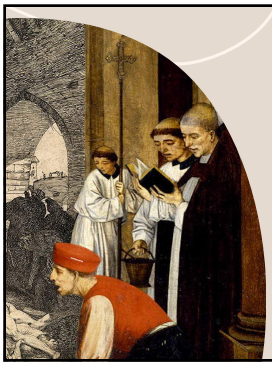

# Bubonic Plague & Its Presence In The United States

Stephanie Blackburn, EdD, MHS, MLS(ASCP)CM

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## Objectives

1. Examine the historical context and evolution of bubonic plague outbreaks.
2. Analyze the primary routes of transmission of bubonic plague.
3. Assess current surveillance systems for detecting and managing bubonic plague cases.



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Plague has roots tracing back to ancient civilizations

3

Divine punishment

Moral failings



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## Geographic Spread

**6th Century**
- Justinian Plague began in Egypt

**14th Century**
- Black Death emerged in Asia

**17th Century**
- Plague outbreaks in London and other European cities



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## Geographic Spread

**19th Century**
- Third Pandemic originated in China

**Early 20th Century**
- Plague re-emerged in various regions

**21st Century**
- Modern outbreaks continue to occur sporadically

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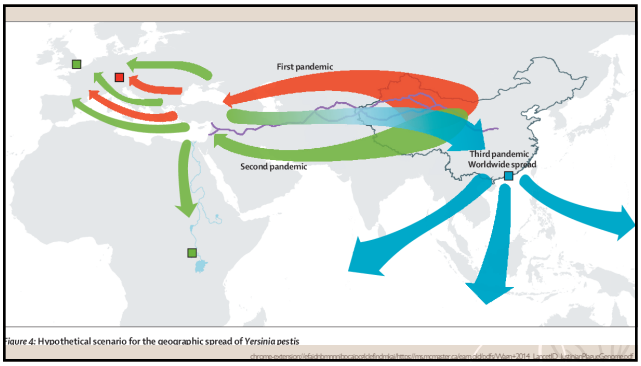


Figure 4: Hypothetical scenario for the geographic spread of *Yersinia pestis*

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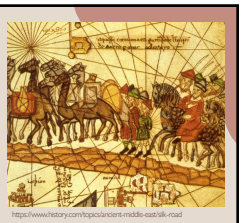
## Role of Trade in Plague Transmission

- Major trade routes allowed for the spread of plague
- Merchant vessels carried infected rats and fleas
- Plague outbreaks caused economic impact on trade



https://www.history.com/topics/ancient-middle-east/silk-road

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## The First Pandemic ~ Justinian Plague

- 541-542 AD
- Spread throughout Byzantine Empire
- Transmitted by fleas on rats
  - Human-to-human transmission
- Widespread death


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## The First Pandemic ~ Justinian Plague

- At least 18 waves of plague spread across Mediterranean basin to reach Persia and Ireland (541-750 AD)
- Catalyzed development of early public health measures
  - Laid groundwork for modern epidemiology
- End of pandemic attributed to:
  - Improved public health measures
  - Shifts in trade routes
  - Changes in population immunity

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After the Justinian Plague, the causative bacterium persisted in wild rodents in Central Asia

In the early 1300s, the organism mutated into an extremely virulent strain

Global spreading


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## The Second Pandemic ~ Black Death

- 1347-1352 AD
- Originated in Central Asia and spread westward
- Entered European ports via infected ships
  - Spread through France, Spain, Germany, Switzerland, Austria, England
  - Rapid and devastating outbreaks


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14th Century ~Killed 1/3 of the European population

Considered one of mankind's worst pandemics

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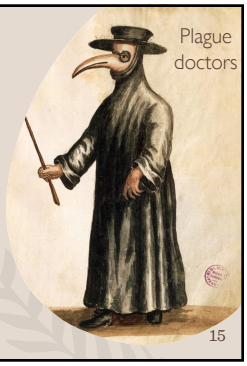
## Black Death



Plague doctors

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## The Aftermath of Black Death

- "Black Death" ended by the end of the 14th century
- Outbreaks resurfaced in Europe over next 400 years
  - 1656-1657 → ⅔ population of Naples and Genoa died from plague
  - 1665-1666 → ¼ population (100,000) of London died from plague
  - 1679 → 100,000 deaths in Vienna
  - 1770-1771 → More than 100,000 deaths in Moscow

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## A New Direction in Medical Knowledge

- Physicians rebelled against ancient medicine
  - Recognized that plague was contagious
- Led to a new approach in medicine

Scientific Revolution

- First quarantine in 1377

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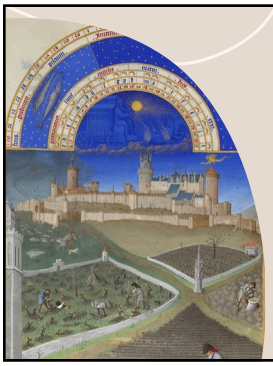

## The Aftermath of Black Death

- European society and economic transformed
  - Reduced workforce
  - Shifts in land ownership
  - Decline in feudalism
- Led to a rise of a more modern economic structure

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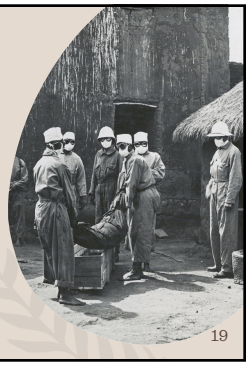
## The Third Pandemic

- 19th Century Pandemic
- 1855 ~ Began in China ~ Global spread
  - 70,000 deaths in Canton (1894)
  - Hong Kong, Japan, India, Australia, South America
  - 12 million deaths in India (1898-1918)
- In 1900 ~ Rats from merchant ships brought plague to San Francisco



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**Since 1950, there have been isolated outbreaks worldwide**

**More than 200 million deaths, worldwide, attributed to plague**

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## Plague in the United States

- Last urban plague epidemic in U.S:
  - 1924-1925 in Los Angeles
- Spread from urban rats to rural rodents that are established in the Western U.S.
  - New Mexico, Arizona, Colorado
  - Oregon, Nevada
- Scattered cases in rural regions

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## Transmission of Plague

- Initially thought to be transmitted by plague-infected fleas from wild rodents to house rats

**NEW EVIDENCE...**

Transmission first by direct human contact with rodents and then via fleas and head lice

Explains the rapid movement from Europe to Africa

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## Causative Agent of Plague

- *Yesinia pestis*
- Vector: *Xenopsylla cheopis* flea
  - About 80 other species also carry *Y. pestis*
- Fleas survive in infected clothing and grains
- Multiplies in infected rodents
  - More than 280 mammalian species are carriers
- Infected fleas regurgitate the bacteria to animal host

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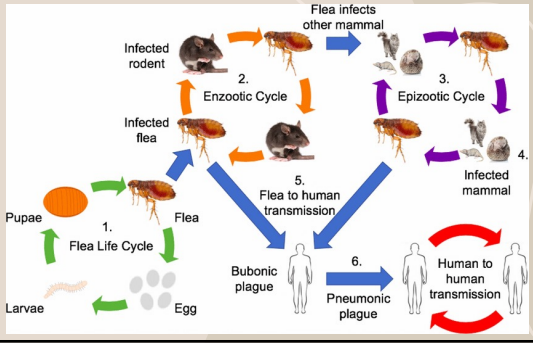


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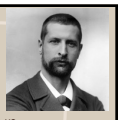
## Evolution of *Yersinia pestis*



- Named after physician, Alexandre Yersin, at the Pasteur Institute
  - Provided most accurate description of causative agent of plague during Hong Kong outbreak in 1894
- 1898 ~ Dr. Paul-Louis Simond in Karachi demonstrated that fleas from infected rates could transmit disease to healthy rats
- 1927 ~ Ricardo Jorge reported that wild rodents serve as a reservoir for plague

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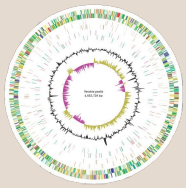

**_Yersinia pestis_ DNA genome identified in two skeletons in Germany ~ dated approximately 3800 years old**

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## Three clinical forms of plague

- Bubonic Plague
- Septicemic Plague
- Pneumonic Plague

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## Bubonic Plague

- Most common type
- Sudden onset of fever, chills, headache, fatigue
- Development of **buboes** – Swollen and painful lymph nodes
  - Closest to site of flea bite

Buboes
- Hallmark of bubonic plague
- Armpit, groin, or neck
- May become necrotic

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## Bubonic Plague

Without prompt treatment → Progression to septicemic plague → Overwhelming, systemic infection → Multi-organ failure & death

~ 60% untreated victims die within 1 week of exposure

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## Septicemic Plague

- *Yersinia pestis* enters bloodstream
- Causes systemic infection

Primary infection OR Secondary to untreated bubonic plague

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## Septicemic Plague

- Fever, chills, abdominal pain, septic shock
- May present with disseminated intravascular coagulation (DIC)
  - Necrosis, primarily in extremities, ears, or nose
- High risk:
  - Endemic areas
  - Immunocompromised
- Complications:
  - Organ failure
  - Septic shock

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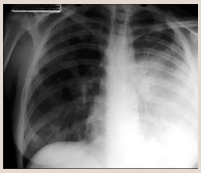
## Pneumonic Plague



- Transmitted through respiratory droplets from infected person or animal
  - Highly contagious
  - Initially, flu-like symptoms
  - Progresses to frothy or bloody sputum
- If untreated:
  - Rapid respiratory failure
  - 90% mortality rate within 24 hours of onset of symptoms

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## Pneumonic plague as a bioweapon?

- Classified as a Category A biologic agent for potential bioterrorism
- May be isolated and grown in the lab
- Easily aerosolized
- People exposed would develop pneumonic plague within 6 days
- Transmitted person to person

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## Pneumonic plague as a bioweapon?

- Major public health hazard
  - Quarantine
  - Widespread economic devastation
- Bacteria viable for 1 hour
- Historic acts of bioterrorism:
  - 1346 - Caffa
  - 1940 - WWII

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## Treatment


- Early recognition
- Bubonic plague:
  - Streptomycin or gentamycin
  - Combination of doxycycline, ciprofloxacin, and chloramphenicol
- Recent study:
  - 66% mortality rate in U.S. (1900-1942)
  - 13% mortality rate in U.S. after 1942 – arrival of antibiotics

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## Prophylaxis

- Family members or others in close contact with victim of plague
- Chemoprophylaxis with oral doxycycline or ciprofloxacin for 7 days
- Current research to produce a vaccine effective against pneumonic plague

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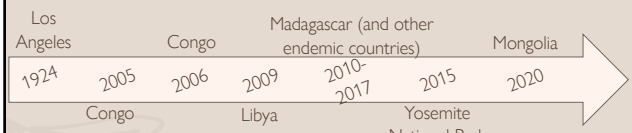
## Modern Plague Outbreaks

- We still have occasional outbreaks
- Variety of animal hosts

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## Cases of Plague Worldwide (2013-2018)


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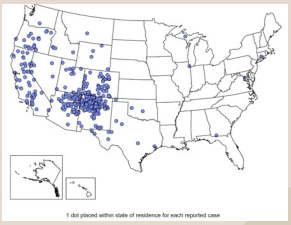
## U.S. Cases of Plague ~ 1970-2022




- 80% of cases in U.S. are bubonic plague
- Average of 7 cases/year
  - Affect all ages
- Most cases in the western U.S.

Feb 2024 ~ Oregon
May 2024 ~ prairie dogs in South Dakota
July 2024 ~ Colorado
Sept 2024 ~ a blind deer in Idaho

https://www.cdc.gov/plague/maps-statistics/index.html

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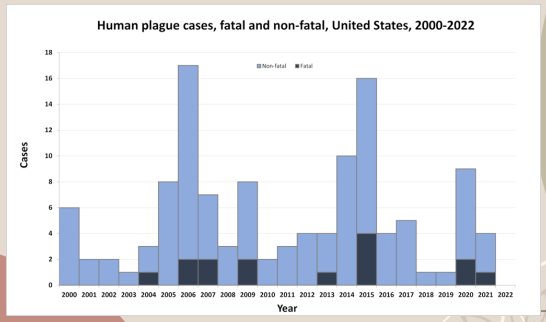


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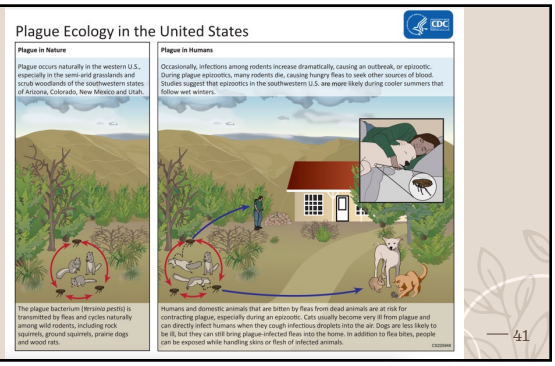


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## Plague Prevention

1. Reduce rodent habitats around home, workplace, and recreational areas
2. Wear gloves when handling potentially infected animals
3. Wear repellent (DEET) if potential flea exposure
4. Keep fleas off pets
5. Do not allow pets that roam outside in endemic areas to sleep on your bed

https://www.cdc.gov/plague/prevention/index.html

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## Attempts to eradicate plague

- Union of Soviet Socialist Republics (USSR) tried for many years, up until 1991 launched a plague-eradication program
  - Poisons placed in thousands of rodent burrows
  - Number of cases decreased
- Toxicity to humans and other animals from the insecticides
  - Shifted to vector control (as opposed to eradication)
- Not possible to completely eradicate because *Y. pestis* has an animal reservoir

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## Surveillance Systems


- Goal: Detect early warning signs & prevent further exposure
- Epidemiological sampling
  - Monitor presence of *Y. pestis* in local rodent populations
  - Limited to endemic areas
- Balance ongoing surveillance of vectors with protecting environment
- Genomic sequencing and epidemiological modeling has improved tracking plague strains

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**Box 1. International Health Regulations**

- The International Health Regulations, which came into effect in 2007, require the notification of any event of potential international public health concern within 24 hours of assessment.
- The decision instrument of the Regulations provides an algorithm that can assist in assessing whether an event should be reported. The criteria include the following questions.
  - Is the public health impact of the event serious?
  - Is the event unusual or unexpected?
  - Is there a significant risk of international spread?
  - Is there a significant need for international restrictions on travel and trade?
- Plague cases should be notified only if the assessment done by the country shows that the public health impact can be considered serious and the event has at least one of the following characteristics: it is an unusual or unexpected event; there is a risk of international spread; there is a significant risk to international travel; or there is a significant need to restrict trade.
- **The algorithm must always be used when there are cases of suspected pneumonic plague due to its potential to have serious public health impacts and to spread rapidly.**
- It is not always necessary to wait for laboratory confirmation of plague; a suspected case of plague that occurs in an area not known to be endemic should be reported as an event to WHO.
- If the outcome of the decision tool is a requirement for notification, the national government should inform WHO about the plague event and provide the following details: the region affected, number of cases, number of deaths, control measures taken and current situation.
- Refer to the *International Health Regulations (16).*



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## Role of the Laboratory

- Essential component of surveillance
- National plague reference lab in endemic countries
  - Linked to national public health system
- Geographical areas for surveillance determined by:
  - Known focus of plague
  - Detection of *Y. pestis*
  - Suspected human case(s)

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## Animal-based surveillance

**TABLE 11. Early warning signals of increased risk of human plague**

| Early warning signal | Surveillance mechanism for detection |
|---|---|
| Sudden decreases in rodent density or identification of greater than normal numbers of dead rats (i.e. rat fall)[a] | Rodent surveillance |
| Total flea index or specific flea index > 1[b] | Flea surveillance |
| Increase in positive serum samples from canines[c] | Carnivore surveillance |
| Identification of *Yersinia pestis* in rodent or other host carcasses | Carcass surveillance (including rat fall surveillance) |



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## Conclusion

- *Yersinia pestis* is still out there causing sporadic outbreaks of plague
- Although illness is rare in the U.S., people need to take appropriate precautions if traveling to areas in western U.S.
- Advancement in the development of a vaccine
- Ongoing public health initiatives and surveillance
- Growing focus on educating communities in endemic regions

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