A BRIEF ANALYSIS OF MAJOR MEDICAL DEVELOPMENTS SINCE 1348 AND THEIR INFLUENCE ON THE MEDICAL FIELD'S REACTION TO PLAGUES

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Introduction (written by entire team)

Plagues and epidemics have proven to be a formidable enemy to humanity since the dawn of civilization, taking millions of human lives and making enormous changes to our society. Throughout history, humans have made many significant medical developments in order to combat plagues; therefore, by analyzing how humans in the past fought against epidemics, our generation can learn invaluable lessons about controlling and stopping the ravage of plagues. This study examines the major medical developments in Europe that have contributed to the fight against plagues and how they affected the European medical community's responses to infectious diseases since 1348.

Our research focuses on European medical practices and achievements in the medical field from the Black Death, the beginning of the Second plague pandemic, to COVID-19, and is divided into five parts with each part covering a specific period of time. At the time of the Black Death, physicians and surgeons concocted their remedies based on false ideas from antiquity about the human body. In the face of the Black Death, the European medical practitioners' failure in combating the plague, a territory that was entirely new to them, forced them to slowly change their

views of diseases. Following the fall of traditional medicine after the Black Death was the rise of practical medicine, which would significantly affect the medical field and the authorities' response to 1666 London Pandemic. From 1666 to 1794, the ideas of the Age of Enlightenment revolutionized medicine and other related science, shifting people's perspective on science, including medicine, which laid out a strong basis for future breakthroughs in the field. After 1794 were two main medical innovations: the introduction of vaccines and the germ theory of disease, both of which opened up to new possibilities when it came to dealing with and researching infectious diseases. From the ravage of the Spanish Flu onwards, the world witnessed three more important achievements in the field of medicine up to present time: the invention and development of blood tests, the discovery of antibiotics, and the production of various types of vaccines.

In general, much of the knowledge in the European medical field before the 19th century was based on ancient ideas about the human body, therefore, despite the fact that there was significant development of medicine contributing to success in curing many diseases, medical practitioners could not control or stop many epidemics because of limited understanding of the true nature of plague. However, major innovations in the medical field in Europe such as the germ theory of disease and vaccines changed the situation and doctors started to eventually gain control of plagues. Other aspects such as culture and religion, which all have a significant influence on the medical developments in Europe and are capable of shaping the communal reactions to major epidemics, need to be examined in order for us construct a detailed picture of the European medical field's relationship with plagues.

A base to build on: The medical field up to the Black Death (written by Dang Ngoc Khoi)

The Black Death of the fourteenth century is undoubtedly one of the worst catastrophes in human history, killing at least one-third of the contemporary European population. However, it is

undeniable that the Black Death played a crucial role in Europe's medical development in the late Middle Ages. To realize this role, one must understand the pre-Plague medical practices in Europe, in other words, how European physicians and surgeons, the two main groups of medical practitioners in the late Middle Ages, responded to medieval diseases, specifically that during the Black Death.

Most medical practitioners in Europe at that time were physicians trained by medical universities of the era. However, most of the knowledge they had was based on outdated ideas about the human body and diseases, which relied heavily on astrology and natural philosophy from ancient time. Therefore, though they were highly respected by the public, most of their medicine showed little effect when it came to curing real-life diseases. At the center of medieval medicine was the humoral theory, developed by Hippocrates, a physician from the 4th century BCE, and Gallen, who lived in the 2nd century BCE. Hippocrates suggested that humours were the body's essential fluids, including blood, yellow bile, phlegm, and "black bile", representing natural qualities such as warmth, cold, moist, and dry. These four humours needed to be balanced inside an individual so that they could be healthy; as a result, diseases were a result of an imbalance of the humours. Galen then developed the theory further, suggesting how to treat illnesses using the theory of opposites. His curing methods were still based on a logical application of the humoral theory (Vanneste 20).

> "If it is chilled, it should be warmed; if moistened, it should be dried; similarly if it has been immoderately heated, it should be chilled, and if dried out it should be moistened. These are the four simple methods of curing." (Galen, *On the Therapeutic Method,* II.4.17).

The four methods were matched in many ways to create composites (hot and dry versus cold and moist, etc.). According to Galen, diseases were caused by one of the eight possible

dispositions mentioned above and to cure diseases, the physician relied on diet, remedies, blood-letting and other medicines in eight possible methods to counter the dispositions and restore the balance inside the patient's (Vanneste 20). As these methods were used to treat individual cases, an infectious disease like the Black Death was entirely new for European medical practitioners. It sent them, especially physicians, into confusion and made extremely difficult to explain the causes and devise treatments to combat the diseases since they were not trained or prepared to face such a disaster on a large scale. Surgeons, unfortunately, only was only a little bit more successful in combating the disease.

In the time of the Black Death, surgery was not yet developed and was considered manual labor by many physicians. However, surgeons' medical preparation was based on experience rather than just reasons like physicians, allowing them to make more effective medicine through observing their patients' progress. In the time of the Black Death, surgeons mainly performed blood-letting, trepanation, amputations, cauterization, and up to as far as outstanding manipulation of bones, which saved many lives, especially injured soldiers. The most important figure of the formal education of surgery - Guy de Chauliac claimed that a proper surgeon should have specific knowledge of the human body along with food and diet of the patient, and their environment along with any ailments which may have affected the patients in order to reach an accurate diagnosis (Mc Vaugh 284). In this way, surgery began to become a professional form of medicine. In the face of the Black Death, however, surgery showed little effect. Surgeons without protection had to come into close contact with the patients, which became an easy target of the Plague itself. Examination of bodies could not help them understand more about the disease as, like physicians, they had limited to no understanding of the true nature of the plague.

Although most European medical practitioners realized that the Black Death was infectious, the best thing they could do was to use specific remedies to keep people calm and healthy, along with the advice to flee from infected places. (Vanneste 41). Consequently, medical practitioners in Europe slowly moved away from their reliance on authorities from antiquity and toward their own observation and experience. (Legan 36). Therefore, it can be considered that European medicine had entered a new era since the Black Death, gradually building up the foundation for science in the 19th century to receive a new modern shape.

From the Black Death to 1666 Great Plague of London (written by Hoang Khanh Nam)

The Black Death, one of the worst catastrophes in late medieval Europe, killed more than a third of its population. This five-year pandemic left great changes in every aspect of society, especially in the medical field.

As mentioned previously, physicians' failure in citing the cause of the Black Death marked the downfall of traditional and theoretical medicine. In the years following the Black Death, their slide quickly escalated. For example, the Report of Paris Medical Faculty in 1348 stated that "configuration of the heaven" had caused "a deadly corruption of the air around us", thus creating the disease. False interpretations such as above, along with the impotent of physicians in healing the illness (confessed in several comments said that fleeing was the best choice to avoid the "punishment of God") had led to a conclusion: "Learned medicine and its practitioners were falling all over Europe" (Vanneste 39). However, while the theoretical medical treatment became ineffective in handling the plague, remedies had appeared through the practical experience with the patient, as shown in the tractate of Gentile da Foligno – which focuses not only on the cause of the disease, but also on the way to treat it (Bleeding, covering in plaster to draw out the poison, and using some medicines to strengthen the patients) (Vanneste 45). Although in the end, he said

that fleeing from the infectious areas was the best "remedy", he still offered a way to cure the illness.

After the deadly epidemic was the rise of the practical medical method, represented by the surgeons, whose position was underestimated before the Black Death. They became more influential in the medical field, especially during the Hundred Years' War when the surgeon was necessary to heal the soldiers' battle wounds (Vanneste 48). Two of the most famous participants in this field in this time, Guy de Chauliac and John Arderne, were both surgeons. Practical tractates and surgical manuals were produced and became popular. The documents were also vernacularized (*Il trattat in volgare della peste* by Michele Savonarola) or written by non-medical practitioners (John Lydgate's poems) (Vanneste 49), reflect the fact that traditional university education – signed by Latin document – was decayed, and losing control over the medical document. Although the universities and authorities tried to keep this movement controlled, the practical medical continued to flourish, making its way into the Renaissance.

The Renaissance, which started around the mid-fifteenth century, was the period of innovation. New thoughts appeared in almost every subject, including medical. Giloramo Fracastoro, a Verona physicist, hypothesized that disease may come from pathogen outside the body, which he described in his book, *De Contagione et Contagiosis Morbis*, "I call fomites such things as clothes, linen, etc., which although not themselves corrupt, can nevertheless foster the essential seeds of the contagion and thus cause infection." (Fracastoro). Another man, Andreas Vesalius, a Flemish anatomist, examined corpses and wrote a book, *De Humani Corporis Fabrica*, detailing the structure of the human body. The knowledge of the human body was also illustrated in Michelangelo and Leonardo da Vinci's artworks, including Sistine's Chapel painting, David, and Vitruvian Man (The MNT Editorial Team). Despite the objections from the Catholic Church,

these men continued their work and contributed significantly to the development of the medical study.

All in all, while the surgeons made great strides in their field during this time, their efforts were ultimately insufficient. Physicists still struggled with finding a cure to infectious diseases, consistently citing outdated ideas to back their claims. This weakness was exposed during the 1666 Great Plague of London, a major plague that killed over 20% of the London population. Some physicists, again, blamed "corrupted air" as the cause of the disease, so cleansing was recommended; The other stated that cats and dogs are the main pathogens (School History) , which led to large scale massacre of these animals in London (National Archive), which, ironically, boost the rise of mice, the real pathogen.

However, the authorities, with better knowledge, and the formation of The Royal Society recently, had soon decided social distancing as the main method to stop the pandemic, including the halt of all public events and gatherings, and sign every quarantined house (Newitz). These methods came out to be effective: the pandemic ended in winter 1666, as Europe history advanced into a new chapter.

From 1666 to 1796: Between the Plague of London and the introduction of Vaccine in Europe

(written by Pham Ha Phuong)

The 17th and 18th century in Europe was a time of immense intellectual growth in philosophy and multiple areas of science. As the power and influence of the Catholic Church weakened, thinkers were given more space to express and execute their unique ideas, many of which laid the groundwork for major breakthroughs in the fields of biology and medicine that would come after this period.

In the 1670s, the famous Dutch businessman and scientist Antonie van Leeuwenhoek became the first to observe and experiment with microbes using microscopes of his own design. Though the use of optics to manipulate light and magnify a specific object of small size has been of interest to many scientists and inventors for thousands of years, it was van Leeuwenhoek who popularized the idea of utilizing this technology in studying living things. “Leeuwenhoek's 1677 paper, the famous ‘letter on the protozoa’, gives the first detailed description of protists and bacteria living in a range of environments. The colloquial, diaristic style conceals the workings of a startlingly original experimental mind.” (Lane) The works of van Leeuwenheok was a starting point for an area that would one day be heavily associated with epidemiology and disease control, microbiology. He has, thus, been referred to as the “Father of Microbiology”, having discovered both protists and bacteria. (Lane)

As European history approached a new phase, the Age of Enlightenment, the role of medicine in society was given a new look, resulting in a novel way of approaching the field. Risse’s (1992) essay found the following:

> Health came to be perceived as a positive and desirable tenet, preserved and even capable of recovery with the aid of a proper life style, public and personal hygiene and the aid of medicines. Such belief was an essential component of Enlightenment ideology, striving for human progress and perfectibility. Under the circumstances, the role of medicine was recast to provide explanations and restorative guidelines. To this effect leading contemporary physicians eagerly arranged new classifications of diseases and searched for basic principles to formulate new medical theories. Although system-building proved short-lived, the implementation of public hygiene measures, hospital and dispensary foundations, smallpox inoculation, and popular health education through books and

pamphlets all fostered the “medicalization “ of society, establishing the foundations for modern biomedicine. (149)

The turning point for the medicine for the age of plague had yet to come, but it would never have happened, if it had not been for the change in perspective and the basis to build on that the Age of Enlightenment had to offer. One specific way in which this era in Europe influenced how people in the future approach biology and medicine was its emphasis on empiricism. During this time, scientists conducted research and collected massive datasets to prove their theories. In the case of the Hunter brothers, John and William Hunter, both of whom were known for anatomical works, gathered an enormous amount of samples to conduct research and base their findings on. (G. and L. Friedlaender) Though the idea of having to validate one’s points using concrete evidence was not new to any science field in general before the 17th century, it was not until the Enlightenment did it become the socially acknowledged way to study science.

As we noted above, despite the fact that the medical field had changed, it did reach the point where these changes can completely alter how those studying and practicing medicine as well as biology react to plagues. Considering the case of the great plague in Marseille or Russia, both of which were catastrophic outbreaks that killed off the rich as well as the poor, the aristocrats as well as the peasants, we can see that beside quarantine and treating pre-existing conditions, if possible, the medicine of the time still had no choice but to wait for the outbreak to end on its own. It was not until the introduction of vaccines, which will be discussed with more detail in the next section, that medical professionals had a tool for saving lives effectively and gave them a clearer direction when it came to combating plagues and infection diseases.

From Smallpox to the Spanish Flu: Between 1794 and 1920 (written by Pham Ngoc Phuong Linh)

From smallpox to the Spanish flu, humans throughout history have constantly been hit with one infectious disease after another. It was not until the introduction of the first vaccine in 1796 did human's relationship with plagues begin to change drastically.

Vaccines started a great shift in medicine, completely altering how people dealt with infectious diseases. By definition, a vaccine is "an inactivated or attenuated pathogen or a component of a pathogen (nucleic acid, protein) that when administered to the host, stimulates a protective response of the cells in the immune system," or it is "an immune-biological substance designed to produce specific protection against a given disease." (Lahariya). Up until now, it has been considered one of the most crucial inventions in history, which quickly became the key to prevent a multitude of both infectious and non-infectious diseases (Le). It all started in 1796, when a British doctor, Edward Jenner experimented with the idea of vaccination for the first time in Europe. Jenner took pus from the hand of a milkmaid with cowpox, scratched it into the arm of an 8-year-old boy, James Phipps, and six weeks later inoculated the boy with smallpox. His experiment was a major success, making the child immune to the *variola virus*, the cause to both cowpox and smallpox. ("Vaccine").

Since vaccines were introduced, they have become both the most effective preventive method for most infectious diseases and the key to ending outbreaks. At the end of the eighteenth century, smallpox killed 400,000 people a year in Europe ("Smallpox"), and in the 20 century, it was estimated to be the cause of from 300 to 500 million deaths (Báo Vinmec). Until the 1950s, about 50 million patients who were infected with the *variola virus* ("History of Smallpox") had been recorded all over the world per year ("Smallpox"). In December 1979, however, smallpox became the first pestilence to be eradicated globally by excellent vaccination campaigns ("Smallpox"). Without the help of vaccines, the virulence of many diseases cannot be stopped, and

the consequences would be a lot more dangerous. Take Spanish flu as an example. Doctors and scientists of the time struggled with their lack of knowledge and mistook that not virus but bacteria caused the disease (Báo Vinmec). Therefore, there was no vaccine to fight against the flu. All efforts to prevent the spread of disease were limited to non-pharmaceutical solutions such as being in quarantine, having good personal hygiene, using disinfectants and avoiding gathering in public places. While smallpox was stopped by the vaccine, the Spanish flu infected 500 million people ("Spanish Flu"), was the cause of at least 50 million deaths all over the world (Báo Vinmec – Những đại dịch bệnh lớn trên thế giới) and had many other adverse effects on society.

As we mentioned, when the vaccine was invented, people only had imagined that there were "pathogens" that caused infectious diseases, without understanding precisely the biological nature of them until the introduction of *The germ theory of disease*. Some even believed that illnesses were punishments for the iniquities of humans. *The germ theory of disease* states that "certain diseases are caused by the invasion of the body by microorganisms, organisms too small to be seen except through a microscope." ("Germ theory"). Most people usually disregarded this opinion, "even many educated individuals, such as the prominent seventeenth-century English physician William Harvey, believed that epidemics were caused by *miasmas.*" (Kusinitz). In 1857, Microbiologist Louis Pasteur ascertained the "disease of wine and beer" and noticed the close affinities between the diseases of animals or humans and the diseases of beer and wine. He then moved on to prove the existence of microorganisms in the air that can contaminate a few kinds of aseptic solutions. However, it was not until in 1876 did Robert Koch, a German physician, demonstrate that those types of organisms could cause diseases. His findings "helped to destroy the notion of spontaneous generation, and laid the foundation for modern medical microbiology." (Kusinitz) Then, he and other German microbiologists discovered the agents that cause many other

diseases: anthrax, tuberculosis, cholera, pneumonia, etc. The discovery of the causes of diseases, in general, and infectious diseases such as dysentery or bubonic plague, in particular, was an important milestone in the historical development of medicine, changed the way we cured diseases, controlled and prevented them from killing thousands of people each year (Le). Since then, the germ theory of diseases has opened up more opportunities for doctors and scientists to devise new and more effective treatments for patients as well as carry out more extensive studies. Gradually, the spread of many infections in different communities has considerably decreased while the advances in the field of science and technology have brought microbiological research in general to a new level.

From the Spanish Flu to our present day (written by Tran Hoang Thy Uyen)

The 20th and the 21th century were the centuries of medical achievements, including the introduction of blood tests, the discovery of antibiotics, and the development of multiple vaccines. These achievements have profoundly affected the way humans reacted to diseases and plagues.

For decades now, blood tests have been an immense help to doctors when it comes to diagnosing diseases. The first blood test was introduced in the 1940s by Robin Coombs - a British immunologist, whose version is still widely used nowadays to identify different kinds of anemia and avoid negative responses to transfusions. In the years following this invention, many more blood tests were developed and classified into various types: complete blood count, microscopic examination of blood sample, antibiotic susceptibility test, antibody test, etc. All these tests aimed at identifying pathogens, checking for antibodies (‘large, Y-shaped proteins produced mainly by plasma cells that are used by the immune system to neutralize pathogens’ - Wikipedia) against diseases, or testing the sensitivity of pathogens to a drug. During the COVID-19 pandemic. There have been blood tests developed to detect coronavirus in approximately 20 minutes, allowing

doctors to tell whether someone is currently infected or they have been infected in the past. According to researchers, this method allows hundreds of blood samples to be tested every hour with a simple laboratory setup.

The history of antibiotics started in the 1920s, when the British scientist Alexander Fleming discovered a naturally growing substance, which he referred to as penicillin, and its ability to attack certain types of bacteria. As researchers in Europe started recreating Fleming's experiments to obtain penicillin and test it out on animals and humans in subsequent years, they found that a low level of penicillin could cure serious infections in 1941, and began producing it for commercial use in the mid to late 40s. During the 1940s and 1950s, streptomycin, chloramphenicol, and tetracycline were discovered, and were collectively named 'antibiotics'. After the early success of these substances, the race to produce antibiotics fast and in large quantities took place in the following decades. Penicillin was, at one point, considered a miracle drug and was used extensively to treat soldiers' wounds in World War II. As time went by, antibiotics continued to increase in popularity. Nowadays, doctors still use antibiotics to treat infectious diseases such as pneumonia, bronchitis, strep throat and other diseases caused by bacteria.

Another important medical development in our times is the introduction of a multitude of vaccines. Based on the first few vaccines released in the 18th and 19th century, various types of novel vaccines were produced every year during the 20th and 21th century. In the 1920s, there were vaccines for diphtheria, scarlet fever, tetanus, and pertussis. In the 1930s, vaccines for yellow fever, typhus, and influenza were produced. In subsequent decades, the world saw many more new vaccines for multiple childhood diseases such as measles, mumps, chicken pox, etc. as well as other serious diseases, for example Q fever, hepatitis A and B, malaria, etc. Many parents choose to vaccinate their children at an early age, sometimes as early as a few months after their birth, in

order to prevent them from catching severe illnesses such as polio, diphtheria, measles, etc. later in life. More than two hundred years after its debut, vaccination has become the most effective preventive and disease control method for both infectious and non-infectious diseases. In the case of major outbreaks, vaccination, more than any other measures, is now the key to fight and end these pandemics. Vaccines have truly become an indispensable part of medicine and even our lives in general.

In conclusion, from the Spanish flu to the COVID-19, humans have developed means to protect themselves from diseases, to diagnose illnesses and to treat infectious diseases. This period has seen the development of several important productions such as medical tests, types of vaccines and antibiotics, which truly help humans identify and cure serious illnesses with unrecorded speed, accuracy and success.

Conclusion (written by entire team)

The paper has given an overview of the medical developments in Europe and the changes in the way people face diseases from the Black Death to our present day COVID-19 situation. Providing a comprehensive view of the breakthroughs in medicine, this paper also highlights their importance in improving human life and protecting people from the devastating consequences of these diseases.

At the beginning of the fourteenth century, humans still diagnosed diseases based on theories developed in ancient times. Despite several advances in healthcare and surgery, most medical practitioners only had a vague understanding of the true nature of plagues. The Black Death, as devastating as it was, also opened the door to an era that was associated with medical innovations and the significant changes in humans' perceptions of diseases. A certain number of scientists had begun to direct their studies in a progressive way, gaining a better understanding of

the nature of diseases and learning to minimize their negative effects on society. With the fall of traditional medicine, represented by university-trained physicians with outdated ideas of the human body, came the rise of surgeons and their practices which were largely based on the practitioners' experience with patients. This important beginning paved the way for the many breakthroughs that would lay out the foundation for modern medicine. Since then, history has witnessed a multitude of discoveries about the human body and its relations with illnesses, prompting people to make more effective moves in dealing with diseases. Nevertheless, the answer to the cause of the plagues and how to cure them did not come as soon as the Renaissance. From then until 1794, the development of the microscope, the transformation in people's perceptions, and the rising status of the scientific method were another turning point in the history of medicine, bringing us into a new era of massive developments in many respects. In the late 18th century onward, the introduction of vaccines and the Germ theory of disease played a key role in broadening our understanding of diseases and introducing more ways to combat plagues, followed by the invention of medical tests and test kits, the discovery of antibiotics and the development of many more types of vaccines in the 20th and 21st century.

Overall, we can see that the medical field has been growing exponentially, beginning to take up its speed around the late 18th century. There are undoubtedly an immense number of breakthroughs in the field that we cannot include in this short paper. We chose to focus on the ideas, theories and technical advances that had a direct link or a close connection with our societal reactions, especially that of medical professionals, to plagues, or infectious diseases in general. We also decided to place our interest mostly in Europe due to the continent's relationship with modern medicine and the precursor of it.

Upon closing, there are many questions yet to be answered. Our next step is to focus on

other aspects that may affect medical developments throughout time, which could contribute to the response of major diseases from Black Death (1348) to COVID-19 (2020). Some features that we might consider are religions, cultures, and economic states in different areas at different times, which may impact medical developments in both positive and negative ways. The second direction is to study the medical developments in some other parts of the world (Asia, Africa, Oceania, America, etc.) and examine some of their deadly pandemics that did not spread to Europe, or at least, did not devastate Europe like they did in other places (Smallpox Pandemic in the New World, The Third Wave, etc.). More extensive comparative works may give us the answer to these questions, and extend our knowledge on diseases' impact on development of society and medicine.

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