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Evolution of Masks As Public Health Intervention in the Control of Respiratory Outbreaks

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Beginning of the Concept

Protection of respiratory tract from harmful contaminants goes back to 23-79 AD when Pliny the Elder, a Roman philosopher and naturalist, emphasized on use of loose animal bladder skins to filter dust from being inhaled while crushing cinnabar, which is a toxic, mercuric sulfide mineral.[1]

Centuries later, Leonardo da Vinci (1452-1519) insisted the use of wet cloths over the mouth and nose as a form of protection against inhaling harmful particles. In the 1700s, Bernardino Ramazzini, known as the father of occupational medicine advocated advancement of respiratory protection, especially against the hazards of arsenic, gypsum, lime, tobacco, and silica dust.

Over centuries, these protections emerged as surgical masks and respirators which are now considered as important pillars of personal protection in respiratory pandemics.

Initially, surgical mask, a loose-fitting, disposable device was used to prevent the release of potential contaminants from the user into their immediate environment and confer protection to the patients during operations; but with time their design, function and uses have expanded and now their role in protecting the wearer from contracting infection has become equally important.

Usage of Mask in protection of the patients from contracting infections

In 1878, AJ Jessup, Physician, New York, U.S.A was the first to observe that cotton gauze stoppers prevent bacteria from entering the test tube and proposed to extrapolate it to human beings. "May we not hope, by preventing the entrance of germs into lungs and blood, by a properly constructed filtering cotton gauge and mask." As with many great ideas, this idea was also not met with much enthusiasm at first.

Later in 1897, Carl Flugge, a German bacteriologist and hygienist, laid the ground of droplet transmission as a route for the spread of respiratory diseases. He explained that when a surgeon coughs, sneezes or even talks during operation, expiratory droplets are generated, which if contaminated with bacteria, may cause sepsis of the surgical wound. These droplets were called "flugge's droplets". He emphasized that surgeons should cover their mouths while operation. This led to the use of roller gauge strip placed over mouth as crude masks.[2]

Alice Hamilton, in 1905, demonstrated that virulent bacteria such as haemolytical streptococci, staphylococci, diplococcic etc. were present in the droplets released from the mouth of surgeons while speaking on the operation table. She the idea of scarlet fever being disseminated through droplet infection and recommended the use of masks by nurses and doctors at the time of handling sterile supplies and surgery.[3]

In 1927, "Seasonal incidence of hemolytic streptococcus in the nose and throat in a surgical operating personnel; Significance of masking during Operation" a study by Frank Lamont Meleney, MD from New York was published in JAMA showed that 33% of the surgical staff were asymptomatic carriers of hemolytic streptococcus in throat and nose. He speculated that they might be the cause of a series of severe haemolytical streptococcal infection in post operative wounds of the patients at Presbyterian hospital, New York. Following a strict advisory that all doctors, nurses and other staff in the operation theater must wear a mask, no incidence of infection was reported in the following 8 months. [4]

Usage of Mask in protection of the wearer from contracting infections

The aforementioned uses of masks, however, were intended to protect the patient rather than the

wearer. So the use of masks by health care workers started as a precautionary measure for the benefit of patients but its role as a protective measure for the wearer was most probably brought forth by Meltzer in 1915 who advised the use of fine-mesh gauze to cover the face of patients with infantile paralysis and also the attendant along with them.

Following this, in January, 1918, Dr. George H. Weaver, at Durland Hospital in Chicago, reported that over a two-year period use of mask of double thickness gauze by the attendants of patients with diphtheria, brought the incidence of diphtheria contracted by attendants to zero, which previously used to be a great menace. His foresight in proper use of mask remains remarkable in that, at the time, he advocated that a mask should not be worn a second time until it had been sterilized, that the mask should be not be used after it became moist and that hands should not be placed on the mask. [5.]

In 1918, Joseph A. Capps, to control the problem of cross respiratory infections in military hospitals at the time of World War I, advised wearing of masks by attendants. And after a five-month period, none of the attendants contracted the disease of the patients they were working with. He then made all patients entering ambulances and all patients with contagious diseases wear masks. (This was a gauze mask of three to four layers, 5 x 7 inches in size.) Simultaneously, all the doctors and attendants wore this mask. The results were spectacular when it became evident that the mask was 95% efficient in preventing cross infections and infections in attendants .[6, 7]

Due to the inference of these studies, which indicated that masks were successful in preventing respiratory infections, many more studies were conducted on the efficiency of masks. Doust and Lyon on the basis of their study were first to summarize the efficiency of various types of masks. [8] They concluded that the coarse gauze was inefficient, regardless of the thickness, and that finer gauze was able to prevent the spread of droplets efficiently.

These results were reaffirmed by a study done and published by Weaver in 1919. He concluded that fine-mesh gauze, with 44 x 40 threads to the inch, was more efficient than butter cloth which has 28 x 30 threads to the inch.

During the period from 1920-1940, the importance of the surgical mask was stressed and new masks kept on developing.

But from 1940 onwards, the antibiotics gained importance and development of masks took a back seat.

Significant Role of mask in containing respiatory epidemics

Usage of mask in Manchurian plague in 1911

The role of masks as public health intervention tools in containing respiratory epidemic was demonstrated by Dr. Wu Lien-teh, a Cambridge-educated Chinese physician who advocated the use of masks during the Manchurian Plague of 1910-11.[9] This plague broke out in the Chinese-Russian frontier town of Manzhouli and quickly spread south along the railroads to Harbin and other Manchurian cities where it caused havoc. To counter this crisis, which involved three empires namely the Chinese, Russian and Japanese; the Chinese imperial court appointed the Dr.Wu Lien-teh as the head of its anti-plague efforts. He established that the plague was pneumonic and insisted on wearing a protective mask. Wu emphasized the mandatory use of "anti-plague mask," which were similar to surgical face-worn protective devices but had more protective layers and a more complex tying process. These changes were helpful in keeping the mask in place while working in the adverse open-air conditions. Use of face mask along with other epidemic measures like quarantine, isolation and travel restriction was helpful in containing the outbreak.

Usage of mask in Spanish flu in 1918

Wearing of a mask was made compulsory during the Spanish flu of 1989 among the general public, to mitigate the spread of disease in many American cities, failing which a person had to pay penalty, face imprisonment or both.[10] The dimension of the mask was supposed to be five to seven inches wide, consisting of four layers of fine gauge with strings at four corners to keep it secure. Wearing mask along with other public health measures such as prohibiting public assembly, closure of educational institutions etc. is said to have slowed down the infection and thus prevent many deaths.

Role of mask in containing epidemic was supported by another incidence in which the captain of a ship made wearing a mask compulsory in the return trip from New York to South Hampton. There was no incidence of infection in this trip as compared to the previous trip from South Hampton to New York, where over hundred cases were reported in absence of a mask.

Role of Mask in prevention of MDR TB

Dharmadhikari et al. reported that surgical mask worn by patient reduced the transmission of MDR TB by 56%. [11]

Respirator masks

The need to develop respirators arose from the need to provide superior protection to miners from hazardous dust and gases, soldiers from chemical warfare agents, and firefighters from smoke and carbon monoxide. Though concept of this superior protection originated much earlier, modern respirators were mostly developed around the 1900s.

Today there are two types of respirators: the air-purifying and the air-supplying respirator.

The first U.S. patent for an air-purifying respirator was granted on June 12, 1849 to Lewis P. Haslett. His Haslett Lung Protector used a moistened wool filter or similar porous material and one-way clapper valves to filter dust.

In July 1850, Benjamin Lane got the first U.S patent for a self-contained breathing apparatus called the gas mask.

In 1877, the English invented and patented the Nealy Smoke Mask. The Nealy Smoke Mask used a series of water-saturated sponges and a bag of water attached to a neck strap. The wearer could squeeze the bag of water to re-saturate the sponges to filter out some of the smoke.[12]

For the rest of the 19th century, other inventors added to these works.

On January 15, 1920 the Gibbs respirator developed by an engineer, W. E. Gibbs became the first respirator to be approved for industrial use.[13] It was an emergency escape breathing apparatus that could be used in mine rescue. Later on, Gibbs also developed an aviator re-breathing apparatus and soda lime canisters to absorb carbon dioxide in submarines, lengthening their submersion time from the previous record of 12 hours to 48 hours.

Over the years respirators evolved gradually, being frequently modified in response to demands in various situations. In 1972, 3M introduced the first, single-use N95 mask, which instead of fiberglass was made up of very thin layers of fibers by air-blasting melted polymer.

Its use in the medical field gained importance as late as 1990s, when health care providers started wearing them to protect themselves from the airborne spread of drug-resistant tuberculosis from H.I.V patients .[14]

In recent times, N-95 gained significant attention during the SARS outbreak of 2002-2004 as a highly efficient personal protective equipment. Also, planning efforts for pandemic influenza in 2006-07 [15] led to considerable discussion about the role of small particle inhalation in disease transmission and the use of respirators to protect healthcare personnel from airborne influenza particles.

This simple personal protective equipment with its past of the gradual adoption has now become an efficacious tool in the struggle against respiratory epidemics. It does not simply protect its wearers from infection but also portrays them and their immediate social environment in a spectacle of medical reason and hygienic awareness.

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