodent or



Quarantine tug *Neptune* pumping carbon monoxide (funnel gas) into holds of vessels, New Orleans.



Assistant Surgeon C. L. Williams and laboratory crew, New Orleans, 1914.

human plague infection were instituted. A total of 378,563 animals was received by the end of June 30, 1915. These included:

Animals	*Number*
Norway rats	176, 091
Roof rats, Alexandrine	8, 857
Roof rats, black	5, 353
Mice	161, 709
Unclassified rats	21, 953
Wood rats	1, 349
Putrid rats, species not determined	1, 443
Muskrats	1, 765
Guinea pigs	20
Minks	3
Rabbits	5
Opossums	4
Squirrels	10
Puppy	1
Total	378, 563

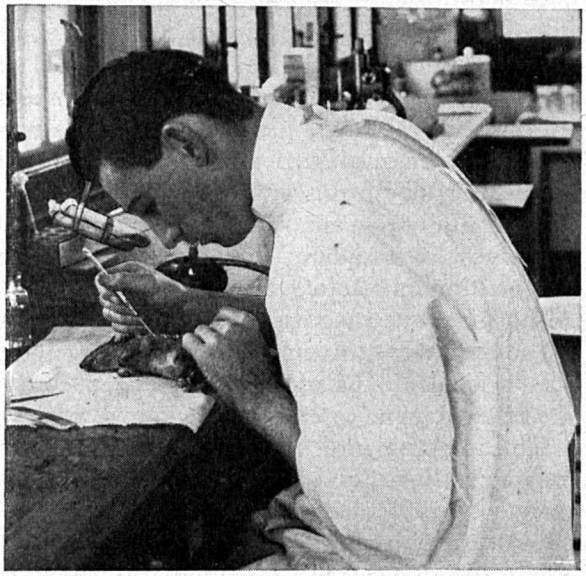
The total numbers of infected rodents, by species, were:

Rodent	*Number*
Rattus norvegicus	216
Rattus rattus alexandrinus	8
Rattus rattus rattus	16
Mus musculus musculus	4
Total	244

Flea infestation of rodents in New Orleans was of interest not only because of the general seasonal fluctuation in numbers of fleas but because of variation in the numbers of different species of rodents. No marked variation was noted in flea infestation of the different rodent species. The species of fleas found on rats in New Orleans were *Xenopsylla cheopis, Nosopsyllus fasciatus, Pulex irritans, Leptopsylla segnis, Ctenocephalides canis,* and *Ctenocephalides felis.* Species other than *X. cheopsis* and *N. fasciatus* were rare. *X. cheopsis* was most prevalent in hot weather, reaching a maximum of 18 per rat in August. From November to April, the number averaged about one per rat. During July, August, and September, *X. cheopis* was practically the only species of flea found on rats and was therefore assumed to be the species chiefly involved in the spread of plague.

The first plague-infected rat in New Orleans was found on July 11, 1914, at 1904 Magazine Street, in a shed in the rear yard of a coffee shop. Of the 244 infected rodents obtained during the fiscal year 1915, 49 were found dead and 195 were captured. Infected rats were found in various places: in dwellings, 66; in sewers, 2; in open sheds, 11; in food depots, 60; in wharves, 39; in stables, 45; in open areas, 12; and in business establishments, 9.

At the first appearance of rodent infection, all foci were vigorously treated by summary removal of rodent harborage, initiation of ratproofing, and intensive trapping. Upon the discovery of human plague, the measures employed consisted of fumigation of the infected building with sulfur, spraying of the entire premises with 2-percent kerosene emulsion to destroy fleas, and intensive rat trapping. Ratproofing of the premises was completed at



Combing fleas from rats, New Orleans.

Removal of rat harborage at 1013 Magazine Street, New Orleans.

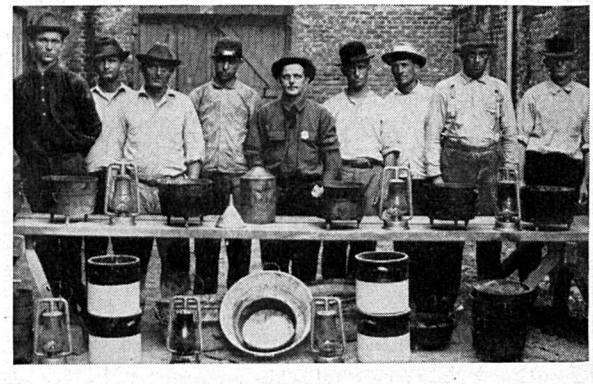
the earliest possible date. As a precaution, premises were fumigated to kill any dispersed infected fleas, but this was not considered an effective eradicative measure.

The ineffectiveness of fumigating buildings to destroy rats was amply demonstrated in several rodent foci. In two buildings, sulfur fumigation was carried out as thoroughly as possible. When the flooring of the buildings was removed, just subsequent to the fumigation, many live rats were captured, and those that were found dead were plague-infected. It seemed evident that fumigation had no effect on the rodents harboring beneath the floors or in the walls. Although the fumigation of human foci was continued in a routine way, this procedure was discarded in the treatment of rodent foci after the first month or two of the campaign. Good results were obtained by the removal of rat harborage, and this was considered the most logical and valuable of all eradicative measures.

The elimination of plague infection in New Orleans was considered to be ultimately due to the diminution of the rodent population. Although ratproofing was considered a valuable adjunctive measure, an efficient trapping force was believed to be of the utmost importance in the antiplague campaign.

The trapping force was made up of units of four to six men, each unit in charge of a foreman, who saw to it that traps were properly placed, baited, and kept in good condition. The foreman checked to see that trappers were carefully and legibly tagging each rodent, and he kept a record of the daily catch of his squad. A supervising inspector directed the work of the trapping units in each district. He checked on the foremen and the trappers, settled personal differences, maintained discipline, and carried out policies as directed by the district officer.

The maximum number of trappers was employed during the first 2 months of the epidemic, not only to effect the earliest possible reduction in the rodent population, but also for the immediate delineation of the infected zones. During the latter part of August, 320 trappers and 60 foremen were employed. In the beginning, trappers were paid on a flat salary basis of $2 per day. By the third month, the total rat catch declined so markedly that trappers were paid $1.75 a day plus 10 cents a rat, with a $5 bonus for each infected rat. Immediately, the total rat catch increased every week for 4 weeks, after which a gradual decrease in the catch took place because rats were becoming harder to find.



Fumigating crew, New Orleans.

During July and early August, trapping was confined to the area between the river and Claiborne Avenue, from Esplanade to Louisiana Avenues, but subsequently these boundaries were extended to include all of New Orleans. In the winter months, large numbers of three species of wood rats were trapped in rural districts around New Orleans; but as it became evident that these species were not infected with plague, trapping was discontinued.

Previous to the rat-trapping campaign, garbage had not been satisfactorily collected or disposed of in New Orleans. During the cam-

Acting Assistant Surgeon Mark Hollis and Passed Assistant Surgeon Hugh de Valin with force of District 4, New Orleans.

paign, the scavenger force was greatly augmented, and metal cans were installed in place of open barrels, boxes, and other containers. However, no acceptable garbage disposal method had been installed by the end of the first year of the antiplague campaign.

At the commencement of the campaign, a conjoint committee of Service officers, the attorney for the board of health, and the superintendent of public health met and drafted four ordinances:

1. *Ordinance 17*, as amended by ordinance 21 and superseded by ordinance 2512, required all buildings in New Orleans to be ratproof.

2. *Ordinance 16*, as amended by ordinance 20, required the furnishing of metal, watertight garbage cans and prescribed the use of same, the segregation of garbage from dry trash, and divided the city into districts for the collection of garbage.

Trapping crew, New Orleans.

3. *Ordinance 14*, as amended by ordinance 22, provided conditions under which animals could be kept.

4. *Ordinance 15*, as amended by ordinance 19, required vessels to fend off 8 feet, use ratguards on all lines, guard gangplanks, use gangplanks only during loading and unloading, required lighting of gangplanks during the night, and inspection of crated cargo (*24*).

Enforcement of the ratproofing ordinances constituted the bulk of Service work. Inspectors made daily rounds and entered on an inspection blank for each premises the actual conditions found that were pertinent to the ratproofing requirements. On the reverse side of the inspection card, notations were made as to the structural repairs necessary to make the property ratproof. Reports were returned to the district

Ratproofing in progress on Canal Street, New Orleans.

office, where a ratproofing notice was prepared and sent to the property owner. Owners were given a time limit for compliance with the ratproofing ordinance, and during the first year nearly 4 million dollars was spent on ratproofing. Because of their dilapidated condition, 7,088 buildings were demolished or dismantled by the owners in preference to ratproofing them.

At the beginning of the campaign, it was contemplated that the expense of the work would be borne proportionately by the Federal, State, and city governments. During the first 2 months, the Federal Government and the city each assumed approximately 40 percent and the State 20 percent of the total expense. After October 1, the State, which had contributed $20,000, refused to make any further expendi-

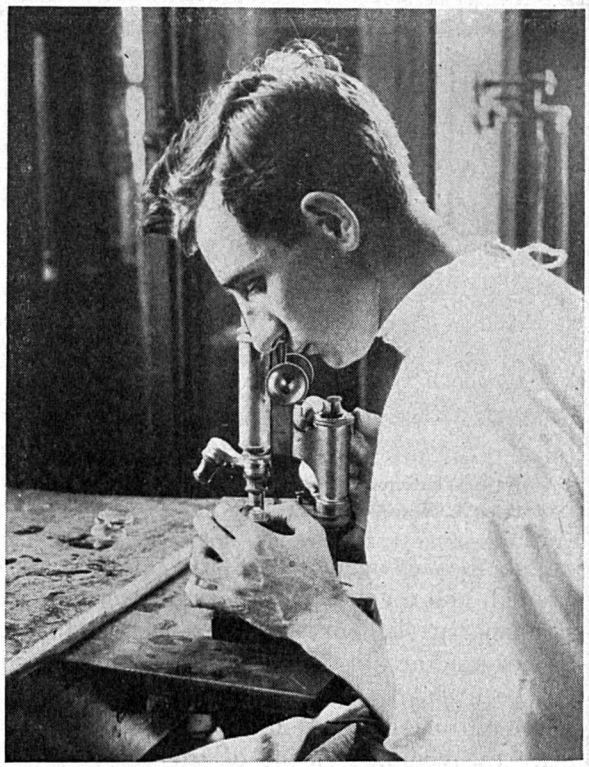
ture. The Federal Government gradually appropriated a proportionately greater share of the cost of plague control so that at the end of the first year it was contributing about 90 percent, mainly for salaries and expendable supplies.

The last human case of plague in the New Orleans epidemic occurred on September 30, 1914, when the 30th person (C.Y.) fell ill (*24*). The outbreak had been relatively sharp and fairly short. Plague-infected rodents continued to be found, but no further human infection took place until September 1915, when one case of plague was diagnosed (*28*).

During the second year of the epidemic, hydrocyanic acid gas was adopted as the fumigant of choice for both buildings and ships. This gas was generated in oak barrels containing sulfuric acid into which the cyanide was lowered. One hour's exposure was allowed and good kills were recorded of rats, roaches, lice, bedbugs, fleas, and mosquitoes.

In this second year, over 100,000 animals were examined in the laboratory and 67 were found infected, 65 rats and 2 mice. Fifty-six of these were obtained from New Orleans and the other 11 from 6 small communities located on the opposite bank of the Mississippi River in Orleans, Jefferson, and St. Bernard Parishes.

In addition to the regular macroscopic examination of animals at autopsy, microscopic examinations were made of smears from the livers and spleens of all rats examined. By this means, 12 plague-infected rats were found which showed no gross lesions. Heretofore, it had been advocated by the Commission for the In-



Assistant Surgeon C. L. Williams examining tissue smears microscopically.

vestigation of Plague in India, and upheld by other experimenters, that visual examination of rats by a competent observer was more satisfactory than microscopic examination alone, and that, in large-scale investigations, omission of routine microscopy of every rat would not necessarily impair the accuracy of the work. However, the finding of the 12 infected rats with no visible lesions of plague indicated that an appreciable number of plague-positive rodents would have been missed unavoidably if dependence had been placed on macroscopic inspection only.

Rats trapped alive were examined in the laboratory for fleas. Beginning in the latter part of May and continuing through June, there was a notable rise in the number of fleas per rat, and coincident with the increase in the flea index, there was an exacerbation of rodent plague, as follows:

Month	*X. cheopis per rat*	*Plague-positive rats*
April	1. 0	4
May	2. 0	5
June	5. 4	15

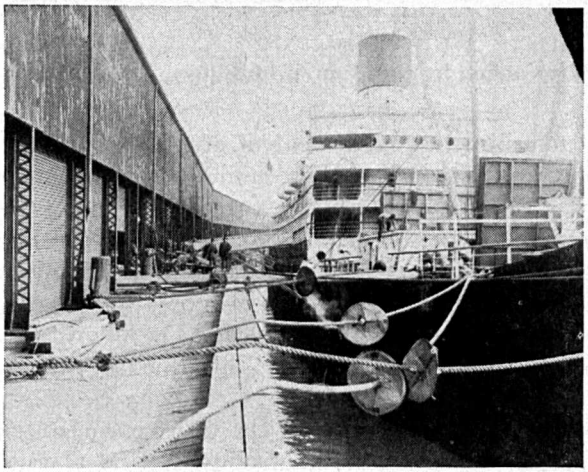
Fumigating crew from quarantine station, New Orleans.

Another occurrence of interest during the second year was the finding of rodent plague on board the British S. S. *Trevelyan* when, in April 1916, she arrived at New Orleans quarantine in ballast from Karachi, India, via European ports. The ship was immediately fumigated with sulfur, and a thorough search was made for rats; 28 dead rats were picked up and 10 rats were trapped. All were sent to the laboratory for examination, and 1 of the 28 rats which had been found dead proved to be plague-infected. This was the second instance in which plague infection in rats was proved on board ships in American ports.

Proportionately more plague-infected rats were obtained from food depots than from dwellings, in the ratio of 10 plague-positive rats from 2,865 food depots to 28 positives from 67,589 dwellings. In contradistinction to the first year of the epidemic, when 45 plague-positive rats were found in stables, no positives were obtained during this fiscal year (1916) in 3,888 premises. Because of the marked decrease in the number of Norway rats trapped, the average number of rats trapped per day fell from about 300 at the beginning of the year to about 200 at the end. The total number of rodents obtained remained about the same because of the big increase in the number of mice trapped.

The ratproofing ordinances (Nos. 17 and 21) of the city of New Orleans were contested in court by a taxpayers organization. The suit was carried to the State Supreme Court, which declared the ratproofing ordinances unconstitutional in June 1915. A new ordinance was drafted, passed, and again put through the same legal test; this time it was declared constitutional. This legal argument delayed ratproofing somewhat, but by the end of the second year of the epidemic the situation was entirely clarified.

In the third year of antiplague activities, fiscal 1917, no human cases of plague occurred. Only 42 plague-positive rodents were found, and all but 3 of these during the first 6 months. The average flea index per rat was considerably smaller than in the previous year. About half as many fleas per rat were found in June 1917 as in June 1916 (*29*). Several districts were merged so that by the end of the third year there were only four districts. There were no major changes in any of the operational procedures. The laboratory examined 76,765 rodents and 306 other animals, a total of 77,071 animals out of 387,732 received. No infected mice were found, and the proportion of rats with well-marked plague findings decreased, with a proportionate increase in rats with indefinite evidence of plague. This was thought to be due to a decrease in virulence of the organism or to a greater resistance on the part of the rodent hosts. Infected rats were again found in four of the communities on the south bank of the Mississippi River. Norway rats again showed a decrease in the number caught, although this decrease was not as marked as in the previous years.



Rat guards on hawsers of ship, New Orleans.

During this fiscal year, a plague-infected rat was found on board the S. S. *Eggsford*, which arrived at New Orleans on September 20, 1916. She had not touched at any known plague port for over a year. Trapping was begun on the ship the following day, and 31 rats were obtained; 1 rat was proved to be plague-infected. Subsequent trapping and fumigation yielded another 38 rats, none of which was found to be infected. As in the case of the S. S. *Trevelyan*, the ship was fended off and properly ratguarded, and the finding of an infected rat on board so soon after arrival made it fairly evident that the offending rat was imported with the ship and pointed out a method by which plague might have been brought to this country (*29*).

Ratproofing by elevation of buildings, New Orleans.

During the fourth year of antiplague activities in New Orleans, the number of personnel was reduced markedly. No case of human or rodent plague occurred, and on April 20, 1918, New Orleans was declared to be a clean port. Nevertheless, plague-control operations were continued on a restricted basis. The laboratory examined 48,143 animals out of 178,635 received (*30*).

In the fiscal year 1919, the fifth year of antiplague activities, no human or rodent plague was found in New Orleans. The city had been almost entirely ratproofed, and a further reduction was made in personnel. Only 7,464 rodents were received and examined during the part of the year the laboratory was in operation. It was concluded that the declaration of the city as a clean port had been justified and that the danger from the 1914 epidemic had passed (*31*).

About the time that the citizens of New Orleans were congratulating themselves on the successful eradication of plague, a second epidemic started. On October 29, 1919, a death (H. E. D.) from plague occurred at Charity Hospital, and immediately thereafter, plague-positive rats again were found in the city, the first since April 1917. The antiplague forces were quickly reassembled; their work was patterned after the district organization of 1914, except that it was on a somewhat larger scale. From a standby force of 13 men, the personnel increased in a short time to 362. Many former employees were reinstated, thereby lessening the training problem (*32*).

Although no effort was made to give the situation undue publicity, it was believed that the best policy was to advise interested persons fully and frankly of the progress of the infection. Meetings were held with city and State officials, the dock board, business interests, and the medical society. The frankness of the New Orleans authorities and of the press created confidence among the neighboring States and among foreign countries that everything possible was being done and that nothing vital was being concealed from the public. This again resulted in saving the city from troublesome restrictions and in securing a relatively free and unrestricted commerce.

Maritime restrictions were put into effect immediately upon the discovery of plague. Ships mooring at local wharves were required to fend off at least 4 feet, to have all mooring lines properly ratguarded, and to raise gangplanks at night. All vessels bound for other ports in the United States, its dependencies, and possessions were fumigated for rodent destruction prior to departure. Later, vessels bound for ports in Cuba, Mexico, Haiti, and San Domingo were fumigated as well.

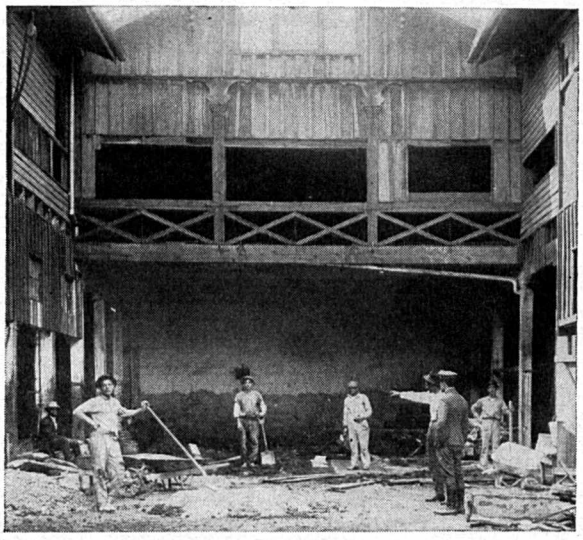
Two interesting events took place in the course of ship fumigation. The S. S. *Managua* arrived in New Orleans in December 1919 with a cargo of bananas from Nicaragua. She was unloaded and fumigated on December 24; 15 rats were recovered, and 1 rat proved to be plague-infected. The S. S. *Historian* arrived at New Orleans in February 1920. During the previous year she had been in New Orleans, Calcutta, and Liverpool. She was fumigated on February 12, and 48 rats and 1 mouse were recovered. One rat proved to be plague-infected.

The laboratory received and examined 260,615 animals, 260,488 of which were rodents. Of these, 569—538 rats, 29 mice, 1 wood rat, and 1 guinea pig—were positive for plague. Infected rodents came from the following sources:

Source	Number of rodents
Dwellings	79
Food depots	192
Wharves	53
Open areas	106
Warehouses (nonfood)	65
Sheds	17
Sewers	2
Stables	2
Miscellaneous buildings	53
Total	569

As a routine measure in controlling human plague, both the patient's residence and his place of employment were at once fumigated with cyanide gas to destroy rodents and fleas. In controlling rodent plague, premises from which rats had been recovered were immediately inspected upon receipt of a report from the laboratory that the rats were plague-positive. Treatment of the focus depended upon the character of the surroundings. If the premises consisted of open areas, little was done other than a general cleanup, elevation of any material stored therein, intensive rat-trapping, and when practical, poisoning of rats. Buildings to which human and rodent plague were traced were fumigated at once with cyanide gas, and intensive trapping was begun. Wherever there was no danger to humans or to livestock, poisoning was done with arsenic paste smeared over bread cut into small cubes.

Suspected rat harbors were exposed. Nearly



Demolition of nonratproof building as alternative to ratproofing, New Orleans.

Ratproofed wharf, New Orleans.

100,000 square yards of planking was removed by the demolition squads and by property owners in nonratproof structures. Whenever defects were found in ratproofed buildings, they were ordered corrected. Some owners preferred to demolish buildings rather than to take the steps necessary to ratproof them.

The city was divided into four sections called trapping zones, which were further subdivided into trapping districts and trapping areas. A squad of trappers under the direction of a foreman covered each district, and individual trappers were assigned to the trapping areas. The character and number of structures in an area determined its size. A chief trapper and four assistants supervised the work of the foreman and the trappers in each district. Trappers were paid a monthly salary and a bounty of 25 cents each for live rats, 10 cents for dead rats, and 5 cents for mice. The number of rodents obtained averaged from five to eight per man per day (*32*).

During the fiscal year 1921, human and rodent plague continued to be reported in New Orleans. Quarantine restrictions were maintained until November 1920, when, because of the great reduction in the percentage of infected rodents, the following modifications were made:

1. Vessels at ratproofed wharves were not required to fend off or to use ratguards and were fumigated only every 3 months.

2. Vessels at nonratproofed wharves were treated as before, with fending off, ratguards, and routine fumigation required.

3. Vessels lying alongside structures which

projected entirely over water but which still lacked the required tight decking were required to fend off and ratguard, but were fumigated only once in 3 months.

4. Vessels that loaded freight which had been stored, handled, or otherwise exposed to rat infestation at premises known or suspected to be plague-infected and where suppressive measures had not been instituted, were fumigated after loading.

5. Whenever the circumstances surrounding the movements of ships permitted, a thorough and complete search for dead rats followed each fumigation. When practical, intensive trapping aboard ships was instituted, especially before fumigation.

The laboratory received nearly 400,000 rodents and examined 212,102. Of these, 202,398 were rats, 653 were mice, 2,695 were wood rats, and the rest were miscellaneous unclassified and putrid animals. Of the total examined, 51 rats were proved plague-positive. Of the infected rats, 13 were recovered after fumigation, 8 were found dead, 21 were obtained by trapping, and 9 represented inoculation of tissue from pools of rats. Infected rats came from:

Source	Number of rats
Dwellings (yards)	6
Food depots	28
Wharves	2
Dumps	2
Sheds	2
Stables	2
Unknown	9
Total	51

Little change was made in the operational methods previously employed. Trapping, poisoning, ratproofing, and elimination of harborage continued (*34*).

During the following fiscal year, 1922, no human plague was recorded and only one case of rodent plague, bringing the 1919 antiplague campaign to an apparently successful conclusion. Quarantine restrictions were strictly enforced along the same lines as during the previous year, established laboratory routines were followed, and in addition, mass inoculations were made of all rodents presenting even doubtful lesions. By this method, one positive finding was recorded on August 10, 1921, just 4 months after the last previous plague-positive rat was found. Nearly 200,000 rodents were received in the laboratory, of which 130,899 were examined.

Trapping was continued on a restricted scale; with the number of personnel reduced to 60 trappers. Work was entirely abandoned in those sections which had been free of plague infection for more than 1 year. After 6 months, the trapping force was reduced to 40 men, and the plague-rat premium was raised from $5 to $25.

Plans were submitted by the city engineer for city-owned and -operated garbage collecting equipment and incinerators. Trucks and trailers were purchased and construction was started on the first incinerator, with others to be built at the rate of one per year (*35*).

The enforcement of the ratproofing ordinance constituted the bulk of the plague-eradication work, which was carried on until June 30,1923 (*36*). The last case of human plague had occurred on August 20, 1920, the last plague-infected rat was trapped on August 10, 1921, and no infected animals had been found among approximately 200,000 rodents examined since that date. Maritime restrictions had been considerably relaxed because only three wharves remained nonratproofed.

During the final year of the first New Orleans epidemic, 67,240 rats were examined. Trapping was continued with a reduced force in a much smaller area; ratproofing was decreased, and attention was given primarily to new buildings. A survey of downtown New Orleans showed that about two-thirds of all buildings were ratproof (*36*).

In the second epidemic, 20 cases of plague were recorded. In retrospect, antiplague measures were divided into two distinct periods of activity. The first period began with the discovery of the first human case of plague in October 1919 and ended with the occurrence of the last one in August 1920. Plague-suppressive measures were the primary concern. During this period of nearly a year, efforts were devoted to the rapid destruction of rat harborages and to attempts to prevent additional human cases of plague.

The second period extended from the time

the last human case occurred until June 1923, when the work was completed. During this time, the primary aim was to obliterate all known foci of infection and to prevent the creation of new foci. Ratproofing and intensive rat trapping were believed to have been particularly valuable.

The entire campaign was marked by cooperation on all sides and, on the part of the public, by a general understanding of the situation and a willingness to undertake the necessary work. After the Service withdrew from plague-eradication activities in New Orleans in 1923, the city authorities planned to continue ratproofing activities and to maintain a laboratory to continue checking the rodents trapped (*36*).

Plague has never again struck the human population of New Orleans. A tremendous job had been accomplished and much of the work was permanent. Although there were 51 cases of plague and 18 deaths in the two epidemics, plague-suppressive measures resulted in many permanent benefits to the city—better buildings, better garbage-disposal systems, reduction in fire hazards, and a much-improved system of wharves.

A sequel to the epidemics occurred on October 27, 1924, when the Greek S. S. *Atlanticos* arrived at the New Orleans quarantine station from the Mediterranean. The following day a stowaway became ill and was sent to the Marine Hospital, where plague was diagnosed. On November 12, plague-infected rats were found in a pool of rats from the S. S. *Craftsman*, which had sailed from India. Intensive trapping was begun at once where the ships had docked, and late in November, an infected rat was found. The antiplague organization was again gathered together, but on a smaller scale. No human cases of plague occurred in the city, but 12 plague-positive rats were found among over 135,000 rats trapped within a period of 6 months. The last infected rat was found on January 17, 1925. Intensive trapping was continued until June 30, 1925, when the port was once more declared free of plague (*38*). Again, on October 24, 1926, the Japanese S. S. *Manila Maru* arrived at the New Orleans Quarantine Station from Brazil with two cases of human plague on board. The ship was fumigated repeatedly during the process of unloading the cargo onto lighters; 429 rats were recovered, 6 of which were infected (*40*).

The last chapter on plague in New Orleans was written in 1933 and 1934, when about 30,000 rats were trapped in the city and examined in the laboratory without any plague-infected rats being found (*56*).

Chapter VII

Plague in Gulf Coast Cities

In the annual report of the United States Public Health Service for the fiscal year 1912, an urgent appeal is recorded for systematic trapping and examination of rodents in all gulf and Atlantic seaports of the United States. The immediate reason for this request was the epidemic of plague which was taking place in Puerto Rico. It was believed imperative to determine whether or not hidden infection had occurred in those seaports, and if so, to prevent human cases by antiplague operations. It was noted that "several of the ports . . . responded to this suggestion" (*21*). New Orleans was one of these, and a plague-infected rat was reported to have been found there in the summer of 1912 (*54*). There is no record that any of the other ports undertook surveys at that time.

On June 11, 1920, a suspected case of plague in Pensacola, Fla., was reported to the Surgeon General of the United States Public Health Service. The laboratory car "Hamilton" in charge of Passed Assistant Surgeon R. R. Spencer, who had been making a rodent survey of Mobile, Ala., was ordered to Pensacola and arrived there on June 17. A second case of plague occurred on June 15, and a third on June 18. A review of the city records disclosed that a 16-year-old Negro boy (M. J.) had become ill on May 31 and had died 2 days later. In retrospect, this was diagnosed as a case of plague, and therefore was the first of the epidemic. The 10th and last case (M. M.) occurred on August 31; 7 of the 10 cases were fatal.

Trapping operations were begun on June 18. The entire city was divided into trapping areas of four blocks each. Rats obtained were carefully tagged, dipped in oil to kill fleas, and brought to the laboratory in canvas bags or covered buckets. Wire cage traps, snap traps, and steel traps were used. Over 35,000 rats and mice were examined for plague in the first year; 36 were found to be infected. Whenever a rat was diagnosed as infected, an immediate inspection was made of the premises where it had been trapped. The usual routine was to destroy all rat harborages, fumigate the premises with cyanide gas, start intensive trapping, begin ratproofing, and kill fleas by spraying the ground areas with a pulicide emulsion.

Extra garbage wagons were put on by the city authorities, and attempts were made to deprive the rats of readily available sources of food. Poison baits were distributed on dumps and in areas where there was little danger to human beings. Ratproofing, garbage disposal, and vessel ordinances were passed to give legal backing to these procedures, and a certain amount of legal prosecution was necessary. Measures were taken to prevent the spread of infected rodents by way of freight cars. Inspectors were placed at all freight sheds handling outbound freight. Cars and sheds were ratproofed. Freight inspection continued to December 31, 1920 (*34*). On August 15, 1921, all plague-suppressive work was discontinued (*35*).

Almost simultaneously with the appearance of plague in Pensacola, the disease occurred in Galveston, Tex. On June 16, 1920, a human case (E. N.) was reported, and on June 20 Surgeon H. F. White took charge of plague eradicative measures. The following day, the first infected rodent was found. The last and 18th case of human plague (E. R. J.) occurred on November 11, 1920. Twelve of the cases were fatal. Two of the patients left Galveston either during the incubation period or early in the course of the disease. One patient went to Houston and the other to Port Arthur, where the disease was diagnosed.

During the last week of September, an active program was instituted for the destruction of

rat harborages. Over a million square feet of flooring which was on or near the ground was removed. A marked reduction then occurred in the number of both human and rodent plague cases. Trapping operations were carried on in the usual manner and poisoning was done to a limited extent along the seawall. Nearly 99,000 rodents were obtained and 93,755 were examined. Of these, 68 rats were found infected, the last being discovered on December 2, 1920. Notices were served on the owners of nearly 12,000 buildings, and ratproofing efforts were pushed vigorously. Vessels were fumigated after every trip until January 15, 1921. Between that date and March 1, fumigation was required only every 2 months, and every 3 months thereafter (*34*).

During the second year of operations, fumigation, ratproofing, and rattrapping were continued. Over 40,000 rodents were received at the laboratory, and 17,521 were examined. There was a noticeable decrease in the rat population. No rat showed any gross lesions of plague, but eight mass inoculations of tissue were positive (*35*). Trapping operations were discontinued on October 15, 1922, and the Galveston station was closed on January 15, 1923 (*36*).

Shortly after plague was discovered in Pensacola and Galveston, it also was found in Beaumont, Tex. The first case (M. P.) was reported on June 19, 1920, and the 14th on August 23, 1920. Six cases were fatal. Surgeon H. F. White immediately took charge of the plague-suppressive and -eradicative measures, which followed the pattern of the New Orleans organization of 1914. The following measures were instituted:

1. Fumigation of all premises where rodent or human plague occurred.
2. Trapping.
3. Laboratory examination of rodents.
4. Destruction of rodent harborage.
5. Inspection of buildings for purposes of ratproofing.

All vessels at wharves were required to fend off, ratguard, raise gangplanks at night, and fumigate prior to departure. All freight cars were ratproofed before loading, and all buildings and warehouses handling outgoing freight were required to be ratproof.

During the year, 96,251 rodents were examined at the laboratory. Of the 122 infected rats, 48 were found in yards, 23 in dwellings, 18 in food depots, 7 in sheds, 4 in dumps, 2 in stables, 1 in a wharf, and 19 in miscellaneous buildings. Of the total infected rats, 31 were found dead.

The city was divided into districts and subdistricts, with two chief trappers and three assistants in charge of all foremen and trappers. In the beginning, when rodent infection was so general, a very intensive wrecking program was instituted. Three crews totaling 40 men systematically removed rat harborage block by block. Plague infection disappeared in proportion to the amount of harborage destroyed. Over 10,000 buildings were ratproofed the first year (*34*). Fumigation and trapping were discontinued on July 31, 1921 (*35*).

Plague-suppressive measures were instituted in Port Arthur, Tex., because of the death from plague of a dock worker who died on the day of his arrival from Galveston, where he had become ill 5 days previously. One infected rat was found. Wrecking and fumigating were started in October. Intensive trapping was carried on from July 18, 1920, until June 15, 1921. Over 50,000 rodents were examined by the laboratory (*34*).

A certain amount of plague-suppressive work was carried on in rural Jefferson County, because an infected rat was found on October 11, 1920, 6 miles outside of Beaumont. Over 40,000 rodents were examined by the laboratory between November 1920 and June 30, 1921 (*34*).

Other cities in Texas began rodent surveys under the direction of Passed Assistant Surgeon R. M. Grimm, using the laboratory car "Hamilton." In July and August 1920, Orange, Houston, Freeport, Corpus Christi, and Aransas Pass started rat surveys. Over 1,000 rodents in Orange, nearly 3,000 in Houston, nearly 100 in Freeport, nearly 1,000 in Corpus Christi, and 35 in Aransas Pass were examined, with negative results (*34*).

In August 1920, the presence of plague in the gulf coast ports prompted the assignment of Passed Assistant Surgeon L. L. Williams, Jr., to promote surveys for infected rodents in New England ports. Rat surveys were made in 16 municipalities in Massachusetts where

waterfronts were used for shipping. A special appropriation from the Massachusetts Legislature allowed a rat survey and rat-trapping program in Boston, where 6,228 rodents were caught in 5 months. None was plague-infected. In Connecticut, the Service officer made a preliminary rat survey of all seaports; similar surveys were made in Rhode Island and Maine. In Maine, funds were obtained from the Portland Board of Health for conducting a rat survey.

In July 1920, a preliminary rat survey was made in Charleston, S. C., under the supervision of Passed Assistant Surgeon C. V. Akin; as a result, the city council voted $5,000 to conduct a survey. The laboratory force consisted of the city bacteriologist and four assistants. The trapping force averaged nine men for the 4-month period. Nearly 13,000 rodents were obtained; none showed signs of plague.

In August 1920, under the direction of Passed Assistant Surgeon W. S. Bean, a 2-month search for plague-infected rats at Savannah, Ga., netted over 10,000 rats, none of which was infected. In July 1920, Assistant Surgeon M. F. Haralson visited Jacksonville, Fernandina, St. Augustine, Daytona, West Palm Beach, Miami, Key West, Tampa, Cedar Keys, Carrabelle, Apalachicola, Panama City, and Milton, Fla. He pointed out the importance of making rodent surveys, with examination of all rats at one of the State board of health laboratories, and attempted to get passage of ratproofing and garbage collection ordinances. As a result, rat-trapping was instituted and action was taken on passage of ordinances. No plague-positive rats were found.

In April and May 1921, Junior Assistant Sanitary Engineer E. C. Sullivan made a survey of ratproofing on the New York City waterfront. In May and June 1921, Associate Sanitary Engineer A. F. Allen made a survey of rodent infestation and ratproofing conditions in Baltimore, Md. (*34*). A 3-month rat survey of Portland, Maine, begun in November 1921, netted 2,450 rodents, none of which was infected with plague. In Boston, Mass., the preliminary work started in the summer of 1920 was continued, and another 7,000 plague-free rodents were obtained. Findings from a 6-month survey at New Bedford, Mass., begun in January 1922, totaled 2,000 rodents with no signs of infection. During a 6-month survey of New York City, begun in January 1922, nearly 10,000 rodents were captured, none of which was plague-infected (*35*). From July through September 1922, and from December 1922 to February 1923, Boston again trapped and examined about 2,500 plague-free rodents. Fleas were also identified. From July 1922 to May 1923, New York continued rattrapping, obtained nearly 20,000 rodents, and collected about 1,000 fleas. In September 1922,Providence, R. I., began a rodent survey, and about 5,300 rodents were captured and examined without finding plague. New Bedford, Mass., continued its survey, and more than 2,700 rats were trapped and examined (*36*). Boston discontinued its rodent-flea survey in November 1923. New York continued its rodent-flea survey and obtained over 18,000 rodents and 6,000 fleas by the end of June 1924 (*37*).

In the 4-year period June 1920 through June 1924, a tremendous amount of rattrapping had been done and no plague had been found in any of these seaports. The most recent search for plague in the south took place in the year ending June 30, 1948, when the Plague Suppressive Measures Laboratory at San Francisco, Calif., received fleas which had been collected from rats during typhus control activities in Savannah, Ga.; Pensacola, Fla.; Charleston, S. C.; and Portsmouth, Va. The fleas were injected into guinea pigs, but no signs of plague were found (*57*).

Los Angeles Pneumonic Plague Outbreak

On October 29, 1924, a physician telephoned the Los Angeles City Health Department and the Los Angeles General Hospital and reported that a number of Mexicans were desperately ill in the Macy Street district in Los Angeles and in the Belvedere district in Los Angeles County. He said that these patients were suffering from some malady which he thought was highly contagious since several families in the neighborhood were similarly affected. The symptoms were high fever, pain in the back and chest, and expectoration of a profuse bloody sputum.

A resident physician of the Los Angeles General Hospital answered the call from the Belvedere district. He found a Mexican woman suffering from coughing spells and a Mexican man restless and feverish. They had fallen ill the day before with severe pain in the front of the chest and along the spine, a few reddish spots on the chest, and a fever of 104° F. The physician then visited a nearby home and found a young man, his wife, and a young girl suffering from similar symptoms. Four boys, relatives of these patients, were stated to be ill at home in the Macy Street district and their father (G. S.) had died in the hospital the week previously of a disease which had been diagnosed as pneumonia.

A medical inspector from the Los Angeles City Health Department visited the Macy Street district and found similar conditions there, except that all cases had been hospitalized.

On October 31, 1924, an autopsy was held on H. G., a resident of the Macy Street district, and smears from the lungs showed gram-negative bipolar staining bacilli characteristic of plague. Sections from the lungs supported the diagnosis of pneumonic plague. Sections were then made from the lungs of G. S., the patient who had died the previous week. This tissue also showed evidence of plague. These were the first diagnoses of plague made in the epidemic. H. G. was a cousin of L. S., G. S.'s wife, and through this relationship the boardinghouse described below, where most of the plague cases originated, was located.

On the same day, the case which was responsible for the beginning of the outbreak was found. The patient (J. L.), a 55-year-old Mexican man, had fallen ill on October 1. He had a small femoral bubo, associated with constitutional symptoms, which was diagnosed as a venereal bubo. When he was found on October 31, he still had a draining sinus at the site of the old bubo. Smears made from the discharge showed characteristic plague organisms and cultures, and animal inoculations verified the diagnosis of bubonic plague. Nine months later, the serum of this patient agglutinated plague organisms and gave a positive Bordet-Gengou reaction.

J. L.'s daughter (F. L.), who also became ill on October 1, had a cervical adenitis with severe clinical symptoms. She died 4 days later, and the diagnosis made by the autopsy surgeon was lobar pneumonia. Undoubtedly, this was a secondary plague pneumonia and was the origin of the series of cases of pneumonic plague.

The L. family lived on the same street and only half a block from a rooming- and boarding-house at 742 Clara Street, where the greatest number of plague cases occurred and from which most of the disease spread. The rooming- and boarding-house was maintained by L. S., who lived there with her husband and family. L. S. became ill on October 14 and died on October 19. An autopsy was performed, but nothing of unusual interest was found. On October 22, her husband (G. S.) and the practical nurse (J. F.) who had cared

for her both became ill and died 5 and 4 days later, respectively.

The epidemic broke out on October 28. On that day, the following persons fell ill:

R. S. R., sister of J. F.
R. S., son of G. S.
A. B., son of L. S.
V. S., brother of G. S.
M. S., mother of G. S.
J. H., mother of L. S.
E. H., uncle of L. S.
H. G., cousin of L. S.
A. G., cousin of L. S.
J. V., cousin of L. S.
G. V., cousin of L. S.
F. O., boarder
J. B., boarder
J. M., friend of L. S.
Father M. B., G. S.'s priest

On succeeding days, the following persons fell ill:

October 29.
M. L. C., G. S.'s nurse
R. S., son of G. S.
G. S., son of G. S.
J. C., sister of L. S.
M. J., boarder
O. H., friend of G. S.
P. H., friend of G. S.

October 30.
J. McL., ambulance driver who took G. S. to the hospital
F. P. (no known contact)
M. S., cousin of G. S.

November 1.
R. R., J. McL.'s nurse

November 2.
E. P., boarder
J. J., boarder

November 3.
M. R. (plague-infected rats found under home)

November 4.
T. V., boarder

November 7.
M. R. (plague-infected rats found under home)

November 11.
R. E., contact of R. R.

November 22.
M. A. (no known contact)

January 1, 1925.
M. D. (no known contact)

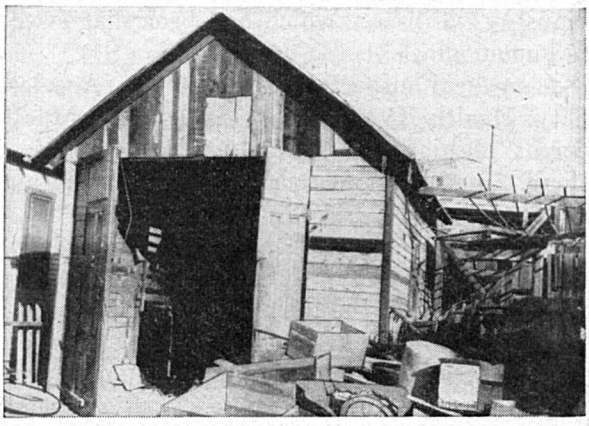
January 10, 1925.
J. P. (no known contact)

The original patient (J. L.) had bubonic plague. The case of his daughter (F. L.) started as bubonic plague and terminated as pneumonic plague. There were six other cases of bubonic plague: R. E., M. R., M. R., M. A., M. D., and J. P., four of which terminated fatally. Of the 32 patients who had pneumonic plague, 2 recovered: M. L. C., the nurse who took care of G. S.; and R. S., one of G. S.'s sons (*58*).

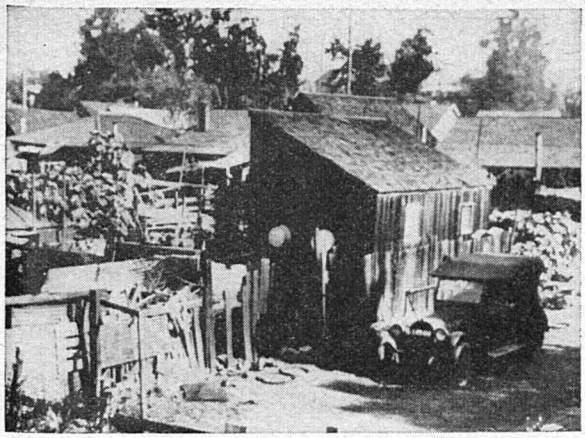
Rooming- and boarding-house at 742 Clara Street, Los Angeles, where epidemic of pneumonic plague occurred.

As soon as the diagnosis of plague was confirmed on October 31, the districts where cases had occurred were quarantined. The following plan was agreed upon and placed in operation:

1. Strict quarantine of all areas where plague cases had occurred or might occur.
2. Segregation of the inhabitants of these districts and prevention of the gathering of groups of people.
3. A daily house-to-house inspection within the quarantined area.
4. Hospitalization of all known contacts of



Backyard at 742 Clara Street, Los Angeles (shack was used for sleeping quarters).



Premises on North Anderson Street, Los Angeles, where two cases of bubonic plague occurred.

persons with pneumonic plague and hospitalization of all ill persons found within the quarantined area.

5. Examination of all dead bodies by physicians, and autopsies by the pathologist at the Los Angeles General Hospital on all patients who died of unknown causes or in which a diagnosis had not been established definitely.

6. Establishment of a bacteriological laboratory exclusively for examinations for rodent and human plague.

7. A special force of men for widespread trapping and poisoning of rats and ratproofing of buildings.

8. Disinfection of premises by petroleum spray.

9. Tagging of all rats, mice, and squirrels collected, so that the locations of any infected rodents would be known and the progress of infection mapped out, and the tagging and special marking of all rodents from the harbor district.

10. Proper disposal of garbage and the separation of the rat from his food supply.

11. Eradication of ground squirrels under the direction of the county horticultural commissioner, who had an efficient and well-organized department of rodent control.

Each district where cases of plague occurred was declared to be an infected area and a cordon was placed around it. The area surrounded was large enough to include all possible contacts of persons with plague. There were five such districts:

1. The Macy Street district, where the original cases occurred, included eight city blocks and housed 2,500 Mexicans.

2. The South Street district consisted of one large apartment house inhabited by Mexicans.

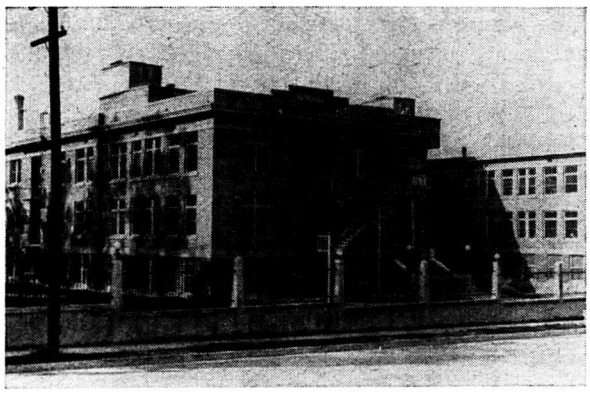
3. The Marengo Street district, with several isolated Mexican homes.

4. The Pomeroy Street district, with a few Mexican homes.

5. The Belvedere Gardens district in Los Angeles County, with several blocks housing 500 Mexicans.

The inhabitants of each house were forbidden to leave the premises, and gatherings of any kind were prevented. The quarantine lasted until 12 days after the onset of the last case of plague. To feed the quarantined population, the Los Angeles County Charities, with the assistance of the public school authorities and the school nurses of each district, made a census of the occupants of each home. A 7-day ration was then distributed to each house, thus facilitating the enforcement of house quarantine.

Raul Samarano, sole survivor among the patients at 742 Clara Street, Los Angeles, and one of the two pneumonic plague patients in Los Angeles who recovered.



Contagious disease building, Los Angeles General Hospital, where all plague cases were hospitalized.

The Baptist Church Mission in the Macy Street district was made available to the health authorities for use as sleeping quarters for those persons caught within the cordon in that area. Later on, this building was utilized as the laboratory for examination of rats.

Public health physicians and nurses were placed in each district, a daily census was made of each household, and all inhabitants were inspected. All cases of illness were investigated and all persons with illnesses suspicious of plague were hospitalized. Six cases of pneumonic plague and five cases of bubonic plague were discovered by these methods. No secondary cases occurred from contact with any of these. Clinic directors, physicians, and ministers were requested to report suspicious illnesses and to ask for consultation if indicated. All told, 150 special investigations of such calls were made.

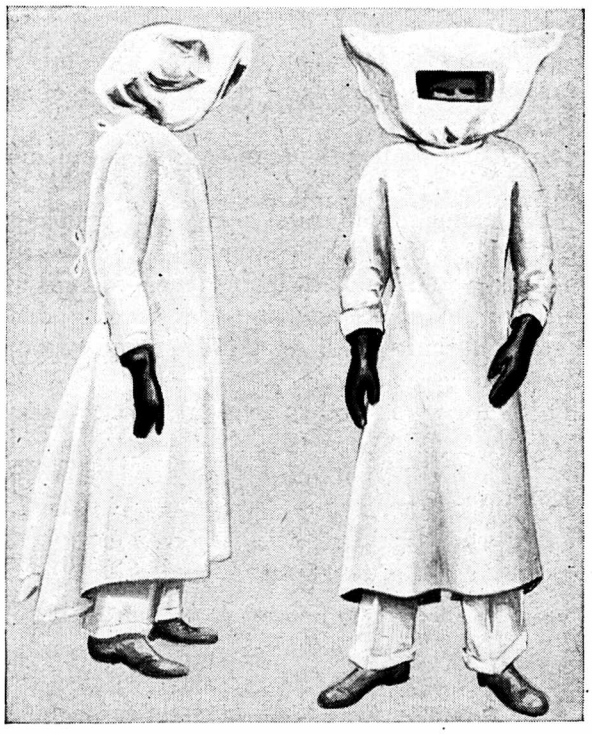
The following instructions for sending specimens to the laboratory were issued to all persons caring for the sick:

1. Pus or gland fluid from buboes aspirated by syringe or collected after incision to be planted in agar slants or placed in sterilized glass bottles, securely stoppered.
2. Portion of tissue affected, removed at operation, to be put in sterilized glass bottles, securely stoppered.
3. Sputum or mucus from nose or mouth to be collected in sterilized glass bottles, securely stoppered.
4. All specimens to be labeled with name, sex, age, race, occupation, and place of occupation, with residence and date of onset of illness.

On admission to the hospital, each patient, his nursing chart, and the nursing unit were labeled with a red ticket, which meant that the patient was of interest from a plague viewpoint. Patients were diagnosed as having pneumonic plague, suspected pneumonic plague, bubonic plague, or suspected bubonic plague. Autopsies were performed on all deceased patients, and plague was eliminated as a diagnosis only after negative pathological and bacteriological findings.

Autopsies were required on the bodies of all persons whose diagnosis was doubtful. In infected districts, bodies of Mexicans were not permitted to be embalmed until they had been examined by a physician appointed as an inspector of the dead.

Between October 1, 1924, and January 10, 1925, 33 cases of pneumonic plague occurred in Los Angeles, including the original case, which began as bubonic plague. Thirty-one cases were fatal. There were 8 cases of bubonic plague; 3 patients survived. There were admitted to the hospital for observation 114 persons with a history of having been in contact



Attire worn by attendants while caring for pneumonic plague patients.

Rodents tacked to boards, ready for dissection, plague laboratory, Los Angeles.

with known cases of pneumonic plague. A total of 82 persons suspected of having plague were admitted to the hospital and held in isolation until a definite diagnosis was made.

On November 6, 1924, intensive rat-eradication operations were started in Los Angeles. The city was divided into districts, each of which was under the supervision of a district foreman, who supervised the distribution of traps and the work of the trappers, poisoners, and wrecking crews. From November 6, 1924, to May 13, 1925, 106,951 rats were examined at the laboratory; of these, 187 were plague-infected. Out of 16,094 squirrels examined, 9 were plague-infected. No infection was found in 3,812 mice examined. Most of the plague-positive rats (111) were captured in the city of Los Angeles; 6 were from a hog ranch in San Pedro, 43 were from hog ranches in Los Angeles County, and 27 were from a packinghouse center in Vernon. Seven of the positive squirrels were from Los Angeles and two were from the county. All foci were thoroughly trapped and poisoned, and ratproofing of a permanent nature was instituted in every instance where human or rodent plague was proved to exist (*38*).

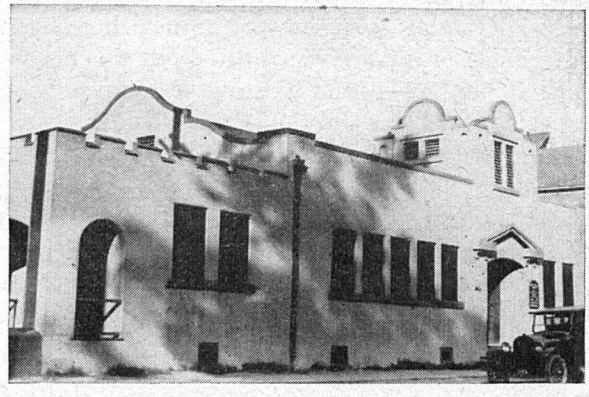
Special attention was paid to the harbor area and to Vernon, where plague-positive rats were found on a hog ranch and around packinghouses. The hog ranch in San Pedro was demolished, and ratproofing was carried on in all warehouses and wharves in the harbor. The business interests of Vernon subscribed funds sufficient to institute an extensive rat-extermination program, and to ratproof all their buildings thoroughly.

Wherever plague-infected rats and squirrels were found on hog ranches in both the city and the county, eradication measures were undertaken and buildings were ratproofed.

The eradication of squirrels was under the direction of the county horticultural commission. As reports came in of finding positive squirrels, crews were put into these districts and remained until the squirrels had been eliminated. Carbon bisulfide, waste balls, poisoned fruit and grain, and shooting were used to rid the area of these rodents. Squirrels were eradicated from over 28,000 infected acres in four different areas.

All freight going to Mexico was fumigated. Interstate quarantine measures were not applied, but all outgoing freight was carefully inspected to guard against the possibility of transporting plague-infected rodents. All railroad yards and railway warehouses were thoroughly trapped and poisoned. Ratproofing was instituted in the vicinity of all railway and waterway transportation warehouses, docks, and freight stations (*58*).

From the beginning of plague control until June 3, 1925, the campaign was under the general direction of the California State Board of Health, with some advice and assistance from the United States Public Health Service. On June 3, the city board of health assumed control of the work and requested the



Baptist Church Mission in the Macy Street district, Los Angeles, where the plague-control laboratory was first established.

Public Health Service to take charge. On June 16, Assistant Surgeon General Rupert Blue was placed in charge and 10 commissioned officers were ordered to Los Angeles to assist him. An officer was placed in charge of each district, to which was assigned a force of employees consisting of stenographers, inspectors, foremen, and trappers. Fumigators, wreckers, poison distributors, hunters, and miscellaneous personnel were attached to headquarters to be assigned for temporary duty in the various districts as needed.

Store at Macy and Avila Streets, Los Angeles, where the first plague-infected rat was found.

The question of legislation immediately arose. An ordinance had been passed on November 21, 1924, which authorized plague control measures such as entering and inspecting premises, abatement of nuisances, elimination of rat harborages, and protection of food products. The ordinance provided for ratproofing in a general way, but it was not specific and left the method to the discretion of the health officer. A stronger ordinance was drafted but was never passed, and even the existing ordinance was repealed, effective July 1, 1926. Under these handicaps, the Public Health Service carried on control activities for over a year.

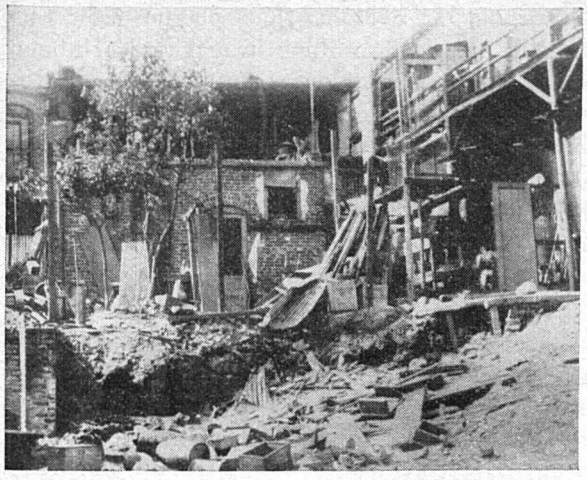
At the time the city requested Federal aid, there were no human cases of plague in Los Angeles, and only an occasional plague-infected rodent was found. The public was entirely disinterested. The newspapers were neutral, and publicity was hard to get. A series of nearly 60 public meetings was held, largely attended by property owners, and the reasons for antiplague operations were explained. As a result, no active opposition to the ratproofing campaign developed.

Trapping operations were continued throughout the year. The maximum number of men employed at one time was 183, on September 18, 1925. The wholesale and manufacturing district of the city furnished a large proportion of the total rodents collected. The other sections of the city were not very heavily infested with rats, but had a large population of mice and miscellaneous rodents. The squirrel infestation was heavy in open areas. Altogether, 255,720 rodents were collected, and 106,936 were examined in the laboratory. This discrepancy between numbers collected and number examined was due to the fact that only a small proportion of mice were examined. Twelve Norway rats were found to be plague-infected. Tularemia was isolated on three occasions and was reported for the first time in domestic rats. A flea survey showed 3.8 fleas per rat, nearly 92 percent of which were *X. cheopis*.

Wrecking operations were confined to the immediate premises from which infected or suspected rodents were taken and to adjoining properties. These operations consisted of the removal of rat harborages, such as wooden floors, double walls, and ceilings. In the city, 412,587 square yards of planking was removed from buildings, and 1,400 truckloads of rubbish, representing over 1 million cubic feet, were hauled away.

Poisoning of rodents was done only on a limited scale. During June 1925, about 600,000

Rat harborage, later removed, Los Angeles.



Section of Chinatown being ratproofed, Los Angeles.

poisoned baits were distributed in the commercial area along the Los Angeles River. Only 169 rats were found poisoned. Again in May and June 1926, 24,230 poisoned baits were distributed in the same area and 405 rodents were recovered. A small amount of fumigation was accomplished with hydrocyanic acid gas and with carbon monoxide. Recovered rodents on at least two occasions proved to be positive for plague.

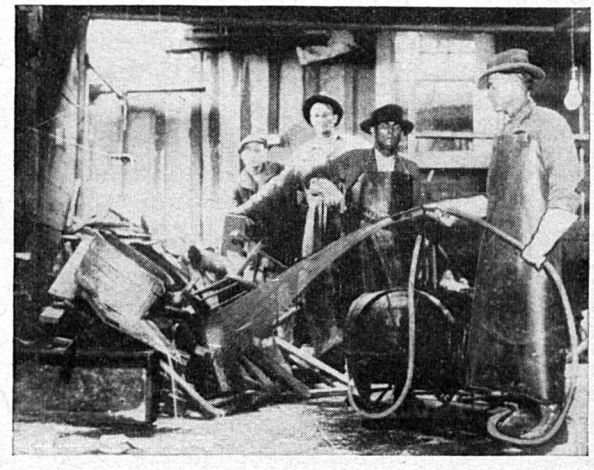
Ratproofing was intensified during August 1925, after trapping, wrecking, and other emergency work had been well developed. The various types of buildings were divided into three major categories: food depots, nonfood depots, and stables. Food depots were required to have concrete floors, protected by a concrete wall extending 18 inches into the ground and 12 inches above the floor. All openings in the superstructure were closed in a manner to prevent the ingress or egress of rats. Nonfood depots were ratproofed by constructing a continuous 6-inch-thick wall around the building, extending 18 inches into the ground and upward beneath the floor. Stables were required to have concrete floors and a protecting wall, with special provisions for the protection of feed and the handling of manure. Notices were served on property owners, calling attention to the existing defects and to the requirements for their correction. Thirty days were allowed for the completion of ratproofing.

Particular attention was given to business places, food depots, nonfood depots, and residences in the commercial, metropolitan, and congested sections of the city. Very few notices were given to property owners in the residential area, and court proceedings were found to be unnecessary. It was estimated that over $3 million worth of ratproofing was accomplished by these efforts.

On June 30, 1926, the Public Health Service withdrew its active participation in plague control in Los Angeles and recommended: (1) That trapping operations and laboratory examinations of rodents be continued as a routine measure; (2) that the building code be amended in such a way as to provide for ratproof construction; (3) that provision be made (under general police power) for the elimination of rat harborages and rat colonies wherever found; (4) that antirat installations be considered as a sanitary prerequisite in granting permits for the conduct of business places; (5) that a modern system of refuse collection and waste disposal be installed; and (6) that an arrangement be made with the county authorities whereby similar measures will be enforced in the towns and communities with which Los Angeles is connected (*39*).

The antiplague campaign in the first 7 months cost a total of $380,074 (*58*):

Agency	*Expenditure*
Los Angeles City	$275, 000
County Health Department	80, 000
County Horticultural Commission	15, 074
California State Board of Health	10, 000
Total	380, 074



Disinfecting squad at work, Los Angeles.

The next year's expenses were greater (*39*):

Agency	*Expenditure*
Los Angeles City	$325, 000
U. S. Government	120, 000
Total	445, 000

When the estimated value of over $3 million worth of ratproofing is added to the above figures, it is evident that plague cost Los Angeles nearly $4 million in a period of about 19 months. These figures emphasize the statement previously made that, although plague has never been a major public health problem in the United States, measured in terms of morbidity and mortality, it cannot be classified as a minor disease.

Chapter IX

Maritime Quarantine Measures

Plague has existed along trade routes ever since the beginning of commerce. When overland routes were the principal means of transportation, dissemination of this disease was relatively slow but with the development of ocean travel, the speed of its dissemination was proportionately increased. For many centuries rat-infested ships continued to carry plague back and forth across the high seas. Today, however, seagoing vessels are practically free from rats, and the danger of their transporting plague has been nearly eliminated. The story of how this occurred is an interesting chapter in world history, and the part played by the Public Health Service constitutes one of the most valuable contributions to plague prevention which has ever been made by any organization.

The first official recognition of the danger of importing plague from across the seas was recorded in 1127 at Venice, Italy. Every traveler from the Levant was required to remain in the house of St. Lazarus for 40 days before being admitted to the city. After the Black Death of 1346 to 1355, overseers of public health (proveditori sopra la saluti della terra) were appointed in Venice to isolate vessels, persons, and goods suspected of carrying infection. In 1403, a maritime quarantine station was established; and in 1448, quarantine regulations were formulated on which all later measures have been based.

Over eight centuries elapsed between the time the Venetians first attempted to halt the spread of plague by quarantine measures and the period when ships practically ceased to be carriers of the disease. During these 812 years (1127–1938), quarantine measures must have had some deterrent effect on the spread of plague (*59*).

Legislation authorizing the establishment of quarantine procedures in American seaports by the United States Marine-Hospital Service dates back to 1796. However, little action was taken along these lines until nearly 80 years later. In the meantime, a system of State and local maritime quarantine had developed, the earliest quarantine being established in Boston in 1647. By 1875, the utter lack of uniformity between quarantine procedures in the various ports in the United States led to such confusion and interference with shipping that the Supervising Surgeon General of the United States Marine-Hospital Service voiced an appeal for a national quarantine. On April 29, 1878, a National Quarantine Act was passed which provided for the institution of Federal quarantine facilities at certain points of danger and prescribed regulations for all quarantine activities. On June 2, 1879, a National Board of Health was created for supervision of Federal quarantine, and two stations were set up: on Ship Island near Biloxi, Miss. (Gulf Quarantine), and on Blackbeard Island near Savannah, Ga. (South Atlantic Quarantine). In addition, a quarantine barge was operated at Cape Charles, Va., and a fleet of quarantine vessels patrolled the Mississippi River. Subsequently, quarantine stations were opened at the following points: Cape Charles, Va., and Delaware Breakwater, Del., 1884; Dry Tortugas, Fla., San Diego and San Francisco, Calif., and Port Townsend, Wash., 1889; Sandy Hook, N. J., 1892; Reedy Island, Del., and Brunswick, Ga., 1893.

In 1893, the cholera epidemic in Europe was directly responsible for the Federal legislation of February 15, which determined that enforcement of quarantine regulations was properly a Federal function and which made provision for supervision and acquisition of local quarantine stations. Additional legislation in 1906 pro-

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vided for acquisition of quarantine stations then in operation by State or city governments by condemnation or purchase. By 1921, the last local quarantine stations (New York and Baltimore) had been acquired by the Federal Government, and subsequently there existed a truly national maritime quarantine in all of the United States and its Territories. By 1940, quarantine was being carried on at 52 United States ports, 33 Territorial and insular stations, 41 airports, and 17 border stations and in the Panama Canal Zone (*60*).

Quarantine measures in the latter part of the 19th century placed most of the emphasis on fumigation and disinfection. Ships were fumigated with a 10-percent volume of sulfur dioxide for 48 hours. For every 1,000 cubic feet of air space, 10¼ pounds of sulfur was burned in an SO_2 generator. Steam was used to disinfect the clothing and baggage of crew and passengers; and while their effects were being sterilized, the personnel were bathed. Bichloride of mercury was used liberally in disinfecting various parts of the ship, and even the ballast which remained aboard was dipped in a 1/800 solution of this antiseptic. Any ship which came from a port known to be infected with one of the quarantinable diseases (cholera, yellow fever, plague, typhus, and smallpox) was subject to these procedures; and if such diseases were or had been present during the voyage, the crew and passengers were subject to detention and observation. Hospitals and detention camps were essential parts of quarantine stations. The role of the rat and its fleas had not yet been well defined or accepted, and antirat measures as such were not carried out. Fumigation no doubt was responsible for some rat control, but this was purely incidental to the primary purpose of destroying disease organisms (*2*).

In December 1902, a Service officer on duty during the San Francisco epidemic stated: "I consider it very important that coastwise and other vessels docking here guard against infected rats." He probably was more concerned with the spread of plague from San Francisco to other ports than he was with the importation of plague to San Francisco.

On June 26, 1903, a letter was directed by the Acting Surgeon General of the United States Public Health and Marine-Hospital Service to officers stationed in Yokohama, Nagasaki, and Kobe, Japan, requesting cooperation in securing sulfur fumigation of all ships leaving those ports for the United States, in order that the possibility of the introduction of plague would be reduced to a minimum. In the annual report of the Service for the fiscal year 1903, mention was made of fumigations done primarily to rid ships of rats at Savannah and Tampa (*11*). The use of rat guards on mooring lines of ships was first mentioned in the annual report of the Service for the fiscal year 1904, at San Francisco quarantine (*12*).

In 1907, after the onset of the second plague epidemic in San Francisco, the United States quarantine officer was ordered to fumigate all ships leaving that city for any port in Canada, Mexico, Hawaii, or the United States. Precautions were taken not only to keep ships rat-free by fumigating every 30 days, but also to prevent rats from going aboard while the ships were at dock. Each ship was fumigated for 5 hours with 2½-percent sulfur dioxide gas. All rats obtained after fumigation were examined for plague. Precautions against rats on ships consisted of fending off 6 feet from the dock, using funnels on all lines, and raising gangplanks at night. Certificates of fumigation were issued for each vessel, for the information of the quarantine officer at the ship's destination. The certificate showed the date of fumigation, the compartments treated, the length of the exposure, the strength of gas used, and the precautions taken. Several vessels were fumigated from which over 500 rats were recovered. Even oil tankers, which were popularly thought to be vermin-free, yielded dead rats in quantity after fumigation. Subsequent fumigations usually resulted in fewer dead rats being obtained, and as the conditions in San Francisco improved, the 30-day period between fumigations was lengthened to 60 days. From September 2, 1907, until June 30, 1908, the end of the fiscal year, 2,796 vessels were fumigated (*15*).

During the period 1908–10, the Service investigated the fumigation of ships for rats and prepared a list of the ports in the Orient and in the New World where such fumigations were done. This project was undertaken with the

idea of creating a universal sentiment in favor of the destruction of rats on vessels (*15, 18, 19*).

The practice of inspecting ships to determine whether or not they should be fumigated was carried on in Seattle in 1908 (*15*). However, it was not until the fiscal year 1913 that general attention began to be paid to the degree of rat infestation on a ship rather than merely to the latest date of fumigation (*22*). The art of inspection was subsequently developed to the point where an experienced person could determine very accurately the total number of rats on a ship. It finally became accepted practice to fumigate ships on the basis of the result of inspection rather than on the length of time since the last fumigation, and standards were prescribed which allowed maximum numbers of rats in relation to the ship's tonnage, under certain conditions.

The use of carbon monoxide gas as a ship fumigant was instituted at Philadelphia during the fiscal year 1912, when the steamer *Bratton* was equipped with a Harker fumigating apparatus which could force 1,500 cubic feet of carbon monoxide per minute into the hold of the vessel to be fumigated (*21*).

Hydrocyanic acid gas, which first had been authorized by the Service in 1910, was extensively used in the fall of 1914 on ships fumigated at the port of New Orleans (*24*). This fumigant has increased in popularity until it is almost universally used at the present time. Cyanide was found to be superior to sulfur, especially in loaded vessels, where its penetrating power was much superior, and it was less destructive to certain types of cargo. The following standards (*61*) were determined experimentally in New Orleans:

Vermin	*Cyanide per 1,000 cubic feet*
Mosquitoes	0.4 oz., 15 min.
Fleas	2½ ozs., 15 min.
Bedbugs	5 ozs., 1 hr.
Roaches	10 ozs., 1 hr.
Body lice	10 ozs., 2 hrs.
Rats	5 ozs., 1 hr.

Later on, because of the danger to human life, standard precautions were set up for the use of cyanide; and although accidents have occurred, the number has not been excessive. Included among the precautions was the development of the use of a lacrimating gas (chloropicrin), which is incorporated into the fumigant and serves as a warning that lethal quantities of cyanide still may be present.

The earliest attempts at ratproofing ships were made by Grubbs and Holsendorf in Puerto Rico in 1912. Ratproofing consisted of removal, before fumigation, of dunnage, planking boards, casings, and other material which would give protection to rats from the fumigant gas or would keep the gas from circulating properly (*65*). Following this, Grubbs and Holsendorf developed a system that they called partial ratproofing. As a result, steamship companies began to make removable panels, which could easily be taken out or opened on hinges, for those places which fumigating crews had previously damaged by opening.

During the fiscal year 1924, at New York quarantine, studies were initiated on the ratproofing of ships. It was considered that while fumigation of vessels and trapping of rats would continue to be valuable, ratproofing should take its place among antiplague quarantine procedures on ships in a manner similar to its use in buildings (*38*). By the following year, ratproofing methods had been developed to the point where they were practicable.

In spite of the fact that ratproofing was done on a voluntary basis, there was more demand from steamship companies for demonstration of ratproofing than could be handled by the quarantine station. By midyear 1925, ratproofing was being done on 13 vessels under the supervision of Service personnel, and steamship companies were quick to recognize the benefits which resulted in economic savings (*38*).

By the middle of 1926, ratproofing of ships was being done not only in New York but in Southampton, Bremen, Danzig, Buenos Aires, Gothenburg, and Bergen. Several New York steamship companies maintained regular ratproofing crews who worked on their ships while in port, under the supervision of Service inspectors. The next step was the ratproofing of ships as they were built, and shipbuilding companies began to get consultation and advice from the Service in this respect (*39*).

During the fiscal year 1927, a ratproofing division was established at the New York quarantine station, and five inspectors were kept busy supervising the ratproofing of ships in that port. The War Department instituted

ratproofing of all vessels of the United States Army Transport Service, and the Navy Department requested ratproofing manuals for each naval vessel. Personnel of quarantine stations were given training in ratproofing so that they would be acquainted with the details on return to their respective stations (*40*). A complete set of technical drawings covering ratproofing of vessels then was prepared at New York quarantine and these specifications were approved by the American Marine Standards Committee of the Department of Commerce on February 8, 1929 (*42*).

During the fiscal year 1931, training of Service personnel was continued, and in addition, nine representatives of foreign countries were given practical instruction in ratproofing. Ratproofing had been carried on so extensively that 75 percent of all better-class ships coming into New York had been ratproofed. Ratproofing had been completed or was being accomplished in 288 vessels belonging to 47 different companies of 14 nations. The general acceptance of ratproofing of ships on a voluntary basis was probably not so much due to the fact that disease was being prevented, but rather to the obvious economic gain. Ratproofing ships prevented destruction of cargo by rats, and ratproofed and rat-free ships eventually became exempt from the time-consuming processes involved in routine fumigations (*44*).

Although rodent plague on board ships was common in the early part of the 20th century, it has decreased to a point where it is now exceedingly rare. The primary reason for this accomplishment has been the warfare against rats on board ships. Between 1925 and 1927, records at the New York Quarantine Station indicate that approximately 50 percent of all ships entering that port were rat-infested. In contrast to this, only 8.4 percent of the 4,418 ships entering Atlantic ports from July 1, 1936, to January 31, 1937, were rat-infested. This marked reduction in rat infestation of ships is believed to be the direct result of quarantine measures such as fumigation, ratproofing, international certification, and inspection (*64*).

The Public Health Service has played a vital part in this improvement in ship sanitation. Credit is due to those who have helped to make and to keep ships of all nationalities rat-free. By this means, plague has probably been limited in its spread not only to this country but to many others as well.

Chapter X

Plague in the Territory of Hawaii

On December 12, 1899, Dr. George Herbert, of Honolulu, was called by a Chinese physician to see a patient who was seriously ill. Dr. Herbert suspected that the patient might have plague, and when he died, Dr. Herbert notified the Hawaiian health authorities, who ordered an autopsy. This was performed by Dr. Hoffman, bacteriologist of the Territorial Board of Health, with Dr. Day, Dr. Herbert, and Surgeon D. A. Carmichael of the United States Marine-Hospital Service present. Examination of the body strongly suggested that death was caused by bubonic plague. Specimens for bacteriological examination were taken from enlarged glands, blood, pericardial fluid, and viscera. Stained preparations of fluid from the enlarged glands showed large numbers of a short bacillus rounded at both ends, which resembled that of bubonic plague. A guinea pig was inoculated on December 12, a rabbit on the 13th, and a rat on the 15th. The guinea pig and the rat both died on the 17th, and showed typical plague pathology. Cultures of the organism revealed a typical plague bacillus.

A patient had died under similar circumstances on December 11 and the body was examined with the same result. Three more deaths were investigated; two had occurred on December 11 and one on December 12. Plague bacilli were eventually recovered from two of the bodies. A sixth death occurred on December 14, but was never proved to be due to plague. All of the victims had been residents of Honolulu for at least a year; four were Chinese, one was a Hawaiian, and one was a South Sea Islander. Today, only two of the six cases are officially listed as plague by the Territorial health department.

The Hawaiian Board of Health surrounded Chinatown with a sanitary cordon, divided the district into sections, and began a house-to-house inspection for further cases of plague. No communication was permitted between Chinatown and the rest of the city except by officials on duty. The Council of State for Hawaii appropriated $25,000 to begin sanitary work. A receiving hospital was planned and a crematory was built for disposing of bodies. A morgue was provided and detention camps were prepared (*66*). Buildings where cases of plague occurred were condemned and burned under the direction of the city fire department.

Communication with the other islands was prohibited except under quarantine restrictions. All vessels plying between island ports were required to undergo a detention period of at least 7 days before proceeding to their destinations. Vessels from other islands were not permitted to dock at wharves but were required to anchor in the stream. For a time, all steerage passengers were refused by vessels bound for the United States, and only one liner would accept cabin-class passengers. No Asiatic passengers, baggage, or freight were shipped for several months, and some vessels would not even take mail. Passengers were accepted only from noninfected centers, were kept under observation for 15 days, and their baggage was disinfected before departure. Many travelers were inoculated with Haffkine's vaccine before leaving. Steamships were kept breasted off from docks and were required to tar all mooring lines and to provide them with ratproof funnels. Otherwise, they were anchored in the stream, and cargo was lightered to and from the vessels. Passengers in transit were confined to the vessels, and none of the crews were given shore leave. Guards were placed around Honolulu to prevent anyone from leaving the city. Sugar was the only

cargo shipped to the United States, and special precautions were taken to insure that it was kept clean (*2*).

On December 19, 1899, the quarantine against the infected district was raised, and on December 22, Honolulu was declared to be free from infectious, contagious, or dangerous disease. However, cases of plague began to recur, with 8 deaths during the last 8 days of December (*67*). By this time, the receiving hospital at Kaakako was ready, radical measures were being adopted for cleansing Chinatown, and part of the district was depopulated (*68*).

By the beginning of the year 1900, the board of health had decided that it was necessary to pursue more radical measures for stamping out plague. These measures included the removal of residents from infected places, removal and fumigation of such goods as could be thoroughly disinfected, destruction by fire of infected houses which could not be thoroughly disinfected, building of camps for the detention of suspects until such time as they could safely be allowed their liberty, furnishing of food and bedding for suspects while they were under detention, building of warehouses for disinfected goods, maintenance of quarantine in several localities, removal and care of persons attacked by plague, cremation of persons dying of plague, general inspection and disinfection of premises, and other matters incident to the campaign against the disease. Orders were issued for the establishment of camps of wooden buildings to accommodate 5,000 persons.

On December 30, 1899, the board of health had requested $80,000 for public improvements in the infected districts and $20,000 for an incinerator to burn garbage. The board had also recommended a filtration plant for the municipal water supply ($120,000) and completion of the sewer system which had already been started in the central part of Honolulu (*69*).

On January 4, 1900, the board of health requested the Council of State to appropriate $250,000 to combat plague (*69*). A citizen's committee was organized about January 17 to assist the board of health to stamp out plague. The city was divided into 40 districts, each under the supervision of an inspector, who was responsible to the central committee for the health of the occupants and the sanitary condition of every house in his district. Each inspector divided his district into subdistricts small enough so that the inhabitants could be inspected by one man in an hour. Subinspectors made a census of all persons in each subdistrict twice a day (*70*).

By January 20, a total of 44 cases and 36 deaths had occurred since the beginning of the epidemic, about three-quarters of them in the month of January. On the 20th, during the burning of a house where plague had occurred, the fire got beyond control and the major part of Chinatown was destroyed. The fire swept from Kukui Street on the north to Nuuanu Stream in the west and to the harbor on the south. No lives were lost, but about 5,000 Asiatics and Hawaiians were made homeless. These persons were immediately rounded up and lodged temporarily in Kawaiahao Church and grounds, where they were provided food and shelter. Later on, they were transferred to detention quarters at Kalihi. After the fire, the foci of infection were not numerous and were considerably scattered. Only one case occurred at the detention camp (*2*). Before long, there were over 7,000 persons quartered in detention camps: 5,000 at Kalihi, 1,200 at the Honolulu drill shed, and 1,160 at Kaakako (*71*).

The last case of plague in this epidemic occurred on March 31, 1900, making a total of 71 cases, with 61 deaths. The Hawaiian Islands, including the port of Honolulu, were declared to be free of infection on April 30, 1900. Interisland traffic was resumed without restrictions (*2*).

As early as December 18, 1899, Dr. Carmichael had stated that plague might have been brought into Hawaii by rats from oriental steamers (*66*). On January 12, 1900, he recommended that ships not be allowed to moor directly to docks, in order that infection by vermin might be avoided (*71*). On January 23, he reported a death from plague and remarked that a dead rat had been found in the store where the victim worked (*72*). On February 8, he commented, "Two new foci of infection have been found in the business part of the city adjoining Chinatown, which seem to point strongly to the fact that the infection has been spread by rats or other vermin driven from Chinatown" [by the fire]

(*73a*). On March 2, he noted that a crusade against rats and other vermin by poisoning had been inaugurated but had met with poor success (*74*). On March 31, he stated, "If an active crusade against the rats was now carried on in conjunction with other sanitary measures we might hope for a speedy cessation of the disease" (*75*).

On March 26, the *Hawaiian Star* printed an article which stated: "During the period when only sporadic cases are occurring the board of health might, however, spend its time in a rat campaign, so that when the quarantine is at last lifted there will be no fresh danger from this source. The danger from rats is not exaggerated. . . . There is a unanimous concensus of opinion upon the danger from rats, and a clear idea that a place cannot be considered plague proof unless the rats are exterminated. On the other hand there is an apparent unwillingness on the part of our health authorities to enter upon the campaign of extermination. . . ." About the same time, the *Maui News* stated: "There seems but one thing left to Honolulu, in order to rid herself of plague, and that is to rid herself of rats. . . . as long as sick rats are left to run along the telephone wires from one end of Honolulu to the other, just so long will the yellow flag fly on her housetops" (*76*). As a result of this publicity, an official rat catcher was employed by the city and a bounty of 25 cents per rat was paid. No general campaign was undertaken, however.

The above evidence shows that there was a good deal of insight into the role played by the domestic rat in the transmission of plague. This is surprising, because the rat-flea theory of plague transmission had been advanced only a year or so before and was not conclusively proved nor generally accepted until several years later, after extensive research in India. Infected rats were found in Honolulu, but, as in other current epidemics, preventive methods were not directed against rats, but emphasized isolation, quarantine, disinfection, and destruction of infected premises by fire.

In the spring of 1901, plague again occurred in Honolulu. A Japanese woman succumbed to the disease on March 29. The diagnosis was proved by autopsy, animal inoculation, and bacteriological study (*77*). Cases of plague continued to occur throughout the year, with a total of 20 cases and 19 deaths. Two of these deaths were remarkable because dead rats had been found in the patients' places of occupation; plague bacilli had been demonstrated in a rat from one of the places. On June 22, 1901, plague infection was reported among 21 rats caught near Beretania and Nuuanu Streets and in about 20 caught at the slaughterhouse (*73a*). On July 2, a dead rat was found within 150 feet of a bakery. A fatal case of plague occurred 4 days later in an employee of the bakery (*78*).

On June 19, 1901, the Surgeon General advised the disinfection of all baggage of outgoing steerage passengers, and inspection of all passengers and crew. These requirements were put into effect on July 9, in addition to spreading rat poison on wharves and breasting ships off a distance of 8 feet (*80*). These restrictions were removed on August 17, 1901, after the lapse of a 30-day period during which no human or rodent cases of plague were found (*81*).

Table 7. Human cases of locally acquired plague on the Island of Oahu, 1899–1910

Year	Deaths	Recoveries	Total cases
1899	11	1	12
1900	50	9	59
1901	19	0	19
1902	37	0	37
1903	17	0	17
1904	8	0	8
1905	13	0	13
1906	17	1	18
1907	30	12	42
1908	0	1	1
1909	0	0	0
1910	2	0	2
Total	204	24	228

On October 11, 1901, dead rats were found in the hold of the interisland S. S. *Waialeale*, which plied between Honolulu and the Island of Kauai. The ship was fumigated, and approximately 13 dead rats found; 1 rat selected at random was found to have plague (*82*).

In the early part of November, the following plan was adopted by the Territorial Board of Health:

"1. The town to be divided into districts and each district covered by an inspector, who shall distribute rat traps and poison, see that they are properly used, deodorize the traps, and collect all rats.

"2. The district as a whole to be under the supervision of two superintendents.

"3. The methods of exterminating rats to be confined to traps, poison, and sulfur fumigations; the rat-bounty method not to be used.

"4. All rubbish to be cleared up and burned.

"5. All interisland vessels to be fumigated.

"6. All wharves and warehouses to be made airtight for sulfur fumigation; this to include underneath the wharves.

"7. The rats are to be kept separated according to the district from which they come, and are to be examined bacteriologically for the purpose of determining whether or not a certain district is probably infected and is in need of special attention" (*79*).

Table 8. Plague on board ships arriving at Honolulu, T. H., August 1904–June 1910

Ship	Arrival date	Sailed from—	Human cases	Plague-infected rats
	1904			
S. S. *Coptic*	Aug. 22	?	1	?
	1907			
S. S. *American Maru.*	Jan. 29	Orient	1	?
S. S. *Sierra*	Sept. 14	San Francisco.	1	?
	1910			
S. S. *Nippon Maru.*	June 10	Kobe and Yokohama.	3	3

Table 9. Deaths from plague on the Island of Kauai, T. H., 1901–1902

Year	Place of death			Number of deaths
	Kealia	Eleele	Wahiawa	
1901	2			2
1902		5	4	9
Total	2	5	4	11

Table 10. Distribution of human cases of plague on the Island of Maui, T. H., 1900–1938

Year	Number of cases of plague						
	Kahului	Wailuku	Kula	Makawao	Puunene	Unknown	Total
1900	7	2					9
1930						1	1
1931			1				1
1932				[1] 4			4
1938					1		1
Total	7	2	1	[1] 4	1	1	16

[1] 1 recovery (*83*).

Restrictions on shipping were instituted at intervals during subsequent years, as follows:

Date instituted	*Date removed*
Nov. 14, 1901	Apr. 2, 1902
May 12, 1902	June 12, 1902
Aug. 7, 1902	Oct. 5, 1902
Aug. 26, 1904	Oct. 24, 1904
Oct. 24, 1905	Dec. 28, 1905
May 14, 1906	June 14, 1906

In 1907, widespread examination of domestic rodents for plague was started. A plague-positive rat was found at Aiea, near Honolulu, on September 1, 1907, and another on April 13, 1910. During all these years, human cases of plague continued to occur on the Island of Oahu (see table 7). In addition to the locally acquired cases, during the period August 1904 through June 1910, six human cases of plague and three plague-infected rats were found on board ships arriving at Honolulu (see table 8).

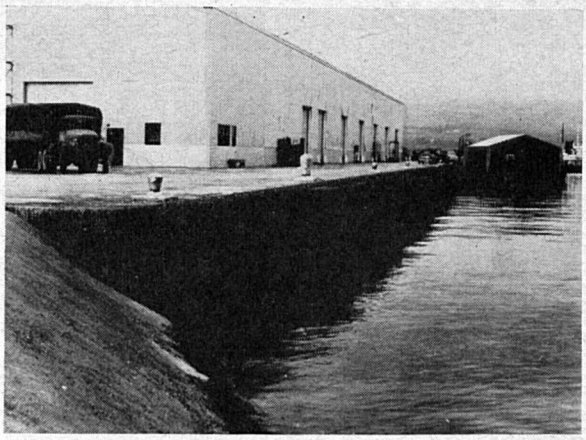
Plague disappeared from the Island of Oahu after 1910 and has never returned. It seems likely that its disappearance was due to natural causes rather than to the direct result of control efforts, because intensive antiplague measures were never instituted in Oahu. Trapping and poisoning of rats were carried out only in a desultory manner and could not have been responsible for any marked effect upon rodent populations.

On the Island of Kauai, the first death from plague occurred on November 5, 1901, at Kealia. Subsequent cases occurred there and

at two other small ports, Eleele and Wahiawa. An epizootic was noted among rats in a large warehouse at Eleele in 1902 during the time that human cases of plague were reported at that port. Altogether, 11 fatal cases occurred (see table 9).

Three of the deaths occurring during January 1902, two at Wahiawa and one at Eleele, are listed by the Hawaii health department as typhoid fever, intermittent fever, and typhoid fever, respectively (all with question marks). Although two cases of plague are listed in some reports for 1906, no official records exist in the health department to support these diagnoses (*83*).

At the end of January 1900, cases of plague began to occur on the Island of Maui, at Kahului and at nearby Wailuku. The disease was supposed to have been imported from Honolulu in foodstuffs shipped before December 12, 1899, but which were not unpacked until shortly before the cases of plague occurred. The first death took place on February 4, with eight more deaths during the following 3 weeks. Eight of the deaths were among Asiatics. Chinatown was at once depopulated and the infected area was destroyed by fire. Infected persons were removed to an improvised detention camp at the race track. Infested rats



Wharf and warehouse, Hilo.

were found at Kahului, and the last human death was alleged to have been caused from contact with an infected rat which had escaped from Chinatown (*2*).

Although plague was not reported again officially until 31 years later, there is reason to believe that it probably existed on Maui in the interim. The presence of fatal rat epizootics as far back as 1916, the fatal termination of a case of inguinal adenitis in 1925, and several suspicious cases of illness suggestive of plague in the fall of 1930 all point toward the fact that plague may have continued to exist on the

Table 11. Distribution of human cases of plague in Hilo, Hawaii, and vicinity, 1900–1918

Year	Hilo	Olaa	Papaiko	Pepeekeo	Laupahoehoe	Total
1900	5					5
1903	[1] 5					5
1904	[2] 5					5
1905	2	2				4
1907		3				3
1908	2					2
1909		[3] 7	2	1		10
1910	[4] 6					6
1912				1		1
1918					2	2
Total	25	12	2	2	2	43

[1] 1 recovery. [2] 2 recoveries. [3] 4 recoveries.
[4] 2 recoveries (*83*).

Table 12. Human plague in the Hamakua district, Hawaii, 1910–49

Year	Number of deaths	Year	Number of deaths
1910	3	1927	7
1911	5	1928	8
1912	7	1929	[1] 5
1913	4	1932	2
1914	4	1933	2
1915	4	1934	2
1917	5	1935	1
1919	7	1939	1
1920	4	1943	7
1921	4	1944	5
1922	12	1945	1
1923	1	1949	1
1924	2		
1925	1	Total	112
1926	7		

[1] 1 recovery.

Examination of daily catch of rats at the plague laboratory, Honokaa.

Island of Maui, at least part of the time. A laboratory study was made of one of the cases which occurred during the fall of 1930. Smears made from an inoculated guinea pig subsequent to its death showed typical coccobacilli (*84*).

The last human case of plague on the Island of Maui occurred during 1938. Distribution of the 16 cases during the period 1900–1938 is shown in table 10. Between August 1931 and January 1933, 15 plague-infected rats were obtained on the island.

Plague was first proved to exist on the Island of Hawaii in 1900, when a death from the disease occurred in Hilo on February 6. With the exception of two deaths from doubtful causes in Naalehu in the southern part of the island in 1906, plague has been confined to the districts of the northern coast (*84*).

Plague in the vicinity of Hilo, the second largest port in the islands, appears to have smoldered along for several years without ever becoming epidemic. Infection among rodents was more widespread than the human cases recorded. The distribution of 43 cases of human plague in Hilo and nearby plantations (*83*) is shown in table 11.

From 1907 to 1913, some 40 infected rats were found in Hilo and on the nearby plantations. Infected rats were found as far away as Hakalua plantation, 17 miles from Hilo.

An energetic campaign against rats was started in Hilo in the fall of 1907, and for several years rats were systematically obtained and examined. In the fall of 1908, Hilo was divided into three districts. In the "infected district," it was advised that:

1. Rat harbors be destroyed.
2. Poison be placed in every home.
3. Traps be placed in each house and visited daily.
4. Carbon bisulfide fumigation of all ratholes be done twice a week.
5. Bounty be given for plague rats.
6. Garbage be collected daily.

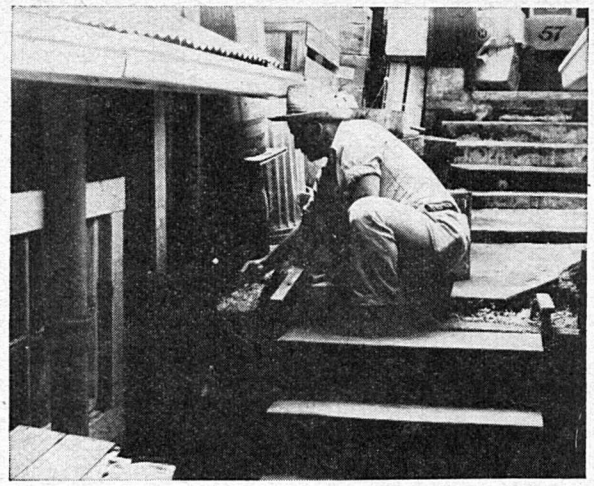
In the other districts, it was decided to place traps and poisons in each house.

However, as in other parts of the Hawaiian Islands, plague seems to have disappeared from Hilo because of natural forces at work rather than from any efforts of man to control the disease.

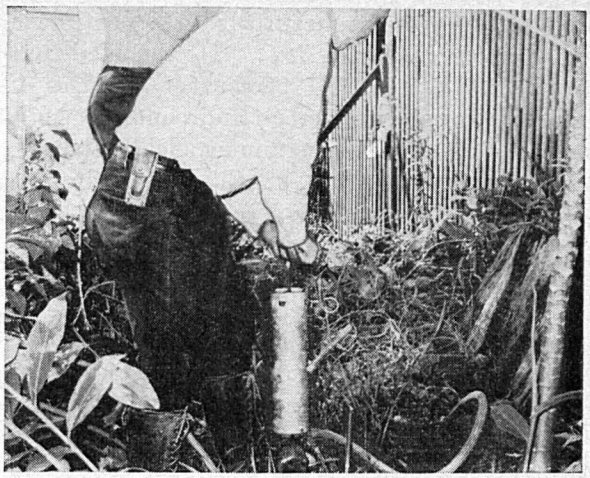
Plague in the Hamakua district of the Island of Hawaii has exhibited a persistence which has not been seen anywhere else in the islands, with the exception of Maui. Plague was first reported in this area in March 1910, when two girls who had a history of having handled dead rats died of the disease. Some 69 rats were proved to be plague infected in the 3-year period 1912–14, and between 1915 and 1933, plague was demonstrated in an additional 151 rats. Plague-infected rats have been found every year since 1933 and are still being reported. Human cases of plague occurred almost every year during the period 1910–49 (see table 12). All cases but one were fatal.

Some very interesting facts regarding the

DDT dusting in attics, Hamakua District.



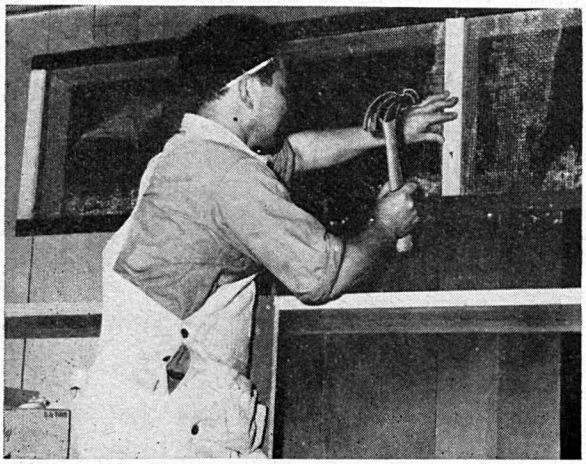
Plague surveillance by trapping, Hamakua District.



Cyanogassing rodent burrows, Hamakua District.

Use of carbon bisulfide to destroy rats in rockpile, Hamakua District.

Distribution of poison torpedoes in canefield, Hamakua District.



Ratproofing in Hamakua District.

DDT spray used as pulicide, Hamakua District.

epidemiology of plague in this area have been pointed out by Eskey (*84*). He reported that from 1910 to 1922, 51 percent of all cases of plague were among women and children, while only 12 percent were among field laborers. During the period 1923–32, this proportion was reversed, with only 18 percent of the plague cases among women and children and 64 percent among field laborers. During the period 1915–21, about 60 percent of the plague-positive rats were found in and under buildings, whereas in the 1923–32 period, only 15 percent of the plague-positive rats came from buildings. This was probably due to the ratproofing and rat-eradication measures which were conducted in and around buildings.

Dr. Eskey concludes that there have been two types of plague in the Hawaiian Islands: an urban type, which appeared to be a self-limited epidemic variety and which occurred in association with domestic rodents and the *X. cheopis* flea; and a rural type, which occurred in the Hamakua District of Hawaii and on Maui Island. The rural type appears to be extremely persistent and is associated with domestic rodents infested with the flea *Xenopsylla hawaiiensis* (*84*).

The very high mortality rate from plague in the Hawaiian Islands is due to the fact that the disease is not usually recognized until the patient dies. Mortality rates of this magnitude (91 percent) have not been observed in other localities, but there is no reason to believe that plague causes more deaths in Hawaii than elsewhere.

The extreme persistence of plague in the Hamakua District of the Island of Hawaii, in spite of years of antirodent activities, makes one wonder whether or not such control work is the answer to the plague problem.

A review in the spring of 1951 showed that plague control activities in the Hamakua District are directed toward protection of the human population. Rodent control activities, such as trapping, gassing, and poisoning, are carried on in areas adjacent to human habitations. Spraying and dusting with DDT are used as a flea control measure in and around houses. These efforts must have some effect on prevention of human infections. However, they do not exert influence against the source of the difficulty—the infection of the rodent reservoir hosts and the ectoparasite vectors.

In May 1951, the Communicable Disease Center of the Public Health Service and the Territory of Hawaii Department of Public Health agreed to undertake a joint investigation to determine whether or not plague could be eradicated from the Island of Hawaii. It was proposed that studies be initiated to find out whether DDT could be used in an attack on the flea as a method of breaking the chain of infection. It was thought that it would require about a year's time to develop and perfect a method of using DDT in the area.

It was realized that several difficulties would be encountered if DDT were distributed by conventional methods: (*a*) the humid, rainy climate might inactivate DDT; (*b*) it would be difficult to reach the rat's habitat through dense sugarcane or brush; (*c*) DDT would certainly destroy beneficial insects imported to combat cane borers and leafhoppers (sugarcane predators); and (*d*) if DDT were used liberally on growing sugarcane, it could possibly become part of the raw sugar product.

These difficulties serve to make ectoparasite control in the Hawaiian Islands somewhat more difficult than in other areas of the world. However, it was believed that the difficulties were not insurmountable, and studies along these lines were initiated in December 1951. It will be interesting to watch their progress and to see whether or not a practicable method of ectoparasite control is developed.

Plague in Puerto Rico

On June 17, 1912, an official announcement was made that plague existed in the Island of Puerto Rico. Several cases had occurred by that date and a total of 55 cases with 36 deaths was recorded by September 13, 1912. These were distributed as follows:

Locality	*Cases*	*Deaths*
San Juan	51	32
Carolina	3	3
Dorado	1	1
Total	55	36

On June 20, the following outgoing quarantine regulations were put into force:

1. Fumigation of vessels.
2. Prevention of rats going aboard vessels directly or in freight.
3. Deratization and ratproofing of piers and waterfront.
4. Inspection of passengers' baggage (vessels were allowed at wharves only from 6 a. m. to 6 p. m.) (*21*).

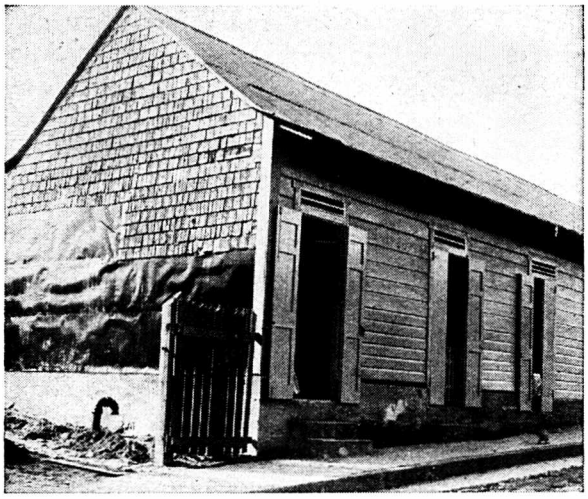
On June 27, Passed Assistant Surgeon R. H. Creel and Assistant Surgeon C. L. Williams arrived at San Juan, and the eradicative features of the campaign were turned over to the Public Health Service on June 30. The Insular Department of Sanitation attended to the hospitalization of patients, maintenance of isolation and detention camps, furnishing of office and laboratory buildings necessary for operations, provision of unexpendable supplies, collection and disposal of garbage, and inspection of suspicious dead. Necropsy of suspicious cases was carried out jointly by the Public Health Service and the Insular Department of Sanitation. Later on, the maintenance of detention camps and hospitalization of cases were also turned over to the Service.

The plans for eradication of plague included the following (*22*):

1. The quickest possible ratproofing of the entire city.
2. The thorough supervision of inland-bound freight so that no rodents should escape from San Juan in packages of merchandise.
3. A special force of men for widespread trapping and poisoning of rodents.
4. A laboratory force to examine all captured rodents.
5. The tagging of rats collected so that the location of any infected rodent would be known and the progress of infection mapped out.
6. The sulfur fumigation of all infected premises.
7. Flea destruction measures (sulfur fumigation and petroleum spray).

On July 11, 1912, a proclamation was issued by the Acting Governor of Puerto Rico promulgating regulations for the construction and ratproofing of all buildings on the island. Some time previously a tentative ratproofing law had been drafted by the insular board of health; and at the suggestion of the Service representative, a section was added which dealt with buildings already constructed. Dwellings were required to be elevated 2 feet, with free underpinning, or to be surrounded at their perimeter by a concrete wall extending 2 feet below the surface of the ground and fitting flush to the floor. Groceries, markets, bakeries, and other places that kept provisions were required to have concrete floors and concrete walls which extended 2 feet below the ground and 1 foot above the floor level. Specifications also were given for ratproofing stables and chickenhouses.

The city of San Juan was divided into eight districts, and an inspector was assigned to each district. In addition, two men were employed as special inspectors to supervise the ratproofing of the old city, where most of the construction was of the type known as mamposteria, with



Ratproofing in San Juan.

massive, thick walls of material similar to adobe. These buildings were ratproofed by installing concrete floors in all places where provisions were stored and by placing a 4-inch capping on the walls, which extended 2 feet below the ground and upward above the floor level. In warehouses, the wall extended 4 feet above floor level, and in smaller buildings, 1 foot.

Table 13 give a summary of the ratproofing accomplished the first year of the plague epidemic in La Perla, Puerta de Tierra, and Santurce, all "barrios," or suburbs, of San Juan. In Puerta de Tierra, 50 houses were destroyed as soon as the epidemic started. In Santurce,

Ratproofing in the Marina District, San Juan.

the better residential part of the city, there were relatively few food depots and the dwellings were well kept, free of refuse, and had good garbage disposal facilities.

The ratproofing of public buildings was carried on in the same manner as the ratproofing of private property. The following expenditures were made:

Buildings	*Expenditures*
Customs warehouses	$3, 092. 84
War Department stables	5, 000. 00
Insular Government buildings	7, 758. 48
Total	15, 851. 32

It is estimated that the ratproofing of privately owned buildings in San Juan cost as follows:

Locality	*Expenditures*
La Perla	$100, 000. 00
Puerta de Tierra	80, 487. 27
Santurce	57, 713. 57
Total	238, 200. 84

Altogether, some $250,000 was spent on ratproofing in the city, most of which does not represent the expenditure of public funds.

A serious attempt was made to control shipments of freight from San Juan to other localities in Puerto Rico to prevent infected rodents from setting up other epidemic foci. Inspectors were stationed at various points in San Juan, and all outgoing merchandise was inspected or fumigated. Surveillance was maintained at railroad freight warehouses, docks, ferry station, express office, and at the highway exit from the city. All packages capable of harboring rats were unpacked or exposed to sulfur fumigation. All freight cars leaving San Juan were required to be ratproof. Dead spaces were made tight and inaccessible to rodents. Breaks in car floors were repaired, and windows were made ratproof. All cars left standing on the tracks at night, if loaded or partially loaded, were sealed by the inspector.

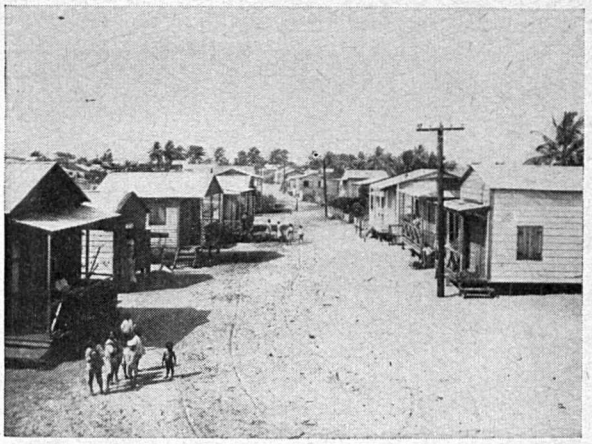
This work was continued until December 1, 1912, by which time 57 rodents had been taken from such merchandise. The efficiency of the methods used was attested to by the fact that observations were made at several localities to the effect that previous to such inspections it was not unusual to notice rats leaving freight or freight cars, but that since the beginning of

inspections, no rats had been seen. The following tabulation summarizes the results of freight inspection in San Juan.

Activity	*Number*
Rodents taken from merchandise	57
Cars inspected	2, 683
Oxcarts inspected	6, 075
Pieces of freight fumigated	15, 620
Pieces of freight inspected	397, 708

Trapping was limited at the start because only about 100 traps were available from the local markets. An order was cabled to the United States for 1,500 snap traps and 1,500 cage traps, and eventually the number of traps was increased to 9,000.

The city was divided into 10 districts, with a foreman and 4 men assigned to each district. In addition to his salary, each trapper was paid a bounty for every rat caught. The daily catch averaged about 10 rats during the first week, and rapidly increased to a maximum catch of 178 rodents on July 28, 1912. The average catch then diminished until about half that number were being caught in September and about one-fifth of that number in November.



Ratproofing by elevation in Puerta de Tierra.

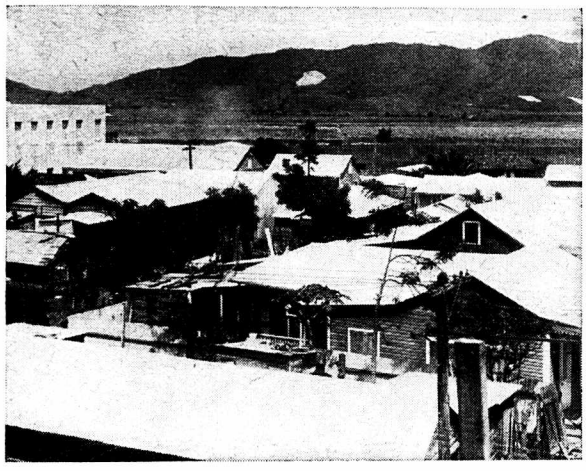
In September, the number of foremen was doubled in order to give more strict supervision and the rat bounty was increased from 5 to 10 cents, with $1.00 being paid for infected rats. Fifty-two infected rats were obtained from San Juan, the first on June 23 and the last 84 days later, on September 11, 1912.

Between the early morning hours, when the trappers turned in their catches of rats, and the

Table 13. Ratproofing accomplished in three barrios of San Juan, P. R.

Type of building	Barrio					
	La Perla		Puerta de Tierra		Santurce	
	Total buildings	Number ratproofed	Total buildings	Number ratproofed	Total buildings	Number ratproofed
Food depots	203	183	69	69	142	142
Dwellings	735	706	1, 006	[1] 170 [2] 507	2, 961	[1] 219 [2] 622
Stables	8	8	44	44	28	28
Stores and other buildings	125	10	----------	----------	----------	----------
Piers and wharves	4	4	----------	----------	----------	----------
Miscellaneous	----------	----------	8	8	39	39
Total buildings ratproofed	----------	911	----------	798	----------	1, 050
Considered ratproof [3]	----------	----------	----------	279	----------	1, 869
Destroyed by fire	----------	----------	----------	50	----------	----------
Noncompliant	----------	----------	----------	----------	----------	251
Grand total	1, 075	[4] 911	1, 127	1, 127	3, 170	3, 170

[1] By concrete. [2] By elevation.
[3] Because of elevation.
[4] An additional 33 buildings were in process of compliance and 131 were noncompliant.



Ratproofing of roofs, Caguas.

afternoon hours, when the traps were baited and reset, the men distributed poison. Arsenic and phosphorus poisons made in the insular chemical laboratory were used. Six hundred pounds of poison were distributed in the 6-month period between July 1, 1912, and January 1, 1913.

An isolated and well-equipped laboratory was opened on June 30, 1912. It was operated for a short time by Major F. F. Russell of the United States Army, and then successively by Passed Assistant Surgeon J. R. Ridlon and Passed Assistant Surgeon C. W. Chapin of the Public Health Service.

Rats were dissected, and any gross pathology was noted. Animal inoculation was required for the diagnosis of plague, although during the first week or two, smears only were made. Several mongooses were examined, but no positives were found among them. Nearly 76,000 rodents were examined during the year, approximately 25,000 coming from the port of San Juan and the remainder from other localities in the island. There was a predominance of *R. norvegicus*, although all three principal species of rats, as well as house mice, were found. The following species of fleas were identified: *X. cheopis*; *C. canis*, *Echidnophaga gallinacea*, and *P. irritans*. Infected rodents were found and human cases of plague occurred in other places on the island (table 14).

Assistant Surgeon C. L. Williams and Passed Assistant Surgeon J. R. Ridlon undertook the task of carrying out antiplague measures in Carolina, Caguas, and Arecibo. Similar measures were instituted in Mayaguez and Ponce, where no plague was ever found in rodents or in humans. Rat-trapping was carried on in Carolina, Rio Piedras, Caguas, Arecibo, Bayamon, Manati, Aguadilla, Mayaguez, and Ponce. In general, the work closely followed the pattern set in San Juan (*22*).

On October 31, 1913, the plague control work of the Service was completed in Puerto Rico. The insular health department continued to examine large numbers of rodents each year for plague, but no positives were found (*23*).

On February 21, 1921, plague again was declared officially to exist in Puerto Rico, by proclamation of the Governor. The disease was discovered after a series of dramatic events, in

Table 14. Plague in Puerto Rico excluding San Juan, July–December 1912

Locality	Human deaths	Infected rodents
Carolina	3	7
Caguas	--------	4
Arecibo	--------	2
Rio Piedras	--------	1
Dorado	1	--------
Total	4	14

Table 15. Plague in Puerto Rico, 1921

Locality	Human plague	Rodent plague
San Juan	6	43
Caguas	3	0
Santurce	3	22
Bayamon	1	1
Carolina	4	1
Puerta de Tierra	4	11
Dorado	1	0
Fajardo	0	1
Arecibo	1	0
Isabela	1	0
Manati	2	2
Guaynabo	0	1
Rio Piedras	0	6
Total	26	88

which a storekeeper, attempting to conceal a rat epizootic, became one of the victims.

About a week before plague was determined to have recurred in San Juan, the local newspapers reported that a number of dead rats were being found in a wholesale provision store at 43 Tetuan Street. The owner of the store did not report the occurrence to the health authorities because he did not want the expense and inconvenience of making the improvements which he was sure would be required to rid his place of rats and make the premises ratproof. Instead, he saw that the 10 to 20 rats found dead every day were placed in the garbage can and concealed under other refuse. The garbage was disposed of in the usual manner at the dump in Puerta de Tierra, between the old city and Santurce.

Within a week after the first dead rats were found, the proprietor's daughter was stricken with a violent illness, accompanied by enlargement of the femoral glands. Although this illness was very suspicious of plague, the diagnosis was never confirmed, and the patient recovered. Shortly afterward, the proprietor himself fell ill and died of typical bubonic plague, which was proved at autopsy. In all, there were four cases of plague, with two deaths, among persons employed in this store. A woman who lived on Tetuan Street opposite the store and who had made frequent visits to see the proprietor's daughter while she was sick also died of plague. During the 1921 epidemic (*34*), human and rodent plague occurred in 13 Puerto Rican communities (table 15).

The antiplague measures which followed this outbreak were conducted by the insular department of health. The Public Health Service was responsible for all quarantine procedures and also for plague control measures along the waterfront. The last human case of plague occurred at Caguas on August 30, 1921; the last rodent case at San Juan on September 8, 1921 (*35*).

In certain respects, the epidemic of plague in Puerto Rico resembles the epidemics in New Orleans. Both places had their first siege of plague several years prior to the second outbreak, with an intervening period of quiescence, during which no rodent plague was known to exist. Whether the second outbreaks were due to reintroduction of the disease or to its persistence in rodents will never be known although disruption of precautionary measures against rats on ships because of World War I may have been a factor in the widespread occurrence of plague in Puerto Rico and the gulf coast cities in the immediate postwar years.

Chapter XII

Modern Plague-Control Methods

There exists in the western part of the United States a vast reservoir of plague in wild animals which may never be entirely eliminated, not only because of the size of the area involved and the prohibitive cost of such widespread operations, but because nature has her own way of counteracting man's efforts whenever he attempts species eradication. No doubt plague will continue to exist in wild animals in this area, and the situation must be accepted and appreciated.

To control plague in wild animals, surveillance should be maintained to prevent spread of the disease to new areas, where it may eventually come closer to important metropolitan areas which are infested with domestic rodents. Educational programs are also in order, not only to warn the general public against the danger of handling sick or dead wild animals, but to remind the physician to bear in mind the possible diagnosis of plague whenever he encounters axillary or inguinal lymphadenopathy or atypical pneumonia of unusual severity. This is emphasized by the Oakland and Los Angeles pneumonic plague outbreaks. The Oakland case was called influenza and the Los Angeles case was diagnosed as a venereal bubo. In both instances, the epidemics might have been limited had a correct diagnosis been made of the original cases.

It is easy to condemn such diagnoses in retrospect, but it must be remembered that at present plague is a rare disease in this country. Furthermore, only by constant awareness on the part of the physician will the disease ever be diagnosed early enough to take suitable precautions against the spread of pneumonic plague.

Persistent efforts should be made to promote and maintain domestic rodent control programs in all communities, of whatever size, which are located near known plague foci and which are infested with domestic rodents. Such activities will decrease the opportunities for plague to be transferred from wild animals to domestic rodents and will obviate the necessity for emergency measures should domestic rodents become infected.

Over 80 percent of the human cases of plague in this country have been associated with plague in domestic rodents, and there is little reason to suspect that any future epidemic will be any different. However, the course of future epidemics should be of a greatly different character because of the development of insecticides such as DDT and 1080 for the control of epizootics in the domestic rat and of antibiotics (streptomycin and sulfadiazine) for the treatment of human beings.

It is accepted generally that, although the epizootic always precedes the epidemic, the human case is usually the sentinel which indicates the presence of plague in any community. There is only one known exception to this rule in this country.

In Tacoma, Wash., plague was discovered in rats in 1942 and persisted for nearly 3 years without the occurrence of a human case (*62*).

In spite of this exception, it is to be expected that the presence of plague in any community in the future will be signaled by the occurrence of a human case. An immediate epidemiological survey should provide clues to indicate whether wild animals or domestic rodents are the source of the infection. If the disease appears to be of wild-animal origin, there need be little immediate concern unless the human case is one of pneumonic plague. In that case, intensive efforts should be made to institute treatment with streptomycin, to maintain strict isolation of the patient to prevent further spread of the disease, and to provide prophylactic sulfadiazine to all contacts of the patient, as

well as to those persons immediately responsible for his medical care.

If infected rodents appear to be the source of the infection, a trapping survey should be made of the residence, place of occupation, and places habitually visited by the patient, and the rats obtained should be autopsied and their ectoparasites injected into guinea pigs. Should plague infection be found in these domestic rats, the immediate inauguration of antiplague efforts is indicated. It is advisable first to try to reduce the ectoparasites of the rodent population before eliminating those hosts. This can readily be done by liberal dusting of premises with 10-percent DDT, beginning in the restricted area where the known plague-positive rats were found and working from there over the entire city wherever there is rat infestation.

Coincident with this preliminary attack on the rodent ectoparasites, intensive trapping and poisoning with 1080 should be begun. Trapping methods have not changed much during the years, but 1080 is the most efficient poison which has been developed for use against the rat. The use of 1080 must be carefully controlled because it is very toxic to human beings and no known effective antidotes exist; fatalities will follow its careless distribution. Warfarin, although much slower in its lethal effect, is a far better rodenticide because of its thoroughness and lesser toxicity.

The use of DDT will minimize the immediate danger of ectoparasites transmitting plague to human beings, and trapping and poisoning will help rid the city of its rat population. Following these emergency measures, operations should be started to deprive the rat of his sources of food and his places of safety. A general cleanup of the city, with special attention to proper garbage collection and disposal, will aid in making it difficult for rats to get food. Wrecking crews are valuable in helping to remove and destroy those places to which rats find ready access and where they find safe harborage. The installation of permanent ratproofing of all buildings in the city is the ultimate objective of the long-range preventive campaign. This requires legal authorization for its institution and considerable education of the public for its general acceptance. Emergency measures should be put into effect while public interest is high because of human cases of plague. Permanent and long-range antirat measures should be planned and started before the general excitement is over and before the public has lost some of its immediate interest.

All of these activities require technically trained personnel and special equipment from the time that plague is suspected until the last building in the city has been made ratproof. There are few communities in this country and relatively few State health departments which have such specialized personnel. The Public Health Service will continue to provide assistance to any community where plague becomes a problem. The Service has done this on many occasions in the past and may be expected to do so in the future.

Chapter XIII

Treatment and Prophylaxis of Plague

Until the recent use of streptomycin in plague therapy, human cases of plague have been treated largely by the application of methods developed elsewhere in the world. Even though these methods were not devised in the United States, a recounting of their development and usage provides an interesting story of the early difficulties encountered in attempts to prevent and treat plague. The innumerable methods employed in the management of individual cases of plague during the past 50 years illustrate the old maxim in medicine that whenever many methods of treatment are recommended for a particular disease probably none of them is of specific value.

In general, the development of the modern treatment and prophylaxis of plague can be described under four topics: serum therapy, vaccines, chemical agents, and chemotherapeutic and antibiotic drugs.

The serotherapy of plague was inaugurated in 1895 when Yersin, Calmette, and Borrel (*85*) undertook the immunization of laboratory animals by injecting them with live germs. A horse which had received injections composed of living and virulent cultures furnished a serum which immunized mice by a dose of 0.1 ml. given 12 hours before the injection of the virulent culture; in a dose of 1.5 ml., the serum cured mice inoculated 12 hours before with a platinum loopful of plague bacilli. The first serum used by Yersin in 1896 (*86*) in the treatment of certain cases of bubonic plague in Canton and Amoy, China, gave excellent results.

In spite of its value, the preparation of antipest serum with living cultures presented many dangers. Therefore, an attempt was made to immunize large animals in a less dangerous manner, by injecting them either with cultures killed by heat or with substances extracted from the bodies of the microbes. However, these methods did not furnish a sufficiently active serum.

At first, Yersin's serum was used in small quantities in the treatment of human plague. Then the experience of Calmette and Salimbeni (*87*) in Oporto (Portugal) demonstrated the advantage of using larger quantities of the serum than were previously considered necessary. In the first San Francisco epidemic, it was recommended that, of 160 to 200 ml. of serum to be given in the first 48 hours of the disease, 40 ml. be given intravenously. Yersin's vaccine was used as a prophylactic also by giving 5 to 10 ml. every 15 days (*2*).

The value of serum in the treatment of plague has been thoroughly debated during the past 50 years. The earlier opinions appeared to agree that its value was proportionately greater the sooner it was given after the onset of symptoms. Table 16, based on a table by Choksy in India (*1*), supports this conclusion.

In 1897, Haffkine prepared a vaccine by growing *Pasteurella pestis* in a bouillon made from goat's flesh macerated with dilute hydrocholoric acid. This bouillon was transferred to large flasks, inoculated with plague organisms, and a certain amount of native butter was added. Although the butter was partially emulsified, most of it floated on the surface of the bouillon as an oily layer and allowed the plague organisms to grow under almost anaerobic conditions. After about 3 weeks, the entire fluid was subjected to a temperature of 70° C., a small proportion of phenol was added, and the vaccine was ready for use. It was recommended that 2 to 5 ml. be used, which indicated that the potency of the vaccine was not too high.

The Pasteur Institute later modified Haffkine's method by growing the organism on agar

Table 16. Increased mortality from plague, according to day of treatment

Day of illness	Number treated	Number recovered	Case mortality (percent)
First	316	220	30. 3
Second	300	142	52. 6
Third	246	91	63. 0
Fourth	105	45	57. 1
Fifth	52	20	61. 5
Sixth	14	6	57. 1
Seventh	4	0	100. 0
Total	1, 037	524	50. 7

plates at 37° C. for 4 days, transferring the growths to peptone-free bouillon (100 ml. for each agar plate), killing the growth by subjecting it to 70° C. temperature for 2 or 3 hours, and then bottling the vaccine.

The Hygienic Laboratory (now National Institutes of Health) of the United States Marine-Hospital Service further modified the method by simply growing virulent cultures of the organism in ordinary peptonized bouillon in flasks which exposed a large surface to the air. The cultures were grown from 3 to 4 weeks and then killed by exposure to 70° C. heat for 2 hours. Each lot was tested bacteriologically to be sure that all organisms had been killed. By July 1900, a total of approximately 400,000 doses of 1 ml. each had been prepared in this manner and used to inoculate persons at Honolulu, Hawaii, and San Francisco, Calif. (*88*).

Figures from the Bombay Presidency (*88*) indicate the apparent efficacy of Haffkine's vaccine (table 17).

Among those inoculated, there was apparently a significant reduction in the number of persons who contracted plague, as well as a marked reduction in the case fatality rate of those who fell ill of the disease. However, no data are given with these figures to indicate whether or not there was uniform exposure to the disease or how the selection of persons to be inoculated was made. The vaccine was reported to be effective for several months, and immunity was increased by second and third inoculations.

Further figures, from Sharwar, India (*88*), support the idea that multiple inoculations were better than single inoculations, especially from the viewpoint of decreasing morbidity (table 18).

Haffkine's vaccine was contraindicated for any person already exposed to plague because of the danger of adding toxin to an existing infection. By August 31, 1900, nearly 2 million doses of Haffkine's vaccine had been distributed to various parts of India by the Plague Research Laboratory in Bombay (*89*).

Other vaccines were prepared during the years which followed, but the most interesting development has been in the use of living cultures. In 1906, Strong (*90*) not only suggested but actually used living avirulent cultures. In 1934, using similar cultures, Otten vaccinated about half the population of a district near Bandoeng, Java, where plague was raging. Later, he reported that among 37,435 vaccinated persons, there were 38 deaths, or 0.1 percent, whereas among 44,757 unvaccinated persons, there were 213 deaths, or 0.5 percent. By 1935, it was claimed that 90 percent of the persons vaccinated obtained an immunity (*1*). However, certain difficulties are encountered in

Table 17. Results of inoculation with Haffkine's vaccine, Bombay, India

Inoculation status	Number of persons	Cases of plague	Morbidity rate (percent)	Deaths	Case fatality rate (percent)
Inoculated	365	13	3. 6	3	23. 1
Not inoculated	363	49	13. 4	38	77. 6

Table 18. Results of inoculation with Haffkine's vaccine, Sharwar, India

Number of inoculations	Number of persons	Cases of plague	Morbidity rate (percent)	Deaths	Case fatality rate (percent)
None	5, 614	957	17. 1	756	80. 0
1	5, 712	69	1. 2	31	44. 9
2	3, 349	9	. 3	5	55. 6

Table 19. Chemicals used in the treatment of plague, according to year first used

Year	Recommended by—	Drug
1894	Michoud	Carbolic acid.
1894	Tensuil	Antimony sodium tartrate.
1913	Todd	Urotropin.
1913	Connor	Tincture of iodine.
1914	Denman	Electrargol.
1915	Deggeler	Fonabsit.
1917	Brayne	Eusol.
1921	Schmit	Neosalvarsan.
1925	Balfour	Mercurochrome.
1926	Bharadway	Bichloride of mercury.

the use of these avirulent cultures, the greatest being that rapid deterioration of the vaccine after preparation prevents its widespread distribution from a central point.

Many different types of chemicals have been used during past years for the treatment of plague because they were thought to be efficacious in the treatment of lung diseases and other infections. These are listed in table 19 in chronological order.

In the late 1930's, encouraging results began to appear on treatment of plague with sulfonamides. Most of the early work with these drugs was done with sulfathiazole and sulfapyridine. A summary of the results obtained in India by Sokhey and his associates (*91*) is given in table 20.

As shown in table 21, when septicemia was present before administration of the drug, the mortality was higher (*91*).

Plum (*92*) in Nairobi in 1942, reported that sulfapyridine acted almost specifically if given early enough. As in serum treatment, results were less favorable in proportion to the delay in treatment.

Day of disease	*Mortality (percent)*
1	12
2	20
3	35
4	90

Development and testing of newer sulfonamides brought out the superior value of sulfadiazine and sulfamerazine. In the mid-forties, observations began to be made on results obtained by the use of streptomycin against plague in experimental animals, and then on its efficacy in the treatment of human cases. Table 22 illustrates results obtained with these agents as reported by Sokhey and coworkers from India (*91*).

As in the case of the older sulfonamides, the newer ones, including streptomycin (*91*) are less effective when septicemia is present before treatment with these agents is started (table 23).

The evidence on the efficiency of these drugs is very encouraging. Marked reductions in mortality have been observed with their use, even in pneumonic plague. These agents, or even better ones which may be developed in the future, will go far toward saving many lives which in earlier years would have been forfeited. Aureomycin, chloromycetin, terramycin, and other antibiotics are being tested. Their efficacy in certain cases has been shown to be good, but adequate clinical experience has not yet been had to point out whether any of them are as good as or superior to streptomycin. Similarly, the optimum amount of

Table 20. Results of use of sulfonamides in treatment of plague

Drug	Number of cases	Number of deaths	Case mortality (percent)
Antiplague serum	157	37	23. 5
Sulfapyridine (M & B 693)[1]	122	33	27. 0
Sulfathiazole	274	59	21. 5
Iodine solution (controls)	149	80	53. 6

[1] Para-aminophenyl-sulfamido-pyridine.

Table 21. Results of use of sulfonamides in treatment of plague accompanied by septicemia

Drug	Number of cases	Number of deaths	Case mortality (percent)
Antiplague serum	71	36	50. 7
Sulfapyridine (M & B 693)[1]	62	31	50. 0
Sulfathiazole	119	50	42. 0
Iodine solution (controls)	75	68	90. 7

[1] Para-aminophenyl-sulfamido-pyridine.

Table 22. Results of use of streptomycin, sulfadiazine, and sulfamerazine in treatment of plague

Drug	Number of cases	Number of deaths	Case mortality (percent)
Streptomycin	148	6	4. 2
Sulfadiazine	180	16	8. 9
Sulfamerazine	113	9	8. 0

Table 23. Results of use of streptomycin, sulfadiazine, and sulfamerazine in treatment of plague accompanied by septicemia

Drug	Number of cases	Number of deaths	Case mortality (percent)
Streptomycin	37	4	10. 8
Sulfadiazine	62	13	21. 0
Sulfamerazine	22	7	31. 8

sulfonamides and antibiotics has yet to be determined.

Karl F. Meyer, in a personal communication to the author, recommended treatment as soon as plague is suspected, without waiting for laboratory confirmation of the diagnosis. His regimen follows:

1. Administer sulfadiazine or any other effective sulfonamide.

2. Puncture the bubo in its earliest stages with an 18-gauge needle mounted on a well-fitted 5- or 10-ml. syringe and aspirate a small amount of gelatinous edema fluid. Spread drops of the exudate on 2 blood plates and in thin films on slides. Polychromatic stains reveal the morphologic characteristics of *P. pestis*.

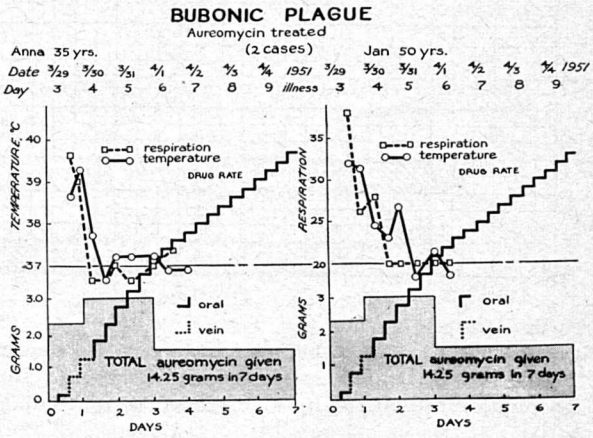
3. Collect 0.5 ml. of blood from the cubital vein and permit 0.25 ml. to run over each of 2 blood agar plates or agar slants. These blood cultures are used to detect plague septicemia. The presence of more than 10 colonies indicates established severe septicemia, while fewer may be interpreted to be temporary showers indicative of mild septicemia.

4. Determine the appropriate dose of streptomycin and begin treatment as soon as possible. In relatively mild bubonic infections, on the first day 0.25 gm. should be given intramuscularly every 4 hours (1.5 gm. during the first day) and thereafter every 6 hours until the temperature remains normal for 3 days. In severe septicemia, the initial dose should be high—between 0.50 and 0.75 gm. every 4 hours during the first and second days; smaller dose may then be administered. Continue treatment for at least 4 or 5 days when the temperature usually has reached normal levels. In cases of exceptional severity, particularly in pneumonic plague, the initial dose of from 4 to 6 gm. daily for 2 days is recommended; for the following 6 days, daily doses of 3 or 4 gm. should be used. The doses of the antibiotic should be large at first, but to economize they may safely be reduced on the third or fourth day of therapy. After the fifth day, streptomycin may be dropped, but sulfadiazine should be continued. In the treatment of plague tentatively the following total maximal quantities of streptomycin are recommended.

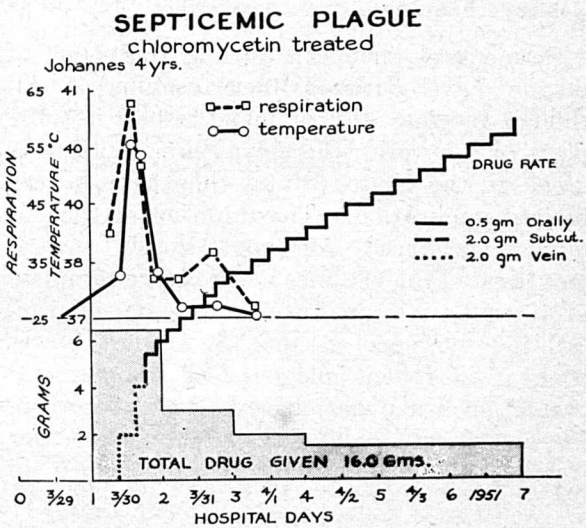
Bubonic plague without septicemia: 4 to 6 gm.

Septicemic and pneumonic plague: 12 to 25 gm.

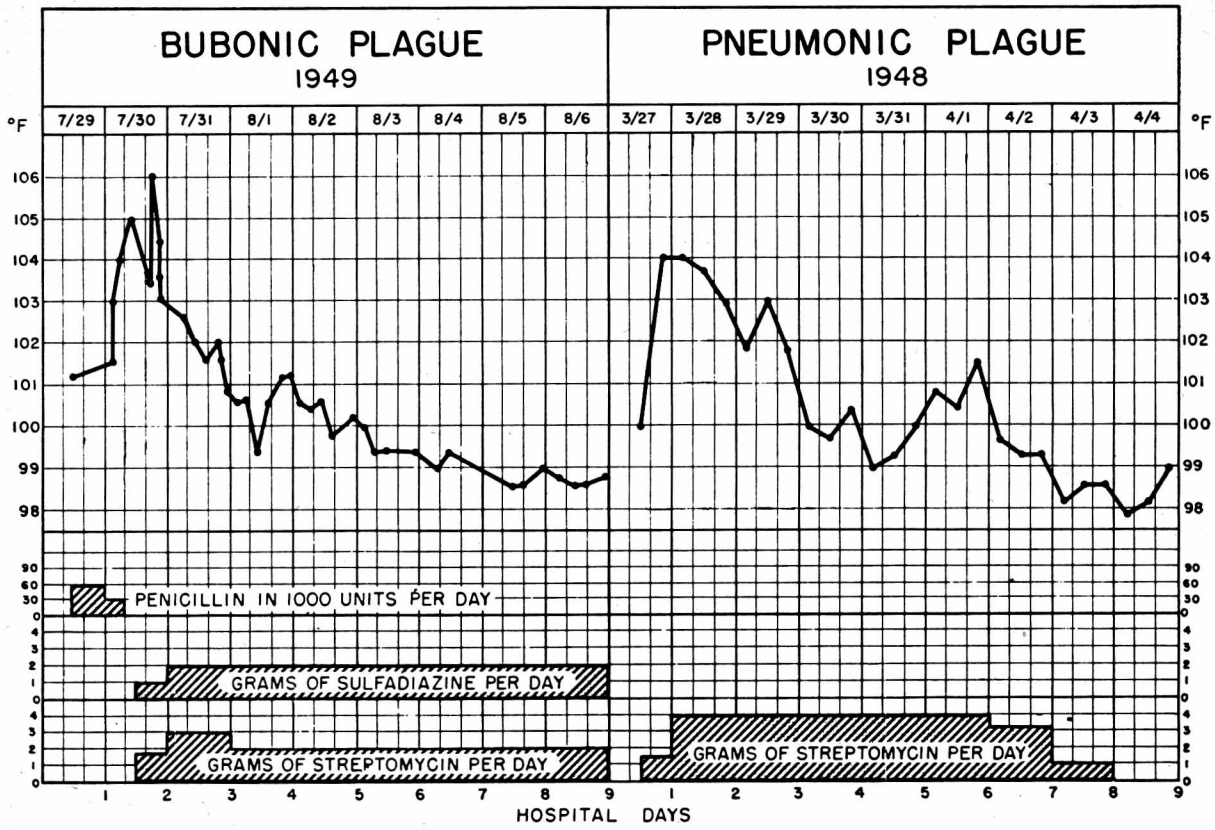
When the patient does not respond to the streptomycin-sulfonamide treatment in 2 or 3 days, even when optimal or larger initial doses have been given, the possibility that the infecting strain is resistant to this



Results of treatment of two cases of bubonic plague with aureomycin.



Results of treatment of case of septicemic plague with chloromycetin.



Results of treatment of bubonic plague with streptomycin. (Observations on bubonic plague by Ashley Pond, III, M. D., Albert M. Rosen, M. D., and Ruth L. Nicholson, M. D., Taos, N. Mex.; observations on pneumonic plague by F. Estrade, M. D., Madagascar.)

antibiotic should be considered. In such cases aerosporin, chloromycetin, aureomycin, and potent antiplague horse serum or rabbit antiplague gamma globulin solution may prove beneficial.

Serum and chemicals in the treatment of plague have outlived their usefulness. Although vaccines still command respect in those parts of the world where exposure to plague is great, in the United States they have a very limited application. The duration of the immunity produced does not exceed several months, and the vaccines never assure complete protection. No one would recommend vaccinating everyone in the 15 western States where wild-rodent plague foci are present, even if such a huge job could be undertaken. More logical methods are available for treating the small number of cases which do occur and for the prevention of ratborne epizootics leading to epidemics. In the United States, the use of vaccines should be limited to persons working on plague studies in places where they are exposed to the possibility of acquiring the disease.

The value of the combination of sulfadiazine and streptomycin in the treatment of plague is unquestionable. Besides the determination of the optimal amounts of each drug to be used routinely, the only unknown factor is how low the mortality from plague can be reduced when the drugs are given early in adequate quantity. The availability of sulfadiazine and streptomycin should do a great deal toward removing the fear which is invariably expressed during outbreaks of plague.

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Summary of cases of human plague in the United States, 1900–1951

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1900	*1900*
1	W. C. G.	M	41	San Francisco, Calif	Feb. 7	Mar. 6
2	C. G.	M	22	do		Mar. 15
3	N. A. G.	M	35	do		Mar. 17
4	L. S. K.	M	47	do		Mar. 18
5	L. A.	M	56	do		Apr. 24
6	L. F. M.	F	16	do		May 11
7	C. M.	F	46	do	May 8	May 13
8	C. S.	M	38	do		May 11
9	H. W. J.	M	53	do		May 17
10	D. H.	M	40	do		May 29
11	C. K. K.	M	49	do	May 29[1]	June 2
12	J. M. T.	M	60	do		June 9
13	L. W. T.	M	40	do	July 1	July 6
14	W. M.	M	34	do	Aug. 7	Aug. 11
15	H. T.	M	29	do		Aug. 15
16	C. Y.	M	37	do	Sept. 27[1]	Oct. 10
17	L. D. H.	M	50	do	Oct. 1[1]	Oct. 5
18	L. D. L.	M	39	do	Oct. 10	Oct. 14
19	M. L. C. Y.	F	30	do	Oct. 27[1]	Oct. 31
20	W. N. Y.	F	9	do	Oct. 29[1]	Nov. 1
21	A. R.	F	28	do	Oct. 31	Nov. 3
22	L. H.	M	36	do	Dec. 2[1]	Dec. 7
					1901	*1901*
23	C. W. L.	M	60	do		Jan. 6
24	L. W. L.	M	59	do		Jan. 15
25	A. C.	M	?	do		Jan. 15
26	L. H. Y.	M	37	do	Jan. 17[1]	Feb. 6
27	W. C. L.	M	50	do	Jan. 25[1]	Feb. 7
28	C. A. C.	M	44	do		Feb. 5
29	N. A. B.	M	45	do	Jan. 29[1]	Feb. 11
30	F. A. F.	F	10	do	Jan. 30[1]	Feb. 12
31	C. M. W. S.	F	?	do	Feb. 2	Feb. 10
32	T. S.	M	51	do	Feb. 4[1]	Feb. 10
33	F. L. W.	M	33	do	Feb. 11[1]	Feb. 24
34	L. S.	M	43	do		Apr. 1
35	L. T. G.	M	59	do	Apr. 1[1]	Apr. 4
36	C. B. H.	M	20	Ann Arbor, Mich	Apr. 3	(4)
37	L. A. W.	M	46	San Francisco, Calif	July 1	July 5
38	T. S.	F	23	do	July 3[1]	July 9
39	M. I.	F	22	do	July 3[1]	July 9
40	U.	F	?	do	July 9	(4)
41	I. F.	F	19	do	July 10	July 11
42	L. M. C.	M	40	do		Aug. 29
43	M. K.	F	?	do		Aug. ?
44	N. C.	?	?	do		Sept. 11
45	T. C. F.	M	48	do		Sept. 14
46	A. W.	M	?	do		Sept. 16
47	L. M. S.	M	49	do		Sept. 27
48	M. S.	F	52	do		Sept. 27
49	C. B. Y.	M	41	do		Sept. 29

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1901	*1901*
50	W. T.	?	?	San Francisco, Calif.		Oct. 10
51	L. C. H.	M	37	do		Oct. 19
52	C. F.	?	?	do		Oct. 22
53	F. S.	M	35	do		Oct. 30
54	M. H.	M	43	do	Nov. 4	Nov. 4
55	H. J.	?	?	do	Dec. 12	[4]
					1902	*1902*
56	C. M. C.	M	56	do		Feb. 21
57	C. S. K.	M	31	do	Apr. 20	Apr. 20
58	L. M.	M	46	do	May 19	May 19
59	C. K.	M	21	do	May 25	May 25
60	L. Y. H.	M	25	do		May 26
61	T. Q.	M	4	do	May 29	May 29
62	C. G.	M	32	do		July 13
63	L. Y. N.	M	27	do		July 18
64	Y. W. C.	M	56	do		July 19
65	C. H.	M	45	do	July 20	July 20
66	Mrs. F. C.	F	26	do		Aug. 6
67	G. K. Y.	M	25	do		Aug. 17
68	Y. C.	M	47	do		Aug. 19
69	L. T.	M	45	do		Aug. 19
70	S. W.	M	35	do		Aug. 20
71	Q. K.	M	29	do		Aug. 22
72	L. Y. M.	M	57	do		Aug. 23
73	T. H. F.	M	35	do	Aug. 25	Aug. 26
74	D. H.	M	42	do		Aug. 30
75	L. H.	F	35	do	Aug. 31	Sept. 1
76	L. C.	M	54	do		Sept. 2
77	C. M. Y. S.	F	33	do		Sept. 9
78	N. C. H.	M	25	do		Sept. 11
79	L. H. C.	M	58	do		Sept. 16
80	C. H. M.	M	47	do		Sept. 16
81	L. G.	M	48	do		Sept. 20
82	H. C. B.	M	36	do		Sept. 23
83	Mrs. G. F.	F	51	do	Sept. 23	Sept. 25
84	C. K. P.	M	39	do		Sept. 25
85	H. C.	M	38	do		Sept. 26
86	Y. F. L.	M	52	do		Oct. 4
87	C. L.	M	29	do		Oct. 5
88	C. M. K. S.	F	28	do		Oct. 5
89	W. C. C.	M	45	do		Oct. 8
90	Y. P. W.	M	36	do		Oct. 11
91	O. Y. N.	M	48	do		Oct. 16
92	H. H. B.	M	47	do		Oct. 16
93	A. W. C.	M	33	do	Oct. 29	Oct. 31
94	W. N.	M	30	do	Nov. 5	Nov. 16
95	W. H.	M	36	do	Nov. 18	Nov. 19
96	L. S.	M	50	do		Nov. 26
97	D. Y. Y.	M	38	do		Dec. 11
					[1] *1903*	*1903*
98	A. M.	F	20	do		Mar. 16
99	W. T. H.	M	45	do		June 5
100	Mrs. P. B.	F	62	do	July 13	July 20
101	C. G.	M	62	do		July 15
102	P. S.	M	34	do	July 15	July 19

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1903	*1903*
103	Y. K. J.	M	44	San Francisco, Calif		July 29
104	C. B.	M	33	Pacheco, Calif		Aug. 9
105	W. C. C.	M	44	San Francisco, Calif		Aug. 21
106	?	M	?	Pinole, Calif		Sept. 11
107	?	M	?	San Ramon, Calif		Sept. 11
108	E. T. S.	M	31	San Francisco, Calif		Sept. 13
109	I. K.	M	26	do		Oct. 3
110	?	?	?	do	Oct. 7	Oct. 9
111	J. M. T. S.	F	23	do		Oct. 20
112	C. L.	M	54	do		Oct. 23
113	I. H.	M	16	do		Oct. 24
114	L. S.	M	57	do		Oct. 29
115	S. C.	F	7	do		Nov. 4
116	C. S.	F	7	do		Nov. 7
117	C. M. J. S.	F	52	do		Nov. 11
					1904	*1904*
118	H. M. C. S.	F	26	do		Jan. 10
119	L. W. W.	M	64	do		Jan. 12
120	L. N. L.	M	61	do		Jan. 12
121	K. C.	F	18	do	Feb. 7[3]	(4)
122	G. R.	M	55	do	Feb. 8	Feb. 12
123	I. R.	F	14	do		Feb. 9
124	L. R.	F	33	do	Feb. 12	Feb. 19
125	F. B.	M	45	do		Feb. 14
126	M. M. S.	F	33	Concord, Calif	Feb. 24	Feb. 29
					1906	*1906*
127	S.	M	14	East Oakland, Calif	Apr. ?	(4)
					1907	*1907*
128	O. T.	M	24	San Francisco, Calif	May 24	May 26
129	W. T. M.	M	56	do	Aug. 1	Oct. 30
130	A. R.	M	21	do	Aug. 8	Aug. 12
131	G. M.	M	24	do	Aug. 9	Aug. 13
132	J. H.	M	20	do	Aug. 10	Aug. 13
133	I. C.	F	23	do		Aug. 12
134	F. C.	M	31	do	Aug. 12[3]	(4)
135	Mrs. J. D.	F	42	Richmond, Calif	Aug. 15	Sept. 1
136	J. L.	M	48	San Francisco, Calif	Aug. 20	Aug. 28
137	H. D.	M	30	do	Aug. 22	(4)
138	J. O.	M	63	do	Aug. 22	Aug. 24
139	G. S.	M	25	do	Aug. 23[3]	(4)
140	C. J., M. D.	M	29	do	Aug. 23	(4)
141	G. B.	M	25	do	Aug. 24	(4)
142	N. J.	M	41	do	Aug. 25	(4)
143	M. S. K.	F	22	do	Aug. 26	(4)
144	C. M. W.	M	65	do	Aug. 26	Sept. 11
145	J. C.	M	40	do	Aug. 27	Sept. 9
146	E. C.	F	18	do	Aug. 28	(4)
147	R. C.	F	15	do	Aug. 28	(4)
148	T. F. T.	M	43	do	Aug. 29	(4)
149	D. B.	M	26	do	Aug. 31	Sept. 4
150	J. A.	M	4	do	Sept. 1	(4)
151	D. D.	F	25	do	Sept. 3	(4)
152	H. P.	M	27	do	Sept. 3	(4)
153	H. B.	M	47	do	Sept. 3	Sept. 9

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1907	*1907*
154	R. M.	M	32	San Francisco, Calif	Sept. 4	(4)
155	A. Z.	M	22	do	Sept. 4	Sept. 12
156	J. G.	F	5	do	Sept. 6	(4)
157	J. T. W.	M	30	do	Sept. 7	Sept. 10
158	S. R.	M	35	do	Sept. 7	Sept. 13
159	G. R.	M	50	do	Sept. 8	(4)
160	J. I.	M	5	do	Sept. 10	(4)
161	Mrs. M. I.	F	30	do	Sept. 10	(4)
162	H. H.	F	35	Oakland, Calif	Sept. 10	Sept. 12
163	J. S.	M	38	San Francisco, Calif	Sept. 10 [3]	Sept. 14
164	V. I.	M	9	do	Sept. 10	Sept. 15
165	C. F. R.	M	37	do	Sept. 10	Sept. 15
166	H. L. K.	M	40	do	Sept. 11	Sept. 11
167	G. F.	F	16	do	Sept. 11	(4)
168	J. D. S.	M	56	do	Sept. 11	Sept. 13
169	J. M.	M	3	do	Sept. 12	(4)
170	S. M.	M	1	do	Sept. 12	Sept. 14
171	J. T.	M	8	do	Sept. 13	(4)
172	M. L.	F	32	do	Sept. 14	Sept. 14
173	J. P.	F	7 mos.	do	Sept. 14	Sept. 15
174	E. K.	M	11	do	Sept. 14	(4)
175	R. K.	M	9	do	Sept. 14	(4)
176	Mrs. F. M.	F	32	do	Sept. 14	(4)
177	Mrs. F. T.	F	24	do	Sept. 14	(4)
178	A. G.	F	12	do	Sept. 14	Sept. 19
179	C. F.	F	14	do	Sept. 15	(4)
180	P. L.	M	30	Oakland, Calif	Sept. 15	Sept. 18
181	C. L.	F	32	San Francisco, Calif	Sept. 16	Oct. 26
182	R. F.	F	12	do	Sept. 19	(4)
183	L. S. C.	M	40	do	Sept. 19	(4)
184	H. Y.	F	50	do	Sept. 19	Sept. 21
185	P. S.	M	20	do		Sept. 20
186	M. H. C.	F	1	do	Sept. 20	Sept. 27
187	A. C.	M	20	do	Sept. 21	(4)
188	M. P.	M	27	do	Sept. 21	(4)
189	M. G.	M	1	do	Sept. 21	(4)
190	T. W.	F	1 mo.	do	Sept. 21	Sept. 22
191	P. P.	M	3	do	Sept. 21	Sept. 26
192	P. S.	M	51	do	Sept. 21	Sept. 27
193	M. P. E.	M	54	do	Sept. 22	Oct. 14
194	S. A.	F	28	do	Sept. 22	Oct. 17
195	A. G.	M	10	do	Sept. 23	Sept. 26
196	A. D.	F	23	do	Sept. 24	(4)
197	H. S.	M	30	do	Sept. 24	(4)
198	R. D.	F	42	do	Sept. 25	(4)
199	B. V.	F	5	do	Sept. 25	(4)
200	J. M.	M	25	do	Sept. 25	Sept. 28
201	E. R.	F	10	do	Sept. 26	Oct. 1
202	G. N.	M	10	do	Sept. 26	Oct. 29
203	J. Z.	M	24	do	Sept. 27	(4)
204	H. N.	M	27	do		Oct. 28
205	M. L.	M	40	do	Sept. 28	(4)
206	M. O.	F	3	do	Sept. 28	(4)
207	I. W.	M	34	do	Sept. 28	(4)

See footnotes on p. 101.

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1907	*1907*
208	L. B.	M	1	San Francisco, Calif	Sept. 28	Oct. 4
209	W. F. K.	M	26	do	Sept. 28	Oct. 6
210	E. L. F.	M	42	do	Sept. 30	[4]
211	J. G.	M	24	do	Sept. 30	[4]
212	D. S.	M	4	do	Sept. 30	[4]
213	H. O.	F	34	Oakland, Calif	Oct. 1	Oct. 5
214	J. B. D.	M	30	San Francisco, Calif	Oct. 2	Oct. 6
215	J. B.	F	23	do	Oct. 5	[4]
216	T. H.	F	5	do	Oct. 5	Oct. 7
217	M. P.	F	38	do	Oct. 5	Oct. 7
218	A. T.	M	18	do	Oct. 6	Oct. 8
219	P. H.	F	68	do	Oct. 6	Oct. 10
220	F. B. E.	M	71	do	Oct. 6	Oct. 11
221	E. C. O.	M	27	Seattle, Wash	Oct. 7	Oct. 13
222	T. P.	M	?	San Francisco, Calif	Oct. 8 [3]	[4]
223	E. W.	M	42	do	Oct. 8	Oct. 12
224	P. T.	M	30	do	Oct. 9 [3]	[4]
225	K. M.	F	38	Oakland, Calif	Oct. 10	Oct. 17
226	W. B.	M	26	do	Oct. 12	Oct. 14
227	J. B. O.	M	62	San Francisco, Calif	Oct. 13	Oct. 14
228	L. A.	M	38	do	Oct. 15	[4]
229	L. H.	M	46	do	Oct. 15	Oct. 17
230	L. M. O.	F	33	Seattle, Wash	Oct. 15	Oct. 19
231	J. E.	M	12	San Francisco, Calif	Oct. 15	Oct. 22
232	C. O. E.	M	29	Seattle, Wash	Oct. 16	Oct. 18
233	L. S.	M	48	do	Oct. 16	Oct. 19
234	J. S.	M	50	do	----------	Oct. 17
235	G. C.	M	38	Oakland, Calif	Oct. 17	[4]
236	E. M.	F	17	do	Oct. 17	[4]
237	N. V.	M	26	San Francisco, Calif	Oct. 17	[4]
238	F. K.	M	31	do	Oct. 17	Oct. 19
239	A. I.	M	?	do	Oct. 18 [3]	[4]
240	J. C.	M	23	do	Oct. 18	[4]
241	K. S.	F	65	do	Oct. 19	Oct. 21
242	M. C.	F	16	do	Oct. 19	Oct. 24
243	A. O.	F	21	Seattle, Wash	Oct. 21	Oct. 24
244	C. E.	M	10	San Francisco, Calif	Oct. 22	[4]
245	G. B.	M	16	do	Oct. 22	Oct. 23
246	P. M.	M	47	do	Oct. 24	Oct. 28
247	M. S.	F	70	do	Oct. 24	Nov. 21
248	G. A.	M	28	Oakland, Calif	Oct. 24	[4]
249	N. D.	M	29	San Francisco, Calif	Oct. 25	Oct. 30
250	M. E. O.	F	40	Seattle, Wash	Oct. 25	Oct. 30
251	J. D. C.	M	19	Oakland, Calif	Oct. 27	[4]
252	W. S. H.	M	61	San Francisco, Calif	Oct. 27	[4]
253	L. P.	M	16	do	Oct. 27	Oct. 31
254	A. T.	M	9	do	Oct. 28	Nov. 11
255	A. H.	M	14	do	Oct. 29	[4]
256	G. L.	M	33	Oakland, Calif	Oct. 30	Nov. 3
257	P. B.	M	29	San Francisco, Calif	Oct. 31	[4]
258	J. J.	M	57	do	Oct. 31	Nov. 4
259	Mrs. G.	F	28	Oakland, Calif	Nov. 1	[4]
260	H. S.	M	14	San Francisco, Calif	Nov. 1	[4]
261	M. C.	F	16	do	Nov. 2	[4]
262	G. D.	F	8	do	Nov. 2	[4]

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1907	*1907*
263	N. G.	F	14	San Francisco, Calif	Nov. 2	(4)
264	A. V.	F	12	do	Nov. 2	(4)
265	C. H. C.	M	47	do	Nov. 3	(4)
266	L. F.	M	6	do	Nov. 3	(4)
267	Mrs. M. S.	F	40	do	Nov. 3	Nov. 8
268	C. W.	F	3	do	Nov. 3	Nov. 9
269	D. H. S.	M	42	do	Nov. 4	Nov. 4
270	A. W. S.	F	9	do	Nov. 4	Nov. 11
271	J. B.	M	42	Oakland, Calif	Nov. 6	(4)
272	A. G.	M	48	San Francisco, Calif	Nov. 7	(4)
273	A. T.	M	37	do	Nov. 7	Nov. 11
274	G. C.	M	46	Oakland, Calif	Nov. 9	Nov. 12
275	W. G.	M	57	San Francisco, Calif	Nov. 10	(4)
276	G. T.	M	19	do	Nov. 10	(4)
277	V. B.	F	48	do	Nov. 11	(4)
278	H. M.	F	8	do	Nov. 14	(4)
279	A. M.	F	1	do	Nov. 15	(4)
280	C. L.	M	20	do	Nov. 15	Nov. 20
281	O. H. B.	M	37	do	Nov. 16	Nov. 19
282	L. M. H.	F	6	do	Nov. 17	Nov. 22
283	J. B.	M	3	do	Nov. 18	(4)
284	R. G.	M	26	do	Nov. 19	(4)
285	H. E.	M	20	Berkeley, Calif	Nov. 19	Nov. 25
286	P. A.	M	26	San Francisco, Calif	Nov. 21	(4)
287	J. C.	M	23	do	Nov. 21	(4)
288	F. M.	M	70	do	Nov. 21	(4)
289	I. A.	M	39	do	Nov. 21	Nov. 25
290	M. B.	F	27	do	Nov. 21	Dec. 6
291	M. B., Jr.	F	2	do	Nov. 23	(4)
292	T. M. S.	M	70	do	Nov. 23	(4)
293	H. S. W., M. D.	M	32	do	Nov. 23	(4)
294	D. B.	F	45	do	Nov. 23	Nov. 29
295	G. B.	M	28	do	Nov. 24	(4)
296	P. G.	M	66	do	Nov. 24	(4)
297	B. N.	F	60	do	Nov. 24	(4)
298	H. B.	M	26	do	Nov. 25	(4)
299	A. E.	M	21	do	Nov. 26	(4)
300	W. B. B.	M	52	Point Richmond, Calif	Nov. 27	(4)
301	A. C.	M	34	San Francisco, Calif	Nov. 28	(4)
302	C. A. H.	M	12	do	Nov. 28	(4)
303	A. L.	M	45	do	Nov. 29	(4)
304	E. G. P.	M	2	do	Nov. 29	Dec. 2
305	A. K.	M	59	do	Dec. 2	Dec. 3
306	M. M.	M	23	do	Dec. 5	Dec. 9
307	V. L.	M	30	do	Dec. 7	(4)
308	F. T.	M	49	do	Dec. 10	Dec. 16
309	J. R.	M	23	do	Dec. 11	(4)
310	M. F.	F	18	do	Dec. 13	(4)
311	E. L.	F	8	Oakland, Calif	Dec. 15	(4)
312	O. C. M.	M	53	San Francisco, Calif	Dec. 15	(4)
313	C. M.	M	32	do	Dec. 15	(4)
314	E. J. L.	F	52	Point Richmond, Calif	Dec. 17	Dec. 22
315	E. P.	M	75	San Francisco, Calif	Dec. 19	Dec. 24
316	M. P.	F	45	do		Dec. 20

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1907	*1907*
317	E. L.	F	3	Oakland, Calif		Dec. 22
318	B. M.	F	58	San Francisco, Calif	Dec. 20	Dec. 26
					1908	*1908*
319	F. K.	M	27	Stege, Calif	Jan. 4	Jan. 7
320	T. P.	M	?	Oakland, Calif	Jan. 28	(4)
321	F. M.	M	25	San Francisco, Calif	Jan. 29	(4)
322	T. C.	F	8	Oakland, Calif		Feb. 28
323	G. I.	M	19	San Francisco, Calif	Mar. 7 [3]	(4)
324	R. F.	M	7	Concord, Calif	July 11	July 15
325	J. J. S.	M	37	Oakland, Calif	July 17	July 21
326	M. E. P.	F	24	Briones Valley, Calif	July 21	July 25
327	R. M.	M	10	Los Angeles, Calif	Aug. 11	(4)
					1909	*1909*
328	G. R. G.	M	74	Alameda, Calif		June 20
329	M. A.	M	5	Sunol, Calif	July 27	(4)
330	J. M.	M	13	do	July 27	Aug. 12
331	F. B.	M	22	Oakland, Calif	Oct. 26	(4)
					1910	*1910*
332	E. O.	M	33	Hollister, Calif	June 8	June 11
333	K. D.	F	18	Coyote, Calif	Aug. 23	(4)
					1911	*1911*
334	?	M	?	Modesto, Calif	Apr. 11	(4)
335	?	M	?	do	July 20	(4)
336	H. H. F.	M	7	Lafayette, Calif	July 21	July 26
337	J. K.	M	16	Oakland, Calif	Aug. 8	(4)
338	A. B.	M	28	Ripon, Calif	Sept. 18	(4)
					1913	*1913*
339	R. N.	F	24	San Juan Baptiste, Calif	June 4	June 13
340	J. W. L.	M	55	Pittsburg, Calif	Sept. 7	Sept. 11
341	L. W.	F	31	Seattle, Wash		Dec. 27
					1914	*1914*
342	E. W. H.	M	38	Walnut Creek, Calif	May 17	(4)
343	C. L.	M	49	New Orleans, La	June 19	June 28
344	R. W.	M	54	do	June 26	(4)
345	J. J.	M	9	do	June 28	July 2
346	L. De J.	M	28	do	July 5	July 10
347	E. D.	F	35	do	July 9	(4)
348	P. G.	F	15	do	July 13	(4)
349	H. S.	F	9	do	July 16	(4)
350	C. J. L.	M	28	do	July 16	(4)
351	R. S.	F	73	do	July 20	July 25
352	W. E.	M	50	do	July 21	(4)
353	R. S.	F	16	do	July 22	(4)
354	J. E. W.	M	24	do	July 23	(4)
355	J. S.	M	41	do	July 24	(4)
356	H. C.	M	22	do	July 29	(4)
357	A. G.	M	52	do	Aug. 6	(4)
358	H. S.	M	17	do	Aug. 7	(4)
359	J. B.	F	20	do	Aug. 11	(4)
360	C. S.	M	72	do	Aug. 15	Aug. ?
361	M. H.	F	40	do	Aug. 16	Aug. ?
362	L. W.	F	24	do	Aug. 17	(4)
363	M. J.	F	84	do	Aug. 26	Aug. ?
364	E. H. R.	M	30	do	Aug. 26	(4)

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1914	*1914*
365	M. N.	M	19	New Orleans, La	Aug. 29	(4)
366	E. F.	F	12	do	Sept. 1	(4)
367	L. W.	M	20	do	Sept. 1	(4)
368	C. A.	F	40	do	Sept. 20	Sept. ?
369	J. J. V.	M	43	do	Sept. 20	Sept. ?
370	Mrs. H. S.	F	18	do	Sept. 21	(4)
371	J. J. K.	M	4	do	Sept. 30	(4)
372	C. Y.	M	51	do	Sept. 30	Oct. 4
					1915	*1915*
373	N. G.	M	21	Concord, Calif	July 13	July 21
374	?	F	?	New Orleans, La	Aug. 27	(4)
					1919	*1919*
375	V. D. B.	M	32	Oakland, Calif	Aug. 15	Aug. 19
376	G. T.	M	32	do	Aug. 25	Aug. 28
377	Mrs. T.	F	?	do	Aug. 28	(4)
378	D. R. Y.	M	57	do	Aug. 29	Sept. 2
379	E. C.	M	31	do	Aug. 30	Sept. 2
380	F. T.	M	31	do	Aug. 31	Sept. 3
381	F. P.	F	43	do	Sept. 1	Sept. 4
382	G. A.	M	32	do	Sept. 5	Sept. 7
383	G. O.	M	35	do	Sept. 5	Sept. 8
384	A. K., M. D.	M	31	do	Sept. 5	Sept. 8
385	A. T.	M	35	do	Sept. 5	Sept. 8
386	J. B. W., M. D.	M	51	do	Sept. 5	Sept. 9
387	A. T.	F	43	do	Sept. 5	Sept. 10
388	Mrs. R. W.	F	28	do	Sept. 6	Sept. 11
389	H. E. D.	M	33	New Orleans, La	----------	Oct. 29
390	H. W.	M	47	do	----------	Nov. 1
391	W. C.	M	26	do	Nov. 2[3]	(4)
392	F. W.	M	38	do	Nov. 2[3]	Nov. 4
393	F. I.	M	16	do	Nov. 5[3]	(4)
394	J. E. S.	M	2	do	Nov. 22[3]	Nov. 24
395	J. W.	M	38	do	Nov. 25[3]	(4)
396	M. J.	M	28	do	Dec. 1[3]	(4)
397	E. T. J.	M	39	do	Dec. 3[3]	Dec. 22
398	S. M.	M	16	do	Dec. 10[3]	(4)
399	J. M.	M	17	do	Dec. 11[3]	(4)
400	J. R.	M	?	do	Dec. 12[3]	(4)
					1920	*1920*
401	C. M.	M	?	do	Feb. 25[3]	(4)
402	M. N.	F	7	Hayward, Calif	Apr. 15	Apr. 19
403	W. A.	M	16	New Orleans, La	May 12[3]	(4)
404	J. D. B.	M	42	New Orleans, La	May 13	(4)
405	M. J.	M	16	Pensacola, Fla	----------	June 2
406	P. G.	M	24	do	June 9[1]	June 12
407	E. R. R.	M	37	New Orleans, La	June 10[3]	(4)
408	O. G.	M	38	Pensacola, Fla	June 11[1]	June 17
409	J. F.	M	?	New Orleans, La	June 15[3]	(4)
410	F. B.	M	45	Pensacola, Fla	June 15[2]	(4)
411	E. N.	M	17	Galveston, Tex	June 16[1]	June 17
412	A. S.	F	22	Galveston, Tex	June 16	(4)
413	Mrs. M. P.	F	44	Beaumont, Tex	June 18[1]	June 19
414	?	?	?	do	June ?	(4)
415	?	?	?	do	June ?	(4)
416	?	?	?	do	June ?	(4)

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1920	*1920*
417	?	?	?	Beaumont, Tex	June ?	(4)
418	?	?	?	do	June ?	(4)
419	?	?	?	do	June ?	(4)
420	H. F.	M	26	do	July 3[1]	July 5
421	A. S.	M	8	do	July 5[1]	July 6
422	C. L.	M	9	Pensacola, Fla	July 8[2]	(4)
423	J. M.	F	32	do	July 11[2]	(4)
424	J. H., Jr.	M	19	do	July 5[1]	July 14
425	C. M.	M	20	Port Arthur, Tex	July 2	July 6
426	L. R.	F	25	Beaumont, Tex	July 17[1]	July 29
427	J. W.	M	?	New Orleans, La		July 25
428	R. P.	F	13	Galveston, Tex	July 26[1]	July 29
429	Mrs. J. R.	F	65	do		July 28
430	?	?	?	Beaumont, Tex	July ?	(4)
431	J. B.	M	41	Galveston, Tex		Aug. 4
432	Mrs. J. M.	F	32	do	Aug. 4	(4)
433	J. L.	M	6	Beaumont, Tex	Aug. 8[1]	Aug. 11
434	L. M.	M	16	Galveston, Tex	Aug. 10[1]	Aug. 11
435	O. L.	F	27	do	Aug. 16[1]	Aug. 18
436	W. K.	M	?	New Orleans, La		Aug. 17
437	?	?	?	Beaumont, Tex		Aug. 23
438	J. S.	M	1	Pensacola, Fla		Aug. 25
439	A. B., M. D.	F	28	Galveston, Tex	Aug. 25	(4)
440	A. A.	M	?	New Orleans, La		Aug. 26
441	E. B.	M	18	Pensacola, Fla	Aug. 29[1]	Sept. 2
442	D. W.	M	42	Galveston, Tex	Aug. 31[1]	Sept. 1
443	M. M.	M	9	Pensacola, Fla	Aug. 31[1]	Sept. 3
444	Mrs. H. L.	F	79	Galveston, Tex	Sept. 5[1]	Sept. 7
445	?	M	3	Houston, Tex	Sept. 26	(4)
446	I. B.	F	17	Galveston, Tex		Sept. 27
447	E. K.	F	17	do	Oct. 4	(4)
448	D. W.	M	35	do	Oct. 8[1]	Oct. 9
449	T. D.	M	58	do	Oct. 20	(4)
450	E. R. J.	M	10	do	Nov. 11[1]	Nov. 13
					1921	*1921*
451	W. J.	M	28	San Juan Baptiste, Calif	Jan. 31	Feb. 7
452	R. S.	M	9	Bitter Water Valley, Calif	June 5	(4)
					1922	*1922*
453	B. L.	M	3	Oakland, Calif	June 23	June 29
454	S. B.	M	18	Soquel, Calif	July 7	(4)
					1923	*1923*
455	K. M.	F	16	Pacific Grove, Calif	Aug. 18	(4)
					1924	*1924*
456	J. L.	M	55	Los Angeles, Calif	Oct. 1	(4)
457	F. L.	F	14	do	Oct. 1	Oct. 5
458	L. S.	F	39	do	Oct. 14	Oct. 19
459	J. F.	F	21	do	Oct. 22	Oct. 25
460	G. S.	M	37	do	Oct. 22	Oct. 26
461	H. G.	M	25	do	Oct. 28	Oct. 30
462	M. S.	F	80	do	Oct. 28	Oct. 30
463	R. S.	M	10	do	Oct. 28	Oct. 30
464	A. G.	M	16	do	Oct. 28	Oct. 31
465	F. O.	M	26	do	Oct. 28	Oct. 31
466	R. S. R.	F	23	do	Oct. 28	Oct. 31
467	J. V.	M	22	do	Oct. 28	Oct. 31

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initials	Sex	Age (years)	Location	Date of onset	Date of death
					1924	*1924*
468	J. B.	M	30	Los Angeles, Calif	Oct. 28	Nov. 1
469	Father M. B.	M	48	do	Oct. 28	Nov. 1
470	E. H.	M	51	do	Oct. 28	Nov. 1
471	J. M.	F	26	do	Oct. 28	Nov. 1
472	V. S.	M	35	do	Oct. 28	Nov. 1
473	G. V.	F	52	do	Oct. 28	Nov. 3
474	J. H.	F	63	do	Oct. 28	Nov. 6
475	A. B.	M	10	do	Oct. 28	Nov. 11
476	M. L. C.	F	32	do	Oct. 29	(4)
477	P. S.	M	6	do	Oct. 29	(4)
478	J. C.	F	58	do	Oct. 29	Nov. 1
479	G. S.	M	7	do	Oct. 29	Nov. 1
480	O. H.	M	23	do	Oct. 29	Nov. 2
481	M. J.	M	27	do	Oct. 29	Nov. 2
482	P. H.	M	33	do	Oct. 29	Nov. 3
483	J. M.	M	48	do	Oct. 30	Nov. 1
484	F. P.	M	40	do	Oct. 30	Nov. 3
485	M. S.	F	18	do	Oct. 31	Nov. 1
486	R. R.	F	24	do	Nov. 1	Nov. 6
487	E. P.	M	22	do	Nov. 2	Nov. 5
488	J. J.	M	25	do	Nov. 2	Nov. 7
489	M. R.	F	1	do	Nov. 3	Nov. 8
490	T. V.	M	10	do	Nov. 4	Nov. 7
491	M. R.	M	9	do	Nov. 7	Nov. 8
492	R. E.	F	45	do	Nov. 11	(4)
493	M. A.	M	16	do	Nov. 22	Nov. 24
					1925	*1925*
494	M. D.	F	11	do	Jan. 2	(4)
495	J. P.	M	14	do	Jan. 10	Jan. 15
					1927	*1927*
496	A. J.	M	5	Clayton, Calif	July 3	July 8
					1928	*1928*
497	A. R.	M	13	Santa Cruz, Calif	Jan. 23	(4)
498	W. E. E.	M	24	Monterey Presidio, Calif	July 23	July 27
499	J. F.	F	12	Santa Ynez, Calif	Aug. 27	Aug. 29
					1933	*1933*
500	L. A. M.	M	67	Whittier, Calif	Aug. 1	Aug. 9
					1934	*1934*
501	C. T. O.	M	30	Lakeview, Oreg	May 16	May 21
502	K. P.	M	10	Posy Creek, Calif	June 19	Oct. 22
					1936	*1936*
503	H. C., D. V. M.	M	37	Santa Rosa, Calif	Apr. 2	(4)
504	V. T.	M	11	San Simeon, Calif	June 17	(4)
505	H. G. Jr.	M	7	Beaver, Utah	June 27	(4)
506	?	M	10	San Bernardino, Calif	July ?	(4)
507	Mrs. L. R.	F	50	Lake Tahoe, Calif	July 23	(4)
					1937	*1937*
508	Mr. W.	M	64	do	May 29	(4)
509	M. F.	F	7	Huntington Lake, Calif	Aug. 14	Aug. 18
					1940	*1940*
510	D. O.	M	13	Emmett, Idaho	----------	Sept 5
					1941	*1941*
511	R. H.	M	10	Montague, Calif	----------	June 24
512	L. V.	M	5	Mt. Shasta City, Calif	----------	Aug. 9

See footnotes on p. 101.

Summary of cases of human plague in the United States, 1900–1951—Continued

Case No.	Initial	Sex	Age (years)	Location	Date of onset	Date of death
					1942	*1943*
513	D. M. D. R.	F	2	Yreka, Calif	Nov. 8	Jan. 10
					1943	
514	T. W.	M	11	Fort Jones, Calif	Aug. 19	[4]
					1944	*1944*
515	J. W. H.	M	36	San Francisco, Calif	May 30	[4]
					1947	*1947*
516	A. F.	M	12	Alturas, Calif	----------	June 20
					1949	*1949*
517	S. S.	M	10	Cerro, N. Mex	July 22	[4]
518	V. G.	M	37	Placitas, N. Mex	July 28	[4]
519	S. R.	M	7	San Patricio, N. Mex	Nov. 1	Nov. 5
					1950	*1950*
520	J. A.	M	27	Maljamar, N. Mex	Jan. 8	[4]
521	C. L.	M	15	Glorieta, N. Mex	July 1	July 4
522	E. Mc.	F	14	Ganado, Ariz	July 23	[4]
					1951	*1951*
523	J. B. W.	M	?	Hobbs, N. Mex	Jan. 6	Jan. 9

[1] About. [2] Diagnosed. [3] Reported. [4] Recovery.

Human plague in the United States, by year and State, 1900–1951

Year	Arizona		California		Florida		Idaho		Louisiana		Michigan		Nevada		New Mexico		Oregon		Texas		Utah		Washington		Total	
	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths	Cases	Deaths
1900	---	---	22	22	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	22	22
1901	---	---	32	30	---	---	---	---	---	---	1	0	---	---	---	---	---	---	---	---	---	---	---	---	33	30
1902	---	---	42	42	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	42	42
1903	---	---	20	20	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	20	20
1904	---	---	9	8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	9	8
1906	---	---	1	0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	0
1907	---	---	184	89	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	7	7	191	96
1908	---	---	9	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	9	5
1909	---	---	4	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	4	2
1910	---	---	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	1
1911	---	---	5	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	5	1
1913	---	---	2	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	3	3
1914	---	---	1	0	---	---	---	---	30	10	---	---	---	---	---	---	---	---	---	---	---	---	---	---	31	10
1915	---	---	1	1	---	---	---	---	1	0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	1
1919	---	---	14	13	---	---	---	---	12	5	---	---	---	---	---	---	---	---	---	---	---	---	---	---	26	18
1920	---	---	1	1	10	7	---	---	8	3	---	---	---	---	---	---	---	---	31	18	---	---	---	---	50	29
1921	---	---	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	1
1922	---	---	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	1
1923	---	---	1	0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	0
1924	---	---	38	34	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	38	34
1925	---	---	2	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	1
1927	---	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1
1928	---	---	3	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3	2
1933	---	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1
1934	---	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	1	1	---	---	---	---	---	---	2	2
1936	---	---	4	0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	0	---	---	5	0
1937	---	---	1	1	---	---	---	---	---	---	---	---	1	0	---	---	---	---	---	---	---	---	---	---	2	1
1940	---	---	0	0	---	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1
1941	---	---	2	2	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	2	2
1942	---	---	1	0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	0
1943	---	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1
1944	---	---	1	0	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	0
1947	---	---	1	1	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1
1949	---	---	---	---	---	---	---	---	---	---	---	---	---	---	3	1	---	---	---	---	---	---	---	---	3	1
1950	1	0	---	---	---	---	---	---	---	---	---	---	---	---	2	1	---	---	---	---	---	---	---	---	3	1
1951	---	---	---	---	---	---	---	---	---	---	---	---	---	---	1	1	---	---	---	---	---	---	---	---	1	1
Total	1	0	411	284	10	7	1	1	51	18	1	0	1	0	6	3	1	1	31	18	1	0	8	8	523	340

Age-sex distribution of human cases of plague in the United States, 1900–1951

Age groups	Deaths			Recoveries			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
0–4	8	7	15	7	3	10	15	10	25
5–9	13	9	22	9	6	15	22	15	37
10–14	14	7	21	11	7	18	25	14	39
15–19	12	5	17	11	13	24	23	18	41
20–24	18	11	29	12	7	19	30	18	48
25–29	24	10	34	18	3	21	42	13	55
30–34	25	9	34	11	5	16	36	14	50
35–39	31	5	36	8	1	9	39	6	45
40–44	19	8	27	8	1	9	27	9	36
45–49	28	3	31	4	2	6	32	5	37
50–54	14	6	20	6	1	7	20	7	27
55–59	15	2	17	3	0	3	18	2	20
60–64	7	2	9	2	1	3	9	3	12
65–69	2	3	5	1	0	1	3	3	6
70–74	3	2	5	2	0	2	5	2	7
75–79	1	1	2	0	0	0	1	1	2
80–84	0	2	2	0	0	0	0	2	2
Age unknown	7	2	9	9	3	12	16	5	21
Age and sex unknown	------	--------	5	------	--------	8	------	--------	13
Total	241	94	340	122	53	183	363	147	523

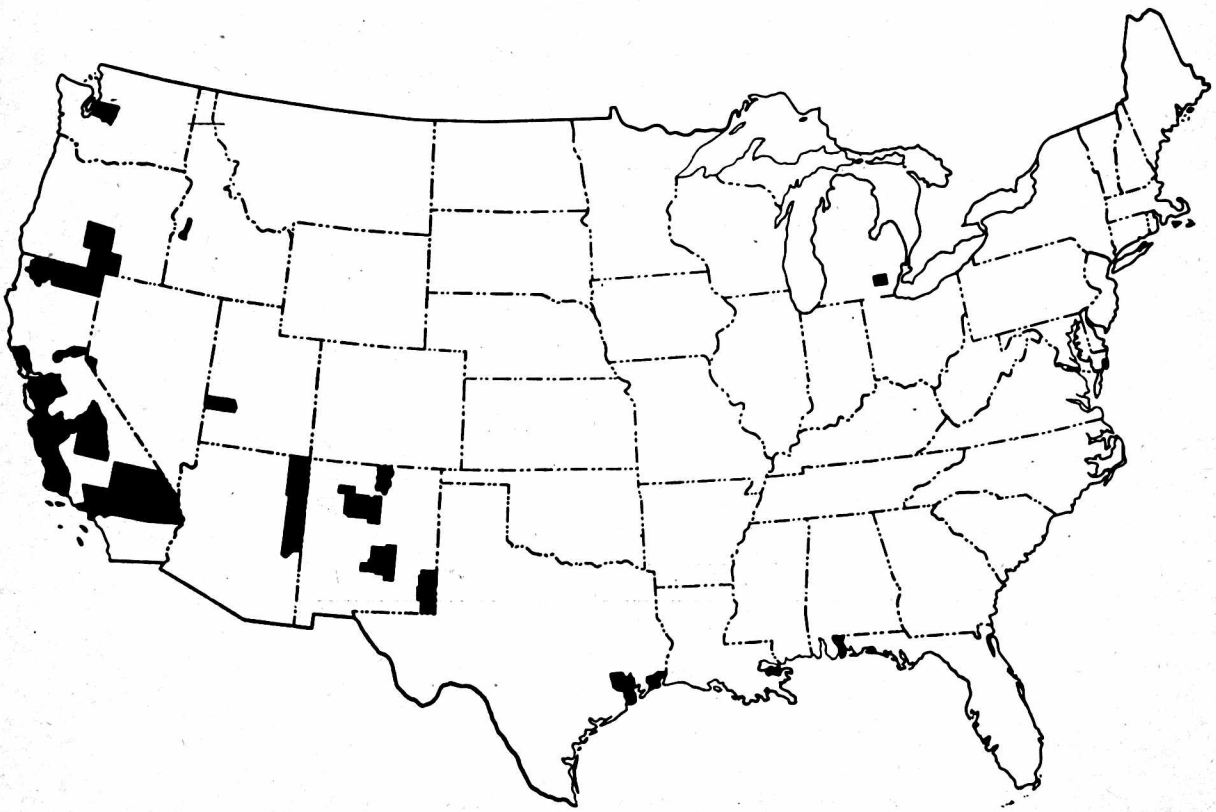
Observed seasonal distribution of human plague in the United States, 1900–1951

Month	Deaths	Recoveries	Total
January	14	5	19
February	12	2	14
March	4	1	5
April	5	4	9
May	12	5	17
June	16	14	30
July	32	21	53
August	50	25	75
September	66	38	104
October	83	21	104
November	34	36	70
December	12	11	23
Total	340	183	523

Human plague in 36 counties in 12 States, 1900–1951

State and county	Cases	Deaths
Arizona: Apache	1	0
California:		
Alameda	41	28
Contra Costa	15	13
Fresno	1	1
Los Angeles	42	36
Modoc	1	1
Monterey	2	1
Placer	1	0
San Benito	4	3
San Bernardino	1	0
San Francisco	289	196
San Joaquin	1	0
San Luis Obispo	1	0
Santa Barbara	1	1
Santa Clara	1	0
Santa Cruz	2	0
Siskiyou	4	3
Sonoma	1	0
Stanislaus	2	0
Tulare	1	1
Florida: Escambia	10	7
Idaho: Gem	1	1
Louisiana: Orleans	51	18
Michigan: Washtenaw	1	0
Nevada: Douglas	1	0
New Mexico:		
Lea	2	1
Lincoln	1	1
Sandoval	1	0
Santa Fe	1	1
Taos	1	0
Oregon: Lake	1	1
Texas:		
Galveston	16	11
Harris	1	0
Jefferson	14	7
Utah: Beaver	1	0
Washington: King	8	8
Total	523	340

Counties in the United States where human plague has occurred, 1900–1951.



Human plague on ships arriving at United States ports, 1899–1926

Date	Port	Ship	From—	Plague	
				Cases	Deaths
June 27, 1899	San Francisco, Calif	S. S. *Nippon Maru*	Hongkong, Honolulu	2	2
Nov. 17, 1899	New York, N. Y	S. S. *J. W. Taylor*	Santos, Brazil	2	2
Jan. 31, 1900	Port Townsend, Wash	S. S. *Nanyo Maru*	Kobe, Yokohama, Honolulu	17	3
Apr. 6, 1906	Reedy Island, Del	S. S. *Burrsfield*	Bombay, Port Said, Algiers, Oran.	2	1
Oct. 28, 1924	New Orleans, La	S. S. *Atlanticos*	Barcelona, Oran	1	0
Oct. 24, 1926	do	S. S. *Manila Maru*	Buenos Aires, Rio De Janeiro, Santos.	2	2
Total				26	10

Cases of animal plague reported in the United States, 1902–51.

State and county	Period	Number of years	Domestic animals	Wild animals	Total cases
Arizona:					
Apache	1938–48	2	0	3	3
Coconino	1949	1	0	2	2
Navajo	1947–48	2	0	2	2
Total (3 counties)	1938–49	4	0	7	7
California:					
Alameda	1907–43	21	161	499	660
Alpine	1942–45	2	0	6	6
Contra Costa	1908–43	18	3	1, 723	1, 726
El Dorado	1936–47	8	0	34	34
Fresno	1911–38	4	0	37	37
Inyo	1943	1	0	1	1
Kern	1934–48	9	0	85	85
Kings	1943	1	0	1	1
Lassen	1935–47	5	0	32	32
Los Angeles	1908–42	9	225	27	252
Marin	1942	1	6	6	12
Merced	1910–45	5	0	9	9
Modoc	1934–47	5	0	44	44
Mono	1942–48	4	0	23	23
Monterey	1910–47	14	0	187	187
Nevada	1943	1	0	1	1
Orange	1946	1	0	1	1
Placer	1936–47	7	0	16	16
Plumas	1938	1	0	1	1
Riverside	1942	1	0	1	1
San Benito	1909–46	21	0	169	169
San Bernardino	1936–46	9	0	51	51
San Diego	1942–43	2	0	7	7
San Francisco	1902–41	8	413	1	414

Cases of animal plague reported in the United States, 1902–51—Continued

State and county	Period	Number of years	Domestic animals	Wild animals	Total cases
California—Continued					
San Joaquin	1910–20	3	0	22	22
San Luis Obispo	1910–48	11	0	82	82
San Mateo	1916–42	7	0	25	25
Santa Barbara	1929–46	3	0	14	14
Santa Clara	1909–45	11	0	66	66
Santa Cruz	1909–41	9	0	69	69
Shasta	1941	1	0	3	3
Siskiyou	1941–47	4	0	65	65
Stanislaus	1910–43	4	0	16	16
Tulare	1934	1	0	53	53
Ventura	1928–46	5	8	38	46
Total (35 counties)	1902–48	44	816	3, 415	4, 231
Colorado:					
Baca	1943–44	2	0	3	3
Clear Creek	1947	1	0	1	1
Custer	1947	1	0	1	1
Huerfano	1943	1	0	1	1
La Plata	1947	1	0	2	2
Larimer	1943	1	0	1	1
Park	1947–49	2	0	19	19
San Miguel	1941	1	0	3	3
Total (8 counties)	1941–49	5	0	31	31
Florida: Escambia	1920	1	36	0	36
Total (1 county)	1920	1	36	0	36
Idaho:					
Ada	1941–42	2	0	27	27
Bannock	1937–45	3	0	10	10
Bear Lake	1938	1	0	3	3
Bonneville	1936	1	0	4	4
Canyon	1941–42	2	0	7	7
Fremont	1939	1	0	1	1
Payette	1941	1	0	1	1
Total (7 counties)	1936–45	7	0	53	53
Kansas:					
Cheyenne	1945	1	0	3	3
Logan	1947–49	2	0	3	3
Morton	1945	1	0	2	2
Rawlins	1950	1	0	1	1
Scott	1946–48	2	0	4	4
Thomas	1949	1	0	4	4
Total (6 counties)	1945–50	6	0	17	17

Cases of animal plague reported in the United States, 1902–51—Continued

State and county	Period	Number of years	Domestic animals	Wild animals	Total cases
Louisiana:					
Jefferson	1914–17	3	11	0	11
Orleans	1912–26	11	987	1	988
St. Bernard	1914–16	2	4	0	4
Total (3 parishes)	1912–26	11	1,002	1	1,003
Montana:					
Beaverhead	1935–49	8	0	38.	38
Big Horn	1944	1	0	1	1
Custer	1943	1	0	4	4
Gallatin	1938	1	0	2	2
Garfield	1943	1	0	5	5
Madison	1937	1	0	3	3
Ravalli	1941	1	0	2	2
Total (7 counties)	1935–49	10	0	55	55
Nevada:					
Clark	1938–39	2	0	10	10
Douglas	1937	1	0	2	2
Elko	1936–40	2	0	5	5
Nye	1950	1	0	1	1
Ormsby	1937	1	0	4	4
Washoe	1942	1	0	1	1
Total (6 counties)	1936–50	7	0	23	23
New Mexico:					
Bernalillo	1949	1	0	1	1
Catron	1938–48	2	0	19	19
Colfax	1949	1	0	2	2
Dona Ana	1939	1	0	1	1
Eddy	1950	1	0	1	1
Guadalupe	1948–49	2	0	7	7
Lea	1950	1	0	11	11
Lincoln	1943–49	3	0	6	6
McKinley	1949	1	0	5	5
Quay	1943–44	2	0	6	6
Rio Arriba	1948–49	2	0	19	19
Sandoval	1943–49	2	0	2	2
San Juan	1949	1	0	1	1
San Miguel	1950	1	0	1	1
Santa Fe	1951	1	0	1	1
Socorro	1948–49	2	0	4	4
Taos	1949	1	0	2	2
Torrance	1943	1	0	1	1
Union	1943–49	3	0	5	5
Valencia	1939–41	2	0	4	4
Total (20 counties)	1938–51	9	0	99	99

Cases of animal plague reported in the United States, 1902–51—Continued

State and county	Period	Number of years	Domestic animals	Wild animals	Total cases
North Dakota: Divide	1941	1	0	4	4
Total (1 county)	1941	1	0	4	4
Oklahoma:					
Cimarron	1944	1	0	2	2
Texas	1950	1	0	1	1
Total (2 counties)	1944–50	2	0	3	3
Oregon:					
Baker	1938	1	0	3	3
Grant	1935–43	6	0	11	11
Harney	1940–42	2	0	5	5
Jackson	1942	1	0	2	2
Josephine	1942	1	0	1	1
Klamath	1942–47	3	0	4	4
Lake	1935–48	6	0	7	7
Malheur	1940–43	4	0	8	8
Union	1938–43	3	0	5	5
Wallowa	1935–40	4	0	7	7
Total (10 counties)	1935–48	12	0	53	53
Texas:					
Cochran	1946–49	2	0	11	11
Dawson	1947–49	2	0	3	3
Dallam	1950	1	0	1	1
Gaines	1948	1	0	6	6
Galveston	1920–22	3	75	0	75
Hartley	1950	1	0	1	1
Jefferson	1920	1	123	0	123
Yoakum	1949	1	0	1	1
Total (8 counties)	1920–50	8	198	23	221
Utah:					
Beaver	1936	1	0	3	3
Garfield	1936	1	0	2	2
Kane	1938	1	0	1	1
Morgan	1937	1	0	1	1
Rich	1938	1	0	2	2
Salt Lake	1948–49	2	0	3	3
Sevier	1936–49	2	0	2	2
Wasatch	1937–38	2	0	2	2
Total (8 counties)	1936–49	5	0	16	16

Cases of animal plague reported in the United States, 1902–51—Continued

State and county	Period	Number of years	Domestic animals	Wild animals	Total cases
Washington:					
Adams	1937–39	3	0	13	13
Douglas	1948–50	2	0	3	3
Grant	1948–50	3	0	7	7
King	1907–17	8	84	0	84
Kittitas	1947–50	4	0	20	20
Lincoln	1938–50	4	0	10	10
Pierce	1942–44	3	109	3	112
Spokane	1939–40	2	0	6	6
Stevens	1941	1	0	2	2
Yakima	1947–49	3	0	16	16
Total (10 counties)	1907–50	20	193	80	273
Wyoming:					
Albany	1945–48	2	0	2	2
Carbon	1943	1	0	1	1
Johnson	1943	1	0	3	3
Laramie	1948	1	0	1	1
Lincoln	1938–49	2	0	36	36
Park	1940	1	0	1	1
Sublette	1938–40	2	0	11	11
Sweetwater	1939–49	2	0	2	2
Uinta	1938–39	2	0	5	5
Yellowstone Park	1936	1	0	1	1
Total (10 counties)	1936–49	8	0	63	63
Grand total (17 States, 145 counties)[1]	1902–51	47	[2] 2, 245	[3] 3, 943	6, 188

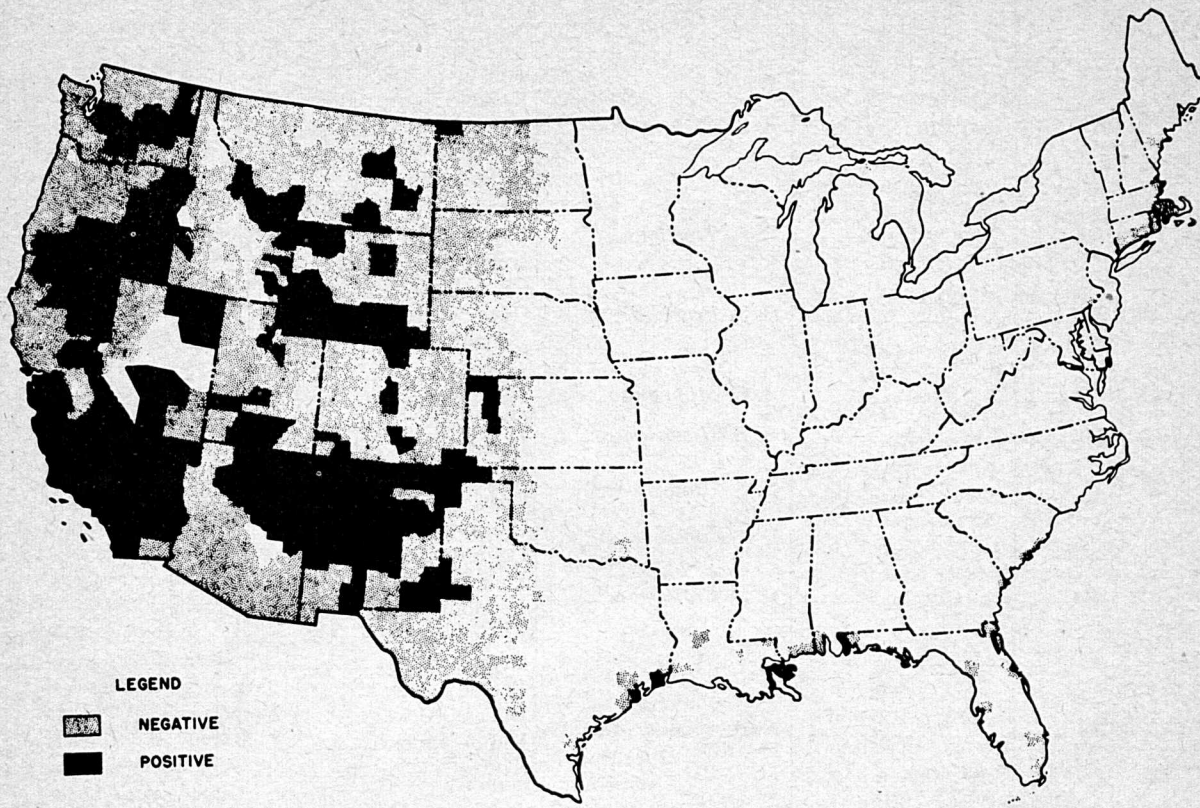
[1] In 8 counties plague was found in both domestic and wild animals.
[2] 14 counties.
[3] 139 counties.

Animals examined and positive results in the United States, fiscal years 1903–50

Fiscal year (July 1–June 30)	Domestic rodents				Wild animals			
	Number examined	Positive results			Number examined	Positive results		
		Tissue	Ecto-parasites	Total		Tissue	Ecto-parasites	Total
1903	2,060	16		16				
1904	3,013	22		22				
1908	172,594	510		510				
1909	168,884	14		14	9,048	43		43
1910	163,452	1		1	115,285	354		354
1911	142,299	0		0	148,570	59		59
1912	154,331	3		3	60,203	631		631
1913	143,216	1		1	30,891	690		690
1914	99,913	40		40	18,322	152		152
1915	293,144	257		257	32,243	67		67
1916	127,478	73		73	71,054	138		138
1917	87,667	41		41	14,425	43		43
1918	58,792	0		0	15,856	18		18
1919	19,016	0		0	72,276	98		98
1920	276,695	566		566	46,591	169		169
1921	442,274	271		271	69,388	28		28
1922	193,362	8		8	3,596	0		0
1923	84,135	0		0	4,345	15		15
1924	33,992	0		0	148	8		8
1925	259,652	253		253	20,853	13		13
1926	178,894	19		19	36,910	5		5
1927	72,595	9		9	20	0		0
1928	39,089	0		0	9	9		9
1929	41,271	0		0	24	26		26
1930	39,648	0		0	65	11		11
1931	44,036	0		0	95	2		2
1932	43,055	4		4	2	2		2
1933	35,715	0		0	2	2		2
1934	27,107	0		0	64	64		64
1935	31,287	0		0	2,099	20		20
1936	26,499	0		0	9,174	42	19	61
1937	23,096	0		0	29,606	18	22	40
1938	33,598	1		1	57,294	37	92	129
1939	28,453	0		0	51,029	26	73	99
1940	29,692	0		0	34,637	4	18	22
1941	32,784	2	4	6	26,494	36	59	95
1942	30,954	0			58,134	41	171	212
1943	45,989	38	61	99	95,193	38	107	145
1944	49,414	0			61,728	8	87	95
1945	50,469	7	16	23	95,709	5	23	28
1946	21,699	5	3	8	77,804	27	73	100
1947	26,256	0		0	109,254	5	53	58
1948	18,057	0		0	56,393	5	67	72
1949	13,477	0		0	51,422	2	76	78
1950 [1]							14	14
Unknown							4	4
Total	3,909,033	2,161	84	2,245	1,586,255	2,961	958	3,919

[1] 6 months.

Counties in the United States surveyed for animal plague, 1900–1950.



Rodent plague on ships arriving at United States ports, 1910–26

Date	Port	Ship	From—	Positive
June 18, 1910	San Francisco	S. S. *Nippon Maru*	Kobe Yokohama Honolulu	1 rat.
Apr. 7, 1916	New Orleans	S. S. *Trevelyan*	Karachi, India Dartmouth, England Dieppe, France New Castle on Tyne Gibraltar	1 *R. alexandrinus.*
Sept. 22, 1916	do	S. S. *Eggsford*	(Had visited no known plague ports within a year).	1 *R. rattus.*
Dec. 24, 1919	do	S. S. *Managua*	Nicaragua	1 *R. rattus.*
Feb. 12, 1920	do	S. S. *Historian*	Calcutta Liverpool	1 *R. alexandrinus.*
Oct. 27, 1924	do	S. S. *Atlanticos*	Barcelona Oran	6 rats.
Nov. 12, 1924	do	S. S. *Craftsman*	Calcutta Columbo Port Said London Liverpool Savannah	3 rats (1 pool).
Nov. 5, 1926	do	S. S. *Manila Maru*	Pacific ports Buenos Aires Rio de Janeiro Santos	6 *R. alexandrinus.*

Animal sources of plague-positive ectoparasites, by State

Arizona:
- *Citellus variegatus*
- *Cynomys gunnisoni zuniensis*
- *Neotoma albigula*
- *Peromyscus boylii*

California:
- *Citellus beecheyi beecheyi*
- *Citellus beecheyi nudipes*
- *Citellus beldingi*
- *Citellus fisheri*
- *Citellus lateralis*
- *Citellus leucurus*
- *Eutamias speciosus*
- *Glaucomys sabrinus lascivus*
- *Lepus californicus*
- *Marmota flaviventris*
- *Microtus californicus*
- *Neotoma fuscipes*
- *Peromyscus maniculatus boylii*
- *Peromyscus maniculatus truei*
- *Rattus rattus alexandrinus*
- *Rattus norvegicus*
- *Rattus rattus rattus*
- *Reithrodontomys megabothris*
- *Sciurus douglasii albolimbatus*
- *Speotyto cunicularia*
- *Sylvilagus auduboni*
- *Sylvilagus bachmani*
- *Thomomys* sp.

Colorado:
- *Citellus lateralis*
- *Citellus richardsoni elegans*
- *Citellus variegatus*
- *Cynomys gunnisoni gunnisoni*
- *Cynomys ludovicianus*
- *Marmota flaviventris*
- *Peromyscus truei*
- *Thomomys fosseor*

Florida:
- *Rattus rattus alexandrinus*
- *Rattus norvegicus*
- *Rattus rattus rattus*

Kansas:
- *Cynomys ludovicianus*
- *Microtus haydeni*
- *Microtus ochrogaster*
- *Neotoma floridana*
- *Onychomys leucogaster*
- *Peromyscus* sp.
- *Sigmodon hispidus*

Idaho:
- *Citellus armatus*
- *Citellus idahoensis*
- *Citellus townsendi mollis*
- *Marmota flaviventris*
- *Microtus* sp.
- *Peromyscus* sp.

Louisiana:
- *Mus musculus*
- *Rattus rattus alexandrinus*
- *Rattus norvegicus*
- *Rattus rattus rattus*
- *Neotoma* sp.

Montana:
- *Citellus armatus*
- *Citellus columbianus*
- *Citellus richardsoni elegans*
- *Cynomys ludovicianus*
- *Marmota flaviventris*

Nevada:
- *Citellus beecheyi beecheyi*
- *Citellus beldingi oregonus*
- *Citellus richardsoni nevadensis*
- *Citellus townsendi mollis*
- *Eutamias speciosus*
- *Neotoma desertorum*

New Mexico:
- *Citellus grammurus*
- *Citellus mexicanus*
- *Citellus spilosoma*
- *Citellus tridecemlineatus*
- *Citellus variegatus*
- *Cynomys gunnisoni gunnisoni*
- *Cynomys gunnisoni zuniensis*
- *Cynomys ludovicidanus*
- *Dipodomys ordii*
- *Marmota flaviventris*
- *Neotoma albigula*
- *Onychomys leucogaster*
- *Onychomys torridus*
- *Peromyscus boylii*
- *Peromyscus leucopus*
- *Peromyscus maniculatus*
- *Peromyscus truei*
- *Reithrodontomys megalotis*
- *Sigmodon* sp.

North Dakota:
- *Citellus richardsoni elegans*

Oklahoma:
- *Neotoma* sp.
- *Peromyscus* sp.

Oregon:
- *Citellus beecheyi douglasi*
- *Citellus beldingi oregonus*
- *Citellus columbianus*
- *Citellus oregonus*
- *Citellus townsendi mollis*
- *Marmota flaviventris*
- *Taxidea taxus neglecta*

Texas:
- *Citellus tridecemlineatus*
- *Cynomys ludovicianus*
- *Dipodomys* sp.
- *Neotoma micropus*
- *Onychomys leucogaster*
- *Rattus rattus alexandrinus*
- *Rattus norvegicus*
- *Rattus rattus rattus*

Utah:
- *Citellus armatus*
- *Citellus variegatus*
- *Cynomys parvidens*
- *Marmota flaviventris*
- *Neotoma desertorum*

Washington:
- *Citellus columbianus*
- *Citellus townsendi yakimaensis*
- *Citellus washingtoni*
- *Eutamias minimus*
- *Lagurus curtatus*
- *Microtus montanus*
- *Microtus townsendi*
- *Peromyscus maniculatus*
- *Rattus rattus alexandrinus*
- *Rattus norvegicus*
- *Rattus rattus rattus*
- *Sylvilagus nuttali*

Wyoming:
- *Citellus armatus*
- *Citellus lateralis*
- *Citellus richardsoni elegans*
- *Cynomys leucurus*
- *Cynomys ludovicianus*
- *Marmota flaviventris*
- *Peromyscus maniculatus*

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