

The History of Plague – Part 1. The Three Great Pandemics

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Plague is an acute infectious disease caused by the bacillus *Yersinia pestis* and is still endemic in indigenous rodent populations of South and North America, Africa and Central Asia. In epidemics plague is transmitted to humans by the bite of the Oriental or Indian rat flea and the human flea. The primary hosts of the fleas are the black urban rat and the brown sewer rat. Plague is also transmissible person to person when in its pneumonic form. *Yersinia pestis* is a very pathogenic organism to both humans and animals and before antibiotics had a very high mortality rate. Bubonic plague also has military significance and is listed by the Centers for Disease Control and Prevention as a Category A bioterrorism agent.¹

There have been three great world pandemics of plague recorded, in 541, 1347, and 1894 CE, each time causing devastating mortality of people and animals across nations and continents. On more than one occasion plague irrevocably changed the social and economic fabric of society.

In most human plague epidemics, infection initially took the form of large purulent abscesses of lymph nodes, the bubo (L. bubo = 'groin', Gr. boubon = 'swelling in the groin'), this was bubonic plague. When bacteraemia followed, it caused haemorrhaging and necrosis of the skin rapidly followed by septicaemic shock and death, *septicaemic* plague. If the disease spread to the lung through the blood, it caused an invariably fatal pneumonia, pneumonic plague, and in that form plague was directly transmissible from person to person.

The three great plague pandemics had different geographic origins and paths of spread. The Justinian Plague of 541 started in central Africa and spread to Egypt and the Mediterranean. The Black Death of 1347 originated in Asia and spread to the Crimea then Europe and Russia. The third pandemic, that of 1894, originated in Yunnan, China, and spread to Hong Kong and India, then to the rest of the world.²

The causative organism, *Yersinia pestis*, was not discovered until the 1894 pandemic and was discovered in Hong Kong by a French Pastorian bacteriologist, Alexandre Yersin. Four years later in 1898 his successor, Paul-Louis Simond, a fellow

Pastorien and a French naval doctor, demonstrated that the Oriental rat flea was the vector for the bacillus and the sources of the bacillus were the sewer rats.^{3,4}

The germ, the rats, and the fleas

Yersinia pestis is most likely a clone that evolved some 1,500 to 20,000 years ago from a common ancestor with *Yersinia pseudotuberculosis*, an animal enteropathogen which does not cause blood infection or plague. The bacillus probably arose in Asia, although it had been present in east-central Africa for the past two millennia and probably longer.^{2,5} There are three biovars of the bacillus based on phenotypic differences, Antiqua, Medievalis, and Orientalis, and it has been postulated that they were responsible for the first, second and third pandemics respectively. A paleomicrobiological analysis by Drancourt et al in 2004 however indicated that all three pandemics were most likely caused by the Orientalis biovar.^{6,7}

There had also been debate for some time whether the Justinian and the Black Death plagues were actually due to *Yersinia pestis* and were not instead epidemic haemorrhagic fevers^{3,8}. Analyses by Drancourt and others have found evidence of the plague bacillus in specimens of persons known to have died in the first two pandemics. It is also very difficult to discount the vivid and accurate descriptions of the bubonic plague that were given by historians such as Procopius of Caesarea, Gabriel de Mussis and Giovanni Boccaccio.

The vector host in the Black Death pandemic was *Rattus rattus* - the 'old English' or black rat. The black rat originated in India and migrated along the Silk Road from Asia to the Middle East, and then travelled in ships on the sea trade routes, settling in most areas of the world and cohabitating comfortably with humans in their houses, factories, and dockyards. The black rat had probably acquired the disease from contact with infected wild rodents from the steppes of Central Asia and Russia, and in fact the disease may have been transported in infested marmot hides taken by Tartar hunters from Manchuria. The brown or sewer rat, *Rattus norvegicus*, didn't become prevalent in the Western world until the 18th century. It originated in Central

Asia and migrated westward on the sea routes from China and India. The brown rat flourished in Europe where there were open sewers and ample breeding grounds and food and in the 18th and 19th centuries replaced the black rat as the main disease host.^{4, 9}

The primary vectors for transmission of the disease from rats to humans were the Oriental or Indian rat flea, *Xenopsylla cheopis*, and the Northern or European rat flea, *Nosopsyllus fasciatus*. The human flea, *Pulex irritans*, and the dog and cat fleas, *Ctenocephalides canis* and *felis*, were secondary vectors. In the pandemics, the infected fleas were able to spread the plague over long distances as they were carried by rats and by humans travelling along trade routes at sea and overland, and also by infesting rice and wheat grain, clothing, and trade merchandise. When infected, the proventriculus of the flea becomes blocked by a mass of bacteria. The flea continues to feed, biting with increasing frequency and agitation, and in an attempt to relieve the obstruction the flea regurgitates the accumulated blood together with a mass of *Yersinia pestis* bacilli directly into the bloodstream of the host. The fleas multiply prolifically on their host and when the host dies they leave immediately, infesting new hosts and thus creating the foundations for an epidemic.^{10, 11}

The Justinian Plague of 541-544

The first great pandemic of bubonic plague where people were recorded as suffering from the characteristic buboes and septicaemia was the *Justinian Plague* of 541 CE, named after Justinian I, the Roman emperor of the Byzantine Empire at the time. The epidemic originated in Ethiopia in Africa and spread to Pelusium in Egypt in 540. It then spread west to Alexandria and east to Gaza, Jerusalem and Antioch, then was carried on ships on the sea trading routes to both sides of the Mediterranean, arriving in Constantinople (now Istanbul) in the autumn of 541.^{12, 13}

The Byzantine court historian, Procopius of Caesarea, in his work *History of the Wars*, described people with fever, delirium and buboes. He wrote that the epidemic was one 'by which the whole human race came near to be annihilated'. Procopius wrote of the symptoms of the disease :

" ... with the majority it came about that they were seized by the disease without becoming aware of what was coming either through a waking vision or a dream. ... They had a sudden fever, some when just roused from sleep, others while walking about, and others while otherwise engaged, without any

regard to what they were doing. And the body showed no change from its previous colour, nor was it hot as might be expected when attacked by a fever, nor indeed did any inflammation set in, but the fever was of such a languid sort from its commencement and up till evening that neither to the sick themselves nor to a physician who touched them would it afford any suspicion of danger. It was natural, therefore, that not one of those who had contracted the disease expected to die from it. But on the same day in some cases, in others on the following day, and in the rest not many days later, a bubonic swelling developed; and this took place not only in the particular part of the body which is called bubo, that is, "below the abdomen," but also inside the armpit, and in some cases also beside the ears, and at different points on the thighs."¹⁴

The focus of the Justinian pandemic was Constantinople, reaching a peak in the spring of 542 with 5,000 deaths per day in the city, although some estimates vary to 10,000 per day, and it went on to kill over a third of the city's population. Victims were too numerous to be buried and were stacked high in the city's churches and city wall towers, their Christian doctrine preventing their disposal by cremation. Over the next three years plague raged through Italy, southern France, the Rhine valley and Iberia. The disease spread as far north as Denmark and west to Ireland, then further to Africa, the Middle East and Asia Minor. Between the years 542 and 546 epidemics in Asia, Africa and Europe killed nearly 100 million people.^{15, 16}

The pandemic had a drastic effect and permanently changed the social fabric of the Western world. It contributed to the demise of Justinian's reign. Food production was severely disrupted and an eight year famine followed. The agrarian system of the empire was restructured to eventually become the three field feudal system. The social and economic disruption caused by the pandemic marked the end of Roman rule and led to the birth of culturally distinctive societal groups that later formed the nations of medieval Europe.¹²

Further major outbreaks occurred throughout Europe and the Middle East over the next 200 years - in Constantinople in the years 573, 600, 698 and 747, in Iraq, Egypt and Syria in the years 669, 683, 698, 713, 732 and 750 and Mesopotamia in 686 and 704. In 664 plague laid waste to Ireland,

and in England it came to be known as the Plague of Cadwaladyr's Time, after a Welsh king who contracted plague but survived it in 682. The plague continued in intermittent cycles in Europe into the mid-8th century and did not re-emerge as a major epidemic until the 14th century.

The 'Black Death' of Europe in 1347 to 1352

The Black Death of 1347 was the first major European outbreak of the second great plague pandemic that occurred over the 14th to 18th centuries. In 1346 it was known in the European seaports that a plague epidemic was present in the East. In 1347 the plague was brought to the Crimea from Asia Minor by the Tartar armies of Khan Janibeg, who had laid siege to the town of Kaffa (now Feodosya in Ukraine), a Genoese trading town on the shores of the Black Sea. The siege of the Tartars was unsuccessful and before they left, from a description by Gabriel de Mussis from Piacenza, in revenge they catapulted over the walls of Kaffa corpses of people who had died from the Black Death. In panic the Genoese traders fled in galleys with 'sickness clinging to their bones' to Constantinople and across the Mediterranean to Messina, Sicily, where the great pandemic of Europe started. By 1348 it had reached Marseille, Paris and Germany, then Spain, England and Norway in 1349, and eastern Europe in 1350. The Tartars left Kaffa and carried the plague away with them spreading it further to Russia and India.¹⁷

A description of symptoms of the plague was given by Giovanni Boccaccio in 1348 in his book *Decameron*, a set of tales of a group of Florentines who secluded themselves in the country to escape the plague :

".. in men and women alike it first betrayed itself by the emergence of certain tumours in the groin or armpits. Some of which grew as large as a common apple, others as an egg, some more, some less, which the common folk called *gavocciolo*. From the two said parts of the body this deadly *gavocciolo* soon began to propagate and spread itself in all directions indifferently; after which the form of the malady began to change, black spots or livid making their appearance in many cases on the arm or the thigh or elsewhere..."¹⁷

The term "Black Death" was not used until much later in history and in 1347 was simply known as "*the pestilence*" or "*pestilentia*", and there are various explanations of the origin of the term. Butler ^[11] states the term refers to the haemorrhagic purpura and ischaemic gangrene of the limbs that sometimes

ensued from the septicaemia. Ziegler¹⁷ states it derives from the translation of the Latin *pestis atra* or *atra mors*, 'atra' meaning 'terrible' or 'dreadful', the connotation of which was 'black', and 'mors' meaning 'death', and so 'atra mors' was translated as meaning 'black death'.

The social impacts of the Black Death in Europe during the 14th century

The overall mortality rate varied from city to city, but in places such as Florence as observed by Boccaccio up to half the population died, the Italians calling the epidemic the *mortalega grande*, 'the great mortality'.^[18] People died with such rapidity that proper burial or cremation could not occur, corpses were thrown into large pits and putrefying bodies lay in their homes and in the streets. People were as much afraid they would suffer a spiritual death as they were a physical death since there were no clergy to perform burial rites:

"Shrift there was none; churches and chapels were open, but neither priest nor penitents entered – all went to the charnelhouse. The sexton and the physician were cast into the same deep and wide grave; the testator and his heirs and executors were hurled from the same cart into the same hole together."¹⁸

Transmission of the disease was thought to be by miasmas, disease carrying vapours emanating from corpses and putrescent matter or from the breath of an infected or sick person. Others thought the Black Death was punishment from God for their sins and immoral behaviour, or was due to astrological and natural phenomena such as earthquakes, comets, and conjunctions of the planets. People turned to patron saints such as St Roch and St Sebastian or to the Virgin Mary, or joined processions of flagellants whipping themselves with nail embedded scourges and incanting hymns and prayers as they passed from town to town.^{17, 19, 20}

"When the flagellants – they were also called cross brethren and cross bearers – entered a town, a borough or a village in a procession their entry was accompanied by the pealing of bells, singing, and a huge crowd of people. As they always marched two abreast, the procession of the numerous penitents reached farther than the eye could see."

^[20]

The only remedies were inhalation of aromatic vapours from flowers and herbs such as rose,

theriaca, aloe, thyme and camphor. Soon there was a shortage of doctors which led to a proliferation of quacks selling useless cures and amulets and other adornments that claimed to offer magical protection.

In this second pandemic, plague again caused great social and economic upheaval. Often whole families were wiped out and villages abandoned. Crops could not be harvested, travelling and trade became curtailed, and food and manufactured goods became short. As there was a shortage of labour, surviving villager labourers, the 'villeins', extorted exorbitant wages from the remaining aristocratic landowners. The villeins prospered and acquired land and property. The plague broke down the normal divisions between the upper and lower classes and led to the emergence of a new middle class.^{17, 9} The plague led to a preoccupation with death as evident from macabre artworks such as the '*Triumph of Death*' by Pieter Breughel the Elder in 1562, which depicted in a panoramic landscape armies of skeletons killing people of all social orders from peasants to kings and cardinals in a variety of macabre and cruel ways.

In the period 1347 to 1350 the Black Death killed a quarter of the population in Europe, over 25 million people, and another 25 million in Asia and Africa.¹¹⁵ Mortality was even higher in cities such as Florence, Venice and Paris where more than half succumbed to the plague. A second major epidemic occurred in 1361, the *pestis secunda*, in which 10 to 20% of Europe's population died.¹³ Other virulent infectious disease epidemics with high mortalities occurred during this time such as smallpox, infantile diarrhoea and dysentery. By 1430, Europe's population was lower than it had been in 1290 and would not recover the pre-pandemic level until the 16th century.^{13, 21}

Quarantine

In 1374 when another epidemic of the Black Death re-emerged in Europe, Venice instituted various public health controls such as isolating victims from healthy people and preventing ships with disease from landing at port. In 1377 the republic of Ragusa on the Adriatic Sea (now Dubrovnik in Yugoslavia) established a ships' landing station far from the city and harbour in which travellers suspected to have the plague had to spend thirty days, the *trentena*, to see whether they became ill and died or whether they remained healthy and could leave. The *trentena* was found to be too short and in 1403 in Venice, travellers from the Levant in the eastern Mediterranean were isolated in a hospital for forty days, the *quarantena* or *quaranta giorni*, from which we derive the term quarantine.^{8, 18} This change to forty days may have also been related to other biblical and historical references such as the Christian observance of Lent,

the period for which Christ fasted in the desert, or the ancient Greek doctrine of "critical days" which held that contagious disease will develop within 40 days after exposure.²² In the 14th and 15th centuries following, most countries in Europe had established quarantine, and in the 18th century Habsburg established a *cordon sanitaire*, a line between infected and clean parts of the continent which ran from the Danube to the Balkans. It was manned by local peasants with checkpoints and quarantine stations to prevent infected people from crossing from eastern to western Europe.⁸

The leather costume of the plague doctors at Nijmegen

In the 15th and 16th centuries doctors wore a peculiar costume to protect themselves from the plague when they attended infected patients, first illustrated in a drawing by Paulus Furst in 1656 and later Jean-Jacques described a similar costume worn by the plague doctors at Nijmegen, an old Dutch town in Gelderland, in his 1721 work *Treatise on the Plague*. They wore a protective garb head to foot with leather or oil cloth robes, leggings, gloves and hood, a wide brimmed hat which denoted their medical profession, and a beak like mask with glass eyes and two breathing nostrils which was filled with aromatic herbs and flowers to ward off the miasmas. They avoided contact with patients by taking their pulse with a stick or issued prescriptions for aromatic herb inhalations passing them through the door, and buboes were lanced with knives several feet long.¹⁹

The Great Plague of London of 1665 to 1666

Plague continued to occur in small epidemics throughout the world but a major outbreak of the pneumonic plague occurred in Europe and England in 1665 to 1666. The epidemic was described by Samuel Pepys in his diaries in 1665 and by Daniel Defoe in 1722 in his *A Journal of a Plague Year*. People were incarcerated in their homes, doors painted with a cross. The epidemic reached a peak in September 1665 when 7,000 people per week were dying in London alone. Between 1665 and 1666 a fifth of London's population died, some 100,000 people.¹¹⁷ The Great Fire of London in 1666 and the subsequent rebuilding of timber and thatch houses with brick and tile disturbed the rats' normal habitat and led to a reduction in their numbers, and may have been a contributing factor to the end of the epidemic.⁹

An old English nursery rhyme published in Kate Greenaway's book *Mother Goose* 1881 reminds us of the symptoms of the plague :

'Ring, a-ring, o'rosies, (a red blistery rash)

A pocket full of posies (fragrant herbs and flowers to ward off the 'miasmas')

Atishoo, atishoo (the sneeze and the cough heralding pneumonia)

We all fall down.' (all dead)

Plague waxed and waned in Europe until the late 18th century, but not with the virulence and mortality of the 14th century European Black Death.

The Third Pandemic of 1894

The plague re-emerged from its wild rodent reservoir in the remote Chinese province of Yunnan in 1855. From there the disease advanced along the tin and opium routes and reached the provincial capital of K'unming in 1866, the Gulf of Tonkin in 1867, and the Kwangtung province port of Pakhoi (now Pei-hai) in 1882. In 1894 it had reached Canton and then spread to Hong Kong. It had spread to Bombay by 1896 and by 1900 had reached ports on every continent, carried by infected rats travelling the international trade routes on the new steamships.^{3,23}

It was in Hong Kong in 1894 that Alexandre Yersin discovered the bacillus now known as *Yersinia pestis*, and in Karachi in 1898 that Paul-Louis Simond discovered the brown rat was the primary host and the rat flea the vector of the disease.^{3, 4, 24, 25}

In 1900 the plague came to Australia where the first major outbreak occurred in Sydney, its epicentre at the Darling Harbour wharves, spreading to the city, Surry Hills, Glebe, Leichhardt, Redfern, and The Rocks, and causing 100 deaths. John Ashburton-Thompson, the chief medical officer, recorded the epidemic and confirmed that rats were the source

and their fleas were the vectors in the epidemic. There were 12 major outbreaks of plague in Australia from 1900 to 1925 with 1371 cases and 535 deaths, most cases occurring in Sydney.²⁶

The third pandemic waxed and waned throughout the world for the next five decades and did not end until 1959, in that time plague had caused over 15 million deaths, the majority of which were in India. There have been outbreaks of plague since, such as in China and Tanzania in 1983, Zaire in 1992, and India, Mozambique and Zimbabwe in 1994^{15, 27}. In Madagascar in the mid-1990's, a multi-drug resistant strain of the bacillus was identified^{15, 28}. Currently around 2,000 cases occur annually, mostly in Africa, Asia and South America, with a global case fatality rate of 5% to 15%.²⁸

Bubonic plague is a virulent disease with a significant mortality rate, transmitted primarily by the bite of the rat flea or through person-to-person when in its pneumonic form. There have been innumerable epidemics of plague throughout history, but it was the pandemics of the 6th, 14th and 20th centuries that have had the most impact on human society, not only in terms of the great mortalities, but also the social, economic and cultural consequences that resulted. The course of development of communities and nations was altered several times. Much has changed to prevent the recurrence of pandemic plague, such as the development of the germ theory and the science of bacteriology, public health measures such as quarantine, and antibiotics such as streptomycin, but plague today is still an important and potentially serious threat to the health of people and animals.

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References

1. Centers for Disease Control and Prevention. Emergency Preparedness and Response: Bioterrorism – Agents/Diseases. Available at : <http://emergency.cdc.gov/agent/agentlist-category.asp>, accessed on 6.11.11.
2. Achtman M, Zurth K, Morelli G, Torrea G, Guiyoule A, Carniel E. *Yersinia pestis*, the cause of plague, is a recently emerged clone of *Yersinia pseudotuberculosis*. *Proc Natl Acad Sci* 1999; 96 (24): 14043-14048. Available at : <http://www.pnas.org/content/96/24/14043.full.pdf> , accessed on 3.11.11.
3. Echenberg M. *Plague Ports*. New York; New York University Press, 2007.
4. Marriott E. *Plague*. New York: Metropolitan Books - Henry Holt & Co, 2003.
5. Gage KL, Kosoy MY. Natural history of plague: perspectives from more than a century of research. *Ann Rev Entomol* 2005; 50: 505-528. Available at : http://www.annualreviews.org/doi/full/10.1146/annurev.ento.50.071803.130337?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%3dpubmed , accessed on 15.11.11.

6. Drancourt M, Roux V, Dang LV, Tran-Hung L, Castex D, Chenal-Francisque V, Ogata H, Fournier P-E, Crubezy E, Raoult D. Genotyping Orientalis-like *Yersinia pestis*, and plague pandemics. *Emerging Inf Dis* 2004; 10 (9): 1585-1592. Available at : http://wwwnc.cdc.gov/eid/article/10/9/03-0933_article.htm , accessed on 3.11.11
7. Raoult D, Drancourt M. *Yersinia Pestis and Plague*. University of Marseille. 2006. Available at : http://ifr48.timone.univ-mrs.fr/Fiches/Yersinia_pestis_Plague.html, accessed on 3.11.11.
8. Dobson M. *Disease: The Extraordinary Stories Behind History's Deadliest Killers*. Quercus: London, 2007.
9. Porter S. *The Great Plague*. Phoenix Mill, Gloucestershire; Sutton Publishing, 1999.
10. Gratz N. Rodent Reservoirs & Flea Vectors of Natural Foci of Plague. In : WHO. *Plague Manual: Epidemiology, Distribution, Surveillance and Control*. 2011. WHO/CDS/CSR/EDC/99.2. Available at : <http://www.who.int/csr/resources/publications/plague/whocdscsredc992b.pdf> , accessed on 19.11.11.
11. Butler T. *Plague and Other Yersinia Infections*. New York: Plenum Medical Book Company, 1983.
12. Rosen W. *Justinian's Flea: The First Great Plague and the End of the Roman Empire*. New York: Viking Penguin, 2007.
13. Gottfried RS. *The Black Death*. London: Robert Hale Ltd, 1983.
14. Halsall P. *Medieval Sourcebook: Procopius: The Plague, 542*. 1998. Available at : <http://www.fordham.edu/halsall/source/542procopius-plague.asp> , accessed on 19.11.11.
15. Tikhomirov E. *Epidemiology and Distribution of Plague*. In : WHO. *Plague Manual: Epidemiology, Distribution, Surveillance and Control*. 2011. WHO/CDS/CSR/EDC/99.2. Available at : <http://www.who.int/csr/resources/publications/plague/whocdscsredc992a.pdf> , accessed on 10.11.11.
16. Morony MG. "For Whom Does the Writer Write ?" *The First Bubonic Plague Pandemic According to Syriac Sources*. In : Little LK. *Plague and the End of Antiquity: The Pandemic of 541-750*. Cambridge: Cambridge University Press, 2007.
17. Zeigler P. *The Black Death*. Godalming, Surrey: Bramley Books, 1969.
18. Garrison F H. *An Introduction to the History of Medicine*. Philadelphia & London: W B Saunders & Co., 1921.
19. Schreiber W, Mathys FK. *Infectio: Infectious Diseases in the History of Medicine*. Basle: F. Hoffman – La Roche & Co, 1987.
20. Nohl J. *The Black Death: A Chronicle of the Plague*. (Translated by CH Clarke). London: George Allen & Unwin, 1926.
21. Damen M. *History and Civilisation: Section 6: The Black Death*. 2010. [On-line] Available at <http://www.usu.edu/markdamen/1320hist&civ/chapters/06plague.htm> , accessed on 1.4.12.
22. Mackowiak PA, Sehdev PS. The origin of quarantine. *Clin Infect Dis* 2002; 35 (9): 1071-1072. Available at : <http://cid.oxfordjournals.org/content/35/9/1071.full>, accessed on 17.11.11
23. Gregg CT. *Plague: An Ancient Disease in the Twentieth Century*. Revised edition. Albuquerque; University of New Mexico Press, 1985.
24. Archives de l' Institut Pasteur. Alexandre Yersin (1863-1943). Available at : http://www.pasteur.fr/infosci/archives/e_yer0.html , accessed on 24.11.10.
25. Archives de l' Institut Pasteur. Paul-Louis Simond (1858-1947). Available at : http://www.pasteur.fr/infosci/archives/e_sim0.html , accessed on 27.10.11.
26. Curson PH. *Times of Crisis: Epidemics in Sydney 1788-1900*. Sydney: Sydney University Press, 1985.
27. Perry RD, Fetherston JD. *Yersinia pestis – etiologic agent of plague*. *Clin Microbiol Rev* 1997; 10 (1): 35-66. Available at : <http://www.ncbi.nlm.nih.gov/pmc/articles/PMC172914/pdf/100035.pdf> , accessed on 2.4.12.
28. WHO. *Zoonotic Infections – Plague*. 2012. Available at : http://www.who.int/vaccine_research/diseases/zoonotic/en/index3.html , accessed on 2.4.12.