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History of PPE: Special Reference to Beaked Masks During the Black Death and Its Aftermath

Sejarah PPE: Rujukan Khas terhadap "Beaked Masks" Semasa Wabak Hitam dan Selepasnya

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ABSTRACT

The background of the research will focus on the cases of the Black Death pandemic in 14th century onwards with particular review on the usage of beaked masks by plague doctors. This peculiar mask can be described as Personal Protective Equipment (PPE) at that time to protect the physicians from being infected when treating patients with Black Death symptoms. This research will evaluate the use of PPE from the medical, history, chemistry, technology and sociology perspectives to reach a detailed understanding of the benefits of wearing this peculiar mask in responding to the challenges presented by the epidemic. Hence, the ingredients and elements of the beaked masks need to be scrutinized in order to underscore the physicians' efforts in inventing such equipment in protecting frontline workers like the plague doctors. Analyzing the evolution of PPE and medical protection will help the public to understand medical history and the roles of community in dealing with cataclysmic epidemics in the past. The research found that beaked masks created as PPE by the physicians were able to support them psychologically in dealing with their patients. Unfortunately, the design and property inside beaked masks do not provide the expected protection unlike PPE in modern time which produced significant result in reducing the possibility of disease transmission.

Keywords: Epidemic; personal protective equipment (PPE); black death; plague doctors; beaked masks

ABSTRAK

Latar belakang kajian ini adalah tertumpu kepada kes-kes Wabak Hitam (Black Death) pada abad ke-14 dan yang selepasnya dengan meninjau penggunaan topeng berparuh burung (beaked masks) oleh para doktor wabak secara khusus. Topeng aneh ini dapat digambarkan sebagai Peralatan Pelindung Diri (PPE) pada waktu itu untuk melindungi para doktor daripada dijangkiti ketika sedang merawat pesakit yang bergejala Wabak Hitam. Penyelidikan ini akan menilai penggunaan PPE dari segi perspektif perubatan, sejarah, kimia, teknologi dan sosiologi untuk mencapai pemahaman yang terperinci mengenai manfaat memakai topeng pelik ini dalam menangani cabaran yang ditimbulkan oleh wabak ini. Maka, bahan dan elemen topeng berparuh burung ini perlu diteliti dalam memperlihatkan keberkesanan penciptaan topeng ini bagi melindungi para doktor wabak sebagai petugas barisan hadapan. Analisis evolusi PPE turut juga dibincangkan bagi membantu para masyarakat memahami sejarah perubatan dan menilai peranan para masyarakat dalam menangani wabak bencana pada masa lalu. Penyelidikan ini mendapati bahawa topeng berparuh burung yang diciptakan sebagai PPE oleh para doktor dapat menyokong mereka secara psikologi dalam menangani pesakit mereka. Sayangnya, reka bentuk dan harta benda di dalam topeng berparuh burung ini tidak memberikan perlindungan yang diharapkan iaitu tidak seperti PPE pada zaman moden yang menghasilkan kesan yang signifikan dalam mengurangkan penularan penyakit berjangkit.

Kata kunci: Epidemik; peralatan perlindungan diri (PPE); wabak hitam; doktor wabak; topeng berparuh burung

INTRODUCTION

To understand diseases like the plague, one first needs to understand the basic concept of the plague. The term "plague" comes from the Latin word *plaque,* which means wound, injury and misfortune. According to Mitchell (2017), "The texts written by people of past societies can offer vital information that improves our comprehension of disease in the past. Written sources and art can describe cultural contexts that not only help us interpret lesions in excavated human remains, but also provide evidence for past disease events themselves" (p. 88). Mitchell (2017) also shared his opinion on the importance of how historical evidence was written. For him, the study of society and the culture of the past

through written texts and oral traditions enhance the palaeopathological analysis of human remains. Thus, gathering all facts concerning the Black Death epidemic is essential in this study because many interesting things about the epidemic have yet to be uncovered, as stated by Lerner (2008). This study mainly focuses on the use of personal protective equipment (PPE) by plague doctors and physicians from late medieval era until 18th century of Western civilization. The objective of this study is to identify and understand the history of personal protective equipment with special reference to beaked masks during the bubonic plague and the aftermath. This research also evaluates the ingredients and elements of the beaked masks to underscore the physicians' efforts in inventing such equipment in protecting frontline workers. The third objective is to analyse the evolution of PPE and medical protection from the Black Death up to our modern era with intention to help the public to understand medical history and the roles of community in dealing with cataclysmic epidemics in the past.

RESEARCH METHODOLOGY

The study has collected scholarly articles about the history of the Black Death in Europe and Asia as well as the history of plague doctors from online sources such as Google Scholar, Elsevier's database, open-access PLOS ONE, Routledge Taylors & Francis Group, e-books and personal reading materials. Subsequently, the study analysed miasma theory before refining the beaked masks content used by plague doctors as well as the use of PPE across the ages. A holistic approach such as combining expertise made this review solid and meaningful. The elements of medical history were analysed by physicians, whereas historians analysed the historical viewpoint. In addition, the ingredients contained in the beaked mask will be examined for the effectiveness of the beaked mask used by plague doctors in treating patients with the symptoms of the outbreak.

In order to achieve the aim of this study which is to identify and understand the history of personal protective equipment and aftermath, scholarly articles about the history of the Black Death in Western and Asian civilization must be assessed – particularly in regards to the equipment worn by the plague doctors. To analyze this data, the history of the Black Death in general needs to be assessed. Evaluating the existing data such as the map is useful to illustrate the spreading of the Black Death pandemic throughout history. For example, the map from Britannica Online below shows the spread of the epidemic in every 1 or 2 years. Other than that, some useful data can be acquired through article journals from reputable journals that are available for online reading such as below. For instance, the graph below represents the Black Death cases in every 50 years. There are also other graphs available that can help to illustrate the events more clearly.

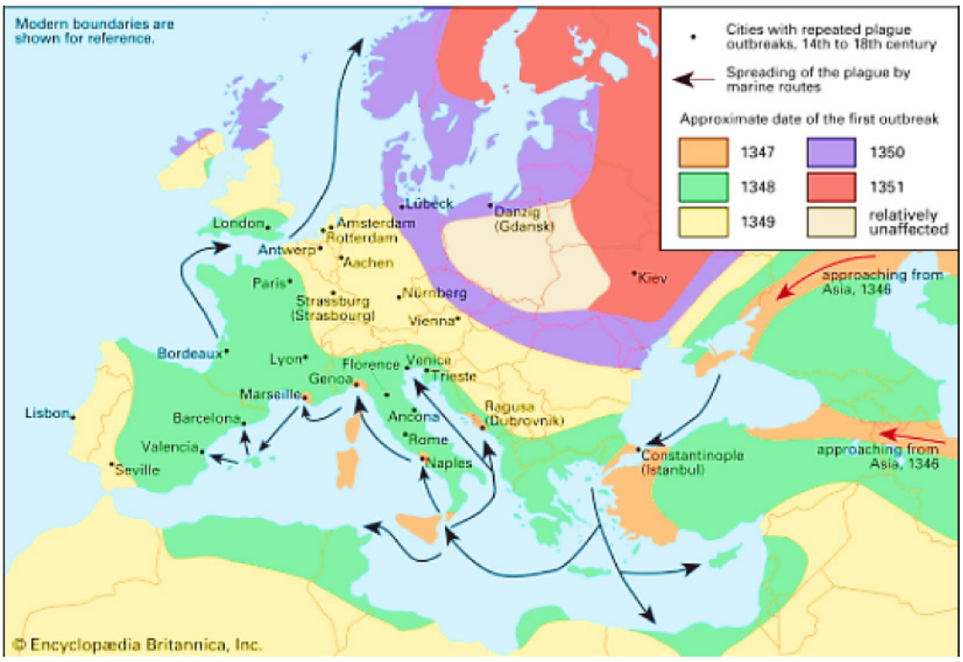

FIGURE 1. The spread of the plague by marine routes in 14th century
Source: Encyclopædia Britannica (2021)

For example, some useful data can be collected through article journal from reputable journal that available online reading such as below. For instance, graph below represent the Black Death cases in every 50 years and quite few graphs that can help to illustrate the event.

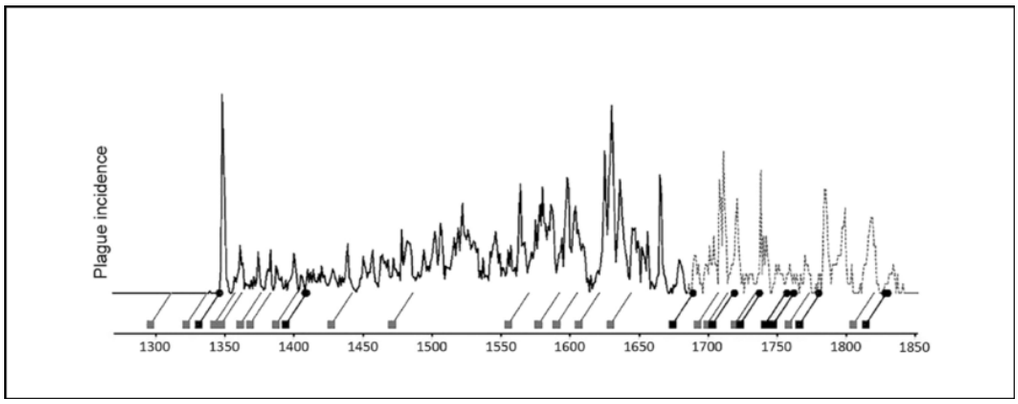

FIGURE 2. Plague incidents from 14th century to 19th century
Source: Roosen & Curtis (2018)

RESEARCH FINDING AND DISCUSSION

This study concludes that the beaked masks used by the plague doctors were ineffective in the sense that that do not protect the plague doctors from getting the disease. Furthermore, this study will also show the ingredients in the masks which originated from miasma theory showed insignificant results regarding suppressing the bacteria. However, we may relate with the creativity produced by the physicians who used the miasma theory of the local religious belief to invent the beaked mask.

FIGURE 3. PPE used by plague doctors and 21st century medical personnel
Source: Shamekh et al. (2020)

This study also reviews the origins and development of face masks and eye protection to counter respiratory infections on the basis of experiments conducted 100 years ago, initiated by the first use of personal protective equipment, PPE, by the plague doctors of the 17th Century.

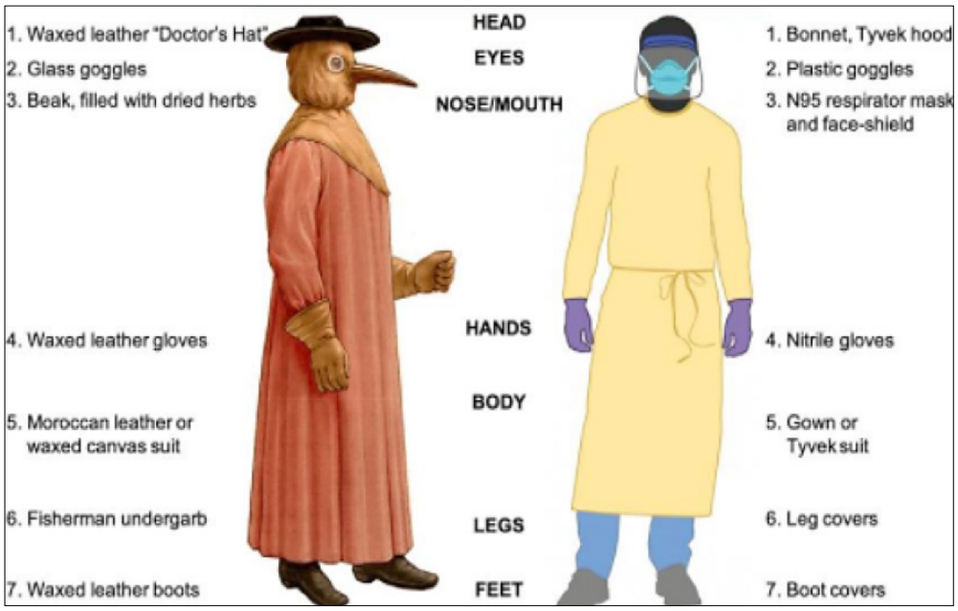

FIGURE 4. Comparison between the personal protective equipment, PPE, used by the 17th Century plague doctors and 21st Century medical personnel
Source: Oldfield & Malwal (2020)

A GLIMPSE OF THE BLACK DEATH EPIDEMIC

In world history, the Black Death can be considered as one of the deadliest epidemics that swept over the majority of Europe in the 14th century. DeWitte & Slavin (2013) claimed that "lasting only a few years, it killed an estimated 30% to 50% of affected populations. In England, the population fell from approximately 4.8 to 2.6 million between 1348 and 1351" (p. 37). Black death is a call for the outbreak of infectious diseases that causes patients to have bubonic symptoms throughout the skin as well as lung inflammation. According to Ditrich (2017), bubonic on the skin occurs because the bacteria that spreads into the bloodstream enters the regional lymph nodes. When an organ in the body is infected, it will cause a human infection through a droplet (water-borne). There was a situation where toxaemia (massive bacterial growth) could happen. The incubation period is typically two to six days for the bodily process of the bacteria. The infected person will endure symptoms such as fever, headache, nausea, and swollen lymph nodes until the person dies. Most infection cases were through human-to-human transmission like coughing and inhalation of contaminated sputum (primary pneumonic plague) (Ditrich 2017).

Due to the increased mortality rate during epidemics, many rumours spread and circulate. Society relates the outbreak of the disease to a natural phenomenon in the absence of empirical studies investigating the issue. Medieval Europe has a feudal system and no advanced scientific knowledge. In many ways, they were well-behind many other civilisations. The society spread the belief that the Black Death happened due to God's wrath for human sins. Religious institutions like the Church played a vital role in propagating such views about the plague. The priests took this opportunity to ask people to repent and return to religion. This idea was propagated in sermons and publications across Europe. Another example was the strange acts perpetrated by the Flagellant Brothers (DeWitte & Slavin 2014). They advocated symbolising guilt to neutralise adversities. Secondly, the community claimed that their wells were poisoned by the Jews.

The Jerrold (2009) ruled out that any plague could create psychological effects on the community. Human values will eventually change to respond to traumatic situations. In the case of the Black Death, there was social stigma and paranoia towards Jews leading Christians to became hostile towards the Jews. This allegation affected the well-being of the Jewish community, and social discrimination towards them flared. Next, some people believed the outbreak was related to a prophetical event heralding the second coming of Jesus Christ. Also, the community believed that the disease was caused by a planetary system like Saturn, Jupiter and Mars aligning. Due to the natural ambivalence, they believed that natural events could create such a

horrendous disease like dissonance among natural powers like the sun and the sea in the Indian Ocean. Lastly, the community perceived that the outbreak happened due to a war between China and Iran (Mitchell 2017).

There was an interesting theory that the Black Death originated in Asia. It was proposed that the cause of the disease was a biological attack by the Mongols over Europe. Hans Ditrich (2017) explains that in 1347, the disease was brought from the Asov Sea through maritime trade to the Mediterranean and later arrived in Europe. Ditrich assessed the account by chronicler Gabriele de Mussis (1280–1356) from Piacenza, Italy, who claimed that the outbreak originated from a biological weapon used by the Mongols. Based on De Mussis' observation, Mongolian traders stopped and released infected mice along the trade route. Gabriele de Mussis reported that the disease had spread to Genoa in 1347-1348 and later in Caffa. De Mussis added, during the war in the Mediterranean, especially between Muslims and Christians, Tartar Muslims catapulted decomposing infected corpses into Christian cities. The mountain of decomposing bodies not only damaged the scenery of the city, the overpowering stench of the rotten corpses also poisoned the wells (Ditrich 2017).

Besides the theory that the bacteria spread to Europe through from Central Asia, Lenz & Hybel (2016) claimed that the rise and advancement of grain trade through maritime routes expedited the process of transporting the bacteria from one place to another. They agreed that *Yersina pestis* was carried by fleas and rats as hosts and were disseminated using marine transports like ships and board vessels along the rivers and canals. The epidemic was facilitated by the transportation of infested fleas in commodities such as wheat (Christakos & Olea 2005). The historical accounts underscore the growing maritime trading across European as early as 11th CE whereby voyages from Ribe (Denmark now) to Flanders (Belgium now) might take only two days.

Following the spread of the disease, a healthcare system was established to manage patients with symptoms of the epidemic. For example, a hospital was established by Order of the Knights of Saint John in Rhodes Island. After the Black Death, another epidemic arose called the Plague of Rhodes of 1498, where the patients were treated in the same hospital. According to Vrioni et al. (2018), Rhodes Hospital was established in 1311. There was a poem written about how the epidemic spread and its medical history is recorded as early as 1500. The Order of Saint John not only delivered their service in national and military security but also helped in health management at Rhodes Island.

MIASMA THEORY

The Miasma Theory dates to ancient times where Hippocrates (c. 460 - 377 BCE), the Greek physician emphasized that bad air as the main cause of pestilence (Sterner, 2007). Ancient societies believed that the disease that befell them was sent by Gods to punish them for their sins and wrong-doings.

Due to this believe, the disease was associated with supernatural power and magical element involved as a part of mechanisms to cure it (Biomedicine and Health, 2020). However, Hippocrates disputed on the supernatural explanation of diseases and brought forward the idea that the cause of the illness is basically due to patient's environment. This idea was acknowledged all over the world by many and embedded in the writings of ancient civilizations (Sterner 2007).

Halliday (2001) elaborated further in his article that the disease process started by inhaling the polluted air which was exposed to corrupting matter. The corrupting matter could be due to exhalation from people already infected, sewage or decaying matter. Karamanou et al. (2012) shared the same view and highlighted that a person could become infected when the infected air (miasma) entered the body and disturbed its vital function. Ibn Khatimah, a Spanish-Arab physician written a tract in 1349 highlighting that the major cause of any disease is due to the filthy air inhaled by people. He added that the process of degeneration could be recognised by its foul vapour (Sterner 2007).

In the mid-19th century, the cholera epidemic outbreak in UK has been the cause of death of many people. Despite taking precautions and avoiding bad air according to the Miasma theory, the spread of disease could not be curbed. During that time, John Snow, a medical scientist, introduced the hypothesis explaining the spread of cholera had not been bad air, it could rather be disseminated through water, food or hand-to-mouth. Snow postulated that cholera was caused by germ cells not by bad air. Based on his research, this germ was transferred from one person to another by drinking contaminated water. Despite

strong basis, Snow's hypothesis was rejected in the 1850s since he was not part of the medical elite (Bingham 2004).

Coming down to the germ theory of disease, it mainly highlighted that the presence and actions of specific microorganisms in the body are the predominant caused of disease. In simpler manner, diseases are caused and spread by germs (Frerichs 2002). Based on this theory, miasma does not simply cause any disease, instead the infection from microorganisms are the culprit. These microorganisms can be transmitted from water, food and contact with each other or the air(droplets). The germ theory provided a profound understanding of how disease was caused and spread in society. This followed in people shifting away from the Miasma Theory to the Germ Theory and through the end of 19th century, Miasma Theory has been dominated by Germ Theory of disease (Maia 2013).

EVOLUTION OF PPE THROUGHOUT HISTORY

In the early modern Europe, the practise of covering the nose and mouth had been one of the vital traditional sanitary implementations to curb spread of the disease. This protection essentially aimed at neutralising so-called miasma in the air through a combination of perfumes and spices placed under a mask, such as the plague doctors' beak-like masks. However, the practices had become infrequent by the 18th century. The recent face masks, as used in our healthcare and community today, date to a more recent period when a new knowledge of contamination based on germ theory was practised in surgery (Strasser & Schlich 2020).

Many articles attributed the early usage of PPE with regards to the occurrence of the Black Death. The Black death was an ominous pandemic combining of bubonic, pneumonic and septicaemic plague strains that collapsed the Western civilisation from 1347 to 1351, sending 25% to 50% of the European population into oblivion while impacting significantly the socio-politics and economics of the country (Gottfried 1985). The plague doctor wore beaked mask to protect themselves from the infection. Details of the beaked mask will be discussed in later part.

PPE IN PRE-MODERN ERA

In 1867, Joseph Lister, a British surgeon, postulated that wound disease was mainly caused by the germs which is microscopically small living entities that Louis Pasteur recently described. Louis Pasteur was a renowned French microbiologist who further developed the germ theory. Lister suggested eradicating germs using antiseptic substances. However, in the 1880s, instead of just ensuring the wound is clean, a new generation of surgeons came up with more thorough strategy of asepsis which directly focusing to inhibit germs from entering wounds in the first place. This, on the other hand, was a risky strategy where the operator's hands, instruments, even their breaths, were suspect now. Johann Mikulicz, head of the surgery department of the University of Breslau (now Wroclaw, Poland) started working with the local bacteriologist Carl Flügge, who experimentally able to prove that the respiratory droplets carried culturable bacteria. Consequently, Mikulicz begin to use a face mask in 1897, which he depicted as "a piece of gauze tied by two strings to the cap, and sweeping across the face so as to cover the nose and mouth and beard". While in Paris, the surgeon Paul Berger began wearing a face mask in the operating theatre in the same year. The face mask became the fundamental primary barrier in the strategy of infection control that aiming on putting the germs away, as opposed to killing them with chemicals (Strasser & Schlich 2020).

Masks usage then became increasingly widespread across the globe. Adams et al. (2016) concluded from his study on the usage of mask by studying more than 1000 photos of surgeons in operating theatres in the US and European hospitals between the year 1863 and 1969 affirmed that by 1923 over two thirds of the surgeons used masks and by 1935 most of them are wearing masks. The significant Manchurian plague epidemic that broke out expeditiously in the Chinese Russian frontier town of Manzhouli and unfurling South along the railroads to Harbin and other Manchurian cities catastrophically causing a death rate of 100%. Rapid spread between humans via airborne, clinical manifestation in pneumonic form, it heaved the Chinese, Japanese and Russian Empires which controlled the different part of Manchuria into biopolitical and geopolitical devastation (Gamsa 2006; Lynteris 2016; Nathan 1967; Summers 2012).

Midst the calamity, the Chinese imperial court appointed Dr. Wu Lian De (Wu Lien-Teh), the Penang-born with Cambridge background education as the head of its anti-plague efforts. Dr. Wu brought forward the bold theory of contagion where he highlighted that the transmission of the disease was directly from human to human. Following this explanation of the epidemic was the development and enhancement of an anti-epidemic technology that Dr. Wu actively propagated as his own, personal invention: the "anti-plague mask". The mask is similar to the recently established surgical face-worn protective devices but improvised with more addition of protective layers and a more intricate tying process, intended to keep the mask in place while operating in the adverse open-air conditions of winter-time in Manchuria. The main focus for this protective device is for the medical personnel who is in contact with the disease, practising in diverse area such as the hospitals, the open-air cremation of plague corpses and the work of removing, guarding and examining the plague contacts. It was also intended to be worn by patients, contacts and to the extent that was possible, to the entire affected populations. This was the first attempt for epidemic containment, corresponded only by parallel efforts across the globe during the 1918 influenza pandemic (Luckingham 1984; Tomes 2010; Lynteris 2018).

PPE IN THE MODERN ERA

Masks underwent historical metamorphosis across centuries and continued to be developed in medicine. In 1930s disposable paper masks started to replace the medical masks and increasingly made of synthetic single use materials in 1960s. This replacement process was in line with extensive transformation in hospital care setting called a "total disposable system" which includes the surgical instruments, syringes, needles and trays. On the other hand, single-used items were able to preserved the state of sterility and cleanliness. However, another rationale opting for disposable masks was the need to cut labour costs, facilitates management of supplies and respond to the demand surge of disposables that aggressive marketing campaigns created among the healthcare workers (Strasser & Schlich 2020).

COVID-19, an infectious disease due to the newly uncovered coronavirus were unknown before the outbreak began in Wuhan, China, in December 2019. COVID-19 has been declared a pandemic as addressed by the World Health Organization (WHO) (Yusoff & Sarifin 2021). People can be infected from another person who contracted the virus. The disease transmitted from person to person through small droplets from the nose or mouth that expelled when an infected person sneezes, coughs or speaks. However, these air-droplets are relatively heavy, do not spread far and immediately descend to the ground. These droplets can land on contactable surfaces like tables, doorknobs and handrails. Anyone who came in contact with the contaminated surfaces, then touched their eyes, nose or mouth will contract the virus. Thus, it is vital to take self-precautions either washing our hands regularly with soap and water or clean with alcohol-based hand rub and most importantly to exercise social distancing, 1 metre away from others WHO.int (2020).

Above all, the most crucial approached in curbing the spread is through the practice of wearing face masks. While medical masks and respirators such as N95, FFP2 or equivalent are highly recommended for and should be reserved for healthcare workers when giving care to infected patients. Close contact with people with suspected or confirmed COVID-19 and their surrounding environment are the main routes of transmission, which means healthcare workers are the highly exposed WHO.int (2020). Thus, it is deemed mandatory for healthcare workers to adorn proper PPE when treating the patients. Infected person who cough, sneeze or talk will generate infectious droplets that can spread the infection. These droplets can reach the face of others nearby and land in the surrounding environment. However, if the infected person is wearing medical mask while coughing, sneezing or talking, this can stop the air-droplets from being transmitted to others thus curb the spread WHO.int (2020). In short, it is undebatable how important the face masks are and how efficient they have become across the centuries.

FUNCTION OF PPE

PPE is personal protective equipment used to minimize exposure and transmission of infections. Currently, PPE consists of gloves, gowns, aprons, masks, goggles, visors, caps, and theatre footwear. The use of PPE is adjusted to the possibility of disease transmission that can occur. PPE has a long history. In this article, we discuss the PPE that medical personnel used during the 13th Century Black Death pandemic. The PPE used today is often called the Plague Doctor clothing (MacNamara

2020). Before the publication of the concept of germs by Louis Pasteur in the 19th century, Smith et al. (2012) said that doctors and other medical staff adhered to the theory of miasma. The community at that time covered his face to prevent transmission of the disease.

Eastman (2009) and Haensch et al. (2010) reported that doctors used PPE in the form of beak-like masks to protect themselves from miasma during the Black Death pandemic. The mask has a protruding beak extending from the nose that can carry aromatic herbal ingredients believed to protect themselves from miasma (MacNamara 2020). The beaked mask is then replaced with the use of the surgical mask. This mask appeared because of the awareness that the surgical wound must be protected from droplets originating from the surgeon's airway. In 1919, the mask was already used globally but did not affect the current epidemic curve during the influenza pandemic. The cause was later discovered because the influenza-causing organism was nanoscopic in size and could pass through a barrier in the mask (Neilson, 2016). At present, PPE has become very important for medical staff, especially since the COVID-19 pandemic (Cook 2020). Like the surgical mask described earlier, Blair (2016) and Lynteris (2018) concluded that PPE is used to protect medical personnel and patients. The efficacy of each component of this PPE in reducing the risk of exposure to contamination and infection has been investigated (Hinkin et al. 2008).

DESCRIPTION OF BEAKED MASK

The plague doctor costume consisted of an ankle-length overcoat, a bird-like beak mask filled with sweet- or strong-smelling substances, gloves and boots. There are glass openings for the eyes. Straps held the beak in front of the doctor's nose, which had two small nose holes and was a type of respirator. Spices, herbs, dried flowers, vinegar sponge or camphor are held in that beaked mask. The mask's purpose was to remove bad smells. The herbs were believed to counter the "evil" smells of the plague and prevent the doctors from being infected. The costume included a wide-brimmed leather hat to indicate the doctor's profession.

FIGURE 5. A sketch of a plague doctor wearing a full "PPE"
Source: National Library of Medicine (1654)

Wooden canes are used to remove clothing from plague victims and examine patients without touching them (Mussap 2019). The nose [is] half a foot long, shaped like a beak, filled with perfume with only two holes, one on each side near the nostrils, but that can suffice to breathe and carry along with the air one breathes the impression of the [herbs] enclosed further along in the beak. Under the coat, we wear boots made in Moroccan leather (goat leather) from the front of the breeches in smooth skin that are attached to said boots, and a short-sleeved blouse in smooth skin, the bottom of which is tucked

into the breeches. The hat and gloves are also made of the same skin … with spectacles over the eyes (Michel Tibayrenc 1994: 680). The main objective of wearing the mask during deadliest epidemic was not the fashion but rather to protect the doctors from miasma (Maestas 2019). Before the germ theory of disease, physicians believed that the plague spread through poisoned air that could create an imbalance in a person's humor or bodily fluids. Sweet and pungent perfumes were thought to fumigate plague-stricken areas and protect the smeller; nosegays, incense, and other perfumes were common in the era (Knirel et al. 2011). Again, the plague doctors filled their masks with theriac, which a compound of more than fifty-five herbs with viper flesh powder, cinnamon, myrrh, and honey. De Lorme thought the mask's beak shape would give the air sufficient time to be suffused by the protective herbs before it hit plague doctors' nostrils and lungs (Mussap 2019).

WHY WEARING BEAKED MASKS?

Knirel et al. (2011) state that it is difficult to find a disease with many similarities with an outbreak that occurred in the past. The Black Death pandemic caused the death of up to 200 million lives (DeWitte 2014). Khan (2004) found that the amount is estimated to be almost a third of the European population. The outbreak is associated with the Angel of Death, doomsday, and the end of all flesh. Several studies conducted on the history of the Black Death are documented to find out the cause of the disease and how it is transmitted (Linkov et al. 2014). Stories range from mystical to scientific explanations of this plague. The scientific explanation that lasted for hundreds of years in the world is the theory of miasma. Maestas (2019) asserts that although germ theory is now widely accepted, some people still think that miasma, or "corrupted water", is an explanation for the widespread of the plague. In his study, Raoult et al. (2013) concluded that sporadic outbreaks could originate from animals with various distribution routes. Zoonotic outbreaks can transmit by contact with animals or their parasites. Most can go through flea bites and move through animal scratches or inhalation of infected particles from animals with respiratory infections or during autopsies of infected animals. After that, transmission takes place from human-to-human (Zietz & Dunkelberg 2004). It can be through direct contact, aerosols, or can be through parasites, such as lice. Aerosol transmission is generally low, but in Madagascar, it reached 8% with most infected individuals showing no symptoms (Raoult et al. 2013). The Black Death spread from human to human through the bite of infected fleas. The disease can also be transmitted by direct contact with tissues or fluids from infected animals and human corpses that have died from the plague. Besides, outbreaks spread through meat that is not cooked properly and through air or aerosols from the respiratory tract of animals or humans with pneumonia's clinical manifestations (Knirel et al. 2011). Duncan (2005) believes that a different disease causes the Black Death from bubonic plague, so the outbreak is called hemorrhagic plague. The mortality rate is 100%. The Black Death spread so quickly that it reached almost all of Europe in less than three years. Quarantine for 40 days during the epidemic was carried out and was very successful for 300 years. The outbreak is known to be very infectious and is called unsafe within a distance of under four meters from the sufferer. Fast and highly infectious human-to-human transmission caused doctors in the 15th and 16th centuries to wear plague doctor costumes. The personal protective equipment is used to reduce the risk of exposure and is added with aromatic herbs and flowers to avoid miasmas (Frith 2012).

INGREDIENTS IN BEAKED MASKS

Beaked Masks are mainly used to avoid contact with infections. Beaked masks consist of herbal medicines. Herbal medicines are believed to cure toxins. Herbal medicines have been used in the treatment of diseases. Currently, several plants have been researched and found that these substances have an antimicrobial effect (Rovna et al. 2015). From the past, various kinds of plants have been used as herbal medicine until now. Although chemical drugs are being produced and considered discoveries and superior for prevention and therapy, 80% of the world's population still uses traditional herbal medicines. now several pharmaceutical companies are starting to revive herbal medicines. (Shohayeb et al. 2014). Chen et al. (2020) found that essential oils have been used to treat several of infections in traditional Chinese medicine. Essential oils extracted from medicinal plants are now promising alternatives to antimicrobial treatment. The important properties of the essential oils are their hydrophobic nature. These properties make essential oils separate the lipids present in cell membranes

and mitochondria, disrupt cell structure, and make cell membranes more permeable. Prabuseenivasan et al. (2006) reported that essential oils had been used since ancient times to speed up wound healing. Essential oils have antibacterial, anti-inflammatory, and antioxidant potential. In this study it was found that Gram-positive bacteria are more resistant to essential oils than Gram-negative bacteria. Besides that, cinnamon, lime, geranium, rosemary, orange, lemon and clove oils are effective against both types of bacteria. From research on 21 essential oils, it was found that 19 essential oils had antibacterial activity in more than one strain.

1. Dried flowers

Drying is the most widely used method in harvesting because this method can inhibit the growth of microorganisms by reducing the number of reactions (Fernandes et al., 2018). Some herbalists are interested in this method for medicinal purposes (Bembelaid et al. 2013). Flowers are very often dried. Floriculture has become an industry that generates financial benefits. Flowers can be dried and processed, but their beauty and value are preserved. The rose is a plant consisting of 10,000 species around the world. Roses come from the genus Rosa, family Rosaceae and impact culture, be it artistic, economic, scientific, psychological, or religious. (Shohayeb et al. 2014). The petals and rose leaves can be used as a diuretic and can also cure sore throat and shortness of breath. Rose also has an antiseptic effect, so it is used to wash the eyes and moisturize the skin. The bioactive agents, such as flavonoids and phenolic compounds, cause roses to have an antifungal, antibacterial, and antioxidant effect (Shohayeb et al. 2014). Rose extract has a better antifungal and antibacterial effect against Gram-positive bacteria. The antibacterial effect of roses is less effective against Gram-negative bacteria due to an outer membrane that can prevent antimicrobial penetration. Gram-positive bacteria do not have an outer membrane and are more susceptible to cytoplasmic leakage. In Shohayeb et al. (2014), essential oils and extracts from *R. damascene* have antimicrobial effects against three Gram-positive bacteria, seven Gram-negative bacteria, one acid-fast bacterium and three fungi. Boskabady et al. (2011) state that in ancient times the therapeutic effect of *R. damascene* was used to treat stomach and chest pain, improve heart function, treat abnormal menstrual bleeding, treat digestive problems, and reduce inflammation. Rose oil steam therapy is also used to treat allergies, headaches and migraines., Rovna et al. (2015) found *R. canina* has antimicrobial effects on *Pseudomonas aeruginosa* and *Escherichia coli*.

2. Mint

In Al-Sum (2013), mint's antimicrobial effect is also present. Mint leaf extract has antibacterial effects against seven pathogenic bacteria, namely *Bacillus fastidious*, *Staphylococcus aureus*, *Proteus mirabilis*, *Proteus vulgaris*, *Salmonella choleraesuis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Klebsiella pneumoniae* and *Serratia odorifera*. Its antibacterial effect can be used to fight resistant bacteria. Mint leaf extract can be used to cure community and nosocomial infections. Liang et al. (2012) state that peppermint is added with peppermint oil nanoemulsions, its anti-bacterial effect can last longer.

3. Spices and herbs

Spices and herbal plant species have active ingredients as antimicrobial effects, making this essential oil able to protect food products from microbial contamination. Antimicrobial from synthetic or natural antimicrobial agents effectively suppresses the growth of microorganisms. Liu et al. (2017) concluded that spices are new antimicrobial agents that can fight pathogens. Spices can stabilize food from microbial disturbances. Spices initially had high microbial exposure, but over time microbial growth slowed down and then suppressed. Souza et al. (2005) found that the antimicrobial effect of spices depends on several factors, such as the type of seasoning, the composition and concentration of the seasonings, the microbes of the seasonings and their level of occurrence, the composition of the substrate and the conditions of processing and storage. Nanoemulsions have a powerful effect against antimicrobials, bacteria, fungi, and viruses. found that spice-based nanoemulsions as potential antimicrobial agents (Nirmala & Nagarajan 2016).

4. Camphor

Cinnamomum camphora is often used for medicine in China. Pharmacological studies have shown that *C. camphora* essential oil has a broad spectrum of antimicrobials against antibacterial, antifungal, anti-inflammatory, and insecticidal properties. There are very few reports on the mechanism of action of *C.*

camphora essential oil (Chen et al., 2020). Chen et al. (2020) found essential oil of *C. camphora* leaves contains linalool (26.6%), eucalyptus (16.8%), α-terpineol (8.7%), isoborneol (8.1%), β-phellandrene (5.1%), and camphor (5.0%). This essential oil has an excellent effect against MRSA, *Staphylococcus aureus*, *Enterococcus faecalis*, *Bacillus subtilis*, *Salmonella gallinarum* and *Escherichia coli*. Chen et al. (2013) also found camphor also has antiviral, antibacterial, antifungal, antimutagenic, antitussive and insecticidal properties.

5. Vinegar sponge

Apple cider vinegar (ACV) coupled with honey can fight infection and protect wounds. Until the sixth century BC, the Babylonians used vinegar for medicinal purposes. Vinegar results from of ethyl alcohol being converted into acetic acid by Acetobacter (apple cider vinegar antimicrobial activity). Ikawa (1999) found that vinegar can significantly reduce the bacterial load in the inoculated sponge in the laboratory. Vinegar has an antimicrobial effect. Vinegar also suppresses microbial growth, mononuclear cytokines, and phagocytic responses. Microbes are damaged after vinegar destroys the integrity, structure and metabolic proteins of cells, including the nucleus. Yagnik et al. (2018) reported that ACV has an antimicrobial effect against *E. coli*, *S. aureus* and *C. albicans*. ACV will reduce the release of inflammatory cytokines in infection. This mechanism will disrupt microbial proteins which can damage the structure of pathogenic proteins and metabolic enzymes.

EFFECTIVENESS OF BEAK MASKS

During the Black Death, doctors wear beaked masks to protect them from being exposed to poison. Previously, doctors believed that the plague spreads through contaminated air. Air can cause an imbalance of a person's body fluids. The beaked mask filled with theriac, which consists of 55 herbs and other components (Mussap 2019). De Lorme assumed that the shape of the beak on the mask could cause air to be exposed to the mask's ingredients before the air enters the airway. Recent research has found that the Black Death is caused by the Yersinia pestis bacteria transmitted from animals and through flea bites, direct contact with contaminated fluids or tissue, and exposure to coughs or sneezes from pneumonia.

In theory, the plague doctor costume could protect doctors from miasma (Maestas 2019). Gaudart and colleagues tried to propose a pneumonic plague transmission theory to explain the rapid spread of the outbreak. Ditrich (2017) states that if the aerosol transmission were a major factor, then the explanation for the Black Death would be obvious. Plague doctor costume can protect against transmission from droplets. Also, it can also slow the spread of infection.

Other vectors, such as bugs and ticks, have been studied but there is not much evidence to support this idea. Of the arthropod species, human fleas are the vectors most likely to transmit bacterial plague (Ditrich 2017). Human-to-human transmission via body lice has been found in the outbreaks of the Mongolian epidemic. Silk is a great habitat for fleas. The ancient Greeks used thick coats and flat armor of leather or iron and a similar type of armor of upholstered. Besides, clothing with animal hair may have contributed to Mongols and Italian traders' infections (Ditrich 2017). Wearing masks or surgical masks are recommended by the World Health Organization (WHO) if they are treating people who are suspected of COVID-19 or when they are sick. Masks will be effective when used in conjunction with washing hands regularly and properly with soap and water or an alcohol hand rub. Besides, those who wear masks must know how to use and dispose of them properly. The Center for Health Protection says that face masks provide a physical barrier for liquids and large-particle droplets. It is added that when used properly, this mask prevents infections that are transmitted by respiratory droplets (Centre for Health Protection 2020).

Maintaining hand hygiene remains one of the most useful tools in preventing healthcare-related infections, cross-infection, and the spread of antimicrobial resistance. Handwashing and compliance are influenced by various factors, including accurate knowledge, correct decontamination techniques, human factors, the environment and effective leadership (Hillier, 2020). Wong et al. (2014) identified 979 articles, and ten randomized controlled trials that met the inclusion criteria. Combined hand hygiene with facemask was significantly more effective against influenza, while hand hygiene alone was ineffective. The meta-regression model did not identify any statistically significant effects of latitude, temperature or

humidity on hand hygiene effectiveness. Cowling et al. (2009) and Sues et al. (2012) suggested that hand hygiene and facemasks can reduce influenza virus transmission if implemented early after symptom onset in an index patient. There may not be sufficient resources available to isolate all infected individuals during a pandemic, so non-pharmaceutical interventions such as home isolation are required in public health control measures against inter-pandemic. The use of face masks has shown mixed results. Subsequent studies were undertaken to evaluate the relative impact of different routes of influenza transmission. Maintaining hand hygiene and wearing face masks in situations with a high risk of exposure, contribute to preventing infection with the pandemic influenza.

CONCLUSION

Epidemiology history repeats as new bacterium and viruses evolved rapidly. With this analysis, we found that beaked masks created as PPE by the physicians were only able to support them psychologically in dealing with their patients. Compared to the beaked masks, the PPE in modern time proves to be more significant in reducing the possibility of disease transmission. The plague doctors' costume and beaked masks did not provide the expected protection.

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