



Review Article

Theme: Recent Advances on Drug Delivery Systems for Viral Infections

Guest Editor: Claudio Salomon

Technological Scenario for Masks in Patent Database During Covid-19 Pandemic

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Abstract. Since January 2020, the World Health Organization announces COVID-19 outbreak a case of public health emergency of international interest, and declaring it a pandemic on March. Due to the high transmission of this disease, rate precautions have been implemented, such as the use of masks by the population, personal protective equipment (PPE), and safety protocols, mainly to health workers. Thus, we performed a patent review to evaluate the current patents related to the protective mask. The review was carried out in the patent database in the period of May 2019 to May 2020. After the process of screening and eligibility, 563 patents were selected for our analysis according to the aim of the study which used masks such as a PPE against dust particles and pathogens, mostly when it is about airborne transmission, such as viruses and bacteria. Here, an overview of the main materials used in the mask manufacturing and their efficiency was described. The results of the review showed that most of the masks used cotton, nylon, silver fiber fabrics, among others as fabrics to develop the masks. It also makes an analysis of masks composed of nanotechnology which provide high filtration efficiency. Moreover, the review also brought possibilities of masking the population, which already have been done in countries such as China and Korea and ways of sterilization for reuse of PPE during COVID-19 outbreak. Thus, this review can further researchers in the developing of masks to decrease the spread of a pandemic disease.

KEY WORDS: virus; COVID-19; masks; coronavirus; nanotechnology.

INTRODUCTION

The Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and its disease, COVID-19, have been considered a pandemic spread and the most devastating global event in modern medicine (1). The first case of that virus was identified in Wuhan, the capital city of Hubei Province, China, in December 2019 (2), and in January 2020, the COVID-19 has become a worldwide pandemic. However, coronaviruses had their first appearance in 1960 and two other highly pathogenic events of this type of viruses have already happened, SARS-CoV that

emerged in Southern China in 2003 (3) and Middle East Respiratory Syndrome-Related CoV (MERS-CoV), which appeared in Saudi Arabia in 2012 (4).

The coronaviruses are capable of adapting to new environments through mutation and recombination; hence, they can alter host range and tissue tropism efficiently (5). Also, the transmission of coronaviruses can be across species barriers (6). Subsequently, there are ways to transmit the virus such as close person-to-person contact, aerosol transmission, transmission by touch (6, 7), also by respiratory droplets during coughing or sneezing (8). Besides that, the COVID-19 can exist for several hours in the state of the smallest of the droplets (9), and infected people may transmit that disease even in the absence of the symptoms (10). Moreover, the virus can be in the stool and urine of infected patients with diarrheal symptoms (11).

According to the WHO, 52 vaccine candidates are being developed for COVID-19, some of which are still in the clinical evaluation stage (12). The vaccine developed by pharmaceutical companies Pfizer and BioNTech has been approved for use in some countries in the UK and the USA, which have announced the start of vaccination. However,

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until the vaccine is available to the general population and other countries, it is necessary to continue effective approaches to control the spread of the virus. In this sense, there have been precautions in the implantation of PPE (13) and safety protocols (14), such as masks, to delay the spread of the virus and reduce the risk of infection (15), making this strategy mandatory in several countries around the world.

There are a lot of kinds of masks that have been used to decrease the risk of spreading the COVID-19 (16), such as N95 masks, medical masks, and homemade masks, which could be made of four-layer kitchen paper and one-layer cloth (17). Due to the situation, medical masks should be prioritized to health workers (10), and if there is no risk of aerosol transmission, surgical masks could be used (18). However, the efficiency of filtration in the masks depends on the filter characteristics and the pore size, therefore, being larger than the virus, which is about 120 nm (16). Besides, the filters have to be quite effective due to the reduced size of the droplets and aerosols, which can be smaller than 5 μm , which allows the virus to travel distances between 7 and 8 m (19), and can remain airborne for a long time (20). Thus, the masks and their use have been one of the main non-pharmacological public health interventions to prevent transmission of the coronavirus airborne (21) and reduce in average daily growth rates of infection (22). Due to the increment in the use of face masks by the general public during COVID-19, the global supply shortage of face masks occurred in the first months of the pandemic, with prices soaring and risks supply constraints for frontline healthcare professionals. For this reason, other alternatives have been developed, such as homemade masks. This type of mask does not guarantee the minimum necessary security; however, it is better than no masking.

A recent publication compared the recommendations on face mask use in community settings by different health authorities (23). For example, China's national guideline has adopted a risk-based approach in offering recommendations for using face masks among health-care workers and the general public. However, UK policy to face masks described that it play a very important role in highly contaminated environments and locations such as hospitals, but there is very little evidence of widespread benefit for members of the public (24). Either way, life without an effective SARS-CoV-2 vaccine makes masks so essential that they are a PPE key to any person to leave home and transit in public places.

The pandemic situation has made masks the first-choice equipment for reducing viral spread. Consequently, the search for new technologies and the improvement of the old ones have increased. For this reason, increasing safety while maintaining or augmenting efficiency is the goal of developing new technologies. This is seen in patents that use nanotechnology to develop nanometric filters and the use of substances, such as activated carbon and antimicrobials or other types of layers and multilayer masks. Thus, all these new approaches intend to raise the masks' filtration capacity and supply the lack of this advice during the coronavirus pandemic.

Considering this scenario, this review aims to evaluate current patents that have developed masks to protect against dust particles and pathogens such as viruses. Thus, this review provides a comprehensive overview of the main materials used to produce the masks as well as their efficiency in protection to prevent the transmission of viruses, such as the coronavirus.

METHODS

The present review shows patents deposited from May 2019 to May 2020. The research was carried out through Espacenet, a database of free access with millions of patent documents from more than 100 countries. The search for patents was carried out using code A41D13/11 of the International Patent Classification (IPC). This code refers to protective face masks, e.g., for surgical use or for use in foul atmospheres. A total of 1284 patents were identified for preliminary assessment from the database, of which 113 patents were duplications, 1 patent was excluded because they had no title available, and 81 were excluded due to the fact that full text was unavailable. Also, after reading the title and abstract, 526 patents were excluded from being outside the focus of our review. So, we excluded patents about masks used for other purposes and not to protect against pathogens such as viruses and dust particles. Finally, 563 patents were selected for our analysis according to the objective of the study. Figure 1 illustrates the systematic base guideline used for patent searching and screening of this review. Subsequently, of these 563 patents, 150 patents were selected and classified into eight groups, among them: masks for dust and particles, masks with several filter layers, antimicrobial masks, fabric masks, face shield, as well as masks involving nanotechnology, ultraviolet, and other types of technologies.

Additionally, cluster and social network analysis was applied in this study to determine the structure of the intellect on masks through patents obtained through the Web of Science and the use of Software VOSviewer. The groupings obtained by the software define terms in a group based on their similarity (25). Thus, a search was carried out on the Derwent Innovations Index with IPC A41D 13/11 from May 2019 to May 2020. A total of 1122 patents were acquired. During the process of obtaining the data map, terms whose frequency was greater than 20 were selected, thus, obtaining in the end 146 related terms. Furthermore, 112 terms have been excluded because they do not meet the search criteria or are not relevant. Finally, a co-occurrence map composed of 34 terms was divided into five clusters.

RESULTS AND DISCUSSION

Patent Searching and Screening

The terms present in a patent can represent its main content, in the same way that the frequency of occurrence and co-occurrence reflect themes focused on a special field to a certain extent. The five terms with a high frequency of co-occurrence are utility model (491), mask main body (220), respirator (216), mouth (186), and fabric (138). In addition to demonstrating that, these terms, in addition to high individual frequency and co-occurrence, demonstrate to attract more attention and have a close relationship with other search terms.

A graph showing the co-occurrence relationship between keywords using the VOSviewer was obtained (Fig. 2). Keywords derived from the Derwent Innovations Index patents have been separated into five clusters that display different colors. When keywords are grouped in the same cluster, they tend to reflect identical topics. In addition, each

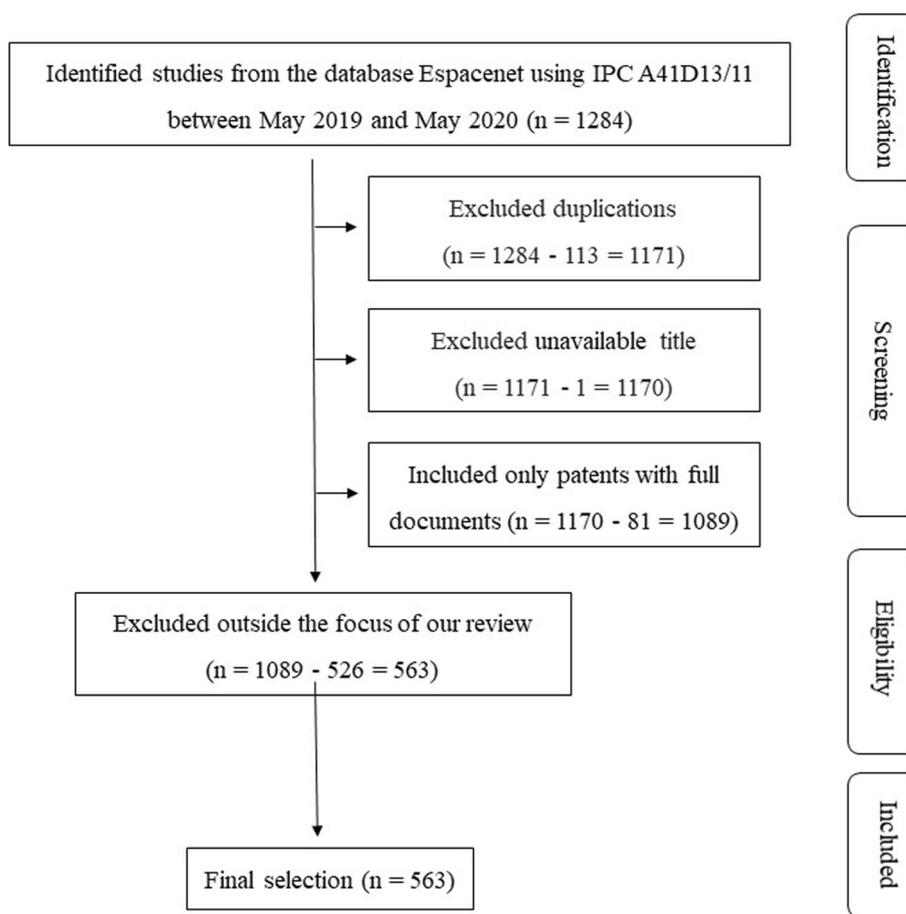


Fig. 1. Flowchart of patent searching and screening

cluster has a number of different keywords, thus indicating that the search fields in masks are wide (25).

Table 1 has detailed information for each cluster. It was observed that cluster 1 has a higher number of keywords, making this the most centralized field. Then, the terms present in this cluster have more attention in the mask field.

The social network map of the co-occurrence matrix (Fig. 2) reflects the frequency of keywords based on the size of the node: the larger the size, the greater the frequency, whereas the thickness of the line reflects the proximity of connection between the keywords (25). According to Fig. 2, the utility model, respirator, mask main body, and node have the highest frequency of keywords, and it can be explained due to the thickness of the line, in the same way as other terms like protective mask, fabric, filter layer, mouth, particle that also have a connection, despite being weaker.

Due to the pandemic situation that the word has been lived, the deposit of patents about masks has grown, as can be seen in the last year, because of the COVID-19 and the recommendations by policies public to wear masks, among the population, to decrease the spread of the virus. In addition, the use of masks has become mandatory as a requirement to circulate in public environments and even to attend trade. The peak of publications was reached in April 2020, with 86 deposits, which fit in the selected requirements. In addition, it can be seen that since January 2020, when COVID-19 became a pandemic, the number of patent filings has increased every month. However, according to Fig. 3,

there was a huge decline in the publications in May, with only two patents, probably this happened because the patents still have been in the publishing process and therefore should not be available for analysis.

Furthermore, according to Fig. 4, most of the patents analyzed belong to countries as China and Korea with 338 and 110 of 563 patents, respectively. Interestingly, masks have always been a hot item in China. They are used not only to prevent the transmission of viruses amid infections, such as influenza, but also to protect themselves from pollution and this may explain the high number of patents filed in that country. Japan and the USA follow those countries with 58 and 21 publications, respectively. Thus, culturally, these are the countries that most file patents. Also, the large number of patents is concentrated in countries on the Asian continent, probably because the coronavirus started there and the first attempts to decrease the spread of the disease, and most of these countries already used masks on a daily basis. It is possible to observe that the countries with the highest patent filings in the last year were the ones that most managed to control the spread of the virus.

Besides the countries, the patents were also classified and divided according to the applicants. The industry is the biggest applicant, with 309 patents about the masks, followed by 161 patents with the type of applicant as an independent inventor (Fig. 5). The high number of patents by the industry was expected because the industry tried to create products and alternatives to experience the pandemic. The industry

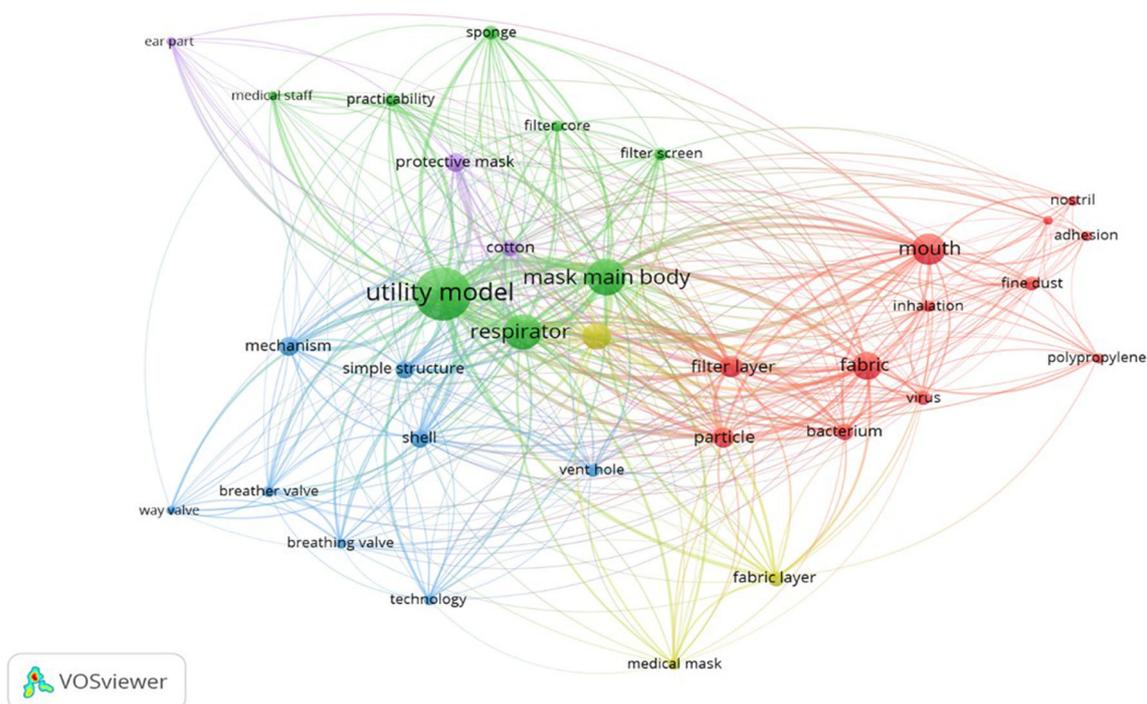


Fig. 2. Social network map of the co-occurrence matrix about masks

has many mask types on the market, such as protective masks, in this case the N95 and non-woven masks using plastic variants such as polypropylene in order to use different raw materials. Therefore, because of the demand, companies have been increasing their manufacture and exportation, such as Honeywell, 3M, Moldex, Kimberly Clark, Uvex, KOWA, and SAS Safety Corp. (26). The filing of patents by independent inventors may be related to people looking for new business opportunities in the midst of the crisis. Moreover, the hospitals/medical centers and the university had filled patents, due to the demand for personal protection in the COVID-19 decrease spread.

The IPC is a patent classification system internationally recognized as a tool that helps search for data related to patents, thus facilitating access to the technological and legal information contained therein. The IPC is composed of letters and numbers, and it is divided into sections, classes, sub-classes, and groups (27). Thus, the patents searched about the masks mostly classified into the A41D, related to outdoor, protective garments, and accessories. Specifically, the classification that appears the most is A41D13/11, with 562 patents, according to Fig. 6, which is about protective face masks, such as for surgical use or for use in foul atmospheres. However, other classifications were found also, such as A62B,

being that the patents are classified into devices, apparatus, or methods for life saving, including the subclassifications A62B18/02, with 148 patents and related to masks, or A62B23/02, with 76 documents, being about respirators.

Patented Masks for Dust and Particles

Face masks act as a basic measure of effective non-pharmaceutical intervention in the prevention of infectious respiratory diseases, helping to reduce the risk of infection. Basically, the mask represents a mouth and nose protection device that minimizes the direct transmission of infectious agents and dust. Among the main types of devices frequently found included surgical masks, medical disposable, and respirators with or without valve (28).

In this context, surgical masks must perform well in the capacity of bacterial filtration and pressure resistance to splash. In addition to being aimed mainly at health professionals in situations of patients with respiratory diseases, while the N95 respiratory protection masks are indicated for user protection. However, its use provides respiratory resistance and thermal discomfort on the part of users. Evidence indicates that personal protective equipment maintains its protection when used for longer periods. However, its use for

Table I. Patent Clusters on Masks

Cluster	Number of keywords	Keywords
1	12	Adhesion; bacterium; fabric; filter layer; fine dust; inhalation; mask main portion; mouth; nostril; particle; polypropylene; virus
2	8	Filter core; filter screen; mask main body; medical staff; practicability; respirator; sponge; utility model
3	8	Breather valve; breathing valve; mechanism; shell; simple structure; technology; vent hole; way valve
4	3	Cloth; fabric layer; medical mask
5	3	Cotton; ear part protective mask

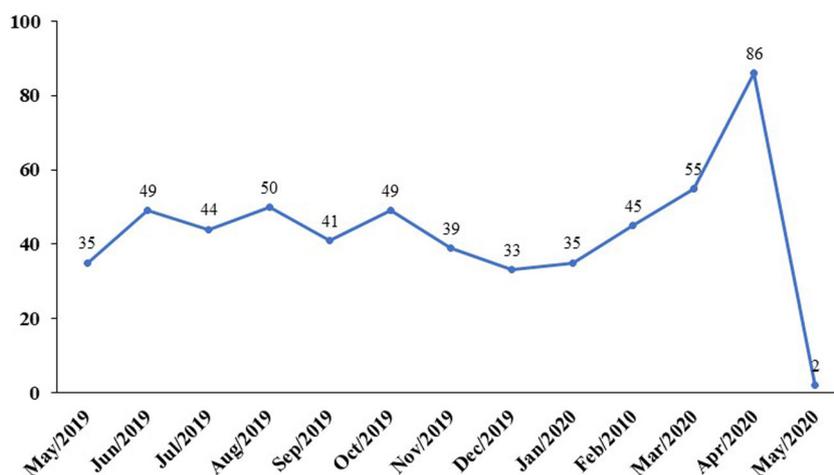


Fig. 3. Patent publication number per period after final selection

more than 4 h can cause discomfort and should be avoided (29–31). This type can be classified based on its filter efficiency and face leak (32) (Table II).

In the present research, of the patents found directed to facial masks for protection against dust, particles, and microorganisms, some present different proposals for improving the use of these devices. The CN209185788U invention discloses an adjustable mask containing length adjustment buckles of the ear supports containing sweat-absorbing cotton chips (33). On the other hand, the utility model disclosed in the patent CN208987852U brings a wireless protection facial mask and with fixation support on both sides of the mask body (34). The invention seeks to replace the ear supports of traditional masks, providing attractiveness and comfort in the use of the device.

Masks designed to protect against smoke were also found. The utility model of the patent CN209047494U is an anti-smoking mask for the operating room (35). Composed of the mask body and a layer of non-woven fabric, thus due to the filter and fabric layer, smoke is blocked from entering the mouth and nose of the medical team. Similarly, patent

KR102031764B1 also discloses a protective mask against smoke, toxic gas, or fine dust (36). The created device also allows covering the user's eyes through an adhesive unit present on the external side of the mask edge.

On the other hand, the invention KR102058075B1 discloses a mask containing a filter that has a manganese catalyst (37). In addition to covering the user's nose and mouth, the device is able to filter fine materials and the manganese catalyst decomposes the ozone present in the inspired air. While the utility model discloses a protection mask against small particles by using a film of coconut fat, this material is used as a layer to capture dust and other particles and has a porous structure and porosity of 88% or more. In addition, it shows good performance in the aspects of dust capture and filtering, resistance to breathed air, adaptation to meteorological changes in the environment.

On the other hand, with a similar goal and different solution, the patent CN110623342A discloses a dustproof mask based on negative ions with the generation of sound energy (39). The device created has an anion generator that produces negative ions that prevent particles from entering

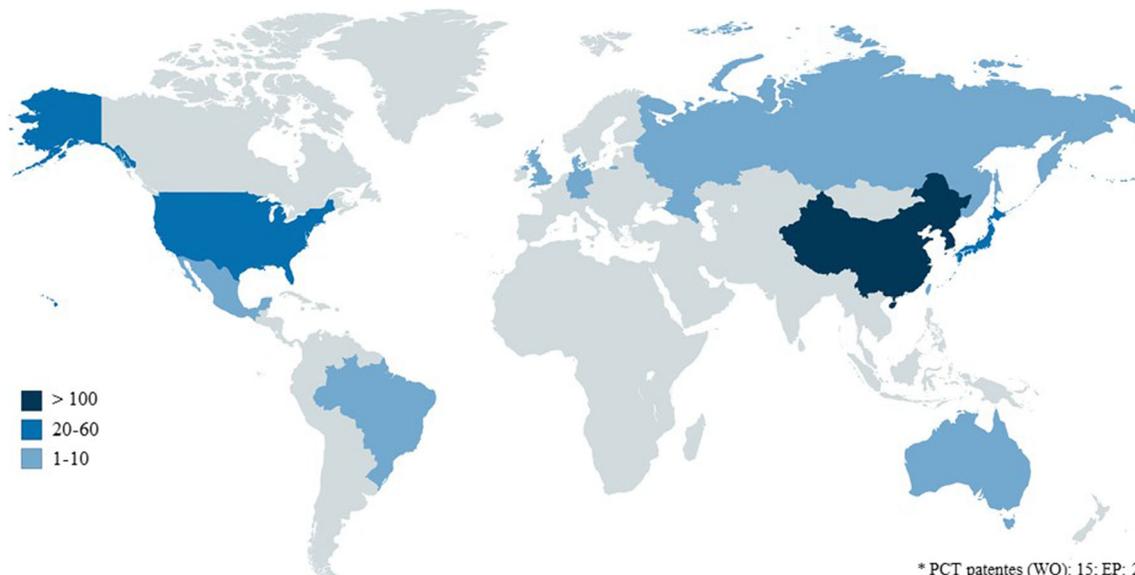


Fig. 4. Number of patent filings by countries

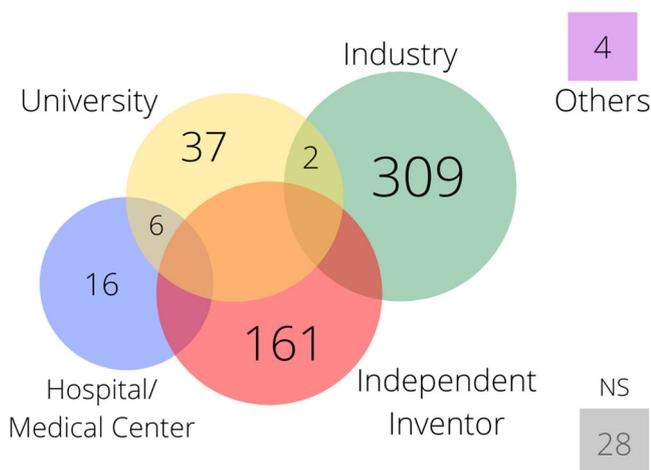


Fig. 5. Final selection of patents: type of applicant

the mask and reaching the user's airway. In addition, the model has an energy generator through captured noise, thus being able to supply energy to the mask, while in the AU2020100449A4 patent, the inventors disclose a model of a face mask with a removable filter (40). Thus, after removal and replacement with a new filter, the used filter is placed in the recycling bag. At the end of a week of using the mask, seven filters of different colors are inserted in the special recycling cylinder together with the mask to renew the filtering capacity of the devices.

Masks with Multiple Layers of Patented Filtration

The mask production should take some features in consideration, such as numbers of layers of fabric/tissue, because it can intervene in the capacity of filtration (42), the breathability of material used, water hydrophobic qualities,

and the shape and fit of the mask (43). The face masks can be produced using synthetic non-woven fabric; also, it is recommended that the mask has three layers: a layer of non-waterproof fabric, breathable fabric, and cotton fabric (44). The inner and outer layers are preferably made of non-woven polypropylene, which prevents moisture absorption by the mask due to the hydrophobic properties of the fabric. Meanwhile, the intermediate layers have a modacrylic support that conforms to the respirator and the non-woven polypropylene layer that captures unwanted particles. Table III exemplifies the main published patents on masks with multiple layers of filtration.

In this context, the patent CN20920202U addresses the invention of a multi-layer mask comprising the body, a first and second fixed connection pad, nose support, and the rear part of the mask body formed by an activated carbon fiber filter (45). The utility model disclosed is capable of filtering the air exhaled and inhaled by the user through the multiple layers that make up its structure. In addition, the inner layer of the filter can be replaced, which improves the flexibility of the use of the device. Similarly, the CN209995412U invention features a replaceable multi-module mask model. It consists of different layers of filter layers, a pair of soft pads, and a HEPA anti-fog filter layer (46).

Meanwhile, the patent JP6572409B1 discloses an adsorbent mask of fine dust containing elastomer gel that restores adhesion after washing with water, making it possible to use it several times, without compromising the quality of protection and filtering of the mask (47). The utility model revealed in patent CN210248482U features a sponge mask formed by several layers comprising a laminated layer of cotton cloth on the inside, a sterilization layer on the outside, and bamboo charcoal fiber on the outside of the sterilization layer (48). The device developed is characterized by the inventors as practical, easy to produce, a high degree of facial adhesion, ability to filter toxic dust and gases, and long service life. The

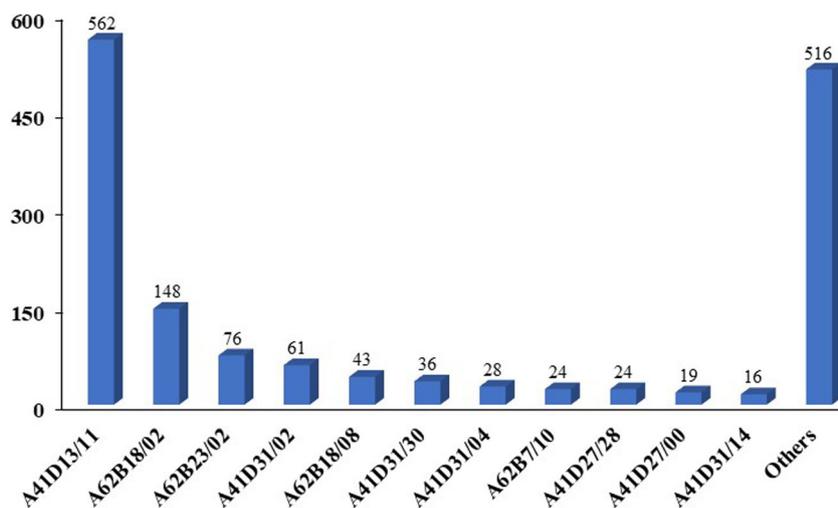


Fig. 6. Final selection of patents: IPC. A41D13/11: protective face masks, e.g., for surgical use, or for use in foul atmospheres; A62B18/02: masks; A62B23/02: for respirators; A41D31/02: layered materials; A62B18/08: component parts for gas-masks or gas-helmets, e.g., windows, straps, speech transmitters, signal devices; A41D31/30: antimicrobial, e.g., anti-bacteria; A41D31/04: characterized by special function or use; A62B7/10: with filter elements; A41D27/28: means for ventilation; A41D27/00: details of garments or of their making; A41D31/14: air permeable, i.e., capable of being penetrated by gases

Table II. Main Patents that Describe Masks for Dust and Particles

Title	Publication number	Country	Applicant type	Innovation	Reference
Adjustable mask	CN209185788U	CN	Independent Inventor	Adjustment buckles of the ear supports	(33)
Cordless protective mask structure	CN208987852U	CN	Independent Inventor	Adhesive mounting bracket	(34)
Anti-smoke mask for operating room	CN209047494U	CN	Independent Inventor	Anti-smoke	(35)
Mask set for protection from smoke	KR102031764B1	KR	Independent Inventor	Adhesive unit for eye, nose and mouth protection	(36)
Filter using Mn oxide catalyst and mask including the same	KR102058075B1	KR	Independent Inventor	Manganese catalyst for ozone decomposition	(37)
Coconut fat film dust-catching protective mask	CN210226990U	CN	Independent Inventor	Coconut fat film	(38)
Negative ion dustproof mask based on noise power generation	CN110623342A	CN	University	Negative ions and generation of sound energy	(39)
Replaceable filter medical mask with recovery	AU2020100449A4	AU	Independent Inventor	Removable filter and recycling bag	(40)
Replaceable charcoal masks	CN110811036 (A)	CN	Independent Inventor	Replaceable bamboo charcoal mask	(41)

CN209527924U invention discloses its protective mask with several layers composed of an activated carbon insulation filter, a layer of activated carbon cloth, and another layer of polypropylene composed of graphene with bacteriostatic properties, ending with an inner layer of non-woven polypropylene fabric (49).

With regard to the use of facial masks to protect against infectious diseases, the CN209965303U invention addresses a mask formed by multiple layers divided into an inner, middle, and outer surface layer (50). The outer layer is formed by non-woven fabric, the inner layer by non-woven polypropylene, and the intermediate layer with activated carbon and chitosan. These last two layers have the advantages of increasing the particle adsorption efficiency through the activated carbon filter and inhibiting bacterial activity due to chitosan. On the other hand, despite the several filtration layers present in the mask of the invention KR20200028741A, the presented utility model allows excellent air collection efficiency and low-pressure loss of 0.1 to 2.0 Pa (51).

The RU190961U1 invention discloses a filter mask composed of an inner, outer, and middle layer that contains a respiratory membrane valve on the side surface (52). The

inner and outer layers are made of knitted fabric and the intermediate layer is filled with activated carbon by three layers located between two layers of cushioning fabric. In order to increase filtration efficiency, HEPA filters are used to remove fine particles from the air. This filter is made using an electrostatically charged fibrous material. The use of the intermediate layer with two HEPA filters separated by a filter layer of different diameters provides maximum protection against the entry of ultrafine dust particles and allergens.

The CN208987851U invention discloses a protective mask composed of several layers of filtration of particles and pathogens (53). The mask body consists of the dustproof layer of non-woven fabric coated with paint and resin, the structural layer of breathable silicone rubber, and the first and second fiber layer made up of bamboo and carbon fiber fabric. These layers block and filter mainly the largest particles suspended in the air. Meanwhile, the intermediate filter layer is filled with activated carbon. Due to its porous structure, the use of activated carbon provides good preliminary adsorption and excellent impurity filtering effect. The various models developed by the inventors obtained excellent results related to the filtration of inorganic and bioorganic aerosols.

Table III. Main Patents that Describe Masks with Multiple Layers of Filtration

Title	Publication number	Country	Applicant type	Innovation	Reference
A mask for patient with infectious disease	CN209202202 (U)	CN	Independent Inventor	Replaceable filter inner layer	(45)
Replaceable multi-module mask	CN209995412 (U)	CN	Independent Inventor	Replaceable HEPA filter	(46)
Fine dust suction device	JP6572409 (B1)	JP	Independent Inventor	Elastomer gel	(47)
Sponge mask convenient to use	CN210248482 (U)	CN	Independent Inventor	Sterilization layer	(48)
Protective mask	CN209527924 (U)	CN	University	Multiple layers of filtration	(49)
Multi-layer composite mask for prevention of respiratory diseases	CN209965303 (U)	CN	University	Filtration layers with activated carbon and antimicrobial with chitosan.	(50)
Multi-layered filter element for mask and method of manufacturing the same	KR20200028741 (A)	KR	Independent Inventor	Low pressure loss	(51)
Carbon filter half mask with HEPA filter	RU190961 (U1)	RU	Independent Inventor	Carbon and HEPA filter	(52)
Medical mask capable of efficiently filtering aerosol	CN208987851 (U)	CN	Independent Inventor	Multiple layers of filtration	(53)

Patented Antimicrobial Masks

Although the various layers of air filters are able to block particles and dust efficiently, in addition to bacteria, fungi, and viruses in the air, these microorganisms can suffer adhesion to the filter surface and reproduce in these layers, representing a secondary risk of contamination. And, the presence and accumulation of these pathogens can compromise the volume of ventilation and quality of the filter due to its blockage. Thus, the presence of agents with antimicrobial properties in the air filter layers in masks is strongly desirable. Among the wide variety of agents are natural products, graphene and its derivatives, metal nanoparticles and metal oxide, and metal-organic structures with biocidal properties (54). Table IV presents the published patents for facial masks with antimicrobial properties.

The CN110541244A patent describes a method of preparing a mask containing a layer of non-woven fabric with antimicrobial properties (55). The bactericidal agent is polyoxymethylene biguanide, with low effective concentration, fast speed of action, a broad spectrum of sterilization, colorless, odorless, non-toxic, and without side effects. Its antimicrobial effect has the ability to kill gram-positive, gram-negative bacteria, fungi, and yeasts such as *Escherichia coli*, *Staphylococcus aureus*, *Candida albicans*, *Neisseria gonorrhoeae*. On the other hand, the KR20200006173A patent presents a mask having a disinfectant metal alloy, capable of filtering pathogens, microorganisms, dust, and fine particles (56). Thus, the inventors developed a mask that has as its main body a copper mesh with bactericidal properties against most pathogens and microorganisms, but harmless to humans. In addition, it has the ability to filter out dust and particles and is impermeable to water. The patent CN110432568A discloses the invention of an anti-infective mask that has in its structure a disinfectant package containing a disinfecting agent, chlorhexidine gluconate (57). Substance often used for disinfecting microorganisms (76). In the present invention, before using the mask, the user squeezes the disinfection package and inserts it into the device's respiratory cap. Thus, when exhaling or inhaling, the air passes through the disinfectant bag, which has a sterilizing effect.

In another selected patent, CN109898324A brings a mask of elastic absorbing antibacterial fabric (58). Its main composition is based on a mixture of ultrafine activated carbon fiber, blackberry fiber, viscose protein, milk, and regenerated graphene cellulose. The presented mask does not have antibacterial agents, but its superficial layer of tissue has an anti-adhesion effect on water, oil, and dirt, such factors make living conditions for microbial growth impossible. The CN209846208U invention discloses a bacteriostatic mask with the presence of silver ions sprayed under the double-layer fiber of the mask. The use of silver ion provides a long-term antibacterial effect, inhibiting the formation of bacteria, destroying cellular DNA, and preventing microbial multiplication (59). The inventors of the CN109760381A invention developed a fabric mask composed of an antibacterial double layer (60). The second layer containing fabric made of bamboo charcoal fiber provides a natural antibacterial coating against *Candida albicans*, *Staphylococcus aureus*, and *E. coli*. In comparison with wool fiber, bamboo charcoal

has a natural substance 'bamboo kun', in addition to an ultra-fine pore structure that allows strong adsorption and elimination of bad odor. The antibacterial effect of the agent is unparalleled with artificial chemical substances, in addition to being natural, durable, healthy, and environmentally friendly.

The CN209898346U invention discloses an anti-infection device for hospital use of a multi-layer mask, among them one with antibacterial property attributed to the layer of nano-silver fabric in its composition (61). When the mask is taken off, the first and second protective sheets are overlapped, the silica gel strip is folded, and the magnetic strips with opposite magnetic properties are close. Close to each other, the bacteria in the air are not to fall inside the mask, and the nano silver antibacterial non-woven layer in the closed space has a certain sterilization effect and good anti-infection effect.

Patent CN208972705U presents a technical solution for elderly patients with abnormal salivation and who need to use masks (62). The utility model has a model capable of quickly and effectively absorbing excess saliva produced by the user out of the mouth, while trying to keep it dry, without affecting the speech or the patient's breathing, as well as providing protection against the invasion of bacteria and protecting the health of the user. The mask has two layers of cotton and carbon fiber filter, a water absorbent layer composed of a sponge made of cotton, and two antibacterial layers. In the utility model provided by the patent CN210184567U, a mask is developed to prevent and treat diseases through a simple and three-layer structure (63). The layers of synthetic fiber, activated carbon, and cotton fiber provide filtration against particles and germs present in the air, in addition to having a layer of antibacterial filter soaked with an unspecified liquid disinfectant that disinfects the mask by exposure to the sun.

Another antibacterial protection mechanism is provided by the patent CN209331228U (64). The developed mask has several layers of non-woven fabrics; the number greater than three layers is enough to isolate most bacteria and dust, thus providing a bacteriostatic layer to the protection device. Like the patent CN110584240A, the developed mask has an antibacterial fabric based on graphene (65). The material obtained is made of porous graphene and fabric fibers. The created model has instant antibacterial capacity, better permeability, and mask temperature maintenance. Finally, the patent CN209420997U provides a mask-shaped anti-infection device that provides protection against external microorganisms that can infect the user, as well as preventing microorganisms exhaled by the patient from being released into the ambient air (66). The mask consists of layers of bamboo charcoal and an absorbent sponge block. These layers make it possible to absorb harmful substances and agents into the air during user exhalation and inhalation.

Patented Fabric Masks

Healthcare workers are essential to fight against the coronavirus during a pandemic (77); however, the real concern for medical staff, in this situation, is the shortage of the PPE, for frontline healthcare workers (77, 78). Due to the short supplies of medical masks, the manufacturing of homemade masks by the community increases (79).

Table IV. Patents that Describe Antimicrobial Masks

Title	Publication number	Country	Applicant type	Innovation	Reference
Antibacterial non-woven fabric, preparation method of antibacterial non-woven fabric and mask with antibacterial non-woven fabric	CN110541244A	CN	Independent inventor	Antibacterial non-woven	(55)
Cidal metal or cidal metal alloy mask	KR20200006173A	KR	Independent inventor	Copper mesh	(56)
Anti-infection breathing mask	CN110432568A	CN	Hospital/University	Disinfection package	(57)
Elastic and bacterial adsorbing and resisting mask fabric	CN109898324A	CN	Independent inventor	Anti-adhesion effect on water, oil, and dirt	(58)
Bacteriostatic and radiation-proof mask	CN209846208U	CN	University	Silver ion	(59)
Natural antibacterial double-layer composite fabric as well as female underpants and masks made of same	CN109760381A	CN	University	Bamboo charcoal fiber	(60)
Anti-infection device for hospital nursing	CN209898346U	CN	Hospital/University	Nano-silver	(61)
Medical mask for patient with saliva	CN208972705U	CN	Independent inventor	Saliva absorbent layer	(62)
Mask for preventing and treating diseases	CN210184567U	CN	Independent inventor	Liquid disinfectant	(63)
Medical mask for infectious disease department	CN209331228U	CN	Hospital	Layers of nonwoven fabric	(64)
Graphene antibacterial, breathable and warm-keeping mask	CN110584240A	CN	Independent inventor	Antibacterial graphene fabric	(65)
Respiratory medicine patient anti-infection device	CN209420997U	CN	Hospital	Layers of bamboo charcoal	(66)
Postoperative anti-infection device based on interventional nursing	CN210329451U	CN	Hospital/University	Air sterilizer	(67)
Isolation device for preventing medical staff from infection for infectious disease department	CN109846114A	CN	Hospital/University	Nano-antibacterial gauze layer	(68)
Protective device for pneumology department clinician	CN210248480U	CN	Hospital	Disinfection ring	(69)
Antibacterial far infrared mask	CN210114069U	CN	Industry	Infrared	(70)
Efficient sterilization medical sanitary mask	CN110710746 (A)	CN	Independent inventor	Medical sanitary mask of efficient sterilization	(71)
Mask capable of maintaining respiratory tract moist	CN110250616 (A)	CN	Independent inventor	Mask capable of maintaining the respiratory tract moist	(72)
Modular mask convenient to combine	CN109924572 (A)	CN	University	Internal and external pressure difference principle, opening and closing of the mask are achieved	(73)
Novel protective mask for treating pneumoconiosis	CN210382755 (U)	CN	Hospital	Protective mask for treating pneumoconiosis	(74)
Nursing type anti-infection breathing mask structure based on pneumology department	CN209898340 (U)	CN	Hospital	High in filtering uniformity and good in filtering effect (activated carbon particles besides the filtering cotton)	(75)

It is recommended that fabric masks consist of three fabric layers: cotton, breathable, and non-waterproof fabric (44). However, the homemade masks provide inferior protection against respiratory disease (80) comparing with the medical masks in blocking emission of particles; meanwhile, these kinds of masks are more effective than no masking (81). The CN210143885 (U), CN109965405 (A), and CN209315009 (U) inventions described masks that used clothes as filter or woven, due to their beneficial characteristics, such as higher facilitating splicing, raise of the fitting the mouth and nose, and increase the used effect, production efficiency, product quality (Table V).

Layered fabric masks usually have empty spaces in the interlayer, which can compromise their effectiveness,

especially when dealing with extremely fine particles. Due to this, CN209171465U, CN210234280U, KR20190054934A, and CN210353324U are patents that use activated carbon to raise the filtering capacity of masks, since the activated carbon decreases the pore thickness (82, 88, 89, 93, 95). Another aspect to improve the capacity of filtration of the masks has been the addition of filters to block the invasion of dust particles, viruses, and bacteria. This development can be seen in the patents CN209521355U, KR102000730B1, and KR102082969B1 (91, 92, 94).

Thus, the patent CN110742339A described an anti-respiratory syncytial virus mask composed by a cotton inner core layer, which can block the particulate matter in the air and isolate the way of the virus into the body (83). However,

the invention indicated that the filter membrane only acts against large molecules of antiviral active substances. Regarding the effectiveness of these masks, a study evaluated the efficiency of filtration of different tissues in filtering particles. Among the evaluated fabrics, cotton presented the best performance. For example, 600 TPI (threads per inch) cotton presented average filtration efficiencies of 79% for particles smaller than 300 nm and 98.4% for particles in the range of 300 nm to 6 μm (96). The ability to filter through the correct use of masks has proven to be a good practice for dealing with the pandemic.

Some of the fabrics used in the production of the masks were cotton, nylon, and polypropylene, among others. Patents, such as CN209171467U, developed masks that use the three types of fabric layer, probably, to guarantee the replacement of the inner layer tilting and to improve the facial contact comfort, as well as increase the capacity of filtration and protect even more the user (84).

Patented Face Shield

During the coronavirus pandemic, the development of new strategies, beyond the masks, to protect the health works and people around the world has increased. Due to this, personal protective equipment (PPE), such as face shields, may promote an option in decreasing the spread of the virus, because of the barrier to the expelled fluid particles (97). A face shield provides a protection to the face area and related mucous membranes, such as eyes, nose, and lips. Most of that type of PPE is composed by a visor, frame, and suspension systems, using plastic as material (98). However, the face shields have not been used alone, needing other equipment to increase their safety, such as cap, mask, and goggle (99).

Besides that, the face shields demonstrate a higher efficacy of protection against larger particles, and in a long-term effect, they have less of protection, because the particles can be able to get in the equipment and accumulate over time, mainly the small particles (100). For this reason, new approaches have been developed, as seen in the patents KR102078959B1, KR102003183B1, CN111084443A, and KR20190143034A, in which new types of material are used, such as mesh-type woven fabric, glue solution layer, and surgical fabric, to increase security with the evaluation of the filtration capacity, improve the ventilation, and make the face shields more comfortable (Table VI).

The patent CN210054705U consisted on a face shield with a filter cloth. Due to the impact of the pandemic, many types of fabric that are not indicated to respiratory protection have been used (109). However, masks and other PPE made of cloth, generally, demonstrate a high level of particle penetration, proving their poor filtration performance (117). Therefore, the low protection of the cloth filter and failures in the barrier of the face shields can perform the protection, through synergisms, incorrectly. On the other hand, the patent US2019217032A1 described a face shield to inhibit the spread of microbes through coughing (105). Regarding the effectiveness of these face shields, a simulation study demonstrated that this PPE can reduce immediate viral exposure to influenza virus by 96%, after being worn by a health care worker within 18 inches of a cough (97).

Reusable PPE that allow long-term use by changing their filters are also ways to feed the lack of it, especially when it comes to the protection of health professionals (118). For that reason, patents, such as KR20200000754U, CN210248483U, and CN210203464U, described face shields able to reuse (108, 110, 115). However, these types of face shields should follow a series of procedures for their use, such as the correct way to take off the PPE, appropriate place for storage, methods of handling, and the correct sterilization (99).

Other patents, such as KR20200000394U and CN209315012U, described the improvement made in the inventions to reach high comfort for the user (103, 107). In the pandemic scenario, the time of use of the masks, mainly by health care workers, has increased in an exacerbated way. Due to the higher comfort, compared with regular surgical or cloth masks, the adoption of the face shields has improved (119). Consequently, the search for this type of PPE also increased and brought with it new innovations, as seen in the patents DE202020101712U1, KR20190126690A, CN210143881U, KR102000552B1, and CN209449709U (104, 106, 112, 114). These patents described innovations in the structure of the face shield, new combinations of approaches, and technologies that give to the PPE functions beyond the protection.

Patented Masks With Technologies Ultraviolet

Although the coronavirus remains on inanimate surfaces for up to 9 days, they can be inactivated through disinfection (118), such as vaporous hydrogen peroxide, ultraviolet germicidal irradiation, moist heat, dry heat, and ozone gas (120). Due to this capacity of disinfection, some patents have been seen using the ultraviolet (UV) germicidal technology, such as AU2020100228 (A4), TW202007419 (A), CN110856559 (A), CN210203464 (U), and KR20200030332 (A), which can improve the durability of the masks (121–124). The increase of the disinfection and reusable devices occurs due to the critical situation that the coronavirus pandemic provided; however, the PPE should be single-used device (125) (Table VII).

Moreover, the masks are considered the most applicable PPE to the routine care to decrease the transmission of acute respiratory infection (125). Thus, the high demand for masks also increased the level of technology and versatility employed in them (138). For example, as seen in the patent CN109797544 (A), which the mask is composed by an anti-ultraviolet fabric to improve the people's quality of life, due to constant exposure to sunlight, beyond the protection against virus and bacteria (126). Also, in the invention CN209527919 (U), besides the anti-UV factor, a shield sunlight is coupled to the mask, which can effectively isolate ultraviolet rays, that have a sunscreen effect and increase its functionality (127, 139). Inventions are also seen, such as US2019166935 (A1), that uses the anti-UV faction with ultra-micro-perforated filtering membrane to raise the filtration capacity (135). Thus, these masks are able to retain the virus and thus prevent transmission and consequently reduce the rates of infection growth.

The type of fabric used in the manufacturing of the masks is an important point to measure the filtration capacity and the level of effectiveness of this equipment, since the

Table V. Patents that Describe Fabric Masks

Title	Publication number	Country	Applicant type	Innovation	Reference
Anti-allergic non-woven fabric mask	CN209171465 (U)	CN	Industry	Anti-allergic non-woven fabric; activated carbon adsorption layer	(82)
Anti-respiratory syncytial virus mask and preparation method thereof	CN110742339 (A)	CN	University	Cotton cloth inner core layer; Forsythia flower extract	(83)
Anti-flu mask	CN209171467 (U)	CN	Hospital	Cotton, nylon, polypropylene	(84)
A mask of paper mulberry nonwoven fabric with an origami wrinkle	KR20190078254(A)	KR	University	Nonwoven fabric containing paper mulberry fiber and origami wrinkles	(85)
Cloth mask	CN210143885 (U)	CN	Independent inventor	Filter cloth	(86)
Convenient-to-splice filter material for face mask	CN109965405 (A)	CN	Industry	Woven cloth	(87)
Filtering protective fabric for mask	CN210234280 (U)	CN	Industry	All-cotton non-woven fabric, activated carbon fiber cloth, chitin non-woven fabric and natural bamboo fiber woven fabric	(88)
Liquid retaining non-woven fabric and face mask which includes said non-woven fabric	KR20190054934(A)	KR	Industry	Cellulose-based fiber; acrylonitrile-based fiber	(89)
Mask	CN209315009 (U)	CN	Industry	Filter cloth	(90)
Medical mask non-woven fabric	CN209521355 (U)	CN	Industry	Antibacterial filtering layer	(91)
Multi-layer knitted structure fabric with air layer using conductive copper material and integrated antibacterial mask using thereof	KR102000730 (B1)	KR	Industry	Antibacterial effect	(92)
Non-woven fabric mask with high sealing degree	CN210353324 (U)	CN	Industry	Activated carbon cloth layer;	(93)
Plasma processed mask for fine dust blocking	KR102082969 (B1)	KR	Independent inventor	Plasma-treated non-woven fabric; electrostatic filter layer; antibacterial and deodorized natural cotton fabric	(94)

ability to filter through the correct use of masks has proven to be a good practice for dealing with the pandemic (140). Due to this, CN208837139 (U) and CN209300308 (U) inventions provided a fluorescent and photocatalyst layer with nano silver and nano titanium dioxide silver particles, respectively, to guarantee the bacteriostatic function, considering that the nano silver presents a good bactericidal effect, besides that, the small particle size contributes to a stronger sterilization performance (131, 132, 141).

Other technologies reported the production of masks involving ultraviolet and light devices. The patents CN209284362 (U), KR102013744 (B1), US2019208843 (A1), CN109794005 (A), WO2019188199 (A1), and KR20190002982 (U) are described since lighting devices to a substrate capable of producing hydrogen without requiring a water supply device (128–130, 133, 136, 137). Thus, these inventions show that the masks are not only a protection device, nowadays, other technologies have been implemented in this PPE, increasing its functionality.

Patented Nanotechnology Masks

Some patents selected in our review describe protective masks associated with nanotechnology, with pore diameter in

the nanometer range, thus providing masks with high-efficiency filtration. Among the patents described in Table VIII, some masks are composed of a nanofiber filter layer. The nanofibers are formed from polymers such as polypropylene, polyethylene, polyethersulfone, and nylon (163).

Based on some inventions, we can mention a dust mask that is effectively blocking fine dust (145). The filter layer of this present invention is composed of two layers of mesh. There is a nanofiber layer between these layers, with the diameter of the fiber being smaller than the diameter of the mesh layers. The invention CN210353320 (U) also relates to a mask made of the nanofiber material and features efficient filtration for air dust (146). Another patent (KR20200028741 (A)) relates to a multilayer filter member composed of a nanofiber layer with an average diameter of 10 to 60 nm (51).

A graphene oxide-based nanofiber mask is also provided. The mask body consists of an outer and inner layer of non-woven fabric and a protective layer. In the test environment, the mask was able to achieve a removal efficiency greater than 99%. This high filtering efficiency may be related to the nanofibers' small diameter and the mask's large surface area. These characteristics can also contribute to good breathability and the possibility of removing inhalable particles from the air, thus ensuring users' health (159).

Table VI. Patents that Describe Face Shield

Title	Publication number	Country	Applicant type	Innovation	Reference
A face mask	KR102078959B1	KR	Independent inventor	Mesh-type woven fabric; changing filters	(101)
A face mask	KR102003183B1	KR	Independent inventor	Mesh fabric	(102)
A face mask	KR20200000394U	KR	Independent inventor	More comfortable fit	(103)
Occupational safety device	DE202020101712U1	DE	Independent inventor	Visor is attached to the spectacle frame on both sides	(104)
Cough mask assembly	US2019217032A1	US	Independent inventor	Spread of microbes through coughing	(105)
Double mask for face cover	KR20190126690A	KR	Independent inventor	Cap combined	(106)
Mask	CN209315012U	CN	Independent inventor	The body can be switched between the state of covering the face and the state of being away from the face	(107)
Protect face filter change mask	KR20200000754U	KR	Independent inventor	Prevents the detachment of the disposable filter	(108)
Veterinary medical practical anti-epidemic mask	CN210054705U	CN	Independent inventor	Filter cloth	(109)
Combined mask	CN210248483U	CN	Independent inventor	Repeated utilization	(110)
Facial mask, mask with facial mask, eyepiece and face shield	CN111084443A	CN	Independent inventor	Glue solution layer	(111)
Face-protecting transparent mask	CN210143881U	CN	Independent inventor	Rotary fastener and a windproof rope	(112)
Device for protecting face of patient	KR20190143034A	KR	University	Surgical fabric	(113)
Face shield and method for controlling the same	KR102000552B1	KR	University	Control unit controlling; vital sign monitor	(114)
Transparent mask with replaceable outer layer	CN210203464U	CN	University	Replaceable outer layer; ventilation device	(115)
A protection device for protecting face of operator	CN209449709U	CN	Hospital	Spectacle frame	(116)

Additionally, research led by Ambipar Group proposes the use of graphene oxide in the production of protective masks. The nanometric properties of graphene allow the retention of the Sars-CoV-2 virus. Thus, it is believed that the masks produced from this nanomaterial have effectiveness in preventing Covid-19 (164).

Other patents have been proposed with the association of nanotechnology and antibacterial activity, such as CN110584239 (A), KR20190080544 (A), and CN110743281 (A). In the latter, an antibacterial mask containing an air filter with nano silver wire was described. The nano silver wire had a diameter on the nanometer scale (10 to 100 nm) (152–154). Nano silver presents a good bactericidal effect; besides that, the small particle size contributes to a stronger sterilization performance (154).

The CN110250618A patent provides a general purpose mask composed of layers of non-woven fabric, layers of catalytic metal and antibacterial adsorption composite, and a nano-porous layer filter polymer with an average pore diameter in the range of 30 to 45 nm (160).

The porous antibacterial adsorption composite layer also has pores in the nanometer range and comprises activated carbon, polyquaternary ammonium salt, and film-forming agent. In this way, a membrane is formed with a dual function: antibacterial and capable of adsorbing odor and dust. Thus, the mask of the present invention can simultaneously act as anti-pollution and antibacterial.

Nanometric systems applied to fabrics, in general, increase their effectiveness and efficiency, but allied to this increases the cost of the final product. However, considering a disease with high transmission capacity and high lethality, the cost of the applied technology may not be as important; therefore, this type of technology is important in environments with a high viral load in hospital environments. In this context, masks produced with diameters in the nanometric range can be effective in protecting against the coronavirus since this virus has a size that is about 120 nm (16). Thus, these masks can retain the virus and thus prevent transmission and consequently reduce infection growth rates.

Patented Masks With Other Types of Technologies

The application of innovative technologies in the manufacture of facial masks is one of the main interests in situations of respiratory diseases. Inventions have been developed seeking to improve the functionality of masks in several ways. Below are some of the main innovations found in the search for this work (165). The patent CN110074486A discloses a mask capable of heating the inspired air to protect the skin from freezing and cracking due to the filter. It also prevents the user from inhaling dust, particles, and microorganisms. The device has a symmetrical gear on both sides with a fan drive shaft. When the user uses it, he must pull the

Table VII. Patents that Describe Ultraviolet Germicidal Technology

Title	Publication number	Country	Applicant type	Innovation	Reference
Anti-ultraviolet non-woven fabric mask and preparation method thereof	CN109797544 (A)	CN	Industry	Anti-ultraviolet non-woven fabric	(126)
Filter mask with UVC LED	AU2020100228 (A4)	AU	Industry	Germicidal and relatively inexpensive UVC LED	(121)
Mask	TW202007419 (A)	TW	Industry	Radiation that disables viruses and bacteria	(122)
Mask	KR20200030332 (A)	KR	Industry	UV blocking effect and antibacterial effect	(123)
Mask	CN209527919 (U)	CN	Industry	Shielding sunlight, anti-UV factor	(127)
Mask	CN209284362 (U)	CN	Industry	Solar element that generates electric energy	(128)
Mask and manufacturing method thereof	KR102013744 (B1)	KR	Industry	Light-transmissive flexible material and an ultraviolet blocking layer	(129)
Mask, and method for detecting adsorption capacity thereof	US2019208843 (A1)	USA	Industry	Photosensitive sensor being configured for sensing intensity of light	(130)
Medical mask	CN208837139 (U)	CN	Industry	Fluorescent layer; nano silver particles or nano zinc oxide	(131)
Medical mask structure	CN209300308 (U)	CN	Industry	Photocatalyst layer	(132)
Photoelectric mask	CN110856559 (A)	CN	Independent inventor	Semiconductor ultraviolet sterilization technology and a photocatalytic waste gas conversion technology	(124)
Protective mask	CN109794005 (A)	CN	Industry	Lighting device	(133)
Transparent mask with replaceable outer layer	CN210203464 (U)	CN	University	Ultraviolet lamp tube as a disinfection device	(134)
Sanitary mask	US2019166935 (A1)	USA	Industry	Anti-UV function	(135)
Substrate provided with photocatalytic particles, breathable sheet, and mask	WO2019188199 (A1)	WO	Industry	The substrate capable of producing hydrogen without requiring a water supply device	(136)
Yellow dust mask reacting ultraviolet rays	KR20190002982 (U)	KR	NS	The color of the mask changes according to the UV concentration	(137)

elastic cord to fix the mask on his face and activate the belt unit that rotates the fan blade. The filtered, heated air flows upwards between the cheeks and, depending on the designer, does not continue to flow upwards, affecting the line of sight (Table IX).

With a similar proposal, but with a simpler utility model, the patent CN209251806U features a self-heating mask. The device consists of the mask body formed by the inner and outer layer, a self-heating body, and ear hooks (167). The patent CN209436298U resembles the previous one but with some peculiarities (168). The utility model presented makes it possible to insert solid or liquid drugs in the storage box for treatment. When turned on, the heat generated by the heater promotes the volatilization of the medication so that the patient inhales properly, guaranteeing the total effect of the drug.

The patent CN110507019A discloses the invention of a mask that has a layer for storing water with atomizing foil and heating body (169). The water can be inserted through the cavity present in the tank and the temperature adjusted to provide a breath of fresh air, free of dust and microorganisms. To use the mask, the user must connect the device to an external battery using a USB power cable. Then turn on the switch to control the circuit board of the atomizing sheet responsible for heating. Then, insert the water into the storage tank and put the mask on your face. The patent CN210299621U also presents a similar utility model, with a heating layer generated by an internal lithium battery coupled to the protective layers of the mask, but without using a water reservoir (170).

Problems related to high humidity in the masks have also been solved in patent found. CN209202196U discloses a mask with a moisture absorption function (171). The model allows the water vapor present in the inspired and expired air to adsorb in the homogenizing tank present in the protection device. The invention allows the reduction of damage of use caused by excessive humidity of the air, as well as problems in users who use makeup. Some patents sought to provide users with adequate humidity in order to make the use of the device more comfortable. The patent CN208875444U has a humidification capsule for the air inhaled through the mask (172). The humidification layer consists of a sealed cloth bag permeable to air and filled with the water-absorbing layer. This layer can be formed of sponge, cotton linter, water-absorbent resin, or non-woven fabric layer, in addition to the addition of fragrances. In the same context, patent KR20190075275A provides a patch-type mask (173). The device seeks to protect the user against dust, and thanks to its model, it allows the addition of patches containing substances and aromas that will provide moisture and hydration to the nose and throat. The addition of a rubber magnet is also elucidated in order to filter metallic components contained in the atmosphere. The invention described in the patent CN210124340U discloses a mask that has a place for storing wet gauze to promote moisture and better control of breathing (174). The gauze used can be easily replaced; the limit of its use is indicated by discoloration through the reagent used in its composition. Thus, as the water evaporates, the reagent undergoes oxidation and changes the color of the gauze, indicating the need for exchange.

Table VIII. Patents that Describe Protective Masks Associated with Nanotechnology

Title	Publication number	Country	Applicant type	Innovation	Reference
Face mask and method of its production	WO2012097762 (A1)	WO	Industry	Filtering layer of polymer nanofibers	(142)
Mask	CN110167372 (A)	CN	Industry	Filter sheets include fibers having a fiber diameter on the nanometer scale	(143)
Mask filter and face mask	JP2019199668 (A)	JP	Industry	Filter medium containing nanofibers	(144)
Dustproof mask	KR102014731 (B1)	KR	Industry	Nanofiber layer	(145)
Multi-layered filter element for mask and method of manufacturing the same	KR20200028741 (A)	KR	Independent inventor	Nanofiber layer	(51)
Nanofiber mask with efficient filtering function	CN210353320 (U)	CN	Industry	Nanofiber mask	(146)
Non-woven fabric for masks and masks	JP3221348 (U)	JP	Industry	Nanofiber mask	(147)
Electrostatic spinning nanofiber mask	CN210094734 (U)	CN	Independent inventor	Electrostatic spinning nanofiber mask	(148)
Mask sheet and mask	JP2020002483 (A)	JP	Industry	Fibrous cellulose (fiber width of 1000 nm or less)	(149)
Nanometer silver-loaded titanium dioxide mask	CN109757809 (A)	CN	Industry	Nanometer mask silver-loaded titanium dioxide	(150)
Multi-functional mask and preparation method thereof	CN109797442 (A)	CN	University	Carbon doped nano titanium dioxide	(151)
Antibacterial mask and manufacturing method thereof	CN110584239 (A)	CN	Industry	Antibacterial mask (prepared by taking an inorganic nano-antibacterial material)	(152)
Antibacterial mask with providing vibration isolation	KR20190080544 (A)	KR	Independent inventor	Antimicrobial mask with an anti-vibration function (nanofiber with an enhanced anti-vibration function)	(153)
Nano silver wire air filtering screen, antibacterial mask and production method	CN110743281 (A)	CN	Industry	Antibacterial mask with nano silver wire filtering membrane	(154)
Nano carbon mask	CN208925292 (U)	CN	School	Nanometer carbon mask	(155)
Superfine fiber mask	CN210382754 (U)	CN	Industry	Superfine fiber mask	(156)
The invention discloses a nano negative ion powder environment-friendly mask	CN208891751 (U)	CN	Industry	Environment-friendly mask a nanometer negative ion powder	(157)
Anti-pollution filtering face mask	WO2019110895 (A1)	WO	Industry	Resilient water-repellent textile material (micro-repellent three-dimensional mesh)	(158)
Graphene oxide-based nanofiber mask	CN209436296 (U)	CN	Industry	Graphene oxide based nanofiber mask	(159)
General-type mask	CN110250618 (A)	CN	Independent inventor	Nanoporous filter polymer layer	(160)
Removable fine dust mask for keep warm	KR20190092977 (A)	KR	Independent inventor	Ultrafine particle mask	(161)
Nano thin film mask	KR20190002899 (U)	KR	NS	Nano thin film mask	(162)

The application of existing and innovative technologies to the field of facial masks has grown. Due to the current pandemic, more technological models have been manufactured to improve the functionality of the masks. Among this, there is the addition of materials with body temperature sensors to assist in the identification of contaminated individuals. Models of surgical masks have already been patented using thermochromic materials that change their color due to the increase in temperature, such as the US2019125011A patent (176). The use of temperature-sensitive dyes causes a color change in the masks at a temperature of 32–33°C, with an interval of change of 1°C in temperature (165). Among the patents found, CN109832692A discloses a mask capable of measuring the user's body temperature. The device contains a specific opening for the insertion of the temperature measuring device when the user wears the mask.

Other innovative devices were also found in the search. CN110652663A discloses a mask containing a speaker to amplify the sound emitted by the user (177). On the other hand, the CN111067165A invention provides a mask model with a system capable of identifying the type of material aspirated and present in the air (178). When using the mask, the particle sensor collects the content present in the open air that is processed by the controller and sends information about the particle content to the display device. Another innovative utility model found is disclosed by patent CN210169119U. The invention brings a comfortable mask to be used with the presence of an intelligent device with a Bluetooth headset. The model also allows you to store the headset in the mask when the user is not using it (179).

Masks designed for children seek to provide quality, comfort, and safety for users. The patent CN209436293U

Table IX. Patents that Describe Other Types of Technologies

Title	Publication number	Country	Applicant type	Innovation	Reference
Mask with air heating function	CN110074486 (A)	CN	Industry	Air heating function	(166)
Self-heating mask	CN209251806 (U)	CN	Industry	Self-heating	(167)
Steam mask with heating function	CN209436298 (U)	CN	Industry	Medicine storage box	(168)
Wearable outdoor mask with heating and atomizing functions	CN110507019 (A)	CN	Industry	Heating and atomizing functions	(169)
Mouth and nose mask	CN210299621 (U)	CN	Industry	Heating mask	(170)
Mask with moisture absorption function	CN209202196 (U)	CN	Industry	Moisture absorption	(171)
Mask	CN208875444 (U)	CN	Industry	Humidifier bag	(172)
Patch insertion type mask	KR20190075275 (A)	KR	Industry	Humidification and hydration with patch	(173)
Breathing and humidity control mask	CN210124340 (U)	CN	Hospital	Humidification with wet gauze	(174)
Mask with temperature measuring function	CN109832692 (A)	CN	Independent Inventor	Temperature measuring	(175)
Temperature sensitive surgical face mask for identifying at risk patients and reducing viral infection	US2019125011 (A)	US	University	Thermochromatic material to indicate fever	(176)
Respiratory protection device	CN110652663 (A)	CN	Industry	Speaker	(177)
Mask	CN111067165 (A)	CN	Industry	Particle sensor	(178)
Intelligent wearable device	CN210169119 (U)	CN	Industry	Bluetooth headset	(179)
Children infection protection mask	CN209436293 (U)	CN	Industry	Disinfection, temperature, humidity and air quality meter	(180)
Mask with air detection device	CN208821772 (U)	CN	Independent Inventor	Air quality detector	(181)
Mask capable of detecting breathing signals in real time	CN209420996 (U)	CN	University	Detects respiratory signs	(182)
Mask for blending anti-tumor drugs	CN209135524 (U)	CN	Hospital	Handling anti-tumor drugs	(183)
Multifunctional intelligent control mask	CN210299624 (U)	CN	University	Speaker	(184)
Self-cleaning foam filter membrane mask capable of being used for long time	CN110897232 (A)	CN	University	Self-cleaning foam	(185)
Capsule mask and preparation method thereof	KR102002108 (B1)	KR	University	Capsule mask	(186)
Disposable mask with smile-mouth shaped containing cavity	CN210169120 (U)	CN	Hospital	Smile-mouth-shaped	(187)
Medical mask	CN109744613 (A)	CN	Industry	Air exhaust pipe	(188)
A pollution mask and control method	EP3630247 (A1)	EP	Industry	Pressure monitoring	(189)
Intelligent detection mask	CN110101146 (A)	CN	Industry	Environmental monitoring	(190)
Smart mask	KR20200032827 (A)	KR	Industry	Coolness and comfort	(191)
Electric respirator	WO2020057602 (A1)	CN	Independent Inventor	Electric respirator	(192)
Global warming prevention traffic safety mask for nasal fossa extension, nasal meatus closing, bacteria-prevention, fogging-prevention and clear word utterance	JP2019173206 (A)	JP	Independent Inventor	Fogging-prevention of glasses, clearly conveys words to a speaker	(193)
Scented pleated face mask	US10486001 (B1)	US	Independent Inventor	Scented mask	(194)
Smart mask	KR102030473 (B1)	KR	Independent Inventor	Automatic control of air intake and exhaust	(195)
Mask with built-in humidifying gauze	CN210203461 (U)	CN	Independent Inventor	Humidifying gauze	(196)
Liquid mask paste and anti-haze antibacterial mask	CN110041764 (A)	CN	Independent Inventor	Anti-haze	(197)
Epidemic prevention mask	CN210226988 (U)	CN	Independent Inventor	Microchip	(198)
Mask-type nasal cannula	US2019262570 (A1)	US	University	Nasal cannula	(199)
Temperature control ventilation mask	CN210299626 (U)	CN	University	Temperature control	(200)
The invention discloses a multifunctional mask capable of containing stomach tubes	CN208896595 (U)	CN	University	Containing stomach tubes	(201)
Air purification mask	CN210076640 (U)	CN	University	Electronic one-way valve	(202)
	CN110754720 (A)	CN	University		(203)

Table IX. (continued)

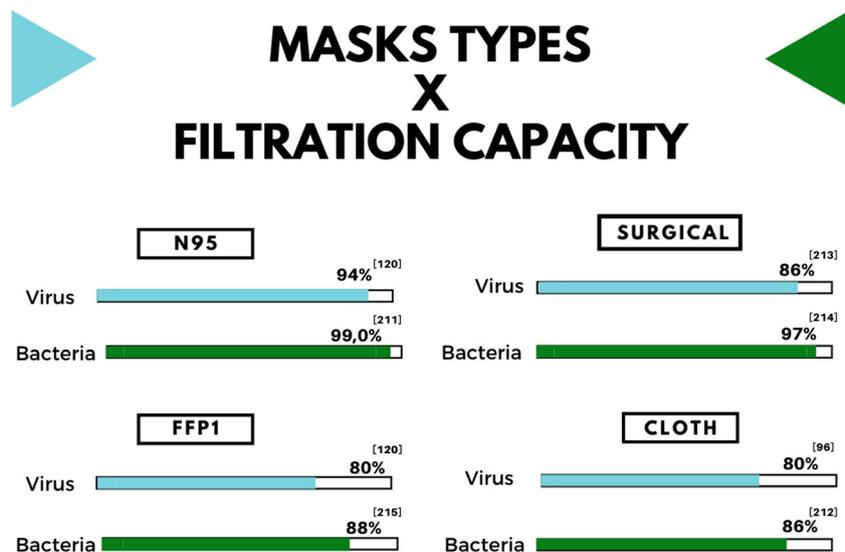
Title	Publication number	Country	Applicant type	Innovation	Reference
Dehumidification self heating active aluminum oxide three-dimensional mask				Dehumidification self heating active aluminum oxide	
Noise insulation protective mask	CN209121337 (U)	CN	Hospital	Noise insulation	(204)
Nursing mask	CN210382749 (U)	CN	University	Greater fixation on the face	(205)
Mask with replaceable filter element	CN210143888 (U)	CN	University	Replaceable filter	(206)
Adhesive onetouch wet fire evacuation mask	KR101995860 (B1)	KR	Industry	Adhesive mask	(207)
Mask for protecting ear facial nerves	CN210043237 (U)	CN	Hospital	Protecting ear	(208)
Tightness-adjustable mask	CN208821774 (U)	CN	Hospital	Tightness-adjustable	(209)

discloses a protective device for childhood infection formed by the mask body and two ear hooks (180), and also composed of a cylinder, a disinfection mechanism, fan, temperature sensor, humidity, air quality, and a controller. The mask body is made of UV-resistant fabric. The disinfection mechanism is formed by an ultraviolet sterilization lamp present in the cylinder located in the two circular filters, while the controller displays data on temperature, humidity, and quality of the air collected outside the mask. For the same purpose, the CN208821772U invention also provides a mask containing an air detection device (181). The item consists of a body made of activated carbon filters, circuit board, battery, detection sensor, and data display screen.

Other technologies applied to facial masks sought to detect respiratory signals in real time in their users. The utility model provided by the patent CN209420996U features a mask with body, humidity sensor, and signal processor (182). The device is capable of detecting changes in humidity around the nasal and oral cavity caused by breathing in real time. The invention has great relevance due to the fact that it obtains information regarding depth, frequency, and respiratory arrest, while the patent CN209135524U seeks to solve the problems related to the manipulation of anti-tumor drugs by health professionals (183). Because these substances irritate the eyes when

manipulated, the utility model features a face mask to promote comfort and safety. The mask replaces the protective glasses with transparent sheets, solving the problem of discomfort. The device also has an exhalation valve to discharge the exhaled hot and humid air, preventing fogging of the transparent eye film.

A multifunctional smart mask was developed by the invention CN210299624U (184). The patent seeks to solve problems of bad air flow, high concentration of carbon dioxide, bacterial growth, and obstructed speech of the user. The device presented provides a ventilation module and valve to improve the flow of air in the mask and to introduce fresh air with reduced levels of carbon dioxide and bacteria. In addition to a loudspeaker to collect the sound produced, amplify and transmit it. As a way of solving problems related to low filtration efficiency, reduced filtration resistance, and multi-layered filtration efficiency over time, the CN110897232A invention discloses a mask model with a self-cleaning foam filter (185). It is formed by two layers, each of foam is on the outside and the filter on the inside. The thickness of the first is 20 mm, filled with plastic foam particles with a diameter of 0.5–1 mm, as polystyrene, polyurethane, and polypropylene foam particles are used, while the filter layer is composed of electrostatic cotton, polypropylene fibers with nanometer

**Fig. 7.** Different types of masks and their filtration capacity for virus and bacteria

diameter, and non-woven fabric. When used by the user, the inhaled air enters the foam layer of the mask, which moves the particles towards the filter layer. Static electricity is generated by the friction between the plastic foam particles and the air. Thus, the dielectric particles in the air attract and remove static electricity. These charged particles move until they are trapped in the filter layer.

In another context, seeking to solve problems related to the volume of masks to be used in emergency situations such as fires, the patent KR102002108B1 discloses a utility model as a technical solution (186). The mask produced is reduced in volume in the form of a capsule, and when wetted with a liquid, it expands and the mask is unfolded in a state in which the liquid is absorbed. The mask body capable of absorbing the liquid is made of at least moldable polyethylene, polypropylene, nylon, or cotton. In the current pandemic situation, the use of masks to protect individuals and medical staff is critical against airborne infectious respiratory diseases. However, the use of such equipment ends up covering the face of health professionals when taking care of their patients, making care uncomfortable. Thus, the CN210169120U invention seeks to solve this problem with a disposable mask with smiling mouth-shaped cavities. In this way, patients feel cordial, lessen the patient's anxiety and pain (187). Its composition consists of an outer layer of non-woven fabric, an activated carbon adsorption layer, a bacteriostatic layer, and an inner layer of non-woven fabric.

As mentioned before, the masks are considered the most applicable PPE to the routine care to decrease the transmission of acute respiratory infection (138). In this context, based on some studies, the Fig. 7 shows some types of masks and their filtering efficiency. The masks most commonly used are cloth masks and surgical masks (210); however, the filtering efficiency of both is not as effective as the N95 respirator (211), which is 94% (120) for virus and almost 100% for bacteria (211). The cloth masks are less effective due to the protective barrier against pathogens, which is 80% for viruses smaller than 300 nm (96), and to bacteria, the cloth masks only block 86% (212). The surgical masks have a filtration capacity of 86% (213) for viruses and 97% for bacteria (214). On the other hand, the FFP1 respirators have a barrier of 80% against the viruses (120) and 88% against the bacteria (215). The penetration of particles through the masks is measured using an appropriate flow rate and an aerosol simulating the particle size mostly with a neutralized polydisperse sodium chloride (216).

The WHO and UNICEF recently issued advice on the use of children's masks in the community in the context of COVID-19 (217). In this recommendation, the mandatory use or not of masks is according to the child's age group. In countries or areas where there is intense community transmission of SARS-CoV-2 and in places where physical distance cannot be achieved, WHO and UNICEF advise to apply the following criteria for the use of masks in common area environments, including schools: (i) masks for children aged 5 and under are not mandatory; (ii) for children between 6 and 11 years of age, a risk and benefit-based approach should be applied to the decision to wear a mask. This approach suggests taking into account factors such as the intensity of transmission of the virus in the area where the child is

attending, social and cultural environment, the child's ability to use the mask properly, the potential impact of the use of the mask on learning, among others (217). (iii) For children and adolescents aged 12 and over, national adult mask guidelines should be followed.

CONCLUSION

The SARS-CoV-2 has been considered the most devastating global event in modern medicine. The disease became a pandemic due to the fast transmission of the virus, which can happen close person-to-person contact, aerosol transmission, and transmission by touch, also by respiratory droplets during coughing or sneezing. The PPE and safety protocols are recommendations implemented to slow the virus spread. In this scenario, the masks are the main way to reduce infection risk, as already seen in other situations involving respiratory diseases, which can serve as reference of how to act in these circumstances. However, in a pandemic scenario, the lack of these apparatus can occur, mainly to the health workers that have been in the frontline against the coronavirus disease which led to an increase in the production of patents in this context in the last year. Thus, to decrease the lack of masks and PPE, disinfection is an alternative, which can use vaporous hydrogen peroxide, ultraviolet germicidal irradiation, moist heat, dry heat, and, ozone gas. Moreover, there are a lot of kinds of masks used as protection, such as N95 masks, medical masks, and homemade masks. Therefore, the development of masks has been increasing and other materials are being used, such as cotton, nylon, silver fiber fabrics, polypropylene, among others in order to create alternatives to face the crisis. Also, technologies, such as nanotechnology, have been included to raise the filtration capacity and the ability to retain the virus of the masks, because the efficiency of filtration in the masks depends on the filter characteristics and the pore size.

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COMPLIANCE WITH ETHICAL STANDARDS

Conflict of Interest The authors declare that they have no conflict of interest.

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