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Journal of Quality in Health care & Economics
ISSN: 2642-6250

A Novel Face Masks and it's Utility during COVID-19 Pandemic: A Comprehensive Review

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Mini Review

Volume 7 Issue 1

Received Date: December 29, 2023

Published Date: January 23, 2024

DOI: 10.23880/jqhe-16000357

Abstract

In recent decades, the rising frequency of infectious illnesses has presented a severe danger to public health. The Centres for Disease Control and Prevention (CDC) in the United States established that an infected or asymptomatic person wearing a surgical mask shields others from the user. This is because virus-laden aerosols and droplets are thought to be the major mode of transmission between persons. The United States continues to have insufficient control over the spread of SARS-CoV-2, even with the extensive use of masks and other mitigating methods. The public health viewpoint on mask usage, the technical specifications of store-bought and homemade masks, and the most current developments in mask engineering, materials, and disinfection will all be covered in this review. Additionally, the sustainability of mask wear and mask manufacture will be discussed.

Keywords: Face Mask; Covid 19; Pandemic; Public Health

Abbreviations: SARS-CoV-2: Severe Acute Respiratory Syndrome Corona Virus 2; WHO: World Health Organisation; ARDS: Acute Respiratory Distress Syndrome; ABS: Acrylonitrile Butadiene Styrene; PLA: Polylactic Acid; TPU: Thermoplastic Polyurethane; RTPCR: Reverse Transcriptase-Polymerase Chain Reaction.

Introduction

During the ongoing COVID-19 epidemic, masks have been heavily explored. The routes of transmission vary, but the respiratory droplet or airborne route has the most potential to impair social interaction while being preventable with a simple facemask Sustainable solutions for fabricating and using a face mask to prevent the spread of the severe acute respiratory syndrome corona virus 2 (SARS-CoV-2) during the 2019 and 2020, corona virus pandemic (COVID-19) are required, as society is directed by the World Health Organisation (WHO) to wear it, resulting in an increasingly large demand, with over 4000000000 masks used globally per day. According to the WHO, the virus is spread through the air by liquid droplets, aerosols, or infected surfaces [1]. COVID-19 is still in circulation in 2021 due to mutations in the new corona virus, which continue to generate COVID-19 infections and deaths in various countries. Infection-laden aerosols and drops are recognized as the primary component of human-to-human transmission. The virus-carrying aerosols have an average diameter of 5 m. These aerosols are mostly produced by exhalation products such as coughing, sneezing, and oral communication. Most masks on the market today did not meet the filtration efficiency criteria for filtering extremely tiny pollutants [2].

According to the research, Asian countries take proactive efforts, whilst Western countries take reactive policy measures. COVID-19 pandemic crisis management is frequently based on effective multi-level governance, encompassing national, regional, and urban institutions, in order to produce timely policy responses in society [3]. Initially, governments adopt non-pharmaceutical management methods (such as lockdown, quarantine, and so on) to deal with the COVID-19 pandemic disaster. Because of the rising frequency of viral infections, the global threat to people's well-being, as well as a complex spectrum of social and economic consequences, has escalated in recent years. Microbial viruses and their interactions with the atmosphere's ecosystem pose a severe danger to the Earth and human survival [4]. Multiple research trials have demonstrated that SARS-CoV-2 genetic material may survive in the air for at least three hours and perhaps up to 16 hours. To avoid Covid-19 transmission from one person to another when there is no wind, national governments have developed strict standards requiring individuals to remain at least 2 metres apart and stay away from frequented places [5].

As a result, the WHO and numerous healthcare professionals advise wearing a facemask as the first line of defence for avoiding infections. Existing facemasks, such as surgical masks and cloth masks, were rare on the market, and it was quickly discovered that single-layer non-medical masks are useless against the Sars-CoV2 virus, and specialised facemasks are required to control infections. Specialised masks, such as N95 and medicated masks were more effective in preventing infections, but their availability was restricted and they were out of reach for the average person. Overall, face masks played important role during pandemic to stop spreading corana virus from one person to another.

Pollution is increasing day by day [6-9]. The use of fabricated masks can also be used in air polluted areas. In this review the detailed explanation about face masks history, types of masks, reuse of masks and future prospective are discussed.

Facemasks: History, Current Materials, Advances and Future Perspectives

History of Facemask: Medical masks were initially used by a Polish surgeon, Jan Mikulicz Radecki, in 1897, with his assistant reporting the following year how the masks might minimise the spread of droplets from the user's lips. This mask covered the mouth with a single sheet of gauze**.** On other hand, using masks in public to convey social values was a hallmark of ancient Greek theatre. Greek tragedies were first presented at week-long festivals honouring the deity Dionysus in Athens in the fifth century BCE, when they began to take on the form we know today. Many academics have emphasised the crucial significance that masks play in these performances. Edith Hall, for example, argued that "tragic and the actor's mask were conceptually wholly inseparable throughout antiquity." [10].

In the 20th century, the widespread use of reusable and eventually disposable medical masks was a result of growing awareness of infection and concern for sepsis. During the Spanish Flu pandemic of 1918–19, mask use also spread into public spaces as several American cities enforced their use, albeit with significant politization and resistance [11]. But the COVID-19 epidemic of the twenty-first century has given the mask an even more complex symbolic meaning. Now, the mask causes division. Within a certain domain, the mask conveys a conviction in medical knowledge and a will to keep one's neighbour safe from illness. On the other hand, the mask conveys disbelief in accepted scientific theories, tyranny, and government over reach. Throughout its historical evolution, masks have always been able to speak, if people choose to listen, and this ability has an impact on people's opinions of themselves and their health.

Why was the Masks necessary During the COVID-19 Pandemic: The coronavirus pandemic of 2019, also known as COVID-19, has caused significant disruptions to almost every facet of everyday life and is thought to be the worst healthcare catastrophe since the Spanish Flu epidemic in the early 20th century. The World Health Organisation (WHO) reported about more than 122 million confirmed cases of COVID-19 during peaktime of COVID-19 (2020-2021), with more than 2.7 million deaths associated with the virus. The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the main cause of this illness, resulting in flu-like symptoms in infected individuals. Dry coughs, chest aches, fevers, anosmia, and in the worst situations, pneumonia, acute respiratory distress syndrome (ARDS), and even mortality, are some of these symptoms. The COVID-19's many traits have significantly increased the difficulty of identifying, tracking, and stopping the virus's propagation [12].

SARS-CoV-2-laden respiratory fluid droplets are considered to be involved in all of these routes of transmission. These droplets are exhaled by the infected individual anytime they engage in respiratory-related activities, such as speaking, singing, coughing, or even breathing. These droplets contain viruses that can transmit the infection for a long time after they become alive and infectious. Fine particles (<5 μm) and coarse particles (>5 μm) are often seen in respiratory fluid droplets. According to reports, coarse particles settle fast because of gravity influences and have a relatively small transit range of around one metre. This can cause contact and facilitate transmission. On the other hand, virus-containing tiny particles have the ability to turn into suspended aerosol particles and remain in the air for extended periods of time, which enables the virus to spread via aerosols across large distances (>1 m), also known as aerosol transmission [13].

Thus, in addition to taking steps like maintaining consistent good hygiene and creating social distancing to avoid the first two pathways, it is imperative to take other infection prevention and control measures like mask wearing, quarantine, and isolation to stop the virus from spreading through aerosols. Thus, respirators or face masks can be a useful and necessary piece of equipment to safeguard patients and members of the public who might come into contact with the virus. Countries like China, Singapore, and South Korea have adopted the universal mask wearing policy based on epidemiological data, demonstrating how well the COVID-19 pandemic has been contained in those regions. Therefore, it is essential to successfully prevent the spread of COVID-19 to use face masks and respirators, especially those with unique features like antiviral ability, super hydrophobicity, reusable design, and recharging capacity.

Different Types of Masks: However, because to the present global COVID-19 epidemic, there is a significant scarcity of both goods and raw materials as a result of the tremendous rise in demand for surgical facemasks and respirators, particularly among healthcare personnel. As a result, action to improve the existing circumstance must be adopted immediately. Finding alternatives to respirators and face masks - such as making handmade face masks or masks out of other materials - is one tactic to lessen the serious issue. The different types of masks used in peak time of Covid 19 are Medical or surgical masks, cloth masks and 3D printed masks.

Medical/ Surgical Masks Medical/ Surgical Masks: Aerosol particles, as opposed to huge drops, contain corona viruses, which can be exhaled normally by the use of a surgical mask, which stops the virus from entering the surrounding air. They consist of three non-woven textile layers. The outside and inner layers of non-woven polypropylene are typically constructed of 20 grammes per square metre (gsm) spun-bond polypropylene, while the filter is made of 25 gsm melt-blown polypropylene [14].

Cloth Masks: Cloth masks, also referred to as barrier masks, community face coverings, or non-medical face masks, cover the user's mouth, nose, and chin. They are composed of one or more layers of commercially available textile materials (knitted, woven, non-woven, etc.), and they require an attachment point for the head or ears, just like other masks. They are reusable or disposable. The majority of the time, non-woven textiles is used to make cloth masks for one-time usage, whereas knits or fabrics are used for several uses. Non-medical masks are widely accessible from several local sources and cannot be sufficiently regulated, which appears to be an issue with material management and protection evaluation [14].

3D-Printed Masks: To address the lack of surgical masks and respirators, researchers and manufacturers have focused on using 3D printing, specifically Additive Manufacturing (AM), to fabricate personal protective equipment (PPE), including masks and their components, in addition to the use of cloth masks. Rapid prototyping with 3D printing is a new and inventive technology that makes it possible to create intricate geometric structures that are difficult to create with conventional manufacturing methods. Many different materials, including polyamide (PA) composite, acrylonitrile butadiene styrene (ABS), nylon PA, polylactic acid (PLA), ULTEM (polyetherimide), and thermoplastic polyurethane (TPU), can be utilised as the basis material in 3D printing. Although certain 3D-printed masks, including cloth masks, could offer some protection for select users, their filtering performance has not yet received regulatory agency approval and they might not fulfill the strict requirements of commercial face masks and respirators. Despite this, 3D printing is still seen to have a lot of potential in an emerging application since it is a cheap and quick production method. Nevertheless, it is not recommended to use 3D-printed masks in place of medical-grade masks and respirators until sufficient thorough and trustworthy testing has been done on the filtering capabilities. Researchers need to look at each of them more [14].

How Masks Guard Against Airborne Illnesses

Three methods can be used to transfer respiratory pathogens: airborne spread, droplet transmission, and contact. Respiratory droplets are physically blocked by masks and other PPE equipment. It was discovered by laser light scattering imaging that by covering the speaker's lips with a slightly moist towel, the number of flashes—which correlates to the number of respiratory droplets—could be maintained at background levels. To evaluate the mask's ability to filter out radiolabelled aerosol released from the source, an in vitro model including source and receiver mannequins was developed. The only experimental setup in which the receiver mannequin could be equally well protected was if the receiver mannequin wore a N95 mask sealed with Vaseline. Masking at the source mannequin was consistently more effective at lowering radio-labelled aerosols reaching the receiver mannequin. As a result, masks that are worn by the individual who emits the droplets seem to be more successful at acting as a physical barrier. Wearing a mask has typically been shown to reduce the amount of virus that infected persons emit. By measuring the quantity of virus in patients' exhaled air, the surgical mask's capacity to stop the spread of different infections was evaluated. Particles that were either > or <5 μm in size may be gathered by the researchers. Wearing the mask led to a noticeable decrease in coronaviruses in both bigger and smaller particles. The mask attenuated influenza viruses present in bigger particles but not in tiny ones. Following mask use, no coronavirus was found in any of the 11 patients, although one patient's respiratory particles (out of 27) had influenza. Rhinovirus counts in bigger or smaller particles were not decreased by the mask. This implies that surgical face masks can lessen an infected person's discharge of influenza and coronavirus.

In a previous influenza investigation, nine sick individuals were made to cough, and despite wearing surgical masks and N95 masks, no influenza was found by reverse transcriptase-polymerase chain reaction (RTPCR). Surgical masks were shown to be extremely successful in removing influenza from the larger coarse fraction (≥5 μm) but less effective from the fraction with smaller particles when the exhaled influenza virus was divided into fractions based on size. It has also been demonstrated that mask wearers are safer while interacting with sick people. Hospital employees were questioned about the precautions they took during the SARS pandemic in five different hospitals in Hong Kong. The answers they provided were associated with whether or not the staff members themselves contracted the virus. Wearing masks was determined to be the single most effective preventive approach in lowering the risk of infection (p = 0:0001), and those who wore surgical masks or N95 masks were not among the 11 staff members who contracted the infection. However, there were two cases of infected individuals using paper masks, indicating that the kind of masks used mattered as well. Among a research, the efficacy of surgical face masks and N95 against viral respiratory infections among healthcare personnel was compared. When using surgical and N95 masks, healthcare personnel showed no discernible difference in the outcomes of influenza infections, indicating that both types of medical masks might provide comparable protection. To investigate the preventive impact of masks, a meta-analysis of clinical research was conducted. A lower risk is indicated by a risk ratio of less than one (risk ratio < 1). This was determined by comparing the infection incidence in the protected group to that of the unprotected group [15].

People who used masks were able to avoid influenza-like illnesses; the risk ratio was 0.34, with a 95% confidence range ranging from 0.14 to 0.82. Similar to the previous study, there was no discernible difference in protection between surgical masks and N95 masks, with a risk ratio of 0.84 and a 95% confidence range of 0.36-1.99 indicating no significant change in risk. The general public's widespread use of face masks can greatly lower the community transmission rate and mortality toll, according to a recent modelling analysis conducted by Eikenberry et al. based on Covid-19 infection data gathered in New York and Washington [16]. As more individuals use masks during the following two months, the cumulative fatality rate was predicted to be lowered to a larger extent, as shown in Figure 2, which is based on data collected from February 20 to March 30. Consequently, the study comes to the conclusion that widespread face mask use has a significant chance of reducing COVID-19 pandemic burden and community transmission.

Recycling and Reuse of Masks (Biodegradability)

The standard synthetic polymers used in the production of disposable surgical face masks are sterilised, packed, and then utilized. Subsequently, they are disposed of in landfills and dumpsites, with some of them just left lying around in public areas. Regrettably, they wind up in the terrestrial, marine, and coastal environments, leading to enormous amounts of polymeric waste. Surgical face masks are mostly meant for the throwaway market, even if their protective components are long-lasting enough for several usage. Therefore, it is important to think about how widespread use of such throwaway media would affect the ecosystem. Reusable or alternative fibre goods derived from environmentally friendly and biodegradable precursors may be one way to address this issue. The creation of surgical face masks made of biodegradable polymers can greatly contribute to the simultaneous protection of human health and the environment. The indiscriminate disposal of COVID face masks presents a pressing concern that intertwines environmental pollution with potential risks to human health. As these masks, primarily composed of non-biodegradable materials such as polypropylene, accumulate in landfills or scatter across landscapes and water bodies, they contribute significantly to plastic pollution. Their gradual degradation into microplastics raises alarms, potentially infiltrating ecosystems and threatening aquatic life. Moreover, the leaching of harmful chemicals from these masks as they deteriorate poses potential hazards to soil and water quality. Furthermore, the mismanagement of discarded masks as potential carriers of pathogens could amplify health risks if these contaminants enter water sources or are inhaled inadvertently. Addressing the proper disposal of COVID face masks is paramount, not just to mitigate environmental degradation but also to safeguard human health from the detrimental consequences posed by this pollution.

Reusing respirators and face masks is another efficient way to lessen the impact on the environment caused by medical waste while also helping to ease the scarcity problem. Organizations and scholars have recently looked at the best ways to reuse masks. Reusing a mask requires inactivating any infections that have collected on it. This is done by decontaminating the mask such that the pathogens are eliminated or sterilised without compromising its structural integrity. This preserves its filtering effectiveness, making it safe for the wearer to use again. Hospitals, labs, and other crucial institutions are using a variety of techniques that have been developed to inactivate bacteria and disinfect or sterilise equipment [17].

In addition to being recyclable, homemade reusable masks contribute to the reduction of the scarcity of supplies and may have positive environmental effects. As was mentioned, a homemade reusable mask may perform just as well as ones made by a company that manufactures surgical masks if the proper materials are used, as well as the right design and assembly. Using readily available household items like a dried hypoallergenic wet wipe, reusable nonwoven bag, and thin cotton cloth for the middle filtering, inner adsorbent, and outer hydrophobic layers, respectively, researchers from A-STAR, Singapore, created a DIY mask that had all the necessary characteristics of a surgical mask [18].

Methodology

1) **Database Selection:** Begin by selecting relevant databases (PubMed, Scopus, Web of Science, etc.) to conduct a comprehensive search. These databases cover medical, scientific, engineering, and multidisciplinary literature.
   - **Search Terms:** Use a combination of keywords, such as "novel face masks," "COVID-19," "respiratory protection," "antiviral masks," "nanotechnology in masks," "transparent masks," etc.
   - **Inclusion and Exclusion Criteria:** Define specific criteria for including studies. For instance, consider including peer-reviewed articles, clinical trials, experimental studies, and expert reviews published within a defined timeframe and exclude duplicates, non-English articles, or non-peer-reviewed sources.

2) **Data Collection and Screening**
   - **Initial Screening:** Conduct an initial screening based on titles and abstracts to identify potentially relevant articles. Exclude studies that do not meet the inclusion criteria.
   - **Full-Text Assessment:** Review full-text articles to further assess their relevance and quality. Extract key information such as study design, methodology, results, and conclusions.
   - **Data Extraction:** Systematically extract relevant data from selected studies. This includes details about the types of novel face masks discussed, their features, effectiveness, limitations, and comparative analyses with traditional masks.

3) **Synthesis and Analysis**
   - **Thematic Analysis:** Organize extracted data into thematic categories. This could include categorizing masks based on their technology (nanotechnology, antiviral coatings, respirators), efficacy, usability, and limitations.
   - **Comparative Evaluation:** Compare and contrast different types of novel face masks with traditional masks. Evaluate their filtration efficiency, breathability, durability, cost-effectiveness, and potential advantages in preventing viral transmission.

Discussion

The COVID-19 pandemic has spurred significant advancements in personal protective equipment, particularly in the development of novel face masks. As the primary mode of transmission of the SARS-CoV-2 virus is through respiratory droplets, the use of face masks has become pivotal in mitigating its spread. This comprehensive review aims to evaluate the utility, effectiveness, and innovations surrounding novel face masks in the context of the ongoing pandemic. While novel face masks present promising advancements, challenges persist. Manufacturing scalability, cost-effectiveness, user comfort, and compliance remain significant considerations. Additionally, ensuring proper fit, adequate filtration efficiency, and consistent use by the general public are crucial for their effectiveness in curbing viral transmission.

Conclusion and Future Outputs

The COVID-19 epidemic has compelled people all around the world to change their lifestyles, and mask wearing is now the standard. In order to provide consumers with improved protection against airborne contaminants and diseases, it has even expedited research and development efforts in mask materials and design. Therefore, in order to provide readers a comprehensive grasp of masks from the standpoint of public health to the areas of material growth, this study offers a holistic account of deep knowledge about face masks. We covered the significance of mask wear early in this study in order to stop the spread of airborne and droplet-borne illnesses. The manufacturing process, function, and significance of masks were then discussed. The battle against infectious illnesses necessitates efforts and solutions in prevention, detection, diagnosis, and treatment, as was said in the outset. Thus, donning a mask is an essential preventative measure against airborne diseases that is difficult to replace. In near future, the masks are very important as pollution is increasing every year but we should try to use only biodegradable masks and have to follow proper methods of disposal for the same.

Finally, taking into account how trash affects the environment brought upon by the current, widespread usage of disposable masks, using alternatives or making multipurpose changes can have a favorable impact on lowering the total amount of mask waste and safeguarding the environment. As previously stated wearing a mask is still an important method of avoiding airborne infections and cannot be readily replaced. In light of this, the least we can do is keep developing such a widely used technology. However, given the present pandemic conditions, like COVID-19, incorrect disposal and reuse of masks and respirators may raise the danger of secondary transmissions. Respirators have been sterilised using a variety of techniques, including UV, bleach, ethylene oxide, and hydrogen peroxide treatment, but there have always been disadvantages. The fact that surgical face masks now produce enormous volumes of biological wastes that might have an irreversible negative effect on the environment makes totally biodegradable, self-sanitizing masks an intriguing topic for further research. Surgical face masks can be made more biodegradable by applying coatings or finishings made of bionanomaterials. Antivirus, reused, and biodegradable masks have drawn particular interest as a sustainable way to address the present scarcity. Another desirable feature of face masks is the chemical deactivation of droplets carrying antiviral, antibacterial, or sanitising chemicals when they pass through the fibrous layers, in addition to filtering and blocking the inhaled aerosols. While these molecules can remain fixed on the mask surface when breathing in dry, cold air, they must be released during exhalation in wet, warm air [19,20].

- **Declaration of Competing Interest:** There are no competing interests.
- **Acknowledgment:** The authors thank Rosilda Selvin for her guidance.
- **Supplementary Data:** No Supplementary data is available.

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