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Tempore Pestis: Epidemics and Countermeasures in Europe. A Comparative Perspective

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Abstract

The outbreak of an infectious disease such as the plague represented a serious problem for 17th-century society. Entire communities were threatened with extinction, entire assets were transmigrated from one family to another or to the Church, even political power passed from hand to hand: the end result was the subversion of the established order, with consequent change of authority. The interest in studying the phenomenon of the plague involves all the consequences on the societies affected by the epidemics: the demographic trend, social behaviours, the phenomenon of plague-spreaders, and the health provisions for the protection of public safety until today. The core tasks of public health surveillance and response include infectious disease outbreak detection and early warning, trend prediction, and public health response modeling and assessment.

Keywords: epidemics; public health; artificial intelligence; management

INTRODUCTION

Beginning in the mid-fourteenth century, the second pandemic of plague afflicted Europe with regular outbreaks until the eighteenth century. Populations learned to live side-by-side with the disease, whereas physicians and public officials tried to understand the nature and behaviour of the plague in order to save lives and guarantee health. The notion of contagion, which was already developed in ancient sources and whose fields of application are not limited to medicine, was tested in everyday experience. The extreme danger associated with a disease like plague impelled practitioners to create means to protect themselves, but this was also a stimulus for them to meditate on their relation with patients and on their own responsibilities. When contagion affects a society, many domains are impacted, including economics, politics, demography, productivity, fertility, and migrations, because of the direct or indirect threat to the interests of states and populations. In fact, ever since the first epidemics of plague, physicians and public officials have conferred and worked together in the interest of public health to ensure the security of populations and prevent mortality, as is illustrated by the works of Carlo Cipolla on the fight against an invisible and deadly enemy. Such collaboration proved potentially beneficial for the governance of society (Cipolla, 1981). Thus, many of the measures adopted during an outbreak of plague were maintained when the outbreak ceased. As the example of London shows, according to the study of Harold J. Cook, this could become a model for governments in introducing medical directives and schemes to preserve health and guarantee order (Cook, 1989). New studies have questioned consolidated knowledge about medieval and early modern plagues, including the agent responsible for the disease. Although many scholars still believe that it was Yersinia pestis in a strain very similar or identical to that identified in 1894, the debate continues (Demeure et al., 2019). The etiological agent of plague is the Gram-negative bacterium Yersinia pestis, discovered by the Institut Pasteur, bacteriologist Alexandre Yersin during a plague outbreak in Hong Kong in 1894.The agent of plague is, however, only one of the fields in which the understanding of the disease is changing (Parker at al., 2023). It is now known that not all medieval and early modern waves of plague shared the same characteristics. Territorial pervasiveness determined not only the demographic effects of plague, but also its political-institutional and economic consequences. The stricken population was unable to recover quickly, and the result of the epidemics was not simply a short-term perturbation, but long-lasting damage in terms of total product and fiscal capacity of the State. Outbreaks were linked to many sociological factors, such as journeys, trading, exchanges between maritime regions, wars, pilgrimages, and so on. Between the mid-sixteenth and the mid-seventeenth centuries, one can count a plague-wave about every ten years, with the persistence of the disease in many areas of Europe. In the medical literature produced during the spread of the first outbreak and the following epidemic waves, these causes were discussed and the discussions enriched by reflections on eclipses, comets, terrestrial and meteorological cataclysms, like earth quakes and storms, as well as by considerations of wars and famine. Moreover, these secondary causes were frequently interpreted as a consequence of God’s wrath, because of men’s sins, religious heresies, the cohabitation with non-Christian people (Muslims and Jews) and persons already sick, such as lepers. Jews were particularly targeted by the accusation of being responsible for the spread of the plague. They were suspected of working with lepers, Muslims, and the devil in order to poison wells, thus spreading the plague. Over time, things have changed. Superstition has been replaced by science. In order to improve the timeliness and accuracy of outbreak detection and early warning approaches, public health researchers continue to investigate and explore sensor data and indicators from the physical world covering health, environmental, societal, and economic aspects, among others. The aim of this paper is to investigate how European epidemics affected different countries, how societies have responded to these health challenges and what potential solutions exist today to prevent them.

The English Case

In the seventeenth century England plague became relatively rare except in large urban centres and, when it occurred, was often an accompaniment to a major epidemic in London. This would be the case for all of the worst epidemics of the century, in 1603, 1625 and 1636, as well as for the more localized outbreak of 1665-66, which ended with the famed Great Fire. London was seemingly the centre of all great English plagues. This is a striking epidemiological characteristic of the country, one which differentiates it from continental Europe where plagues showed much more varied paths of diffusion. English plagues focused on cities and market towns and spared the countryside. It is possible that the geographic isolation of Britain, and maybe also the climate, explain why it was relatively spared by seventeenth century plagues, both in terms of territorial pervasiveness of the epidemics and of mortality rates. All the more general outbreaks of plague of seventeenth century England coincide with epidemics in Germany and the Netherlands. The London plague of 1655 still came from Amsterdam, which in its turn had been infected in 1663 by a ship coming from Smyrna in Turkey. This was the worst outbreak of plague in England since the Black Death of 1348 (Bramanti et al. 2021). London lost roughly 15% of its population. While 68,596 deaths were recorded in the city, the true number was probably over 100,000. Other parts of the country also suffered. The earliest cases of disease occurred in the spring of 1665 in a parish outside the city walls called St Giles-in-the-Fields - one of the largest and most populated parishes of suburban London. The death rate began to rise during the hot summer months and peaked in September when 7,165 Londoners died in one week. Rats carried the fleas that caused the plague. They were attracted by city streets filled with rubbish and waste, especially in the poorest areas. Those who could, including most doctors, lawyers and merchants, fled the city. Charles II and his courtiers left in July for Hampton Court and then Oxford. Parliament was postponed and had to sit in October at Oxford, the increase of the plague being so dreadful. Court cases were also moved from Westminster to Oxford. The Lord Mayor and aldermen (town councillors) remained to enforce the King's orders to try and stop the spread of the disease. The poorest people remained in London with the rats and those people who had the plague. Watchmen locked and kept guard over infected houses. Parish officials provided food. Searchers looked for dead bodies and took them at night to plague pits for burial. All trade with London and other plague towns was stopped. The Council of Scotland declared that the border with England would be closed. There were to be no fairs or trade with other countries. This meant many people lost their jobs – from servants to shoemakers to those who worked on the River Thames. How did Londoners react to this plague that devastated their lives? During a period of about ten months over the summer of 1665, almost 20 percent of the population of London died from an epidemic of bubonic plague. Known as the Great Plague, this was the last of a long series of outbreaks – occurring in England previously in 1603, 1625, and 1636 – which killed about one fifth of London's overall population as part of the centuries-long "second plague pandemic." Among other major epidemics, the Great Plague of London stands out not only for its high body count and the rate at which it killed victims but also for the vast documentation produced at the time. This includes burial counts, especially the weekly "Bills of Mortality" (the weekly reports collected by parish officials and built up to create burial chronicles for all London parishes) as well as personal accounts and narratives. In the case of London, the primary carrier of the bubonic plague was its vast population of black rats. The rat population of seventeenth-century London, a growing capital of commerce and trade, proliferated around granaries, docks, slaughterhouses, factories, landfills, and overcrowded and decaying households, all er London. During the month of May 1665, the presence of the plague became substantial and started moving across London through the slow but extensive, and mostly unnoticeable, movement of black rats. The primary public records available to trace the movement of the disease are the "Bills of Mortality". Despite certainly offering an incomplete picture, the "Bills of Mortality" still constitute an important yardstick to investigate the spatial patterns and intensity of the disease, especially in relation to the social and urban geography of London. For instance, the very structure of the Bills followed the infrastructural layer ing already established by the London Wall. Burial counts were strictly divided between the ninety-seven parishes "within the wall," the sixteen "without the wall," and the rest of London and Westminster, reflecting both the jurisdictional and civic distinction imposed by the Roman barrier. According to the Bills, from late May onwards the epidemic quickly moved across London, reaching the southern side of the Thames by mid-June. Mortality grew throughout the summer, peaking in September with more than three thousand deaths in a fortnight across five outer parishes. On July 4, 1665, the Lord Mayor of the City issued the following order to the Aldermen of the wards: "That a carefull Watch and Ward be constantly kept at the Gates and Landing Places, to restrain and prevent the ingress of all Vagrants, Beggers, Loose and Dangerous people, from the out parts into this City and Liberties; and to bring to punishment such as shall be apprehended doing the same, according to Law.

The Italian Case

Plague was the main cause of demographic decline in seventeenth century Italy. In seventeenth century Italy, plague caused a demographic catastrophe that took many decades to heal. The long-lasting decline in population had purely demographic, and more specifically epidemic, reasons (Alfani, 2010). During the sixteenth and seventeenth centuries, significant proportions of urban populations experienced quarantine directly and observed the quarantine of others within their household, familial, parochial, and occupational units. We do know that the city hardest hit was Naples (Fusco, 2007). The learned Jesuit polymath Athanasius Kircher (1602-80) tells us that 300,000 Neapolitans died within a five-month period during the height of the 1656 outbreak in that city. The plague had beset the city for a much longer period, and Kircher's estimation, like that of other con temporaries, may mistakenly include those who fled the city of their own accord. More rational calculations suggest that the city's population in 1657-8 was two-fifths what it had been in 1654-5, with 240-270,000 persons out of 400 450,000 in Naples and its vicinity dying of plague and allied causes. Genoa, during the same outbreak, lost about 90,000 of its citizens, diminishing in population from 440,000 to 350,000. Venice's population in 1624, before the pandemic of1630, stood at 142,804, whereas at the time of the next accurate count in 1634, that is, post-plague, it had been reduced to 98,804. Having experienced brief outbreaks of the plague from 1524 through 1529, Rome escaped the great pandemic of 1630 unharmed. Furthermore, during the next outbreak, in 1656, thanks to the timely and stringent measures adopted by Pope Alexander VII, the Eternal City suffered a relatively low rate of mortality. One person in early modern Italy did effectively anticipate Pasteur's germ theory by three hundred years, Girolamo Fracastoro of Verona (1478-1553), the "founder of modern pathology." In his *De contagione et de contagiosis morbis et curatione* (Fracastoro, 1546), Fracastoro hypothesized that the contagion was actually disseminated by an invisible living agent, which he called virus. Fracastoro defines contagion as 'an infection that passes from one thing to another' ('contagio sit quaedam ab uno in aliud transiens infectio'). Three kinds of contagion are possible: by direct contact, by a fomes, and at a distance. In all of these cases, the vehicle of contagion are the seeds ('seminaria') emanating from the infected body to the second body, then from the second to the third, and so on. Fracastoro is quite close to the Galenic theory of contagion, since he makes use of a corpuscular theory of miasma (Galen, 1824). Moreover, the seeds cannot act and multiply if they do not find a suitable recipient body. Later, thanks to the seventeenth-century development of the microscope, what was for merly invisible became visible. The ingenious, if at times fanciful, scientist Kircher took up Fracastoro's intuition and with his new lenses discovered the strange, unimagined world of microscopic organisms (which he called corpuscula minima and seminaria), multiplying rapidly in organic liquid material taken from plague victims. What Kircher saw under his microscope – no one is quite sure to what specific organisms he is referring – was not the source of the contagion, that is, the bacterium Yersinia pestis, which would remain elusive to scientific eyes until 1894. Nonetheless, Kircher had identified the only proper, efficacious avenue for further research into the disease's etiology. Early modern society still clung to explanations formulated, centuries before, by the ancients: simply stated, the plague, along with numerous other diseases, was caused and spread by "corrupt air." The famous "miasma theory of disease," first expressed in the ancient Greek medical text, *On Airs, Waters, and Places*, by Hippocrates (ca. 460-377 B.C.), which posited excessive humidity as a cause of disease-bearing miasma. Important elaborations by Galen (ca. A.D. 130-200) and Avicenna (A.D. 980-1037) added the putrefaction of organic materials, and the escape of underground gases, respectively, as contributing factors. Thus, much attention in early modern Italy was devoted to ever-changing meteorological conditions in an attempt to predict and prepare for the arrival of plague. At the same time, early modern scientists taught – and the masses of people accepted the teaching – that astrological factors also played an important role in generating this scourge. Furthermore, once plague had arrived in a locality, it was widely believed – and seemingly confirmed by daily experience – that the mechanisms and vehicles of transmission available to the contagion were frighteningly numerous: not only by touch, but also by breath; indeed, by hearing, sight, imagination, and fear as well, not to mention by deliberate spreading on the part of evil men. As Neapolitan Jesuit poet Giacomo Lubrano (1619-1693) laments in one of his eloquent grief-filled compositions, even the medicines offered to cure the plague could be responsible for its dissemination since they themselves were so easily infected by the mere breath of the already stricken. Most everyone in early modern Italy, scientist and layperson alike, acknowledged that the ultimate, the "real" cause of the plague, its Aristotelian "causa finalis", was to be found not on the natural or physical plane, but rather on the spiritual: it was a response of God himself to the wickedness of humanity. Of course, not all the inhabitants of an infected city or town had the means to flee or a suitably isolated, secure place to which to flee. For those who remained, a stringent regime of quarantine had to be endured. City gates were closed to all but certifiably safe traffic; letters and documents arriving through the mail were fumigated; assemblages of people were prohibited; the air was cleansed by the burning of bonfires; streets, buildings, clothing, and any possibly contaminated surfaces were disinfected with vinegar or sulfur or otherwise destroyed by fire; beggars and prostitutes were rounded up; and dogs were massacred as suspected spreaders of the contagion. Homes in which persons had died of the plague (or were suspected to have died of it) were placed under immediate quarantine. In Florence, all women and children, even of those families free of plague, were forbidden to leave the confines of their homes unless they were wealthy enough to afford a sealed carriage for transport. These remedies were bitterly resented and resisted by the very people they were meant to protect. However, no "remedy" provoked more resistance than the forced confinement to the lazaretto, the public plague "hospital" where victims (or suspected victims) of the plague were sent either to recover or, more likely, to die from the contagion. The lazarettos – dirty, malodorous, overcrowded, crime-ridden, unrelievedly wretched – inspired sheer terror in the minds of early modern Italians. most people seem to have accepted the Church's consistent and adamant explanation regarding the ultimate cause and fundamental meaning of this disease: it was, simply, God's punishment of a sinful disobedient humanity. "Pestis est flagellum et sagitta Dei ob peccata hominibus immissa," the plague is a wrathful God's "scourge and arrow," Kircher declares at the beginning of what is otherwise a scientific investigation of the plague. The source of this explanation of the divine source and punitive-vindictive nature of the plague was, of course, the Bible, the foundational text of all Christian doctrine. As preachers and spiritual writers routinely point out, there is abundant proof in Sacred Scripture that, yes, indeed, God is moved to anger and vengeance by the sins of humankind, and that, furthermore, the plague is one of his preferred instruments of castigation and vengeance (Thiry d'Holbach, 2006).

Public Health and Measures

Although traditional studies tended to focus on the potential tension between public health regulations and religious devotions during plague-time, a balance was sought in communities across Europe to enable the continuation of processions, prayer and worship during epidemics. For those in quarantine, regular religious services were held in places intended to be as visible as possible. Attention was also paid to the unit of the 'sacred household' across the Italian peninsula. One of the administrators of the Genoese plague hospital, during a severe epidemic in the seventeenth century, reflected on the difficulties of keeping patients in designated spaces and dealing with boredom. He recommended trying to fill these patients' days with praiseworthy practices (*lodevoli esercitii*). Between the mid-16th and 17th centuries, greater emphasis was placed on prevention, improving the isolation protocols in case of contagion and daily surveillance. The everyday life of a medical practitioner consisted of such acts, performed in the context of a general mobilization of the entire community (Calcagno and Palermo, 2017). In fact, because of the recurrent outbreaks of plague during the second pandemic, officials and physicians became involved in the creation of public health boards, health officers, permanent institutions and magistracies. Dialogue between officials and physicians was essential in or der to establish the diagnosis of plague and activate public health measures. Medical error or under-estimation of the health situation could cause a delay in carrying out the necessary sanitary measures and thereby lead to a high rate of illness and death. The physician, as well as any person who is going to visit a person afflicted by the plague, is urged to avoid any direct or indirect contact, since the disease can reach a person through infected air, objects, and the sick body itself. Direct and indirect contacts must to be prevented by purifying the air with perfumed smoke, by keeping oneself distant from the excrements and the body of the sick person, and by turning away one's own face in order not to inhale his poisonous breath. The ordinary act of taking the pulse necessitates a specific manoeuvre, with the physician keeping his back turned to the patient. Moreover, the physician is protected by a kind of pharmacological marzipan, the ingredients of which are chosen from the remedies against poison of galenic medicine. Among the most important Italian measures we can count Health Passes. Health passes – Fede or Patente di Sanità in Italian – were created in the Italian peninsula, more precisely in Florence, Genoa, Milan and particularly in Venice. They consisted of pre-printed sheets which attested the traveller's health status and allowed controlling the movement of people, especially in times of epidemics. Subsequently, during the early modern age, the great centres of commerce such as Genoa, Venice and Livorno created a system to control goods and people that remained in force until the 19th century and was also extended to the other Mediterranean ports. Health passes remained a Mediterranean peculiarity, never extending to the Atlantic, where the British opposed such forms of health control. Each ship, before entering the port and unloading its goods, had to show its pass which certified the health status of the crew and attested the places that the vessel had visited along its route. The pass was gradually compiled and updated by the health magistrates of the places where the ship had stopped. It worked like a modern passport, stamped and checked at each border crossing. In case of a suspicious pass – if the ship came from a usual or suspected place of contagion – the crew had to spend a period of time (up to 40 days, hence the word quarantine) in the lazaret. In case of a "bad or foul" pass – when the ship came from a place of bull-blown contagion or in which there were cases of disease on board – the ship was rejected by the port and had to continue its journey, hoping to find shelter in the subsequent stages. The lazarets also housed travellers and sailors who, depending on their origin, could be subjected to forced stops of different lengths, before receiving permission to freely enter the city. Epidemics of any disease put the resources of the health systems of the affected countries under pressure due to the admission of a large number of patients to hospitals. The most recent COVID-19 pandemic shows that the health and non-health impacts of a pandemic could be devastating even with good public health surveillance systems. The rapidly evolving nature of known epidemic diseases, such as cholera, HIV infection, influenza, meningitis, malaria, and tuberculosis still remains a threat for the globe. It is sometimes difficult to effectively access public health measures even in cases of known epidemics. In the case of inadequately undertaken preventive measures such as triage and isolation, the hospitals could be a source of transmission for unknown and emerging pathogens (for instance, MERS) from infected patients. The term "infodemics" is a new health risk among the population in the era of epidemics, which includes the rapid spreading of unauthentic, misleading, and unreliable information through social media nationally and internationally. Infectious disease threats to individual and public health are numerous, varied and frequently unexpected. Artificial intelligence (AI) and related technologies, which are already supporting human decision making in economics, medicine and social science, have the potential to transform the scope and power of infectious disease epidemiology (Kraemer et al., 2025). How can AI enhance existing public health surveillance and response approaches and enable new ones? The answer lies with the fundamental challenges facing public health surveillance and response. Public health surveillance is intrinsically data driven. Identifying early, accurate, and reliable signals of health anomalies and disease outbreaks from a heterogeneous collection of data sources has always been the main objective of public health surveillance. Technically, this translates into two distinct challenges: the data sourcing challenge and the analytics challenge. The first data sourcing challenge is concerned with determining easily operationalizable sources of data that contain useful signals. The second analytics challenge is concerned with developing effective computational frameworks to extract such signals. AI provides a range of methods and techniques to help tackle both challenges. A variety of open data, external to traditional public health surveillance systems, can be fruitfully exploited to enhance the surveillance capabilities.

CONCLUSIONS

Through the examination of the announcements of the central and local authorities, the notarial deeds, the processes and the council deliberations, the ways in which the hygienic-sanitary and medical problem was addressed with all the related implications emerge: difficulties in relationships, isolation, restriction of the freedom of movement of people and goods (Green, 2020). Just think of the measures adopted, including the ten public health regulations, by the mayor and the Court of Aldermen, in order to combat the effects of the Great Plague of London. Defence against contagion, favoured by landings and trade in port and maritime cities, was among the primary aims of health discipline. The contribution aims to address an excursus among the documents related to Italian and English public health, from the improbable medical-alchemical recipes of the sixteenth century to the problem of disease containment and the solutions that governments put in place through regulations and instructions to hospitals and doctors in the area, highlighting the climate of uncertainty and anxiety that characterized the period in which the contagion raged among the population. Compared to those of the 14th-15th centuries, the emergency measures of the first half of the 17th century reveal the progress made by public health during that period: the variety and specialization of interventions had increased, the ability to administer certain institutions such as the lazarettos had increased, and the number of those that had become permanent had grown, the regulation of quarantines had been refined and made more elaborate, and measures to control the movement of goods and people in times of pandemic had been further developed. It is impossible to create a pandemic-free world. But meticulous preparation and rapid response can be helpful to prevent, detect, and respond effectively and rapidly to most episodes from gaining out of power at the very start of a disease outbreak that represents potential international threats As the current world remains vulnerable to epidemic events, the possibility of the next global pandemic could not be ignored. Although the advancement of medical science has been progressing rapidly in recent years, the natural immunity of humans to a newly mutated disease would not develop, and thus there are still concerns about global, sustained, and threatening public health emergencies in the future. Effective interventions are essential to curb the spread of infectious diseases. Assessing the effectiveness of such responses entails analysis of various “what-if” scenarios. Agent based simulations provide an AI-based framework to carry out these assessment-related tasks. Recent years have seen wide adoption of AI techniques in accomplishing these tasks in highly dynamic, complex, and data-rich environments. Given the growing interests and research activities in the interdisciplinary area of AI and public health surveillance, despite the impressive set of accomplishments already achieved, one can almost surely conclude that this area is still in its early stage of development with a lot of potentials yet to be fulfilled.

REFERENCES

Alfani, G. (2010). ‘Pestilenze e “crisi di sistema” in Italia tra XVI e XVII secolo. Perturbazioni di breve periodo o cause di declino economico?’, in S. Cavaciocchi, ed., *Le interazioni fra economia e ambiente biologico*, Firenze, Firenze University Press: 223-247.

Bramanti, B., Wu, Y., Yang, R., Cui, Y., Stenseth, N. C. (2021). Assessing the origins of the European plagues following the Black Death: A synthesis of genomic, historical, and ecological information. *Proc. Natl. Acad. Sci. U.S.A.* 118, e2101940118.

Calcagno, P., Palermo, D. (2017), eds*. La quotidiana emergenza. Molteplici impieghi delle istituzioni sanitarie nel Mediterraneo moderno*, Palermo, New Digital Press.

Cipolla, C.M. (1981). *Fighting the Plague in Seventeenth-Century Italy*, Madison, University of Wisconsin Press.

Cipolla, C.M. (1985). *Contro un nemico invisibile. Epidemie e strutture sanitarie nell’Italia del Rinascimento*. Bologna, Il Mulino.

Cohn S.K. Jr., (2009). *Cultures of Plague: Medical Thinking at the End of the Renaissance*, Oxford, Oxford University Press.

Cook, H.J. (1989). ‘Policing the Health of London: the College of Physicians and the Early Stuart Monarchy’, *Social History of Medicine*, Volume 2, Issue 1, April: 1–33.

Demeure, C.E., Dussurget, O., Mas Fiol, G. et al. (2019). Yersinia pestis and plague: an updated view on evolution, virulence determinants, immune subversion, vaccination, and diagnostics. *Genes Immun* 20: 357–370.

Fosi, I., ed. (2006). La peste a Roma (1656-1657), special number of *Roma Moderna e Contemporanea*, Roma, CROMA:1-3.

Fracastoro, G. (1546). *De sympathia et antipathia rerum liber unus. De contagione, contagiosis morbis et curatione libri* tres (Venetiis: apud heredes Lucaeantonii Iuntae Florentini).

Fusco, I. (2007). *Peste, demografia e fiscalità nel regno di Napoli del XVII secolo*, Franco Angeli, Milano.

Galen, (1824). *De differentiis febrium*, in Galenus, *Opera Omnia*, ed. by D. Carolus Go lob Kühn, vol. (Lipsiae: Prostat in officina libraria Car. Cnoblochii), I. 6.

Green, M.H., (2020). The Four Black Deaths. *American History Review.* 125: 1601–1631.

Kraemer, M.U.G., Tsui, J.LH., Chang, S.Y. et al. (2025). Artificial intelligence for modelling infectious disease epidemics. *Nature* 638: 623–635.

Moor, M. et al. (2023). Foundation models for generalist medical artificial intelligence. *Nature*. 616: 259–265.

C. E. Parker, A. N. Hiss, M. A. Spyrou, G. U. Neumann, P. Slavin, E. A. Nelson, S. Nagel, X. Dalidowski, S. Friederich, J. Krause, A. Herbig, W. Haak, K. I. Bos, 14th century Yersinia pestis genomes support emergence of pestis secunda within Europe. *PLOS Pathog.* 19, e1011404 (2023).

Thiry d’Holbach, P.H. (2006). *La contagion sacrée ou Histoire naturelle de la superstition*, ed. by Jean Pierre Jackson, Paris, Coda.

Wu YX, Yang YM, Nishiura H, Saitoh M. (2018). Deep learning for epidemiological predictions. *ACM/Sigir Proceedings 2018*: 1085-1088.

Zeng, D., Cao, Z., Neill, D.B. (2021). Artificial intelligence–enabled public health surveillance—from local detection to global epidemic monitoring and control, *Artificial Intelligence in Medic*ine: 437-453.