Disease, People, and Environment: The Plague in China

(draft only for discussion)

Michael Shiyung Liu

Senior Fellow, Center for Historical Research, Ohio State University

Since the Age of Discovery, the world has witnessed profound and unprecedented changes in the natural, built, and social environments. Countless new technologies introduced into diverse societies around the globe have altered the ways in which we live. Dramatic changes in the patterns and distribution of human disease were inevitable. Many interdependent variables create a propensity for particular patterns of disease.[1] These variables are woven together into multi-dimensional webs or networks, comprised of strands from the natural and social environments, which in turn powerfully influence the practices and choices of people's daily lives.

Genetic changes in populations occur slowly and do not explain disease patterns that shift over years or decades. Comparatively, environmental changes influence disease patterns much more rapidly and through many different pathways or mechanisms. Several changes in the built and social environments, as well as public health and medical advances, have contributed for the goal of longer life expectancies.

The growth of cities throughout the 1800s created conditions at the beginning of the twentieth century in which infectious diseases flourished. Also, improved sanitation, housing, standards of living, vaccines, antibiotics, and other medical interventions led to dramatic declines in infectious disease morbidity and mortality.[2] This increase in life expectancy was a fundamental dimension of the "epidemiologic transition" to new patterns and distribution of disease, from high mortality among infants and children, along with episodic famine and infectious epidemics affecting all age groups, to more chronic, degenerative diseases.[3] In developing countries, however, infectious diseases continue to be a major cause of morbidity and mortality.[4]

After the Industrial Revolution, especially in the 19th and 20th centuries, human activity began to dominate the world's ecosystems in unprecedented ways. Rapidly developing new technologies exponentially leveraged human power and ingenuity, but technological advancement was on a steep learning curve and unintended

---

[1] Wilson ME., "Travel and the emergence of infectious diseases," *Emerg Infect Dis* 1995;1:39–46. Haines A, Patz JA. "Health effects of climate change," *JAMA* 2004;291: 99–103.

2 Jones PD,Groisman PY, Coughlan M, PlummerN,Wang WC, Karl TR. "Assessment of urbanization effects in time series of surface air temperature over land," *Nature* 1990;347:169–172.

3 Omran A., "The epidemiologic transition: a theory of the epidemiology of population change," *Milbank Quarterly* 1971;49:509-538.

4 Cairncross S., "Sanitation in the developing world: current status and future solutions," *Int J Environ Health Res* 2003;13:S123–S131.

consequences were common.[5] In the 1960s Rachel Carson warned that rapid development and deployment of industrial chemicals in agriculture threatened the entire food web and health of ecological systems.[6] We discovered a kind of mistake born out of profound ignorance—not even knowing what question to ask when considering the impact of a new technology.

Generally speaking, human activity has altered virtually every aspect of ecological systems throughout the world in unprecedented ways. Climate instability with periods of extreme heat, degraded soil, air, and water quality, and loss of biodiversity and ecosystem services collectively increase the risks of a number of diseases or conditions in all people.

Factors of environmental-related diseases

In most of human history, infectious diseases generally appear to have been the major killers of human beings before the medical advances of the 20th century. Several epidemics such as cholera and plague during the 19th and early 20th centuries reflected an unprecedented global convergence of a number of very diverse factors including rapid population growth, high-density human settlement on forest fringes, greater human mobility, long-distance trade, inappropriate use of land and water resources, social and political disruption, and regional climatic disturbances.

Infectious disease patterns under the lens of ecosystem

The transmission of many infectious diseases is linked to biological organisms and processes which may only survive in specific environment. Their survival conditions are especially influenced by fluctuations in environmental variables such as temperature, precipitation and humidity. Most of these fluctuations are part of normal climate variability, as evidenced by the "seasonality" incorporated in the survival strategies evolved by infectious disease agents, toxic organisms, vectors, reservoir species and pests. Climate change, with its considerable regional variation, can therefore be expected to cause widespread shifts in the pattern of a number of infectious diseases.[7] For example, the increase of temperature and humidity commonly generate perfect breeding environment to some insects and the geographic distribution (both altitude and latitude) of vector organisms. Such situation would definitely increase the potential for transmission of many vector-borne diseases. Furthermore, environmental change would also alter the life-cycle dynamics of

---

5 Braden R. Allenby and Deanna J. Richards, eds., *The Greening of Industrial Ecosystems* (Washington D.C., 1994),
6 I.e. Rachel Carson, *Silent Spring* (Houghton Mifflin, 1962).
7 http://whqlibdoc.who.int/hq/1996/WHO_EHG_96.7_(chp4).pdf (3/16/2012 accessed).

vectors and infectious parasites, further influencing transmission potential.[8] Distribution of disease agents that are neither transmitted by vectors, nor otherwise dependent on animal hosts, will probably also be affected by environmental changes.

The passage of a pathogen from one individual to another is obviously dependent on a specific mode of transmission and a particular configuration of various external factors. Among these external factors, temperature and humidity are crucial to pathogen's and its vector's reproduction, survival and infectiousness. Environmental factors also affect the contagiousness of infectious disease by influencing human and social behaviors like the way they cook and use water.[9] Even small changes sometimes in environmental conditions that are well within human tolerance levels can have an indirect, adverse impact upon human health.[10] Cases of water-related diseases and toxics in human history would certainly support the claim above.

The World Health Organization (WHO) has suggested four direct effects of environmental variables on vector biology include the following:[11]

• *Temperature:* An increase in temperature accelerates vectors' metabolic processes, consequently affecting their nutritional requirements. Blood feeding vectors then need to feed more frequently. Their biting rate therefore increases which can, in turn, lead to increases in egg production. Temperature changes can also affect the distribution of many arthropod vectors since this is limited geographically by minimum and maximum temperatures (and humidities). Moreover, since most of the physiological functions of arthropod vectors are subject to optimal temperatures, any changes in minimum temperatures could greatly affect arthropod survival.

• *Humidity:* High relative humidity favors most metabolic processes in vector organisms. At high temperatures, a relatively high humidity prolongs the survival of most arthropods, although their susceptibility to fungal and bacterial infections may increase. Low humidity levels because some vectors to feed more frequently to compensate for dehydration. In areas of high temperature and low humidity, bugs produce two generations per year compared with one generation per year in areas of lower temperature or higher humidity.

• *Precipitation:* Precipitation is an important factor with respect to insects such as mosquitoes and blackflies. These insects have aquatic larvae and pupae stages, and it

---

8 Stephen M. Rappaport and Martyn T. Smith, "Environment and disease risks," *Science* 22 October 2010: 460-461.

9 Daszak, P., Cunningham, A.A. & Hyatt, A.D., "Emerging infectious diseases of wildlife – threats to biodiversity and human health," *Science* 287 (2000): 443–449.

10 Pedersen, A.B., Jones, K.E., Nunn, C.L. & Altizer, S.A., "Infectious disease and mammalian extinction risk," *Conserv. Biol.* 21(200&):1269–1279.

11 http://whqlibdoc.who.int/hq/1996/WHO_EHG_96.7_(chp4).pdf Box4.1 (3/16/2012 accessed).

is precipitation that determines the presence or absence of breeding sites. The impact of precipitation on breeding sites depends on local evaporation rates, soil percolation rates, slope of the terrain, and proximity of rivers and other large bodies of water. Many species breed in the residual water that remains after flooding in the rainy season. However, extremely heavy precipitation will wash vector larvae away, or kill them directly.

• *Wind:* Since winds contribute to the passive dispersal of flying insects, prevailing wind directions and wind speeds affect vector distribution. Some insect vectors, including various *Anopheles* species (malaria mosquitoes), Simuliidae (blackflies) and Phlebotominae (sandflies), can thus be dispersed hundreds of kilometers from their original area.

These four environmental factors had great impacts on the outbreak of epidemic plague in China, especially after the 17th century. And certainly, mice, bacteria, and even human beings all took part in the disaster.

Case study of Chinese plague since the 17th century

In human-made ecosystems, such as cities or areas of intensive agriculture, vector species have adopted and are able to spend much of their life cycle in artificial shelters with buffered microclimates, thereby protecting themselves from some climate extremes. Wild vector species could thus displaced by increased temperatures and changed precipitation patterns to new areas where breeding sites, microclimate, food and shelter favor their survival, which could result in further ecosystems disturbance.

Review of works on Chinese plague

On the background of Black Death in Europe, Chinese scholars Cao Shuji (曹樹基) and Li Yushang (李玉尚) claim that the 13th century Mongolian conquests on the Eurasian continent broke an ecological balance, transforming endemic plague in China into a deadly continent-wide epidemic. Its appearance in the 14th century in both places was devastating. Both Europe and China lost almost half their populations.[12] They divide the 400 years between the 18th and 20th centuries to several stages of plague transmission. Because of the difference in geographic condition, lifestyle, and socio-economic situation, plague in Yunnan kept endemic and slow, while the Muslim Rebellions in 1860s pushed endemic plague out to surrounding areas and finally caused a global crisis in the 19th century. In addition, pneumonic plague in 20th century Manchuria is another focus of scholarly attention.

---

[12]曹樹基、李玉尚，〈歷史時期中國的鼠疫自然疫源地—兼論傳統時代的“天人合一“觀〉，《中國經濟史上的天人關係》，(北京：中國農業出版社，2002)。

The trade of otter fur was a big business in Northern China and the construction of railroad system during the late-19th century made the business even much prosperous. The strong demand for otter pelts in Europe not only increased the hunting in Manchuria, but also promoted need for railroad construction. More hunting settlements and local centers of fur business appeared along the expending railroad system. Peng Weihao (彭偉皓) therefore believes that the strong demand for otter fur and convenient railroad system increased hunting activity in Manchuria. The fast spread of pneumonic plague with no doubt had some relation to these changes.[13]

The major difference between Carol Benedict and previous Chinese scholars was not the origins but the transmission routes and timing. In her B*ubonic Plague in Nineteenth-Century China*, Carol also thinks Yunnan is the origin and the Muslim Rebellions in 1856 played the key role to spread the disease to Kwang Dong regions.[14] She lists the Taiping Rebellion as an additional factor to the acceleration of pandemic plague and Beihaishi (北海市) became the hub for transportation and plague to cities along costal China. While Hong Kong discovered the first case of plague in 1894, the quarantine system in that island soon caused friction between Chinese community and British colonizers. Carol portrays the confrontation of colonized and colonizer in Hong Kong a friction between modern colonial medicine and traditional salvation by Chinese gentry.[15] Cao Shuji and Li Yushang analyzes the reports on *Shenpao*《申報》in Shanghai about the 1894 Hong Kong plague. The earlier report of the Hong Kong plague was merely one of curiosity. However, the press became more serious after the fear of transmission by maritime transportation began to grow. They also claimed that the quarantine regulation in Leased Territory effectively blocked the possible transmission to Shanghai.[16] Moreover, Gou Dongwei(郭東衛) tries to explain why the same epidemic did not spread to Macau. Looking at local newspapers he found that the first case in Macau was in 1895, rather than 1894. His discovery leaves the question of real origin in Macau unanswered. Both Beihaishi and Hong Kong could be the suspects. Like Cao and Li, Gou Dongwei gives credit to modern medicine in Macau to reduce the impacts. He points out the bacteriology of current western medicine was an effective weapon to release crisis.[17] In short, the transmission of plague in China had overlapped with the maritime network of transportation. As Yunan could be the pathological origin of

---

[13] 彭偉皓，〈清代宣統年間東三省鼠疫防治研究〉，(台中：東海大學歷史系碩士論文，2007），第二章第一節。

[14] Carol Benedict, *Bubonic Plague in Nineteenth-Century China*, (CA: Stanford University Press, 1996) pp. 131-149.

[15] Carol Benedict, *Bubonic Plague in Nineteenth-Century China*, pp. 11.

[16] 曹樹基、李玉尚，《鼠疫：戰爭與和平—中國的環境與社會變遷(1230-1960 年)》，第十三章。

[17] 郭東衛，〈1895 年鼠疫：澳門的公共性防疫—以《鏡海叢報》為主要分析背景〉，《文化雜誌》66 期(2008)，頁 146-158。

pandemic plague, Hong Kong in 1894 was actually the epicenter of global panic of epidemic plague.

Discussion:

Chinese plague: when it became epidemic?

Based on the knowledge of Black Death in Europe, Chinese scholars Cao Shuji(曹樹基) and Li Yushang (李玉尚) claim that the Mongolian expedition on Eurasian continent in the 13th century broke the eco-balance, brought endemic plague in China to a deadly global epidemic.[18] In general, the migration following Mongolian expedition laid the route to plague transmission. While the shadow of Black Death vanished in the 16th century Europe, China in Ming Dynasty still suffered the epidemic till the mid-17th century due to the long-term draught and social unrest. Migration re-appeared in China to search food and avoid massacre but also carried the vector of plague to every corners in China.[19] However, without modern laboratory test, scholars have different opinions to the "big plague" in China between the 13th and 17th century. Parts of their doubts are generated by non-typical symptoms of plague in this period. Also, the outbreak of plague before 17th century China clustered but no significant trails of their transmission, a very different sign to the plague epidemic in the 19th century.[20] The one in 19th century has much reliable evidence to the germ Yersinia Pestis, because of the lack and slow development of bacteriology (see the following discussion of cases in Hong Kong and Taiwan).

Carol Benedict's work challenges the position that China suffered epidemic plague before the 17th century. She believes that the bubonic plague remained an endemic disease only in Yunnan Province, a remote southwestern region till the early 19th century. The major factor brought endemic plague out of Yunnan was the exploitation in mountainous areas and increasing trade to outside, starting in the 18th century.[21] Deforestation could increase the risk of plague outbreak. Commonly in the wild, birds, snakes, and cats eat rodents; and may reduce the risk of certain rodent-transmitted diseases, such as the bacteria of human bubonic plague. Hence, the clearing of forested land and opening of hill farming in Southwest China in the

---

[18]曹樹基、李玉尚，〈歷史時期中國的鼠疫自然疫源地—兼論傳統時代的"天人合一"觀〉，《中國經濟史上的天人關係》(北京：中國農業出版社，2002).

[19]曹樹基、李玉尚，《鼠疫：戰爭與和平—中國的環境與社會變遷(1230-1960 年)》，(濟南：山東画報出版社，2006)，第十三章.

[20]郭東衛，〈1895 年鼠疫：澳門的公共性防疫—以《鏡海叢報》為主要分析背景〉，《文化雜誌》，66 期(2008)，頁 146-158.

[21] Carol Benedict, *Bubonic Plague in Nineteenth-Century China* (CA: Stanford University Press, 1996).

mid-1760s,[22] favored the survival rate of mice and their interaction with human being in newly founded agricultural settlements. This resulted in the appearance of a new wave of plague, which soon mutated to a transcontinental epidemic in the 19th century.

Furthermore, the Muslim Rebellions in 1856 forced large populations to escape,[23] spreading the endemic plague to epidemic crisis. Rodents, whether as intermediate infected hosts or as hosts for arthropod vector such as fleas and ticks, are reservoirs for a number of diseases, including bubonic and pneumonic plagues. Their populations are known to fluctuate in respond to local and global climate change. In a warmer environment such as coastal China, rodent population could be anticipated to increase in temperate zones, resulting in greater interaction between humans and rodents, and a higher risk of disease transmission, particularly in urban areas.[24] Indeed, various rat fleas could also survival in different temperature zones by their hosts. Usually, in cool areas, the rat flea does not bite humans, but in warm regions like monsoon China, the Oriental rat flea *(Xenopsylla cheopis*) and the cat flea (*Ctenocephalus felis*) readily bite both rats and humans. This can result in transmission of rat-borne disease organisms, although not necessarily through the biting mouthparts of the flea.[25] Specifically, *Yersinia pestis* (plague) is transmitted through flea faeces. Therefore, the population of rats and fleas on them was very essential to determine the risk of plague outbreak. And the microclimates in cities and human settlements greatly increase their population.

Epidemical environment in monsoon/costal China

The human assisted migration and subsequent successful colonization of new habitats in inland China after the 18th century and the rapid spread to the coastal regions as well as the rest of global in the 19th century to early 20th century, is proof that at least some rodent species can establish themselves in distant new environments within decades.[26] One of the environmental features in monsoon China is regular rainy season. During the season, extreme flooding or hurricanes sometimes lead to outbreaks of bubonic plague. From a case-control study, a 15-fold risk for disease was

---

[22] Nicholas Menzies, "Three hundred years of Taungya: A sustainable system of forestry in south China," *Human Ecology* 16, 4(1988): 361-376.
[23] Michael Dillon, *China's Muslim Hui Community: Migration, Settlement and Sects* (London: Biddles, 1999), pp. 20-25.
[24] Anthony J. McMichael et al., *Climate Change And Human Health: Risks And Responses* **(**World Health Organization, 2003), pp. 109 and 242.
[25] Robert Lee Metcalf and Clele Lee Metcalf, *Destructive and useful insects: Their habits and control* (McGraw-Hill, 1993), pp.21-23.
[26]李貴昌，馬永康，李鏡輝，李天元,〈1999 年到 2004 年雲南省家鼠型鼠疫鼠間疫點發現方式調查〉**,**《中國媒介生物學及控制雜誌》16.6 (2005): 453.

associated with walking through flooded waters.[27] Plague is in fact an environment-sensitive disease that is carried by fleas, and it is associated with populations of rodents, the primary reservoir hosts of the *Yersinia pestis* bacterium. In coastal China in the mid-1930s, plague bacterial levels in rodents have been found to increase in the wake of wet climate conditions following typhoon/hurricane season between June and September–driven wet weather conditions.[28] Historically, according to tree-ring proxy climate data, during the major plague epidemics of 1891–1907, climate conditions became warmer and wetter.[29] The virus spread from the continent to Hong Kong in 1894, then to Taiwan in 1897, and then to the whole of East Asia during the beginning of 20th century. It is interested to note that plague epidemic invaded Japan around 1900. However, the mortality rate in Japan was not as high as in warmer costal China.[30] The situation probably indicates that the rat flea bite humans less in temperate zone such as Japan.

Beside these climatic reasons, routes of migration and trade played much important role in spreading plague in China since the 18th century. The transmission patterns of plague epidemic in China varied due to geographic situations, life-style, and socio-economic conditions. In Yunnan Province, endemic plague moved relatively slowly, because of its remote and isolated geography. The infection usually happened between village and surrounding settlements. The sharp drop in human population of certain settlement could stop or slow down the transmission.[31] Such transmission patterns changed after the Muslim Rebellions in 1856. The rebels flee to other provinces while more Han people strategically moved in and built much strong trading link to coastal China.[32] The disease soon spread throughout China in the 19th century and reached pandemic proportions due to merchants were frequently moving from the country villages to highly populated towns.[33] The formation of major cities and increased travel, the disease rapidly spread throughout Southeast Asia. The bubonic plague followed the trade routes. The trade routes provided access to all corners in coastal China. China suffered horrendously with the population dropping

---

27 Zhao Ping, Zhou Zijiang, "An East Asian subtropical summer monsoon index and its relationship to summer rainfall in China," *Acta Meteorologica Sinica* 23.1(2009):18-28.

28中國醫學科學院流行病微生物學研究所編，《中國鼠疫流行史》(北京：中國醫學科學院流行病微生物學研究所, 1981), p.295.

29 Yu Liu, Hua Tian, Huiming Song, Jianming Liang, "

30藤野恒三郎，《日本細菌學史》，頁 244.

31 Shi Liyun et al., "Comparison of Nutrition Requirement Between Rat Plague Strains and Wild Rodent Plague Strains in Yunnan," *Endemic Diseases Bulletin* 19.2 (2004); Guo Mu, Zhang Hong-ying, Hong Mei, Song Zhi-zhong, Gong Zheng-da, Long Ying-huan, Dong Xing-qi, "Discussion on transmission mechanism of wild rodent plague to human in the northwestern area of Yunnan province," *Chinese Journal of Epidemiology* no.12 (2010).

32 Michael Dillon, *China's Muslim Hui Community: Migration, Settlement and Sects*, p. 28.

33曹樹基、李玉尚，〈歷史時期中國的鼠疫自然疫源地—兼論傳統時代的"天人合一"觀〉，Map 2.

from 125 million to 90 million during just the second half of 19th century.[34]

GIS analysis

Public health researchers such as Hans Rosling have been at the forefront of using data visualization tools to convey complex data to audiences, even those new to the field.[35] Scholars have used digital sources and tools in their research, teaching, or publishing. Since these methods and tools are in their infancy compared to traditional scholarly methodologies, many researchers actively work to share their digital data, methods, and toolsets with others to encourage their spread and the understanding of their impact. However, some datasets so large and complex have never been feasible for use in research. New tools and methodologies are therefore becoming available for making sense of such data and answering research questions. Among all the new development, the GIS technology is the one more acceptable to this topic.

By using the GIS technology to analyze the historical records of Chinese plague since the late 17th century, the result reveals two routes of plague transmission (North and South) in China before the 19th century, while the cases in South recorded earlier. A dataset of 72,000 and more information is generated from local chronicles and personal records such as diaries as well as memoirs between 1770s and 1919. To reduce the mis-diagnosis of plague cases before the 20th century, epidemiological maps in the 1990s are applied to track down the possible location of infection. The cases that do not match the acceptable distribution in 1990s maps, are deleted from the dataset. Eight maps are produced with an interval of ten years. Further analysis is done to spatial pattern. Calculating the statistical relationship among locations, altitude, and distance to nearby water systems, the result indicates river transportation was the key transmitting the diseases. The equation is defined as following:

$$\log\left(\frac{\pi}{1-\pi}\right) = X'\beta + \log(OR)$$

where

π= P(cases)

---

[34]中國醫學科學院流行病微生物學研究所編，《中國鼠疫流行史》(北京：中國醫學科學院流行病微生物學研究所, 1981), p.1604.

[35] See Rosling's website and tool, "GapMinder," http://www.gapminder.org/ (2012/4/16 accessed).

X：a matrix of confounding variables

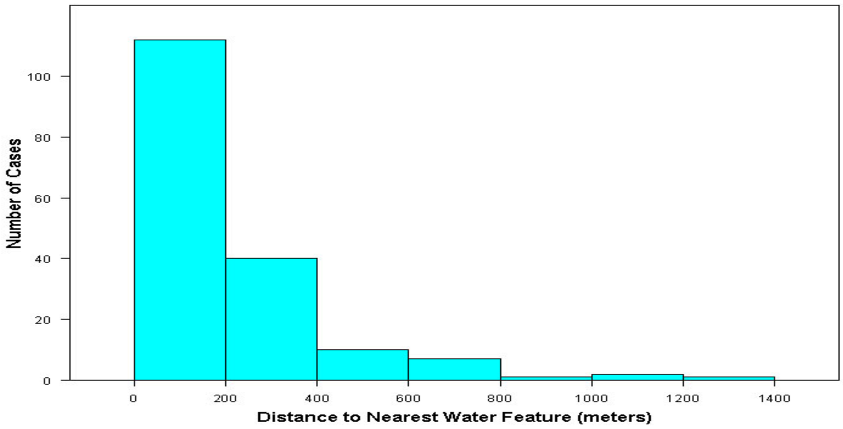
β：a vector of corresponding coefficients

OR：the odds ratio

Result: Before the 19th century, the risk of plague outbreak to the change of altitude is *OR* = 0.7251, higher than to the distance to nearby water system (*OR* = 0.001). It means exploitation in mountainous areas might still have impact to the outbreak. After the 19th century, the impact of altitude dropped to *OR* = 0.451, while to water system increased to *OR* = 0.8022.

Accordingly, Chinese plague before the 19th century would break out due to highland exploitation, but mutated to an epidemic form in the 19th century while the disease travelling by major transportation channels. Such observations supports Carol Benedict's conclusion and, may imply the railroad system in the 20th century Manchuria— the northeast China where the pneumonic plague occurred between 1910 and1912— could played a similar role like river transportation in the 19th century.

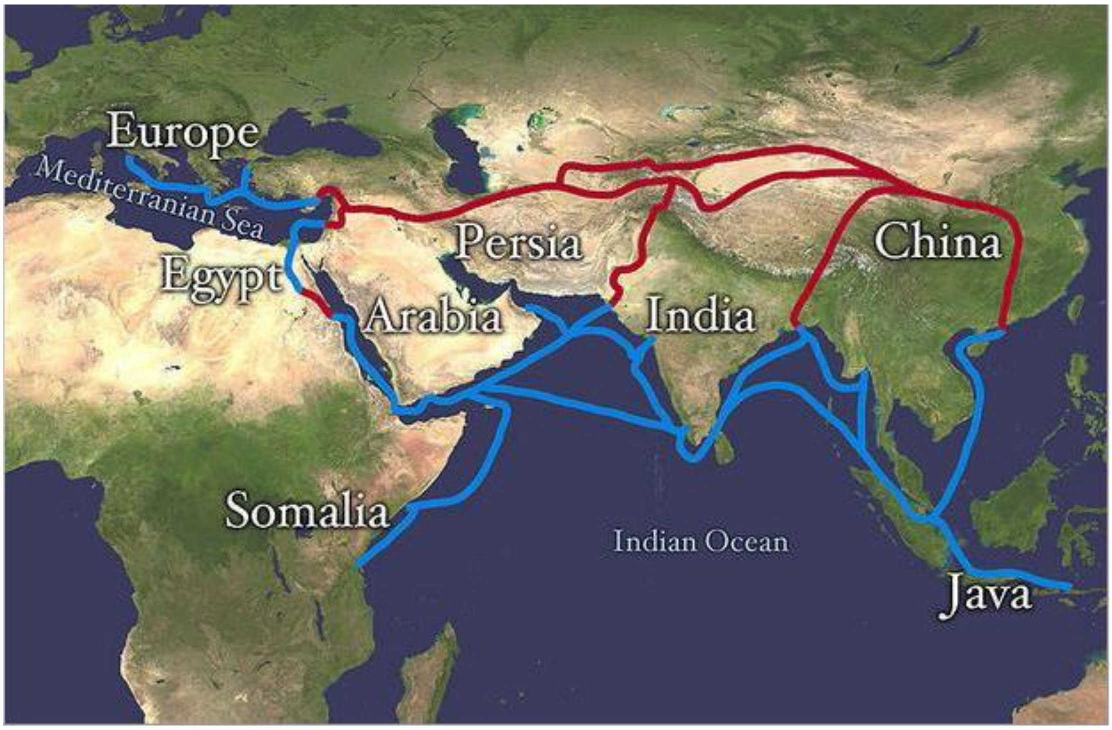
Figure 1: the relationship between plague cases and distance to nearest water feature



Could the close relationship between water system, a major transportation system and plague transmission in South China also support the cases in North China? Pneumonic plague in 20th-century Manchuria might also fit in previous hypothesis of human transportation. The trade of otter fur was a big business in Northern China and the construction of railroad system since the late-19th century made the business even much prosperous. The strong demand of otter fur in Europe not only increased the hunting in Manchuria, but also accelerated the railroad construction. More hunting settlements and local centers of fur business appeared along the expending railroad system. The fast spread of pneumonic plague with no doubt had some relation to these changes.

Paradox: The latest bio-discovery in Chinese plague

There is, however, a new challenge to Benedict's argument. In 2010, an international team of scientists has found the origins of the plague bacillus using DNA fingerprinting analysis. The plague pathogen originated in or near China, then it evolved and emerged multiple times to cause global pandemics. Researchers examined the past 10,000 years of global plague disease events. They traced the roots of the plague to somewhere in or around present-day China.[36] According to the report, the researcher claim that the plague spread over various historical trade routes in the 15th century. Chinese admiral and explorer Zheng He is likely to have carried it to East Central Africa during his travels between 1405 and 1433. The legendary Silk Road as we already know, also may have provided a pathway for disease as it did for trade between China and the Western world. However, based on local records and chronicles, no major epidemic of plague occurred in the period of Zhanhe's voyage. Also, his fleet had no way to contact Yunnan, a remote inland province away from the coastal line.

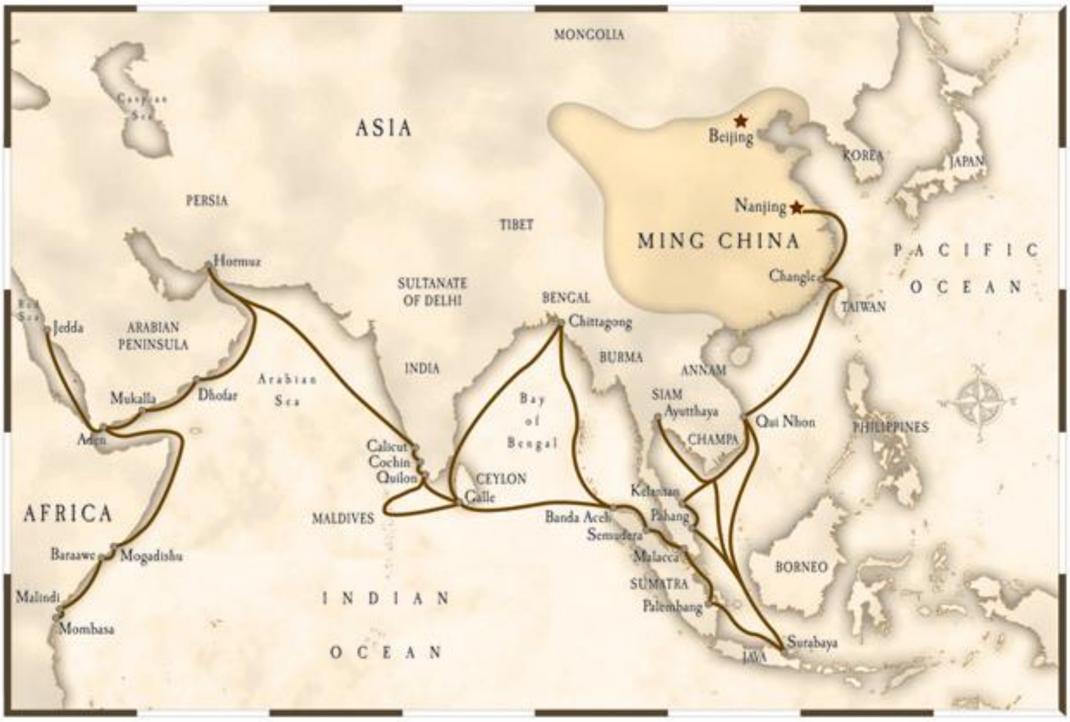


Map 1. Two routes of plague transmission from China

Note: The Silk Road extending from southern Europe through the mid-East till it reaches China. In this map, land routes are red, water routes are blue.

[36] "DNA Fingerprinting Traces Global Path of Plague," *Science Daily* (Nov. 5, 2010) *on web site:* http://www.sciencedaily.com/releases/2010/11/101105151012.htm (2010/6/12 accessed).

Source: http://digitaljournal.com/image/79087 (2012/4/16 accessed).



Map 2: Zhanhe's voyage in the 15th century

Source: http://www.mapillustrations.com.au/thematic_maps.html

Figure 2: A painting of the giraffe (it was called a qilin) which Zheng He's sailors brought back from east Africa.

Sources: http://www.hist.umn.edu/hist1012/primarysource/shendu.htm.

Some final thoughts:

Using the GIS technology, the researcher could combine two vital assistance-epidemiology and historical records for a research like plague in China. Epidemiology is the basic quantitative science of public health and helps historians to deal with vague definition of “plague” in old records and different languages. It describes and seeks to explain the distribution of disease within and between populations. To the study of environmental history, its essential tasks are to identify the factors that cause or influence disease occurrence, and to quantify that causal relationship. From data about the historical experiences of infectious disease such as plague, inferences can thus be drawn about causal relationships.

There are two main problems regarding the interface between epidemiological research methods and the study of eco-history to health impacts. Firstly, environment change health impacts refer to a very long period of time. Yet without the help of historian to translate and covert historical data to modern forms, epidemiology seldom addresses health risks extending beyond today's generations. Secondly, the causal processes associated with the health impacts of environmental change are highly complex. Most of these anticipated impacts will occur not via familiar directly-acting toxicological, metabolic and infective mechanisms, but result predominantly from the combination of natural biogeochemical systems and impact to whole populations. They must therefore be assessed within a broad framework with multi-disciplines such as historical demography and history of disease.

Note to my OSU-CHR readers: At a previous presentation of this work, I was asked for more information about the Hong Kong and Taiwan plagues of 1894 and 1897, and the definitive identification of plague. In the spirit of treating this paper as a working report, I include my account of the events that lead to Yersin's discovery and its confirmation.

International panics: Cases of 1894 Hong Kong and 1897 Taiwan

In 1892, a suspect fever case was found in Kwang Xi and two years later, the major city, Kwangchow in Kwang-Dong Province began to suffer endemic plague. Due to the geographic closeness and convenient travel, Chinese people fled to Hong Kong to avoid the threat of epidemic and probably search for better treatment.

1. 1894 Hong Kong plague

In April, James A Lowson MD., the Deputy-Chief of Government Civil Hospital in HK went to Kwangchow to survey the epidemic. Upon his return to Hong Kong in May 8, a suspect of plague case was reported to Government Civil Hospital while Tung Wah Hospital (in Hong Kong) already had 20 plague patients. More cases reported in following days, the Chinese settlement at Tai Ping Shan Street. Restrictive quarantine regulations were issued and isolation wards as well as a plague ship (the *Hygeia*) were established. The police force and military personnel were all involved in sanitizing streets, houses, and cremation of patients. The fear of infection and anger about these quarantine regulations made the situation much worse.[37] Fearing that the plague would be devastating, the Governor-General of British Hong Kong decided to ask for international assistance on May 10.[38] Japan, as a rising star in the field of modern bacteriology in Asia quickly responded to the call.

Led by Kitasato Shibasaburo and Aoyama Tanemichi, the Japanese team arrived at Hong Kong quickly, on June 12. Upon arrival, Dr. Losown gave a warm welcome to the Japanese team and immediately promised every support for the conduct of their investigation. On June 13 the day after their arrival, Japanese investigators rushed to the hospital, and on the 14th they received a flesh body for pathological dissection. Blood from the heart of body showed a positive reaction to bubonic plague on a laboratory guinea pig.[39] Despite Kitasato wanting to run more tests to confirm the

37 Lerrie L. MacPherson, "Invisible borders: Hong Kong, China and the imperatives of public health," in Milton J. Lewis and Kerrie L. MacPherson eds., P*ublic Health in Asia and Pacific: Historical and Comparative Perspectives*, (London and New York: Routledge, 2008), pp. 16-18.

38 To Dr. Lowson's activities during the period of plague, refer to Gerald H. Choa,"The Lowson Diary : A Record of the Early Phases of the Bubonic Plague in Hong Kong 1894," *Journal of the Hong Kong Branch of the Royal Asiatic Society* , 33 (1993) : 129 - 145.

39 Kitasato S., "The bacillus of bubonic plague," *Lancet* 2 (1984): 428-430.

result, Dr. Lowson was very confident and immediately telegrammed a famous medical journal *Lancet* in London on June 15.[40] *Lancet* posted Dr. Lowson's telegram and announced that "Kitasato succeeded in discovering the bacillus of the plague."[41] At this moment, Alexander Enile John Yersin had just landed in Hong Kong after a voyage from Vietnam on a shabby sampan.

Epidemic plague in Hong Kong reached the peak of mortality rate in May and June with cases more than 80 per day. Ironically, after Kitasato's discovery (Yersin's credit had not been established yet) and the revised regulations that he had initiated, the death rate declined between July and September. Between April and September in 1894, at least 2,500 cases of death recorded in official document, but the actual number was definitely higher. In official records, more than 98% of the deaths were Chinese patients, who had a death rate of 95% and higher, while non-Chinese suffered low mortality rate with less than 50 cases.[42]

Alexander Enile John Yersin's discovery

Compare to Kitasato's reputation in bacteriology in the late 19th century, Yersin was merely a nameless researcher from the French Pasteur Institute. Yersin worked at Pasture Institute between 1886 and 1888 and went to Indo-China next year. Due to his request, when endemic plague occurred, French colonial government and Pasteur Institute sent Yersin to Hong Kong for a strange reason: the "investigation to possible cases of Manchurian Pneumonic Plague epidemic."[43] Yersin did not receive any official welcome from Hong Kong government and was excluded from virtually every pathological autopsy. Most of the bodies were already reserved for the Japanese team.[44] Dr Loswon's had overlooked Yersin's works but had great confidence in Kitasato's international reputation.[45] Certainly, the keen competition between Britain and France on colonies also could explain the attitude of the Hong Kong government and Dr. Lowson toward Yersin.

On June 6, the day after the *Lancet* published Kitasao's big discovery, Yersin finally met his major competitor at an autopsy occasion. Although the meeting was embarrassed and conservation was limited in German, Yersin almost immediately found the fatal mistake in Kitasato's autopsy—the Japanese only extracted blood

---

[40] James A Lowson, *Lowson JA, Diary 1894,* Plague archive vol V., Hong Kong Museum of Medical Sciences.

[41] "Editorial: The plague at Hong Kong" *Lancet* 1(1894): 1581-82.

[42] Numbers and timing of the context, refer to E. G. Pryor, "The great plague of Hong Kong," *Journal of the Royal Asiatic Society Hong Kong Branch*, Vol. 15 (1975); 62-70.

[43] Thomas Solomon, "Alexandre Yersin and the plague bacillus," *The Journal of Tropical Medicine and Hygiene* 98: 3(1995): 209–12.

[44]E. Lagrange, "Concerning the discovery of the plague bacillus," J*ournal of Tropical Medicine and Hygiene* 29(1926): 199-303.

[45] Compare to his confidence on Kitasato, Dr. Lowson commonly called Yersin "the Franceman" instead of his name. Cases refer to James A Lowson, *Lowson JA, Diary 1894,* Plague archive vol V., Hong Kong Museum of Medical Sciences.

sample from patient's organ, avoiding the enlarged lymph nodes—an important clinical symptom of bubonic plague.[46]However, Yersin still could not have a body for examination in the following five days. His works was seemed to a dead-end. June 20, the most influential press in Hong Kong, *China Mail* posted a special interview with Kitasato and Aoyama, credited all the glory to Japanese team.[47] Yersin was so desperate that he decided to bribe the mortuary guard to provide him with a body. Based on his clinical experience, Yersin finally dissected lymph nodes, recovering enough sample of plague pathogen for microscopic examination. Under the lens, Yersin concluded that his sample obviously differed from Kitasato's.[48]

Based on this examination, French Consular in Hong Kong had better grounds to demand the assistance of the Hong Kong government for Yersin's investigation. Even Dr. Lowson admitted in his personal diary that "the Frenchman got his bacillus."[49] Despite Yersin had better results in Hong Kong, his discovery did not hurt Kitasato's reputation until 1900. In fact, Kitasato's Achilles' heel was Aoyama, his first officer but a long-term opponent in the beri-beri debate in the early development of Japanese bacteriology.

Although Aoyama did not enjoy international reputation like Kitasato, he had great influence to medical elites in Japan, especially among the alumni and faculty of Tokyo Imperial University. One reason for his powerful influence among Japanese medical elites could be his close connection with the royal family. Aoyama was selected to be Royal Physician of Meiji Emperor and had the privilege of treating the royal family.[50] Contemporaries once portrayed Aoyama's relation to Tokyo Imperial University as "Aoyama is (Tokyo) Imperial University just like Imperial University is Aoyama."[51] In the debate over beri-beri pathology, Aoyama never doubted Ogata's theory and thus totally could not tolerate Kiatasato's criticism of his mentor in 1892.[52] However, in the field of bacteriological science the key was building an international reputation, and in an international situation, patriotism would temporarily retard internal friction. That could be the main reason why Aoyama keep silent during his work with Kitasato in Hong Kong.

Plague investigation by the Japanese team was under an international spotlight.

---

[46] E. Lagrange, "Concerning the discovery of the plague bacillus," J*ournal of Tropical Medicine and Hygiene* 29(1926): 226.

[47] "Discovery of the plague bacillus," *China Mail* 20 June 1894.

[48] Alexander Yersin, "Le peste bubonique a Hong Kong,"*Annal of Institut Pasteur* 8 (1894): 662-67.

[49] James A Lowson, *Lowson JA, Diary 1894,* Plague archive vol V., Hong Kong Museum of Medical Sciences.

[50] For Aoyama Tanemichi's career, refer to 熊谷謙二，《思い出の青山胤通先生》，(東京：青山先生生誕壹百年祭準備委員会，1959)。

[51]福田真人，〈北里柴三郎試論・問題の所在と初期の教育〉，《言語文化論集》27:2(2006)，頁 14。

[52]青山胤通，〈脚気に就いて〉，《東京医学会雑誌》12 卷(1898)，頁 416-423、445-450、517-527。

Any slight mistake could be devastating to Kitasato's reputation. In addition, Aoyama Tanemechi was infected by the plague and almost died during the investigation, giving him a heroic image in Japanese society.[53] It seemed that Aoyama also discovered a weak spot in Kitasato's examination. Right after their return in July 1894, Aoyama first mentioned his concern about the difference between Kitasato's pathogen and Yersin's bacteria in a speech to medical scientists.[54] In 1895 Aoyama carefully published his concern to *Mitteilung an der Medizin Fach der Kaiser Japan Universität*《東京大學紀要》, focusing one the different results in the Gram test. The article's focus on Kitasato's "First report of Hong Kong plague"[55] indicated that Kitasato's pathogen including two types: bacillus and streptococcus. Moreover, Aoyama added one important bio-chemical phenomenon: Yersin's bacillus revealed Gram-negative, but Kitasato's might have Gram-positive result sometimes.[56] The article had already implied the possibility that Kitasato might have conducted his examination from contaminated samples. Soon, epidemic plague invaded Taiwan in 1896 from Hong Kong and left a great opportunity for Japanese bacteriologists to raise further criticism of Kitasato's work in Hong Kong.

2. 1897 Taiwan plague

Plague in Taiwan was an endemic problem and epidemic threat for the colonial Japanese. In 1896, first case of plague patient was reported by a military surgeon in Anpien, Tainan. The sample was extracted from patients' lymph nodes and send back to Tokyo for laboratory examination. The result was – not surprisingly -- Yersin's bacillus. As soon as the bacteria from Taiwan was identified, a new wave of epidemic plague was transmitted to North Taiwan— a dense Japanese settlement. Fear was rising.[57] The colonial government planned to describe the plague in Southern Taiwan -- Tainan -- as a endemic disease carrying by migrants from coastal China.[58] They gave the plague in North Taiwan the nickname the "Hong Kong disease," indicated the Japanese saw it linked to 1894 Hong Kong plague.[59] Despite of prevailing fear, the image of the "success" of in Japanese experts in controlling the

---

[53] 〈青山石神両氏の病状〉，《中外医事新報》344 (1894)，頁 883-884。

[54] 〈ペスト病の臨床的症候及解剖的変化 医学博士青山胤通氏の演説〉,《中外医事新報》351 (1894)，頁 133-134。

[55] 北里柴三郎，〈ペスト病ノ原因調査第一報告 〉，《東京医学会雑誌》8 (1894)，頁 698-707。

[56] Aoyama Tanemichi, "Ueber die Pestepidemie in Hong-Kong in Jahre, 1894–1895," *Mitteilung an der Medizin Fach der Kaiser Japan Universität*《東京大學紀要》, Tokio, Vol. iii (1895):115–238.

[57]許錫慶，〈日據時期在台防疫工作序幕戰—明治二十九年（1896）之鼠役流行始末〉，《台灣文獻》50 卷 2 期(1999)，頁 253-254。

[58]呂明純，〈明治後期日本與臺灣之鼠疫與防治（1894-1911）〉，《臺灣教育史研究會通訊》44 期(2006)，頁 7。

[59]陳盈華，〈臺灣社會與疾病史中的 SARS 經驗〉，（臺北醫學大學醫學人文研究所碩士論文，2007 年），頁 50-51。

Hong Kong plague brought the hope to colonizers in Taiwan.[60] However, although the colonial government in Taiwan executed severe quarantine regulations through the joint operation of the police force and the public physician team, the result was not as expected.[61] The epidemic continued to 1897 and expended quickly. To block the Chinese migrants and cargos from bringing in the plague, similar quarantine and isolation systems were set by Hong Kong experience. However, the effort did not show the strength as it was in Hong Kong.[62]To the colonial government in Taiwan, Taiwanese plague was obviously much rogue. They would definitely ask assistance from Japan.

With the governmental invitation, a team led by bacteriologist Ogata Masanori and pathological anatomist Yamagiwa Katsusaburo of Tokyo Imperial University conducted an investigation to Taiwan plague till January 3, 1898.[63] The quarantine advice that Ogata gave, mainly focused on interruption of transmission routes, because he conformed the flea was the major host of plague in Taiwan. Finally, various policies issued to encourage hunting rats and clean ditches, streets, and households. More strict regulations were launched to burn out suspected villages and to establish quarantines. Unfortunately, the result was not as obvious as Hong Kong in 1894.[64] In fact, plague in Taiwan only vanished in 1917, followed the ebb of the third weave of pandemic plague.

The major figures of the Taiwan investigation team, Ogata Masanori and Yamagiwa Katsusaburo, had not been members of Hong Kong team. Despite the fact that historians of medicine commonly overlook the Taiwan Plague, what these doctors discovered in Taiwan indeed revealed important features of laboratory bacteriology in Meiji Japan and immediately harmed Kitasato's glory of finding plague pathogens.

The most recognized contribution of Ogata's investigation in Taiwan was the scientific identification of the rat and the flea as intermediate hosts.[65] Furthermore, in his official report " The Report of Pest Disease Study〈ペスト病研究復命書〉"in 1897, Ogata reconfirmed plague bacillus in Taiwan, just like Yersin's, was Gram-negative. Beside of human patients Ogata even dissected mice, taking samples

---

[60]呂明純，〈明治後期日本與臺灣之鼠疫與防治（1894-1911）〉，頁 3-5。

[61]For policy details, see：范燕秋，〈鼠疫與臺灣之公共衛生（1896-1917）〉，《國立中央圖書館臺灣分館館刊》1 卷 3 期(1995)，頁 59-84。董惠文，〈行政監控與醫療規訓：談日治初期傳染病的防治〉，（南華大學社會學研究所碩士論文，2004），頁 84-90。

[62] 許錫慶，〈日據時期在台防疫工作序幕戰—明治二十九年（1896）之鼠役流行始末〉，頁 264-267。

[63]范燕秋，〈鼠疫與臺灣之公共衛生（1896~1917）〉，《國立中央圖書館臺灣分館館刊》，1 卷 3 期(1995)，頁 63。

[64]范燕秋，〈日據前期台灣之公共衛生─以防疫為中心之研究（1895─1920）〉，國立台灣師範大學歷史研究所碩士論文，(臺北：國立台灣師範大學歷史研究所，1994)，頁 102。

[65] 〈緒方博士ペスト病調查報告〉，《明治二十九年台灣ペスト流行記事》，(台北：台灣總督府民政部衛生課，1897)，頁 109-124。

from liver, spleen, and kidney. All had found the same bacillus with Gram-negative reaction. He successfully built the pathological connection among dead mice, infected fleas, and human patients.[66] From today's viewpoint, Ogata's report still has some problems. He discouraged sampling from lymph node because he thought that the plague bacillus would mutate there. Ogata thus insisted on the rule of current pathological anatomy to take organs.[67] Probably because they were all blood samples, Ogata suspected mosquito might be a possible host of plague in the same report. His worry revealed a common concern about malaria and mosquitos among experts of tropical medicine in colonial Taiwan.

Besides his written report, Ogata also brought some plague bacillus samples by solid gelatin cultivation back to Japan. These samples were put through comprehensive studies and it was concluded that the plague bacillus, that is, Yersin's bacillus, was the sole pathogen causing epidemic Taiwan plague in 1897. Kitasato's pathogens had at least three types and only bacillus could vaguely compare to the plague bacillus Ogata found in Taiwan. At the stage, the rumor that Yersin's bacillus was the accurate pathogen of plague prevailed among scholars of Japanese bacteriology.[68] Soon after Ogata and colleagues confirmed the discovery he rewrote the official report to a formal article in German and submitted to famous journal *Zentralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten*.[69] Internal debates on plague pathogen in Japan became a focus to international scholarship of bacteriology. Epidemic plague moved to Kansai region in Japan in 1899. With the fear and practical need, Kolle's and Ogata's researches were again under studied. All reports indicated that Yersin *was* correct.[70]The final verdict to the long time debate on Yersin bacillus vs. Kitasato's pathogens was moving to an end.

The debate by professional scientists was commonly seen a necessary process of truth in science. However, the reason for scientific debate could vary and the focus of debate could change in different non-scientific context. Despite epidemic plague existed in China for at least three hundred years and became serious in the 19th century, the epidemic was seen as a dark side of fate by Chinese society. However, the invasion to Hong Kong in 1894 finally made international society nervous. In addition, Hong Kong, a shining British colony and hub attracting international focus during the late 19th century, finding authentic pathogen of 1894 epidemic was an important

---

[66]緒方規雄，〈緒方正規博士が蚤のペスト病毒傳播を發見した経緯〉，《衛生動物》1 巻 2 期 (1950)，頁 41-44。

[67] 緒方正規，《ペスト病研究復命書》(東京：拓殖務大臣官房文書課，1897)，頁 6-8。

[68] 春日忠善，〈北里柴三郎先生のペスト菌発見とその後の経緯〉，《日本医事新報》2558 號 (1983)，頁 65-66。

[69] Ogata M. "Uber die Pestepidemie in Formosa," *Zentralblatt für Bakteriologie, Parasitenkunde und Infektionskrankheiten* 21(1897): 769-777.

[70]藤野恒三郎，《日本細菌學史》，頁 244。

arena to bacteriologists from various colonial powers. To Japan including Kitasato, it was also a chance to show the muscle in modern medicine, winning respect from White imperialism.