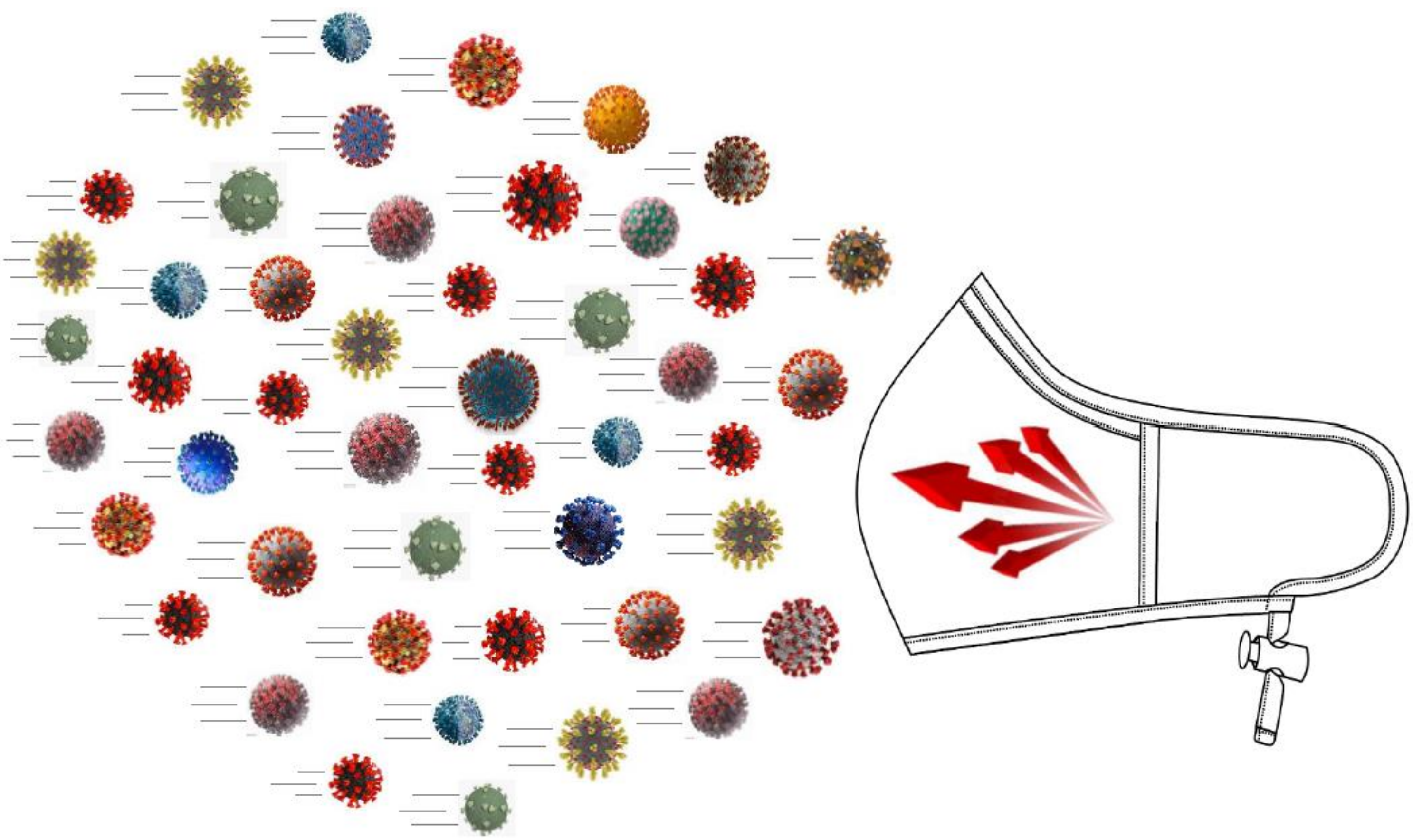
The Definitive Employer Guide to Purchasing Face Masks

for Your Valuable Employees

A clever person solves a problem.
A wise person avoids it.
— *Albert Einstein*



The **TPA NETWORK Research Consortium** is an emerging industry-wide research initiative to help health plan sponsors evaluate new medical technologies and health innovations …by conducting much needed payor-focused translational research and facilitating more, smarter and less costly clinical studies. Learn more at www.ResearchConsortium.org

Table of Contents

About the Author – Richard L. Nicholas

A seasoned industry veteran having four decades of C-suite experience in the self-funded, managed care and outsourcing sectors, Richard Nicholas has owned and held executive positions with national TPAs, BPOs and MCOs; represented more than 200 TPAs before the U.S. Congress and been trusted (with his long-time partner, Nick Cole) to facilitate more TPA mergers and acquisitions than anyone. He recently founded the TPA Network Research Consortium, a new industry-wide research initiative aimed at helping healthplan sponsors evaluate new medical technologies and health innovations by conducting payor-focused translational research and facilitating more, smarter and less costly clinical studies. An innovator, author and newly-minted social entrepreneur, Richard holds a BA *with distinction* from Boston College and an MBA from Duke University's Fuqua Graduate School of Business. To learn more see www.ResearchConsortium.org

The Need for, and Purpose of, this Document

The *Centers for Disease Control and Prevention* issued guidelines for wearing face masks in public in an effort to help slow the spread of COVID-19; recommending that everyone, sick or not, cover his/her face with fabric. Subsequently many states, cities and municipalities are not only *requesting* the use of a mask when outdoors, they're *requiring* employers to provide them to their employees, especially those who are public facing.

While these efforts are well-intended, the author is not convinced that they are adequate, owing in great part to misconceptions that many have on the way COVID-19 is transmitted; the insufficiency of most face masks to act as the first line of defense against the disease; and the risk that a false sense of security may create by providing a less than effective mask. This guide provides employers with all the information they need to feel confident about developing a face mask policy and making an informed buying decision that's right for them.

Unlike researchers, scientists and academics who enjoy the luxury of suspending judgment about the presence or absence of an effect when data is lacking or ambiguous, employers must make choices. Choices that are required to be made under conditions of uncertainty will surely be enhanced however if they are founded upon the best available evidence, even when that evidence may leave some unanswered questions. The information, data, insights and conclusions provided herein will help inform at least some of the choices that need to be made about face masks required to be furnished to employees during a hopefully once-in-a-lifetime pandemic.

More Than a Literature Review

Today, because information is everywhere, buyers are more determined than ever to make sure they find the right solution, select the right product or service and obtain the best deal. They conduct extensive web searches, read numerous articles and scour endless websites and internet ads often to find information that is far too technical, incorrect or so plentiful that it creates confusion. So that you don't have to wade through the plethora of information and data required to become knowledgeable enough to make such an important decision as selecting the right face mask to protect your valued employees, clients and customers, we've done it for you. The ***Definitive Employer Guide to Purchasing Face Masks for Your Valued Employees*** provides *all* of the information employers need to feel confident about making an informed buying decision that is right for them.

Information available on the web, as it relates to COVID-19 in general, and face masks in specific, is often chaotic, contradictory, incoherent, jumbled and irrelevant. It ranges from the pedestrian and glaringly obvious, to fiction and rumor, to jargon-filled scientific studies that are of no value to anyone lacking a PhD. This makes it very difficult for an "ordinary" researcher to develop the clear, accurate and complete understanding of these topics necessary for them to assuredly make the complicated and difficult decisions at hand.

Before reading this document understand that although it is not meant to be scholarly in nature, it's aim is to be thorough and present all of the current knowledge on the topic. Intended to be informative, critical and useful, it is focused on answering the question at hand by identifying, appraising, selecting and synthesizing all of the high-quality evidence and viewpoints relevant to the topic. In doing so, it evaluates and critically analyzes, in a balanced way, all of the relevant evidence on the subject from diverse sources and disciplines.

Despite its length, it is important to appreciate that an enormous quantity of information and data was reviewed, evaluated and synthesized to create this comparatively shorter document. Covering a wide range of subject matter at various levels of completeness and comprehensiveness, the discussions herein have been formatted to move from a broad and general appraisal to a more specific examination of the pertinent issues. Written with appropriate rigor, this survey was prepared by carefully reviewing all of the relevant literature including *more than 250* scientific studies and academic journal articles; conducting numerous consultations with subject experts (including physicians, university professors, scientists, researchers); phone interviews with chemical, textile and apparel manufacturers; and conversations with real world face-mask users having first-hand insights. All totaled, this documents represents nearly 600 man-hours of work.

Rather than a formal annotated bibliography, a simple list of 176 salient information sources is provided.

Summary Discussion

As organizations begin to open up for commerce in the midst of a once-in-a-lifetime global pandemic it is incumbent upon them to take all measures available to prepare and equip their workforces and workplaces in ways to manage this new type of exposure. Experienced managers are familiar with the time-proven ways to manage risk. These include acceptance, avoidance, transference, sharing, mitigation and elimination; ignoring risk is not one of them. Along these lines, it's worth noting Albert Einstein's admonition: "A clever person solves a problem. A wise person avoids it." This document's purpose it to help the reader do the latter.

Knowing that there is a great deal of confusion and misunderstanding about how easy COVID-19 is spread, this document begins with a thorough examination of its transmission. It is intended to impress upon the reader that, unless you live (and intend to remain) on a deserted island, it is not ***if*** you will be exposed to the virus, it is ***when*** and by ***how much***. As detailed herein, the reason for this is a matter of simple mathematics and science. Although it is able to be contracted from surfaces, COVID-19 is spread by coughing, sneezing, singing, talking and even breathing; each of which can provide an adequate viral dose. In part, this is because infected yet asymptomatic people carry viral loads as great as those who are very ill and a few infected "super spreaders" have been shown to account for most of the spread (for biological, genetic or behavioral reasons). Susceptibility to aerosol transmission is purely a matter of proximity to the spreader, air flow and timing. Infection occurs in- or outdoors; in crowded spaces and those just vacated by a spreader; often within minutes.

The ease and speed by which COVID-19 can be spread cannot be overstated: very simply, one diseased person can infect an entire office, shop, factory, school, restaurant or convention literally in short order, and numerous scientific studies bear this out. Active COVID-19 aerosolized particles can linger in a room long after an infected person leaves it; and, given the fact that a single sneeze can contain as many as 30,000 viral droplets – each having as a many as 200,000 aerosol particles – you don't need to be an MIT mathematician to figure out that one's chances of getting infected are fairly high in that it takes fewer than one thousands of those hundreds of millions of viral particulates to infect the typical person. This is why a single asymptomatic virus-positive person taking no (social distancing or mask wearing) precautions can infect 406 people within 30 days.

Social distancing, mask wearing and hand-washing are all methods intended to *minimize the amount* of virus a person will encounter; none will entirely *eliminate* viral exposure and one should not fall victim to the false sense of security created by believing they will. Apart from living on that uninhabited island, all experts agree that the single most effective measure that can be taken to reduce the spread is to wear a mask. It is important to understand however that (*with very few exceptions*) mask wearing is *not intended to protect the wearer* from incoming viral load exposure. While masks will insulate the wearer somewhat from a direct droplet hit, mask wearing is intended to reduce the volume of *outbound* infected pathogens placed into the air by the mask wearer thereby reducing the exposure of others in the wearer's (immediate or recent) vicinity to his/her viral release. The hypothesis is that if everyone wears a mask, the amount of viral content in the environment will be lessened and everyone's exposure to becoming infected will be reduced. It's a communal thing.

Understanding the above, COVID-19 presents many unique ethical, social and legal challenges for employers the majority of which fall outside of the scope of this document. That said, at the federal level, employers must be mindful of OSHA's "general duty" clause which requires them to provide for a safe and hazard-free workplace; realizing that there is no COVID-19 exception or holiday. And, let's not underestimate the good folks in Congress who live by the often hi-jacked phrase originated by the Italian Renaissance "diplomat" Niccolo Machiavelli: "Never let a good crisis go to waste". Taking that to heart, certain passed and pending legislation have, and seek to, codify new ways to transfer more and more risk to employers. Moreover, some states are following or anticipating Congresses lead by expanding employer workers' compensation risks (by legislative and executive fiat) by adding provisions whereby certain categories of workers who test positive for COVID-19 will be presumed to have become infected at work. Indeed, decades-old definitions, limitations and exclusions are being replaced with new and expanded constructs that have yet to be challenged. And, as if all of this weren't enough, plaintiff attorneys are piling on with a host of newly devised legal exposures ascribed to employers, and, many employers will soon find that their general liability insurance policies contain various negligence and public health exclusions that are not very easy to identify. Oy vey!

The reader may ask, "What does all of this have to do with face masks?" Fair question. In the context of this pandemic face masks are universally regarded as the means by which COVID-19 spread may be lessened. However, with our present knowledge of the ways by which virus droplets and aerosols spread, and that anyone can walk into a cloud of viral particulates left in the air by an infected person who is no longer in the vicinity, wearing a mask takes on an added purpose: to protect the wearer from being needlessly infected. Clearly, a person who walks into a viral cloud is better off if wearing a mask. Viewed from this perspective, the mask is a tool of sorts; an implement used to extend the ability of an individual to modify features of the surrounding environment; something that aids in accomplishing a task or purpose; an item that is used to carry out a particular function or achieve a goal. Regardless of what definition the reader prefers, a strong argument can be made that an employee face mask is a tool used to both 1) reduce viral spread and 2) protect the wearer from needlessly, and unwittingly, happening upon a viral cloud in an entirely vulnerable way. This should materially change the way that an employer views an employee face mask: it should be seen as a dual-purpose offensive and defensive tool, device…or piece of equipment…much like protective gloves, goggles or steel tipped shoes.

The question has been raised as to whether or not cloth face masks can or should be considered personal protective equipment (PPE) under OSHA and other similar regulations. Many regulatory compliance lawyers have postulated that cloth face masks, in various environments and under certain conditions, may actually be regarded as PPE. OSHA is not too clear on this issue. The theory is that a face mask is PPE if it is intended in any way to serve as a physical barrier between the wearer's mouth and nose and potential viral contaminants in the immediate environment. Given the shortage of N95 respirators and medical masks, hospitals, medical facilities and even the CDC have requested healthcare workers to wear cloth face masks to prevent patient viral splashes from making contact with the wearer's face. Given this, a strong argument may be made that employers that require their employees to wear a face mask at work, rather than simply allowing them to be worn on a voluntary basis, are essentially exercising a form of administrative control, ergo, the mask is PPE.

If, face masks are a form of PPE, the next question might be "Is any mask good enough?" Unless an employer wants to have that question answered in court by an administrative (or a criminal) judge, prudence dictates that it would be wise to consider the advice of yet another old wise man, Ben Franklin, who posited that "The bitterness of poor quality remains long after the sweetness of low price is forgotten". With consequences as grave as they can possibly be, in the context of COVID-19 where the community's health is at stake, the practical implications of an employer protecting his/her workforce requires that they consider more than their need to meet OSHA's general duty obligation to provide a safe worksite. Employers looking to mitigate their risk and be responsible corporate citizens must to do their homework to evidence that they take this matter seriously and take every measure within their means to provide the best available protection for their workforce. The good news is that the author has fulfilled the homework requirement: the reader, by taking the time to become familiar with its content, is taking a good first step in signaling their intent to do the right thing.

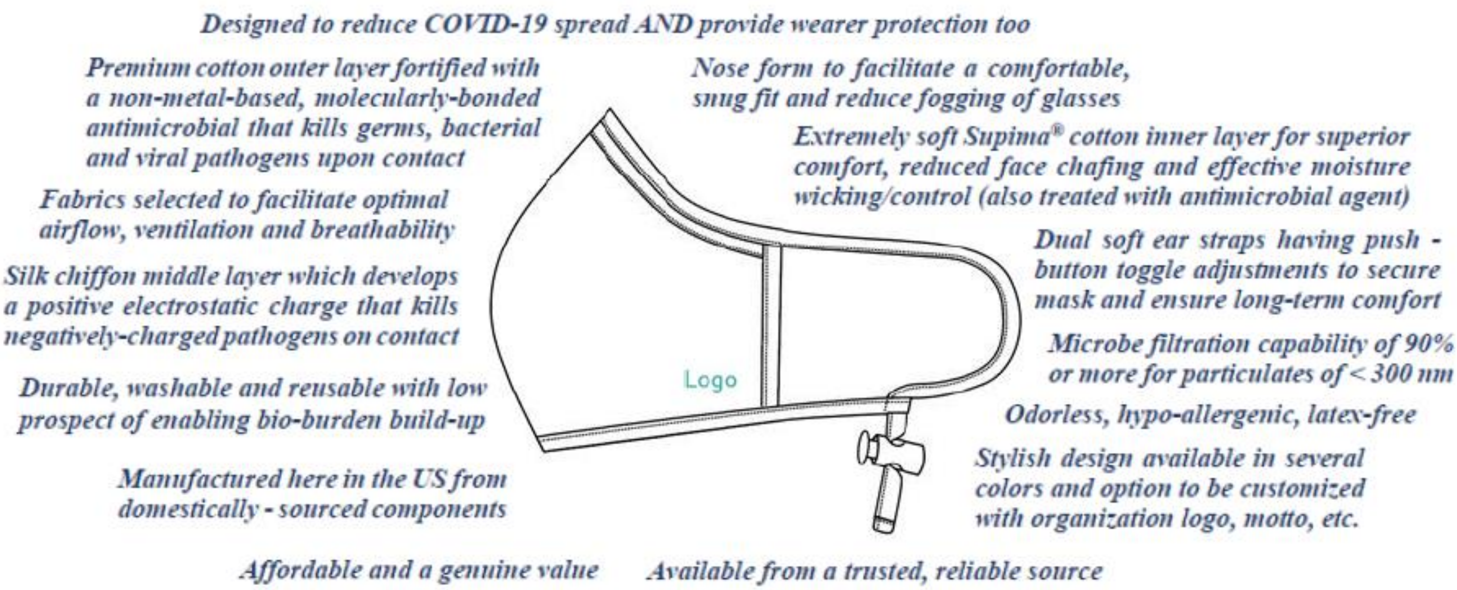
All face masks are not created equal. Their filtration efficiency, breathability, comfort and fit vary greatly owing to their purpose, design, component materials and any technology employed to inactivate viral pathogens. So too are their safety, durability, reliability and cost-of-use over time. To evaluate and assess the various construction types, textiles, fabrics, filtration methods, airflow levels, moisture control variables − and the safety and effectiveness of any types of antimicrobial methods employed to inactivate viral pathogens − the author relied exclusively on scientific evidence by authoritative sources from source documentation. Only complete, original research studies were referenced and relied upon; not abstracts or other people's summaries.

As detailed below, while many face masks may be *adequate* for reducing the volume of viral particles that exist the wearer's mouth, few commercially available masks offer any meaningful wearer protection. N95 respirators are difficult to breathe through. Medical masks fit too loosely. Polyester is a noxious product and enables COVID-19 to survive longer on it. Charcoal filters are unhealthy and don't filter coronavirus-size particles. Valved masks make no sense as they let unfiltered air in. Silver and copper antimicrobials pose a health risk and, like graphene (which is untested for mask applications) they wear off quickly. Masks without nose forms don't enable a snug fit and most ear pieces are unadjustable and uncomfortable. Well, what then?

Ideal Face Mask Characteristics

Despite the drawbacks of most commercial face masks, there is a design and way to construct an effective dual-purpose face mask. The illustration below describes the features that the author contends would together constitute the ideal face mask. Each of the attributes noted is discussed in detail herein and summarized below:

- Most cloth face masks are intended for use by non-medical wearers and designed only to mitigate the spread of COVID-19 by acting as an impediment to reduce the outbound transmission of infected droplets from the wearer to others. Constructed of two to three layers of polyester or cotton blend fabric, these barriers are typically not very effective at filtering inbound microbe-size particles or viral aerosols that are suspended in the air and, as such, they do little to protect the mask wearer from catching the disease.
- Moreover, pathogens like COVID-19 have been found to remain active on many surfaces for as long as seven days. In that traditional face masks, *at best*, serve to act as a barrier for viral particles, their outer layer becomes a petri dish that enables bio-burden build-up from which wearer infection may emanate.
- Two highly effective means exist by which cloth face masks can *protect the wearer* at levels that equal an N95 respirator. First, cotton masks having a silk chiffon inner layer develop a triboelectric charge that kills viral pathogens upon contact; N95s work similarly. Second, advanced antimicrobial agents that molecularly bond to a mask's *inner and outer* layer are also extremely effective at inactivating infectious agents. Together, these measures could protect the wearer at a level that matches or exceeds that of the N95 device and enable the mask to be (re)used safely and without the need for high-temperature washing.
- Studies show that a < 2% gap in a face mask's seal can reduce its protection effectiveness by half. A truly snug fit and seal can only be achieved with both a flexible nose form and adjustable ear loops.
- Comfort isn't a luxury with face masks; it's necessary to support longer wear and reduce dangerous hand-to-face adjustment. A soft Supima® cotton inner layer reduces face chafing and supports moisture control. Being odorless, hypo-allergenic and latex-free enables a mask to be worn by those with such sensitivities.
- Cotton and silk chiffon construction optimizes mask breathability and enables healthy, extended wear.
- Multiple colors appeal to style-conscious wearers; logo customization appeals to corporate promotors.
- Buying American not only supports our economy, national security and workforce, it symbolizes quality.
- Since there are all too many dishonest face mask sellers, sourcing from a reputable supplier is a must.
- The face mask should be affordable on a purchase and cost-to-wear basis and represent a genuine value.



COVID-19 Transmission

No discussion about face masks should occur without developing a thorough understanding about how viruses such as COVID-19 are transmitted and the mechanics of rapid contagion. This is especially so for business managers and others tasked with the responsibility of opening up their organizations in the midst of a respiratory-based infectious pandemic that requires the use of unprecedented disease mitigation policies.

Droplets and Aerosols: A Critically Important Distinction

COVID-19 spreads primarily through droplets and tiny aerosol particles transmitted through the air.

- Droplets are *large* particles of liquid produced by a person who has coughed or sneezed. Because of their size, droplets usually do not travel very far before they fall onto a surface, thereby explaining how transmission occurs from a contaminated surface (e.g., a doorknob, keyboard, tableware).
- Aerosols are extremely small particles that are light enough that they can be suspended in air for a long period of time. They can not only be spread by coughing and sneezing, but also by talking or breathing.

Droplets act like rain, while aerosols act like fog. If you walk under an overhang during the rain you won't get wet because gravity brings the raindrops straight to the ground (barring any wind). On the other hand, fog is so light it can float and occupy almost any space. This is a very important distinct as it relates to a face mask's utility and ability to protect the wearer as well as others in his/her vicinity (including after they leave a space).

Transmission Basics

Presently (July, 2020), no peer-reviewed studies have been conducted that definitely assess the biophysics related to the transmission of exhaled COVID-19 pathogens. Accordingly, no precise numbers exist that evidence specifically how COVID-19 infection occurs. Nonetheless, based on our understanding of how other microorganisms are spread, certain transmission properties may be reasonably inferred. By example, based on our understanding of MERS transmission, an "infectious viral dose" would develop by inhaling some 10,000 particles. University of Birmingham microbiology/infection professor Willem van Schaik, PhD posits that because COVID-19 is far more transmissible than MERS [1], it takes fewer particles to launch an infection; maybe as few as 1,000 (noting that a coronavirus-positive person infects two or three others on average, versus less than one person for MERS). This begs the question: *what does it take to inhale 1,000 viral particles?*

Propensity to Contract COVID-19 for Another Person
Successful Infection = Exposure to Virus x Time Exposed

Action	Released Droplets	Viral Particles Released	Speed of Release	Exposure and Time Required for Infection
Cough	3,000	200,000 viral particles *per droplet*	Est. 50 MPH	Short time indoors. Even if cough/sneeze isn't directed to a person, viral aerosol particles suspended in air can disperse through room, infecting room occupant upon entry, within moments, after taking only a few breaths.
Sneeze	30,000	200,000 viral particles *per droplet*	Est. 200 MPH	
Speaking	Thousands; much more than breathing	Estimated release ~ 200 particles *per minute* with 200,000 viral particles *per droplet*	More velocity than breathing	Within ten minutes. If infected person emits a just 100 viral droplets per minute, in ten minutes they could expose a person to the 1,000 viral particles needed to get infected.
Breathing	50 - 5,000; but less than speaking	Estimated release ~ 20 to 33 particles *per minute* with 200,000 viral particles *per droplet*	Low velocity	Easily within 20 minutes. If infected person emits a low 50 viral droplets per minute, in 20 minutes they could expose a person to the 1,000 viral particles needed to get infected.

Data interpolated by author from research compiled / published by Erin S. Bromage, PhD (Associate Professor of Biology, University of Massachusetts).

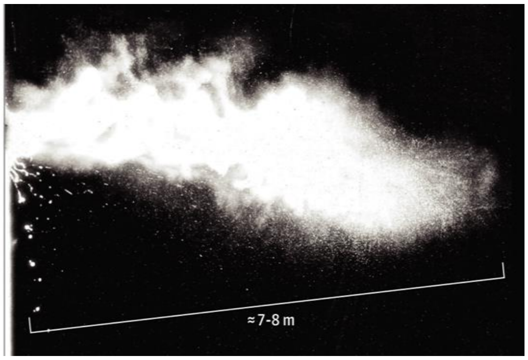
According to a (2009) WHO study entitled "*Natural Ventilation for Infection Control in Health-Care Settings*" [2] a single cough releases ~ 3,000 large droplets that travel at ~ 50 miles/hour; and a single sneeze releases ~ 30,000 small droplets that travel at up to 200 miles/hour. While gravity ultimately causes them to fall, many droplets stay in the air, able to travel across a room in a few seconds. The droplets in a single cough or sneeze may contain as many as 200 *million* viral particles that can be dispersed nearby. Similarly, a study published in the *Journal of Hospital Infection* (May, 2006) noted that a single breath releases up to 5,000 droplets or several million viral particles. [3] Owing to their low velocity projection, they typically fall rapidly to the ground. A few droplets and low levels of particles are released by nose-breathing, that travel at a rate of ~ 30 viral particles/ minute. [4] While these figures aren't coronavirus-specific, they provide strong, reliable guidance.

Likewise, it is increasingly more likely that these viral particles are transmitted by asymptomatic COVID-19 carriers, this according to a recent study published in the *Proceedings of the National Academy of Sciences*. [5] And, while it has long been recognized that high viral loads can be transmitted via droplets generated by coughing or sneezing, we now know that normal speaking can produce thousands of contaminated droplets. Experts like University of Massachusetts Prof. Erin S. Bromage, PhD (see exhibit above) define a *successful infection* as the product of *exposure to virus* multiplied by the *time exposed.* The author is going to trust the accuracy of his math and stipulate to his conclusion that a person having a face-to-face encounter could inhale the ~ 1,000 viral particles needed to become infected if a coronavirus-positive person sneezed or coughed straight at them; and that (owing to infected aerosols hanging in the air for a few moments) a person entering into a room following a cough or sneeze could inhale enough viral particles to become infected. Professor Bromage also calculates that one breath can produce 100 viral particles and that inhaling 10 breathes could cause infection; or 20 breathes of 50 particles; or one large breath. It can also occur from one eye-rub.

In another study conducted by scientists at Princeton University, UCLA and the National Institutes of Health that appeared in *The New England Journal of Medicine* concluded that COVID-19 could remain airborne in aerosol form for up to three hours (an up to four hours on copper; up to a day on cardboard, and several days on plastic and stainless steel). [6] This ability to become infected by airborne particles is especially true in closed, stagnant-air environs where they may remain for eight to fourteen minutes.

As a business owner or manager, what this means is that if a person is simply within close proximity to a person with COVID-19, the viral particles emitted by that infected person's breath would require 50 minutes of contact to infect the other (assuming a transmission rate of only 20 virus particles/minute). However, if a face-to-face conversation were to take place, the transmission rate would increase tenfold to ~200 viral particles/minute and it would take only ~5 minutes for an adequate dose to be transmitted and infect the non-infected participant. [7] Ergo, a ten-minute conversation with an infected person, or even sharing an office with an infected person, could be dangerous…not to mention the potential for a coronavirus-positive person to infect an entire room.

Symptomatic people aren't the only way the virus is shed. A study appearing in the journal *Nature Medical* (April, 2020) [8] concluded that the majority of community-acquired transmissions, and ~ 44% of all infections, emanate from asymptomatic people (who can transmit the virus for up to five days before symptoms manifest). Also, a study cited in *The New England Journal of Medicine* (March, 2020) indicated that asymptomatic infected people seem to have viral loads - the amount of virus in their bodies - just as high as those who are seriously ill, [9] supporting the notion that a small number of infected people may account for most of the spread.

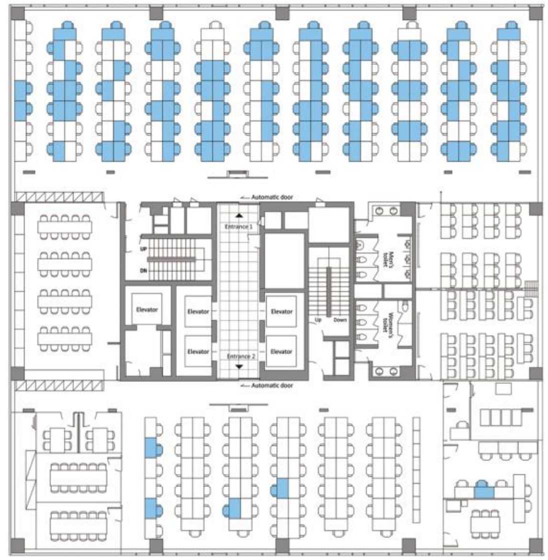


Viral droplets can be spread up to 13 feet according to a research teams from the Academy of Military Medical Sciences in Beijing in a study entitled *Emerging Infectious Diseases* that was published in the CDC's journal [10]. According to fluid dynamics and disease transmission expert Lydia Bourouiba, PhD, a professor at the Harvard-MIT Health Sciences and Technology Institute, the lifetime of a droplet can be extended by a factor of up to 1,000, from a fraction of a second to minutes. Further, the viral particles from a cough can travel as far as 16 feet and those of a sneeze up to 26 feet. Indeed, depending upon a person's particular physiology, or under certain environmental conditions (e.g., an outdoor breeze), the forward momentum of these "clouds" could project viral payloads up to 27 feet. While certain public spaces may be less hostile environments to COVID-19 than others, high-traffic areas (e.g., public bathrooms, elevators) should be avoided or not shared. [11]

Case Study I: Workplace-Specific Risk

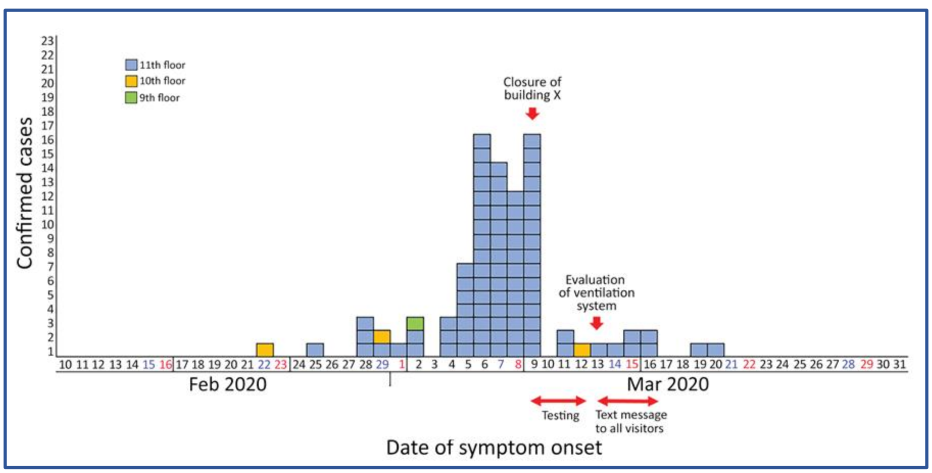
Of particular interest to employers should be the inherent risk of COVID-19 transmission associated with the workplace; especially for those having office environments that house large numbers of employees. Insight into the rapid contagion possibilities attendant to such a situation can be gained from a very recent study that describes the epidemiology of a COVID-19 outbreak in a South Korean call center. Conducted by affiliates of the Korea Centers for Disease Control and Prevention, it was published on the CDC website (April 2020). [12]

While there’s much to be learned from this study, the key take-away is the exceptional danger of exposure to viral infection associated with crowded, enclosed (and open) office settings.



These are the facts. One COVID-positive man went to work on the 11th floor of a building that housed 216 employees. From February 21 - March 8, 2020, 43% of his fellow employees got infected and 92 of those 94 employees became ill, while only 2 remained asymptomatic. Note that the 94 infected persons (in the blue chairs), sat largely on one side of the office and that few employees on the other side of the office were impacted. The researchers did not ascertain the precise number of employees who were infected by respiratory particle exposure versus fomite transmission (e.g., shared door handles, copier keys). There was no evidence of viral transmission via recirculated air from the HVAC unit (as staff on the office’s other side weren’t impacted).

The exhibit at left illustrates how fast the contagion spread and who it impacted. PUI indicates a *patient under investigation* (a person who worked at, lived at or visited the building from February 21 to March 8). A *confirmed case-patient* is a PUI who tested positive for COVID-19.



Of the 1,143 PUIs (922 employees, 201 residents, 20 visitors), when tested, some 97 (8.5%) became confirmed case-patients.

Despite considerable interaction among employees on different floors (e.g., in elevators, building lobby), the spread of COVID-19 was limited to the 11th floor as 94 (97%) of the confirmed case-patients worked there, representing 43.5% of the 216 employees.

Among the 97 confirmed case-patients, 89 (92%) were symptomatic at the time of investigation and 4 (4%) were pre-symptomatic during the time of investigation, but later experienced the onset of symptoms within 14 days of monitoring; 4 (4%) case-patients remained asymptomatic after 14 days of isolation.

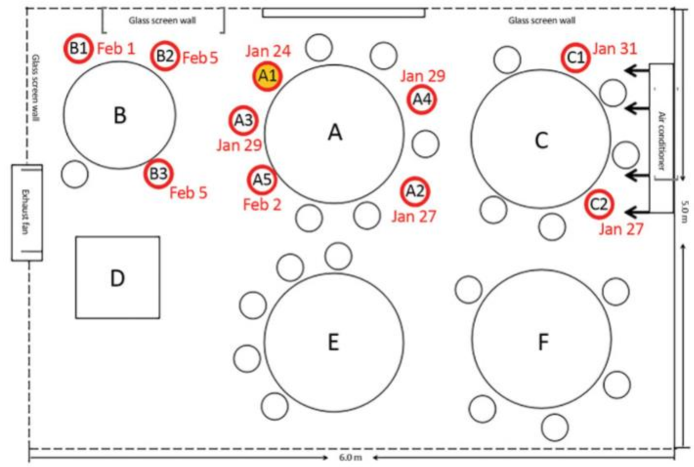
Employers should appreciate that the sheer magnitude and swift nature of the outbreak evidences how a high-density work environment can become a high-risk site and potential source of viral transmission. They must re-think the obvious risks attendant to “low cubicle "open offices, conference rooms and project work spaces.

Lastly, employers should consider making the company standard face masks one that both reduces outbound spread but also protects the wearer. This supports the study conclusion that it was the *duration of interaction* (contact exposure) that was the main source of virus spread.

Case Study II: Droplet and Aerosol Transmission

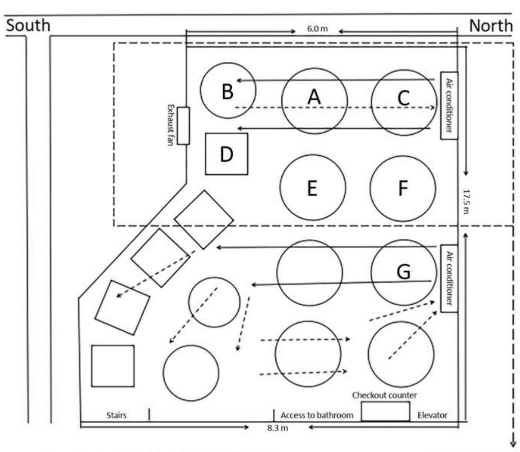
The air in most commercial office spaces is controlled by a heating, ventilating and air-conditioning (HVAC) unit. As this study evidences, these HVAC units can significantly enhance the risk of spreading COVID-19. This study, conducted by the Guangzhou Center for Disease Control and Prevention (April, 2020) it is entitled *COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China* [13] Here are the facts.

A COVID-19 outbreak occurred at an air-conditioned restaurant in Guangzhou, China that affecting ten persons from three family clusters who had lunch at the same air-conditioned restaurant in Guangzhou, China (denoted in the exhibit below as families A, B and C.) The infected person (A1) sat at a table and had lunch with three other family members (A2 – A4). Two other families (B and C) sat at two neighboring tables during the same 1- to 1.5-hour lunch period.



During lunch, the sole asymptomatic coronavirus carrier (A1) released low-levels of the virus into the air from his breathing. Airflow, from the restaurant's various HVAC system vents, moved from right to left. Later that day, patient A1 developed a fever and cough and went to the hospital. Within the next few days, a total of nine others diners became ill. These included four (50%) diners of family A, seated at the infected person's table; three (75%) diners at the adjacent *downwind table* occupied by family B; and two diners of seven-member family C, seated at an upwind table (who were likely infected *as a result of turbulent airflow* created by the building's HVAC unit). Interestingly, no diners at table E or F were infected, as they were seated *out of the main airflow* from the air conditioner on the right of the exhaust fan, on the room's left side.

Researchers concluded that the only known source of exposure for the infected diners in families' B and C was diner A1 *at the restaurant*. They also found that the virus was transmitted to several infected diners of family B and C *during lunch* and that further infections in families' B and C resulted from intra-family transmission.



The 1,550 sq. ft. restaurant is air-conditioned, and windowless. Families B and C were seated for overlapping periods of 53 and 75 minutes, respectively. The day of the outbreak, a total of 91 persons were in the restaurant; eight were staff and 83 diners had lunch at 15 tables. Despite this, interestingly, only the ten diners at the original seating that included the infected diner A got infected.

The study concluded that this outbreak's virus transmission cannot be explained by droplet transmission alone. The distances between infected diner A1 and diners at other tables, especially those at table C, were all more than three feet. However, strong airflow from the air conditioner could have propagated droplets and aerosols from table C to table A, then to table B, and then back to table C.

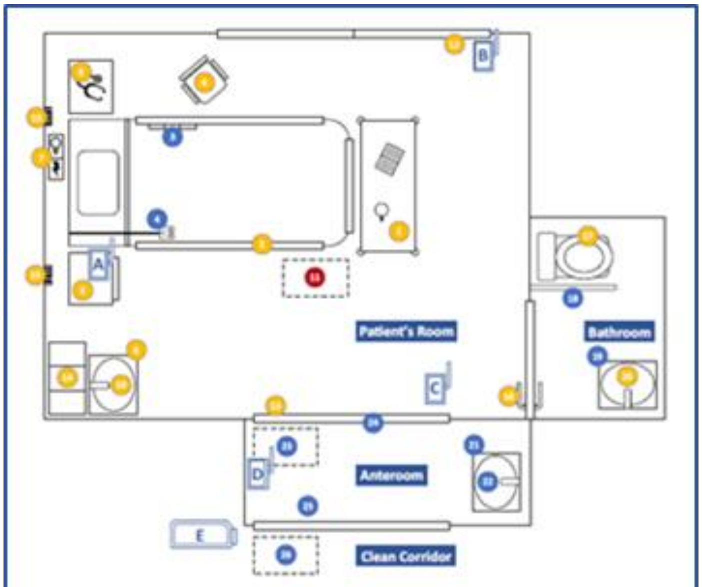
While we know that virus-laden small aerosolized droplets can remain in the air and travel long distances, none of the restaurant staff or other diners on the subject day were infected. Further, the researchers found that the air conditioner's ducts were nucleotide negative; a finding that doesn't support aerosol transmission. In that aerosols follow the airflow; they believe that the lower concentrations of aerosols found at greater distances from the HVAC system wasn't sufficient to cause infection in other parts of the restaurant. As such, they concluded that in this outbreak, COVID-19 infection droplet transmission was enhanced by the HVAC system pushing virus-infected air particles; the key factor being the direction of the airflow. As with the call center case study above, there was no evidence of viral transmission via *recirculated air* from the HVAC system.

Here again, employers should consider face masks that both reduce outbound spread and protect the wearer.

Case Study III: Air Condition / Filtration Risk

The air in most commercial buildings is supplied by a heating, ventilating and air-conditioning (HVAC) unit. While the previous two case studies did not address COVID-19 transmission via a HVAC system, this one does. Indeed, it evidences the degree to which an HVAC system can enhance the transmission of COVID-19.

Reported in the *Journal of the American Medical Association* (March, 2020), and conducted by academic researchers affiliated with the Singapore National Centre for Infectious Diseases, this research letter is entitled *Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a Symptomatic Patient.* [14] This study shows how COVID-19 virus particles found in the ventilation systems in hospital rooms of infected patients were able to remain viable and travel long distances from patients. This study's finding are consistent with the "the turbulent gas cloud hypothesis of disease transmission". Very simply, in this model, an infected patient's exhalations, sneezes and coughs are primarily made up of multiphase turbulent gas puffs or clouds that get drawn along with ambient air and trap and carry within them infected viral particles that are able to evade evaporation and greatly extend the active lifetime of the pathogen causing environmental contamination as a route of transmission.



Numbered labels correspond to environmental sampling sites. Red circles indicate samples with strong positive results. Yellow circles indicate samples with weak positive results. Blue circles indicate samples with no positive results. Blue icons labelled A to E indicate the position of the air samplers within the hospital suite.

These are the study facts. Over a ten-day period beginning in late January, 2020 three patients were hospitalized at a COVID-19 outbreak center located in Singapore. Each patient was situated in his own airborne controlled infection isolation room where the air was exchanged twelve time each hour. Adjacent to each patient's main hospital room was a small ante-room, an essential hospital space designed to control contaminated airflow between the sensitive patient occupied area and the hospital's common areas. Ante-rooms protect the patient occupying the room (from outside contaminated air) and other patients in the hospital from a nosocomial outbreak. Each patient room also had an *ensuite* bathroom.

During the course of the study, surface samples were collected from 26 sites within each hospital suite; as well as from the personal protective equipment of study physicians after exiting a patient's room. A variety of techniques and equipment were used to collect air samples each day, pre- and post-cleanings. These occurred three times each day on schedule.

Patients A's and B's rooms were tested while they were asymptomatic and after they became symptomatic, after routine cleanings and all samples were negative. Patient C had greater viral shedding. Some 87% of room site samples (including air outlet fans) and 60% of bathroom sites tested positive (before routine cleaning). All anteroom, corridor and air samples were negative. Only one of many PPE swabs were positive (due to the low risk of transmission from contaminated footwear, as supported by negative anteroom and corridor results). Post-cleaning samples were negative, indicating that decontamination measures are sufficient.

Although air samples were negative despite the extent of environmental contamination, collections from the *air exhaust outlets* tested positive, suggesting that small virus-laden droplets may be displaced by airflows and deposited on equipment such as vents. These results support the belief that the positive bathroom samples evidence viral shedding in stools as a potential route of transmission. Significant environmental contamination by COVID-19 infected patients through respiratory droplets and fecal shedding suggests the environment as a potential medium of transmission and supports the need for strict adherence to environmental hygiene. This study did have several limitations, and further studies are required to confirm these preliminary results.

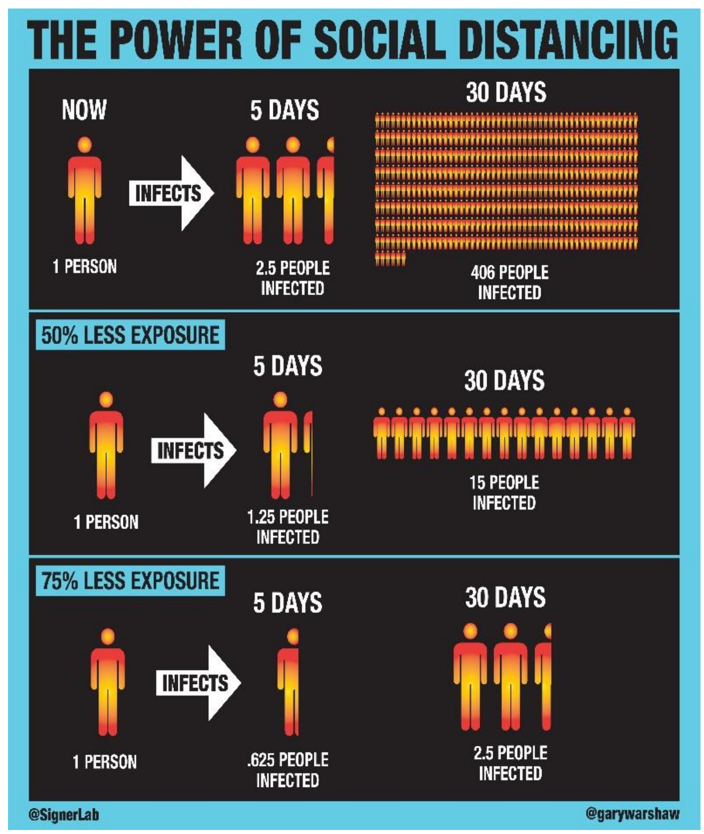
The Impact of Physical Distancing

In public health, social distancing is a set of measures intended to prevent the spread of a contagious disease by maintaining a physical distance between people and reducing the number of times they come into close contact with each other. The theory is that by reducing the probability that a given uninfected person will come into contact with an infected person, the disease transmission can be suppressed, resulting in fewer deaths (by slowing the spread of infectious diseases and avoiding overburdening healthcare systems). Being linguistically precise, the term "*physical* distancing" better describes the intent of the measure as today we can be socially connected via technology. Physical distancing is used in combination with good respiratory hygiene and hand washing; by closing schools and workplaces; selective isolation and quarantine; and no mass gatherings.

Physical distancing is effective when the disease spreads via one or more of these methods: droplet contact (e.g. coughing, sneezing); airborne transmission (if the microorganism can survive in the air for long periods); indirect physical contact (e.g., by touching a contaminated surface); and physical contact (e.g., sexual contact). With the exception of the last method, all of the other transmission methods apply to COVID-19 spread.

To understand how quickly infectious diseases can spread, and how effective physical distancing can be, consider this illustration by Robert A. J. Signer, PhD, Professor at the University of California San Diego. The use of a summation formula makes it possible to estimate the number of new infections over a 30-day period, across three scenarios. [15] The following key assumptions were made to arrive at the figures noted.

- This illustration assumes people keep at least 6 ft. apart; that non-essential crowds and gatherings are avoided; that there is limited contact with those at high risk; that people work from home whenever possible; that no handshakes/hugs take place; and that people go out infrequently, for only essentials.
- Scientists measure the intensity of an infectious disease by its reproduction number or R_0 factor. The COVID-19 basic reproduction factor is estimated to be 2.5, a figure supported by recent research. This means that, on average, an infected person will spread the disease to 2.5 other people.
- The model assumes that the infected person will unknowingly spread COVID-19 over a median five-day incubation period. The person will then begin to develop symptoms, immediately self-quarantine and no longer be a threat of spread.
- A direct linear correlation between social inter-actions and the R_0 is assumed; when an infected person reduces their physical contact with others by 50%, they spread the disease by 50% less.



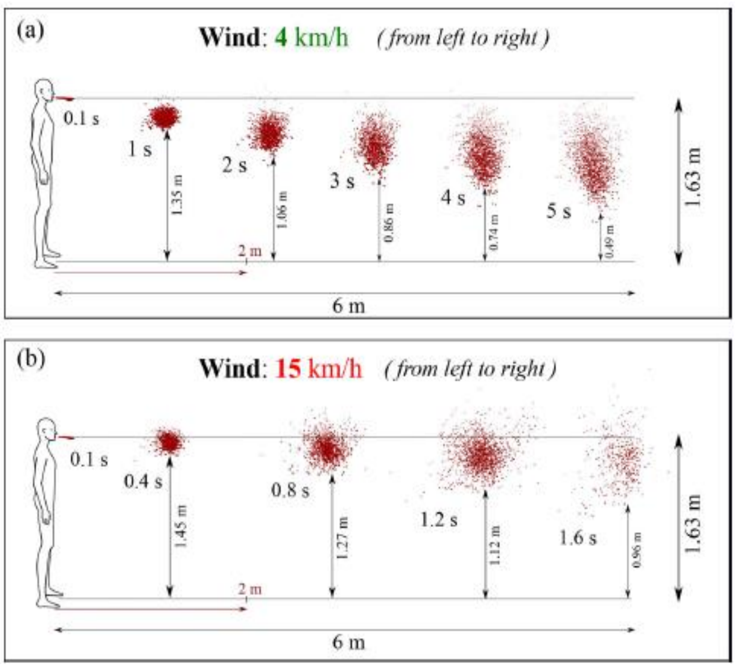
An examination of the results of physical distancing reveals its enormous impact. With a 50% lower exposure rate, the number of people infected by the COVID-19 carrier drops from by 96% from 406 people to 15 people.

These results support a study published in BMC Public Health (April, 2009) by Australian researchers. [16] Rather than using mathematical calculations, it looked at physical distancing from many angles using computer simulations to measure the impact of their *timing* on reducing pandemic effects. The study showed that taking no action resulted in 65% of the population getting infected; that by taking a similar group of physical distancing measures 45% got infected when begun with a 4-week delay; that only 21% got infected with a 3-week delay and just 7% with a 2-week delay. Clearly, timing has a great impact on the magnitude of spread.

Is Six Feet Enough Distance in Light Winds?

The WHO recommendations for social distancing of six feet to reduce the spread of COVID-19 are based on studies that were conducted in the 1930s when it was thought that viral transmission occurred only from the projection of respiratory *droplets* produced from coughing and sneezing. When these studies were conducted the technology to detect submicron aerosols didn't exist. We now know that it's a competition between droplet size, inertia, gravity and evaporation that determines how far viral droplets and aerosols will travel in the air.

We have known for quite some time from numerous studies that viruses like COVID-19 are transmitted as particles travel through the air when people cough ad sneeze. Until recently however, we had little information about how this airborne transmission is impacted by slight breezes. A recent research study that appeared in the American Institute of Physics publication *Physics of Fluids* (May, 2020) [17] provides just that valuable insight. Conducted by Professors Dimitris Drikakis and Talib Dbouk at the University of Nicosia, Cyprus, this study showed that a mild human cough (in air at ~ 70° F and 50% relative humidity) unexpectedly propelled saliva-disease-carrying droplets considerable distances depending on environmental conditions such as wind speed, temperature, pressure and humidity. Some examples from the study are described and illustrated below.



The graphic at left illustrates a person's airborne droplets in slight wind, blowing from left to right. With no wind, the saliva droplets did not travel the full 6-foot recommended physical distance length.

In the first example on the top, with even a slight breeze of ~ 2½ mph, saliva droplets were able to travel a distance of ~20 feet in five seconds and be found suspended at heights from ~ 20 to 65 inches.

In the second example below, with a moderate breeze of ~ 4½ mph, saliva droplets were able to travel the same distance in just 1.6 seconds and be found suspended at heights from ~ 40 to 65 inches.

According to the researchers "The droplet cloud will affect both adults and children of different heights" and "shorter adults and children could be at higher risk if they are located within the trajectory of the traveling saliva droplets."

On the same general topic of how airborne disease-carrying droplets transmit the COVID-19 disease, a study that was recently published in the Proceeding of the National Academy of Sciences (May, 2020) [18] entitled *"The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission"*, researchers from the National Institutes of Health and the University of Pennsylvania School of Medicine proved that *speech* droplets generated by asymptomatic COVID-19 are increasingly considered to be a likely mode of disease transmission. While it has long been known that respiratory viruses can be transmitted via droplets that are generated by coughing or sneezing, it is less widely known that normal speaking can do likewise. This study revealed that normal speaking can emit thousands of oral fluid droplets per second which, in a stagnant air environment, can potentially remain airborne, and stay suspended in the air, for extended periods of as long as fourteen minutes. This research confirms a substantial probability that normal speaking causes viral airborne transmission in a confined setting.

According to an article published in Science (May, 2020) entitled "Transmission of SARS-CoV-2" the authors, (researchers from the University of California, San Diego and the National Sun Yat-Sen University, Taiwan) concluded that "The distance from a smoker at which one smells cigarette smoke indicates the distance in those surroundings at which one could inhale infectious aerosols" [19]. A familiar, clear, understandable and truly disturbing conclusion, to say the least.

The Importance of Wearing a Face Mask

There are many reasons to wear a face mask; especially if you have a chronic illness, respiratory ailment, are vulnerable to contracting the flu or an infectious illness, are immunocompromised…or simply don't want to infect others. Either way, masks are a no-risk, high-reward method to protect respiratory health.

The Centers for Disease Control and Prevention guidelines with regard to wearing face masks in public call for everyone, sick or not, to cover his/her face with fabric; the intent being to keep the wearer's outbound viral pathogens from being transmitted and inhaled by others. [20] Recent guidance provided by the World Health Organization is more specific, as noted in the exhibit below. [21] These measures are the result of new evidence that millions of people having the virus are asymptomatic; that the incubation period for those infected is as long as two weeks before any symptoms may emerge; and that those impacted could possibly infect others.

World Health Organization Guidance on the Use of Face Masks
in the Context of COVID-19 (Updated June 5, 2020)

Population	Situations / Settings	Purpose of Mask Use	Mask Type to Consider Wearing (if Recommended Locally)
General population in public settings, such as grocery stores, at work, social gatherings, mass gatherings, closed settings, including schools, churches, mosques, etc.	Areas with known or suspected widespread transmission and limited or no capacity to implement other containment measures such as physical distancing (of 1+ mtr.), contact tracing, appropriate testing, isolation and care for suspected and confirmed cases	Potential benefit: Prevent infected wearer from transmitting virus	Non-Medical Cloth Face Mask
People living in cramped conditions, and specific settings such as refugee camps, camp-like settings, slums	Settings with high population density where physical distancing (of 1+ mtr.) cannot be achieved; surveillance and testing capacity, and isolation and quarantine facilities are limited	Potential benefit: Prevent infected wearer from transmitting virus	Non-Medical Cloth Face Mask
General public on transportation (e.g., on a bus, plane, trains). Specific working conditions which places the employee in close contact or potential close contact with others e.g., social workers, cashiers, servers	Close contact settings and situations; any setting where physical distancing (of 1+ mtr.) cannot be achieved	Potential benefit: Prevent infected wearer from transmitting virus	Non-Medical Cloth Face Mask
Vulnerable populations: • People aged ≥60 years • People with underlying comorbidities, such as cardiovascular disease or diabetes mellitus, chronic lung disease, cancer, cerebrovascular disease, immunosuppression	Settings and situations where physical distancing (of 1+ mtr.) cannot be achieved; setting and situation where there exists an increased risk of infection and/or negative outcomes	Potenital benefit: Protect the healthy wearer against infection	Single-Use Medical Mask with ≥ 95% Filtration Capability
Persons with any symptoms suggestive of COVID-19 (which may include: fever, cough, fatigue, loss of appetite, shortness of breath, muscle pain, other non-specific symptoms.	Any situation or setting in the community, i.e., this applies to any transmission scenario	Potential benefit: Prevent infected wearer from transmitting virus	Single-Use Medical Mask with ≥ 95% Filtration Capability

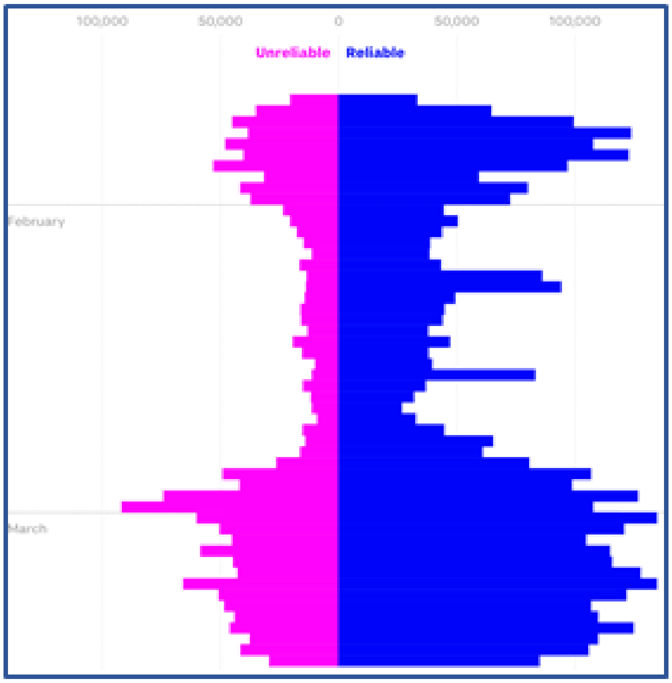
Information adapted , reformatted (and enhanced) by author from exhibit and guidelines published on June 5, 2020 by the World Health Organization

Given our understanding of the turbulent cloud model described above, it is possible that these guidelines are based on a false belief as to the distance, timescale and persistence over which a viral payload may travel; thereby dangerously underestimating the potential exposure to infection. For these reasons, ***the author contends that face masks should be looked at both for source control (i.e., reducing spread from an infected person) and wearer protection (i.e., protecting the uninfected wearer from viral pathogens).***

The *protective* efficacy of a face masks depends entirely on its ability to filter incoming infected aerosolized particles from high-momentum infected clouds and inactivate them. Most commercial cloths face masks are not designed to accomplish this; those that are often make false claims about their effectiveness. Further, even when properly used, ordinary face masks create "bio-burdens" or large populations of viable infected microorganisms as a result of the wearer breathing and coughing infected particulates into them and the wearer coming into contact with others who carry and transmit germs and viruses. This is dangerous as each time the wearer touches, adjusts and discards a mask, a potential to contract or spread the disease is created. As described below, the challenge of attaining inbound viral protection to ensure wearer security can be met with the correct mask design, component materials, proper fit and advanced chemical and electrostatic technologies to inactivate dangerous microbes but killing them upon contact (thereby mitigating cross-contamination risk).

False, Inaccurate and Misleading Face Mask Information

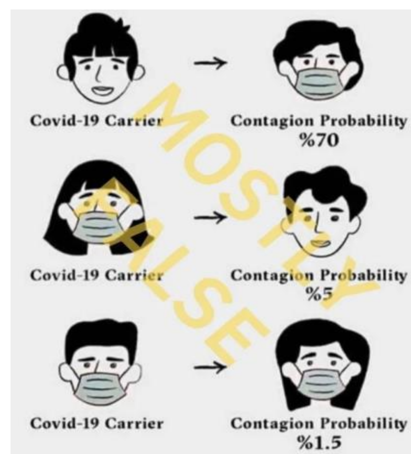
Wearing a face covering in public to help slow the spread of the COVID-19 disease isn't only sound advice, in some circumstances, it is legally required. As employers look to purchase face masks for their employees, they are often met with an onslaught of news, information and data on COVID-19 such that it makes selecting a face mask a daunting challenge for even a skilled buyer. Today, most people begin shopping for almost anything on the web with a search engine. However, the internet is awash with false, misleading, inaccurate, deceptive, "fake" and even intentional *dis*information about everything pandemic, including face masks.



According to the WHO director-general: "We're not just fighting an epidemic. We're fighting an infodemic." Moreover, this "information" isn't all being generated by humans: some experts estimate that as much as half of all web traffic is generated by "bots masquerading as people" (a "bot" is a software app that is programmed to do certain instructed automated tasks to imitate or replace a human user's behavior). As the COVID-19 pandemic surged worldwide, so has misinformation.

The exhibit at left, from a recently released study by Italy's highly-acclaimed Bruno Kessler Foundation, claims that every day in March, 2020 an average of 46,000 new Twitter posts (almost half) linked to inaccurate or misleading info about the COVID-19 crisis. [22] A February, 2020 Reuters report found that six in ten studies published on COVID-19 at the time had not yet been peer reviewed. [23] Knowing this, buyers a wise to be critical of all face mask information.

This illustration is a prime example of disinformation. Appearing in several languages on many web platforms in April, 2020, it is intended to show how effective various types of face masks could be at preventing COVID-19 infection. Not substantiated, it is inaccurate, misleading and dangerous. The exhibit does not specify the type of mask (homemade cloth, surgical or N95) and no studies indicate probability percentages with such specificity.



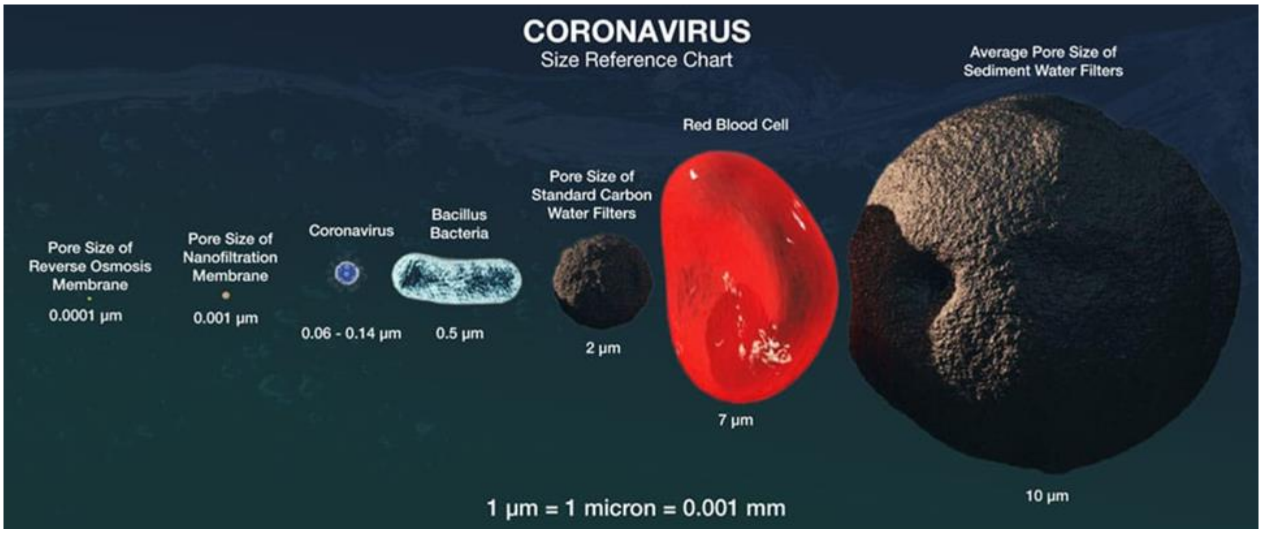
Though the graphic's source hasn't been identified, the odd "%" sign placement indicates possible Turkish origins (especially as a Turkish language version exists). "CDC can't confirm the accuracy of the numbers reflected in this image. Currently we are not finding any data that can quantify risk reduction from the use of masks", a CDC spokesperson told Reuters. The web is rife with similar examples of mis- and disinformation.

While consumers can still find a variety of medical and non-medical face masks online at eBay, Amazon, Etsy and elsewhere some big box stores (e.g., Target, Walmart and others) are no longer selling them. As a result of a lot of false and misleading healthcare claims about mask effectiveness in March, 2020 Facebook banned advertisements and commercial listings for them on its platform. While you can still locate companies that sell face masks using Google, at about the same time it too banned sales of them across all of its ad systems.

One source that does have accurate information on face masks and COVID-19 is the one created by the CDC and the National Personal Protective Technology Laboratory (NPPTL). [24] It contains important information from many reliable resources packaged into respiratory protection infographics that are educational. Available in both English and Spanish, it can be found at www.cdc.gov/niosh/npptl/RespiratorInfographics.html.

Face Mask Basics

All face masks are not created equal. Available in stores and online, face masks come in many grades, materials, designs, styles and varieties which greatly influence their filtering capability, breathability, comfort, moisture control capability, odor and cost. These include one-time use and washable reusable ones; those made from medical-grade paper or all, or in part, from cotton, flannel, polyester, nylon, linen, silk, chiffon, silicone and various synthetic fabrics…woven and non-woven, and every combination thereof…in one to five layers. They can incorporate various filters (HEPA vacuum cleaner bag or air filters; activated charcoal) that are removable or built-in and one or more slit or circular valve inserts. Some include adjustable nose forms and ear loops. With the exception of medical-grade masks, most other "pedestrian" face masks are only good at stopping dust mites, mold spores and pollens. As microscopic items go, these are large compared to bacteria and viruses that are very small (as illustrated below in this graphic from H20Coolers). [25]



And, while there are rigorous standards for evaluating medical-grade masks re: their personal protective equipment (PPE) efficacy, such standards do not yet exit for traditional face masks. Indeed, the claims made of many of the face masks for sale online and otherwise, are exaggerated and outright false.

The fact is that most non-medical products offer little protection against the novel coronavirus or other viruses. Nonetheless, the promise of protection against a lethal disease like COVID-19 has a way of opening up wallets and causing people to purchase the wrong mask, or an ineffective one. This can not only provide a false sense of security but the potential to actually help spread, rather than contain, the disease.

The following is a brief discussion of some of the more common medical and non-medical face masks.

N95 Respirators

An N95 respirator is the most common of seven particulate filtering face-pieces designed to protect the wearer from airborne particles and liquid contaminating the face. While 95% effective, *that rating doesn't refer to the particle's size but only to it leakage and filtering capability* as they are designed to enable a needed close personalized facial fit with proper training. N95 masks can be difficult to breathe through and lead to user distress over time, as they were never intended for extended use.

Designed for one-time use, and having inherent real-life user difficulties, N95 masks not appropriate for daily or long term use. In high demand worldwide, but scarce, these masks are very difficult to obtain and reserved for healthcare workers and medical first responders. Many, especially those made in China, have been found to be ineffective or counterfeit.

The “Magic” Behind the N95 Mask

An N95 particulate respirator is a type of mask that is unique among face pieces in that it is designed to not only reduce the risk of community spread (by acting as a barrier to reduce the volume of infected particles that exit the wearer’s mouth) but to also protect the wearer (by killing the infected particles that are directed toward, and captured, by it). Stated differently, whereas most cloth face masks are intended and designed to protect those around the wearer by reducing the spread of infected particles emanating from them, N95-type respirators (not only do that) are intended to capture inbound infected particles and kill them. N95 masks are named for their ability to filter 95% of the airborne particles in the environment and, to ensure their safety and efficacy, they must be tested and approved by the National Institute for Occupational Safety and Health (NIOSH).

Particulate respirators employ two basic methods by which to block and kill inbound infected particles. In the first case, these masks are constructed of fine strands of plastic that are blown onto a screen to create a complex netting which is then formed to make a mask. This acts as a physical barrier able to catch particles as they try to fly through the mask. In the case of N95 models, they are 95% effective at catching particles as small as 0.3 microns in size. In that the COVID-19 is considerably smaller in size (~ 0.125 microns), this filtration method alone is clearly not adequate enough to be effective against the virus. To make respirators effective against even the smallest of viral microbes, they employ a second technology based on what is commonly referred to as “static electricity”. Built such that the respirator’s components naturally rub together, an electrostatic charge is created that first attracts the infected particles, much like a magnet, and then electrocutes them.

The electrostatic process is essentially the accumulation of electrical charges on the surface of the mask’s exterior, which usually acts as an insulator or non-conductor of electricity. As such, there is no current flowing through the mask as there is with alternating current (AC) or direct current (DC) electricity. As such, static electricity can be simply characterized as electricity that is standing still or having no voltage potential or electron flow. When two dissimilar objects rub together one assumes a positive charge and the other a negative charge, both of equal value. This phenomenon is known as the “triboelectric” effect.

Moreover, unlike the effect experienced when a person walks across a carpet in their socks and gets a mild shock from touching a doorknob, the respirator’s charge does not get extinguished once the pathogenic particles are electrocuted; they continue to retain their charge allowing them to keep pulling and electrocuting additional infected particles. This triboelectric feature improves the filtration efficiency of the particulate respirator “by a multiple of ten” versus an uncharged version, according to Professor Peter Tsai, PhD the recently retired Professor of Material Science and Engineering at the University of Tennessee and *the inventor of the electrostatic filtration technology behind particulate respirators.* [26]

Medical Face Masks

Some types of face masks have become generally known as “medical masks”. There are actually two type of medical masks, the distinction being their purpose and design. Bothe are described below:

- Procedure masks (at right) are intended for use when performing patient procedures. They are used on hospital floors; labor, delivery and intensive care units or when patients are in isolation to protect them from potential contaminants. They are not suitable for use in the operating room. Procedure masks are easily identifiable by the presence of two ear loops to secure the mask to the wearer’s face.
- Surgical masks (below) are primarily used by operating room staff and, instead of face loops, they have two adjustment straps to secure and fit the mask to the wearer’s face by tying them over the top of a surgical or bouffant cap. They are intended to prevent the passage of germs from the surgeon into the patient's wound and to protect the surgeon from sprays/splashes from the patient.

Both masks are designed to be loose-fitting, disposable devices that create a physical barrier between the mouth and nose of the wearer and potential contaminants in the immediate vicinity. Neither is intended to form a seal around the nose and mouth. While they protect others by reducing exposure to the respiratory secretions of the wearer, these single use masks don't provide the wearer with reliable respiratory protection from inhaling airborne microbial particles as they typically filter less than 65% of them. Those with valves that let air in or out (to make them less stuffy to wear) will neither stop the wearer from infecting others or from becoming infected.

Medical masks are created with non-woven fabrics that can affect air permeability and some people have difficulty wearing them for more than a couple of hours (see discussion below). FDA studies [27] and others have shown that COVID-19 can last on these masks for up to seven days thereby creating a bio-burden risk. These masks, and commercial variations thereof, have become very popular worldwide as they are typically readily available and fairly inexpensive (on a single purchase versus cost-over-time basis). Medical masks are intended for limited-time, limited-exposure use; they are not intended for extended (all-day) use. Despite this, many people purchase medical masks and wear them for several days, a practice that is not recommended.

Replaceable Valved Respirators

These non-woven face masks are used to reduce the wearer's risk of inhaling hazardous airborne particles including dust particles, pollen, air pollution, bacteria, infectious agents, allergens, smoke, sawdust, chemicals, gases, vapors, auto exhaust emissions, etc. They provide a considerable degree of protection for upper respiratory and lung health and help mitigate the spread of disease. They are designed for work/industrial applications as well as sports and outdoor activities.

Having one or more replaceable flow valves, they efficiently facilitate the exit of moisture and CO^2 from the mask's interior by a negative-pressure process that uses the suction produced by inhalation to draw air through the filter. They require routine inspection, cleaning and disinfecting; get hot and difficult to wear in warm weather; do not prevent bio-burden build-up and cause communication difficulties.

Activated Carbon Filtered Masks

Several (natural and synthetic) cloth masks feature filters that are permanent or disposable and replaceable. These filters are often made from HEPA furnace filter, coffee filter and vacuum cleaner bag materials. Some masks incorporate the use of activated carbon/charcoal filters. The active filter contains very porous charcoal whereby, through adsorption, toxins that pass through the charcoal become bonded to its surface, hence preventing their inhalation.

While these masks are effective against bacteria, pollutants germs and fungus — and mitigating allergic reactions, claims about the effectiveness of PM2.5 activated carbon filters against viruses are greatly exaggerated as they are much smaller (the COVID-19 envelope is ~ 120 nanometers across). Further, the 70% alcohol mix needed to disinfect them, deteriorates them, ergo the filter must be replaced regularly. Carbon filtered masks can also present significant risks as some contain harmful fibers that can be inhaled. Many are not very breathable for the typical wearer. They don't prevent bio-burden build-up.

Cloth Face Masks

An abundance of studies on the filtration effects of both homemade and commercially available cloth masks conducted by reputable academic researchers, government agencies, medical institutions, industry trade groups and corporations − featured in scholarly periodicals, medical society journals, healthcare publications, technology reports and major national magazines and newspapers − are readily available online. They show that even a simple cloth mask can dramatically reduce the number of viral particles *emitted from* one's mouth.

Few studies have been conducted on the effectiveness of cloth masks *protecting the wearer* from viruses. Indeed, compared with surgical masks and respirators, little scientific research is available on the efficacy of cloth masks for this purpose. While some studies have evaluated how well certain fabrics or designs fare in the lab at blocking virus particle transmission, we found none that tested cloth masks in a clinical setting. *The exception to this are face masks that treated with some form of genuine antiviral (vs. antimicrobial) agent.*

The value and effectiveness of a cloth face mask is highly dependent upon many critical factors, all of which must be adequately addressed. These relate to their design, construction and materials; moisture control, airflow and filtration efficiency; fit and comfort; durability; and microbial and allergy control abilities. Style, cost, value, customization, availability, country of origin and source reputation are also important to many.

Face Mask Material

A product is only as good as the materials it is made from; and this is especially true vis-à-vis face masks. Researchers and chemical safety experts note that the permeability of various materials can vary widely and in unpredictable ways, making it difficult to determine definitively which material is best for a face mask. The type of fabric used, the tightness of woven materials, and their exposure to moistening from the wearer's breath are all factors that impact performance and breathability in unpredictable ways.

For eight decades, the Argonne National Laboratory has answered the biggest questions facing humanity by redefine the possible. Today, it has refocused its unparalleled scientific facilities and talent to fight against COVID-19. To that end, with University of Chicago researchers, it conducted the most extensive study of the filtration efficiencies of common face mask fabrics (e.g., cotton, silk, chiffon, flannel). The study [28] was published in the American Chemical Society's *ACS Nano* (April, 2020) journal and its main exhibit is below.

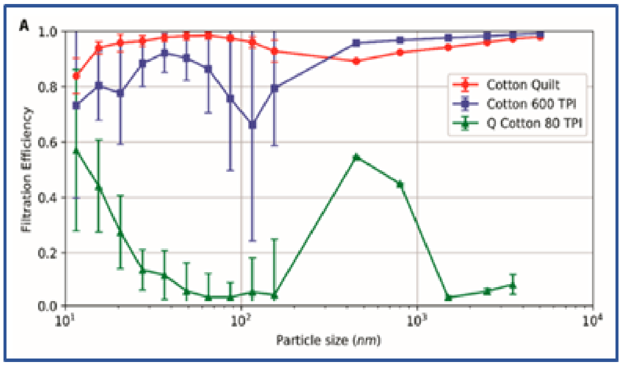
Table 1. Filtration Efficiencies of Various Test Specimens at a Flow Rate of 1.2 CFM and the Corresponding Differential Pressure (ΔP) across the Specimen[a]

sample/fabric	flow rate: 1.2 CFM		
	filter efficiency (%)		pressure differential
	<300 nm average ± error	>300 nm average ± error	ΔP (Pa)
N95 (no gap)	85 ± 15	99.9 ± 0.1	2.2
N95 (with gap)	34 ± 15	12 ± 3	2.2
surgical mask (no gap)	76 ± 22	99.6 ± 0.1	2.5
surgical mask (with gap)	50 ± 7	44 ± 3	2.5
cotton quilt	96 ± 2	96.1 ± 0.3	2.7
quilter's cotton (80 TPI), 1 layer	9 ± 13	14 ± 1	2.2
quilter's cotton (80 TPI), 2 layers	38 ± 11	49 ± 3	2.5
flannel	57 ± 8	44 ± 2	2.2
cotton (600 TPI), 1 layer	79 ± 23	98.4 ± 0.2	2.5
cotton (600 TPI), 2 layers	82 ± 19	99.5 ± 0.1	2.5
chiffon, 1 layer	67 ± 16	73 ± 2	2.7
chiffon, 2 layers	83 ± 9	90 ± 1	3.0
natural silk, 1 layer	54 ± 8	56 ± 2	2.5
natural silk, 2 layers	65 ± 10	65 ± 2	2.7
natural silk, 4 layers	86 ± 5	88 ± 1	2.7
hybrid 1: cotton/chiffon	97 ± 2	99.2 ± 0.2	3.0
hybrid 2: cotton/silk (no gap)	94 ± 2	98.5 ± 0.2	3.0
hybrid 2: cotton/silk (gap)	37 ± 7	32 ± 3	3.0
hybrid 3: cotton/flannel	95 ± 2	96 ± 1	3.0

[a]The filtration efficiencies are the weighted averages for each size range—less than 300 nm and more than 300 nm.

Cotton is the most common material used in cloth masks and different types of cotton exhibit different filtration efficiencies. Thread count is the metric used to denote the relative density (coarseness or fineness) of a fabric and is expressed in threads per inch (TPI). Fabric density, and the number of fabric layers used, directly impact mask filtration efficiency. Generally speaking, cotton fabrics having a tighter weave (i.e., higher thread count) do better at physically blocking bacterial and viral droplets. The theory is that particulates trying to cross through the denser fabric membrane will not make it as they will get caught in the gaps and pores. This was in fact borne out by the *ACS Nano* study, the results of which are presented in the following discussion.

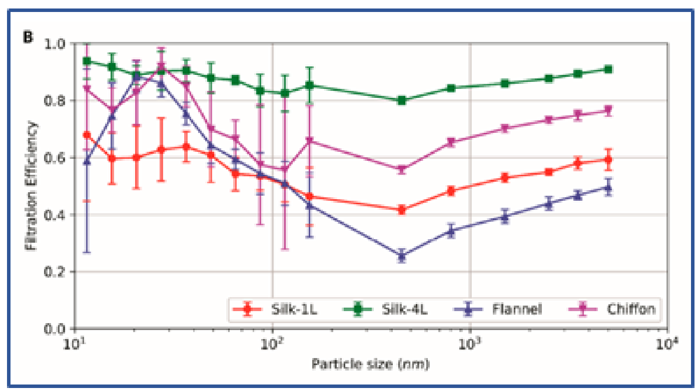
The exhibit below illustrates the filtration efficiencies for cotton with different densities (i.e., different thread counts). The comparison is of three different cotton types: (1) a moderate density (80 TPI) commonly available cotton that sewers often use to make homemade masks, (2) a high density (600 TPI) cotton fabric and (3) cotton quilt (two 120 TPI cotton layers sandwiching a ~.5 cm batting of 90% cotton/5% poly/5% other fibers).



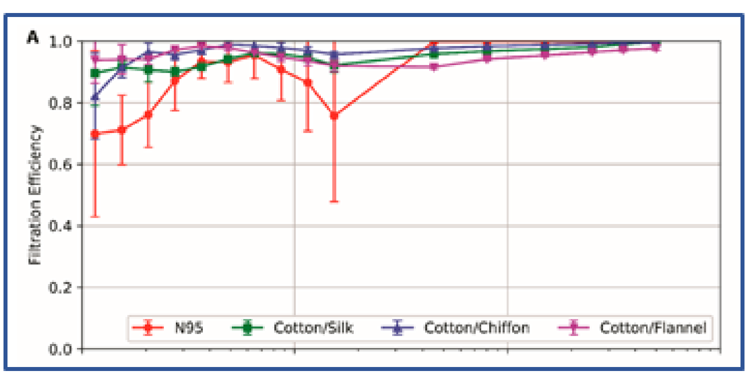
Comparing the cotton fabrics with different thread counts, the 600 TPI cotton is superior having > 65% filtration efficiency at < 300 nm and > 90% at > 300 nm. This tighter woven cotton fabric exhibited outstanding filtration efficiency. By comparison, the single-layer 80 TPI cotton fabric does not perform as well, with filtration efficiencies varying from ~ 5 to ~ 55% depending on the particle size. The cotton quilt also provided excellent filtration efficiency across the entire particle size range (> 80% for < 300 nm and > 90% for > 300 nm) although it is less breathable.

The American Chemical Society's *ACS Nano* study concluded that both *cotton/chiffon and cotton/silk combinations* can effectively filter out most viral-sized aerosol particles, at levels that *match or exceed those of an N95 respirator* (which are designed for one-time, short-term use).

Certain fabrics are known for their electrostatic ability to filter aerosols. As discussed in detail elsewhere in this document, when rubbed together, or with other fabrics, they develop a charge that electrocutes the virus upon contact. The exhibit at the right illustrates the filtration efficiency of four fabrics (used in a face mask without any gap) that are known for their excellent electrostatic ability to filter aerosols. They are 1) one layer of natural silk fabric; 2) four layers of natural silk fabric; 3) one layer of flannel fabric, and lastly (4) one layer of chiffon fabric.



This study clearly indicates silk's superior performance, by itself, at filtering nanosized particles of all sizes, with more layers increasing its performance. Likewise, chiffon evidenced almost equal superior performance.



Moreover, the exhibit on the left illustrates the filtration efficiency of a fabric combination of 600 TPI cotton and chiffon and cotton and silk as compared to that of the N95 respirator. As shown, both approach the performance level of the N95.

Researchers at Cambridge University [29] and the Missouri University of Science & Technology [30] performed studies that showed pure cotton had 70% filtration effectiveness against particles that were *five times smaller than COVID-19.*

Issues with Polyester

The Argonne Laboratory study didn't include polyester, likely owing to its many intrinsic problems. However, a study that appeared in the *Journal of Clinical Microbiology* (February, 2000) [31] on the transfer and survivability of micro-organisms concluded that *bacteria survive longer on polyester vs. cotton and can become a vector for the spread of microorganisms, creating serious infection control implications.* A study in *The Lancet* (April, 2020) [32] noted that "a detectable level of infectious virus could still be present on the outer layer of a surgical mask on day seven". Infectious disease doctors at the Johns Hopkins Health System found that COVID-19 survives better on less porous "artificial fibers" like polyester (and spandex) versus cotton. [33]

Most face masks are made from cotton, polyester or a combination. Cotton and polyester however, couldn't be more different as cotton is natural and polyester is a man-made fiber. While polyester is an inexpensive material to produce, it is otherwise a fairly noxious one. Actually a type of plastic, it is a synthetic material that contains many embedded toxic chemicals. One reason why polyester should not be used in face masks is that it is manufactured with antimony, a known carcinogen. Prolonged polyester fabric contact can cause chronic and severe respiratory infections. Several studies confirm that excessive wearing of polyester fabrics can cause not only skin problems but also lung, heart and other cancers. [34] Made from chemicals like thermoplastic, when heated in the clothes dryer it outgases toxic plastic molecules that are harmful to the home. Derived from petroleum-based products, polyester is dangerous for the environment; not sustainable, nor bio-degradable; causing eco-friendly purchasers to frown on its use. Its production disposes toxins in the water and emits lots of air pollutants. It is hard to recycle and, when it is, it uses more energy than producing natural fibers from scratch. Indeed, it takes two to ten times more energy to produce polyester versus cotton.

Cotton Types and Quality

All cottons are not created equal. Cotton fabric comes in three kinds: knitted, woven and non-woven and distinctive manufacturing techniques can change its appearance and texture. Moreover, there are several industry standards and metrics that are used to assess cotton quality. These include the fineness (measured in thread count); and the fiber's length, tensile strength, elongation, uniformity (diameter) and maturity index/ratio. These factors impact breathability, strength, durability, comfort, absorbency, color retention, washability, drape, transparency, pilling, odor, shrinkage, etc. While a comprehensive examination of this topic is beyond the scope of this document, the following discussion will provide insight into the key elements to consider when evaluating cotton quality for use in a face mask.

The key factor used to determine cotton quality is the length of its fibers. Individual cotton fibers are measured to determine their average length and the longer the staple the better. The advantage lies when twisting the thread. Long-staple fibers can be twisted to produce a thinner thread and higher thread count fabrics. Much stronger thread can be made with long-stable fibers and the longer the fibers are the stronger, softer, and more durable the resulting fabric. Fabrics made of long-staple cottons are more comfortable, fray less, pill less, wrinkle less and even fade less than fabrics made with their short-staple counterpart. Shorter fibers produce fabrics that are rougher on the surface. Long-staple fibers enable the creation of fabrics that are more cool. As long-staple cotton has a 10 - 15 days longer growing period and requires relatively more heat, therefore, it is comparatively more expensive to produce.

Pima cotton is a higher grade cotton with a longer fiber than conventional cotton; averaging 1¼ inches long vs. regular cotton fiber lengths of one-inch. An advantage of Pima cotton is that it enables thicker cloth weaves for a softer, more durable fabric and a white base color that enables greater color intensity. For US consumers, Egyptian cotton has an established reputation for being the world's best; though the "Egyptian cotton" designation doesn't impart any measure of quality; it only references the country of origin, this despite the fact that most Egyptian cotton is grown in India and China! Nonetheless, Giza cotton is a high-end cotton type that's grown and harvested close to the Nile river in Egypt and reputed to possesses some unique qualities not found elsewhere, like exceptional softness and lightness. Giza cotton has recently become well known in the US owing to its use in bed sheets and pillow case coverings, made popular though (endless) TV advertising.

Most cotton products are not what they are represented to be and fraud runs rampant in the industry. By example, *Bloomberg* reports that 83% of tested products labeled 100% Pima cotton were partially or entirely made of another type of cotton, per forensic science biotech company Applied DNA Sciences. [35] Not just a domestic problem, Egypt's cotton verification process is unorganized and unreliable. Only a nominal amount of Egyptian cotton contains extra-long staple fibers and producers often mix Giza with long staple Indian cotton with little fear of getting caught. *The Wall Street Journal* reports that only 20% of Egypt's total cotton volume is Pima-quality; and 90% of products labeled "Egyptian cotton" are fake. [36]

As it regards cotton, there's only one label to be trusted: the one having *Supima® Cotton* on it. Named to denote superior cotton, its legacy dates back a century to when farmers first discovered the superior attributes of Pima cotton. The trademarked brand name of the Supima® Association, a non-profit entity established in 1954 to promote the veracity of the cotton that bears its name, it is unquestionably the world's finest cotton.

The Supima® license has been extended to fewer than 500 family-owned farms, many of which have been passed down from one generation to the next. Some 93% of these are in California, the rest being in Arizona, New Mexico and Texas. Growers, textile mills, manufacturers and apparel brands must meet demanding quality and authenticity requirements to earn the right to use the Supima® designation, which represents less than 1% of the cotton grown in the world and only 3% of the total US cotton production. Supima® cotton is so strictly regulated that a method of DNA testing, called fiberTyping®, was developed to identify fibers from its extra-long staple to distinguish is from all other cotton species. Moreover, building off of the chronological documentation protocol used in the law, a botanical-based chain of custody system is used to document and track the fiber throughout the textile supply chain. Indeed, the system is sufficiently robust to track its whereabouts from its growth through the production of fibers, yarns and fabrics and through the textile processing, testing, laundering and labeling process. Inspectors literally visit Supima® factories on a regular schedule to ensure that it is neither mixed with other fibers not woven on the same machines that weave non-Supima® products. Unable to be altered or adulterated from the time it is planted to the time it is placed on the market, a manufacturer can't make a sheet with 90% Supima® and 10% inferior cotton and pass it off as a genuine Supima® sheet. Few products made anywhere in the world can make such a claim to authenticity. [37]

So then, beyond being rare and validated, what characteristics make this particular cotton so supreme? Imagine Pima but with more bells and whistles. To begin, Supima® cotton's rare extra-long stable fibers average 1.5 inches, a full 50% longer than traditional cotton. This enables it to be twisted to produce a thinner, yet much stronger, thread that is twice as strong as regular cotton and incredibly more resilient. Supima® cotton's extraordinarily longer fibers resists pilling, breaking and tearing; are incredibly more durable and result in fabrics that are able to keep their form and last longer. Fabrics made of Supima®'s long-staple fibers are more comfortable, fray less and wrinkle less than fabrics made with their short-staple counterpart. Supima® cotton is able to be made into higher thread count fabrics that are inherently softer, more luxurious and having an indulgently soft touch, approaching that of silk. The reason for this lies in the weaving process; because Supima® cotton's fibers are so much longer than traditional cotton, there are fewer fiber ends exposed on the surface of the resultant fabric. This means that on a micro-level there's less scratching and friction between the skin and the fabric. Supima® cotton possesses strong color retention properties that facilitate richer, deeper fabric colors that even fade less. Requiring no more care than any other cotton, the more you wash and wear a product made of Supima® cotton, the softer and more luxurious it becomes.

As a result of these premium properties, Supima® cotton is hypoallergenic and won't ever irritate even the most sensitive skin types. Like all cotton, Supima® is eco-friendly, sustainable, renewable and biodegradable. Unlike other cottons however, the fields that produce Supima® cotton are laser-leveled to maximize water use efficiency and the farming practices employed set environmental and ethical standards for cotton around the world. Unmatched and unsurpassed in quality and purity, Supima® cotton is more sought after and therefore far more expensive than any other cotton in the world being three times more expensive than regular cotton and two times more expensive than Pima materials…ergo, its use by premium brands like Brooks Brothers, DKNY, Tommy Bahama, Diesel, Nordstrom, Natori, Bloomingdale's, Tommy Hilfiger and even My Pillow.

US-grown *organic* Supima® cotton is the rarest cotton in all the world, and only represents one percent of all Supima® cotton made. It is in such high demand that it is presently not available until mid-2021 as certain brands actually pay to reserve this cotton at the seed stage well up to one year in advance!

Organic Cotton

Not surprisingly, cotton is the most popular fabric on the planet, accounting for more than half of all fiber produced. What might be surprising to learn is that while cotton only makes up three percent of the globe's cropland, it accounts for the use of some 25% of the world's insecticides. Indeed, upon close examination, conventionally grown cotton is one of the most toxic crops in the world. In large part, this is because to keep up with the demand, cotton growers resort to artificial means and excessive use of highly toxic chemicals to make cotton grow faster. As such, the resultant fabric tends to be full of noxious chemicals that are harmful not only to those who wear it, but those who grow and process it and the population at large as we are all subject to its adverse impact on the environment.

What is Organic Cotton?

Organic cotton is broadly defined as cotton that's grown and processed from non-genetically modified plants, and without the use of any synthetic agricultural chemicals such as fertilizers, pesticides, herbicides or other toxic chemicals. It is certified as being organic by third-party entities that verify that producers use only such materials and the production methods employed in its production (e.g., practices for pest control, growing, fertilizing, the handling of cotton crops and even the seeds used).

The use of these methods and materials are low impact on the environment. Because organic cotton relies upon a chemical-free growing and production process, it is not only ecofriendly by keeping harsh chemicals out of the air and water supply it also helps to replenish and maintain soil fertility, prevent water contamination and support biologically diverse agriculture. Organic cotton uses safer alternatives to chemical dyes and whiteners, utilizing natural or water-based dyes, peroxide for whitening, and safer products are used to manufacture the finished goods. The production of organic cotton uses 80% less water and 60% less energy as compared to traditional cotton use, thereby reducing its carbon footprint.

Interestingly enough, organic cotton is actually less expensive to produce than conventional cotton. It is grown with only natural cotton seeds instead of more expensive processed ones. It does not require the purchase of expensive fertilizers, pesticides, herbicides and chemicals required to make it pest resistant and grow faster. Further, the absence of toxins and chemicals negate the use of storage facilities which increase farming costs. Organic cotton production utilizes only organic-approved fertilizers, herbicides and pesticides from plants, animals and minerals to prevent pests and diseases. This not only serves to protect farmworkers it also reduces the health risk of the cotton product wearer.

Organic clothing products are safer than those made from regular cotton as manufacturers adhere to very rigid and stricter manufacturing standards that result in no chemical retentions. Cotton product wearers having allergies or chemical sensitivities appreciate this. Organic cotton's purity is also enhanced because it is handpicked rather than machine picked which ensures that it is not damaged in the process. Regular cotton, which is in far greater demand owing to its relative low cost, is usually machine-picked to meet that demand. Machine-picking doesn't maintain the purity or quality of the cotton's longer fibers as it often weakens or breaks as a result. Hand-picking not only avoids this damage it results in less waste and lower production costs. In sum, the benefits of organic cotton products shouldn't be measured only in terms of quantity and price but also safety, comfort and good environmental stewardship.

Recognizing its value, and the need to satisfy the increase in demand for it, each year, more organic cotton is grown and more organic cotton growing facilities are put into production. Nonetheless, even with twenty countries now producing organic cotton, it now makes up less than one percent of global cotton production with US farmers producing less than three percent of global organic cotton.

Genetically Modified Organisms

In large part, the reason for the greater toxicity of today's cotton resides in our migration over the past few decades to the unnatural growing and processing of it through genetically engineered means such that much of the cotton produced today is actually a *genetically modified organisms* (GMO). GMOs are living organisms whose genetic material has been artificially manipulated in a laboratory to create a plant, animal, bacteria or virus that doesn't occur in nature or through conventional cross-breeding means. Genetically modified cotton is altered to withstand the direct application of herbicides and insecticides. Specifically, genetically modified cotton is engineered with one of two traits: to make it resistant to herbicides or to stimulate the growth of a toxin that kills the boll-worm, the crop's primary pest. In fact, more than 80% of genetically modified crops grown worldwide have been engineered for herbicide tolerance, a 1,500% increase since GMOs were created.

In addition to being one of the most widely cultivated crops in the world, growing conventional cotton is also one of the most chemical-intensive. In fact, cotton has earned the title "dirtiest crop" because it is sprayed with some of the worst pesticides. It is estimated that 75% of the cotton grown in the US is insect resistant and at least 90% is herbicide tolerant. Indeed, glyphosate, the main ingredient in Monsanto's *Roundup* (used in more than 160 countries, and the most widely used herbicide in the US) has been determined by the World Health Organization to be "probably carcinogenic to humans" and by the European Union to be "dangerous for the environment". [38] Genetically modified crops are responsible for the emergence of "superweeds" and "superbugs," that can only be killed with more toxic poisons. Evidencing the severity of the situation, court settlements that may reach $10 billion are presently being negotiated with US plaintiffs who claim glyphosate caused them to develop cancer.

The long-term impact of genetically modified cotton is unknown as once GMOs and the resultant toxins they produce are released into the environment they cannot be recalled. In addition to genetic modification, the processing of regular cotton uses many unseemly chemicals that can include heavy metals, chlorine toxic chemicals and dyes. Moreover, even after the finished products made with these chemicals are washed, their residue remains and can cause serious skin allergies and other harmful unhealthy reactions. Understanding this, face mask wearers should be concerned about the potential health risks associated with wearing genetically modified cotton on their skin, and breathing through it, continually and repeatedly for extended periods. Further, for the environmentally concerned, these chemicals are some of the most toxic chemicals classified by the US Environmental Protection Agency and have a tremendously adverse impact on the Earth's air, water and soil. Further, they are harmful to the people involved with its growing and production and it is alleged that thousands of farmers and farm workers die each year from exposure to them.

See *Appendix A: Organic Cotton Regulation* for a discussion of how organic cotton is regulated.

The Importance of Thread Count

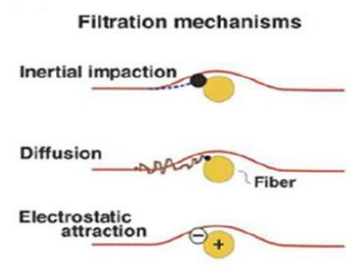
Thread count is the metric used to indicate the relative density of a fabric. Depending on the intended purpose of the textile, it can be an important consideration as it can make a noticeable difference in how a fabric feels, how it wears and how it breathes. As it relates to face mask effectiveness, fabrics with a tighter weave (i.e., higher thread count) do better at physically blocking bacterial and virus droplets.

Indeed, as the Argonne Laboratory research study discussed above demonstrates, 600 thread count cotton is significantly more effective than 80 thread count cotton, filtering out more than 90% of particles larger than 300 nanometers, and more than 65% of those that are smaller. Particulates trying to cross through the denser membrane will not make it as they will get caught in the gaps and pores. This according to Supratik Guha, PhD, Professor of Molecular Engineering at the University of Chicago and Senior Advisor to Argonne National Laboratory's Physical Sciences and Engineering Directorate.

Electrocharged Filtration: Silk and Chiffon Antimicrobials

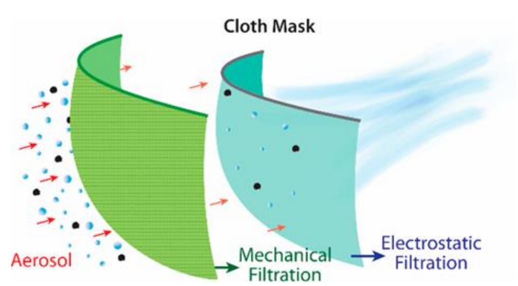
N95 respirators are regarded as the gold standard for viral protection for healthcare workers. In part, this is because they are effective at satisfying two competing requirements: filtration and breathability. To achieve this, a mask filter's pore size must be small enough to trap particles yet not too small to impeded breathing. To optimize this, N95 respirators employ a design that addresses the following three filtration mechanisms:

- ***Inertial Impaction*:** Effectiveness at mitigating the inertia of particulates of 1+ micron in size from flowing around the mask's outer filtration layer's fibers into the mask by intercepting and collecting them;
- ***Diffusion**:* Effectiveness at collecting particulates of between .01 and 1 microns that are diffused by the airstream and attach to the filter's fiber;
- ***Electrostatic Attraction***: Effectiveness at attracting oppositely charged particulates and trapping them with an electrostatically charged fiber.



(Image Credit*: Institute of Medicine* 2006)

As noted in the discussion above, the much-cited Argonne Laboratory study that appeared in *ACS Nano* entitled "Aerosol Filtration Efficiency of Common Fabrics Used in Respiratory Cloth Masks" identified the combination of cotton and silk (chiffon) mask fabrics as being among the very most effective at filtering bacteria- (97% ± 2%) and viral- (99.2% ± 0.2%) sized particles (presupposing no mask gaps). This study pointed out that while a mask's outer layer can be fairly effective as a mechanical barrier in stopping particulates, *much like the electrostatic polymer layer used in the highly-acclaimed (but one-time-use) N95 respirators*, fabrics that hold an electrical charge can serve as an electrostatic barrier by attracting, holding and killing the viral-size particles that might otherwise pass through the outer cotton layer's pores.



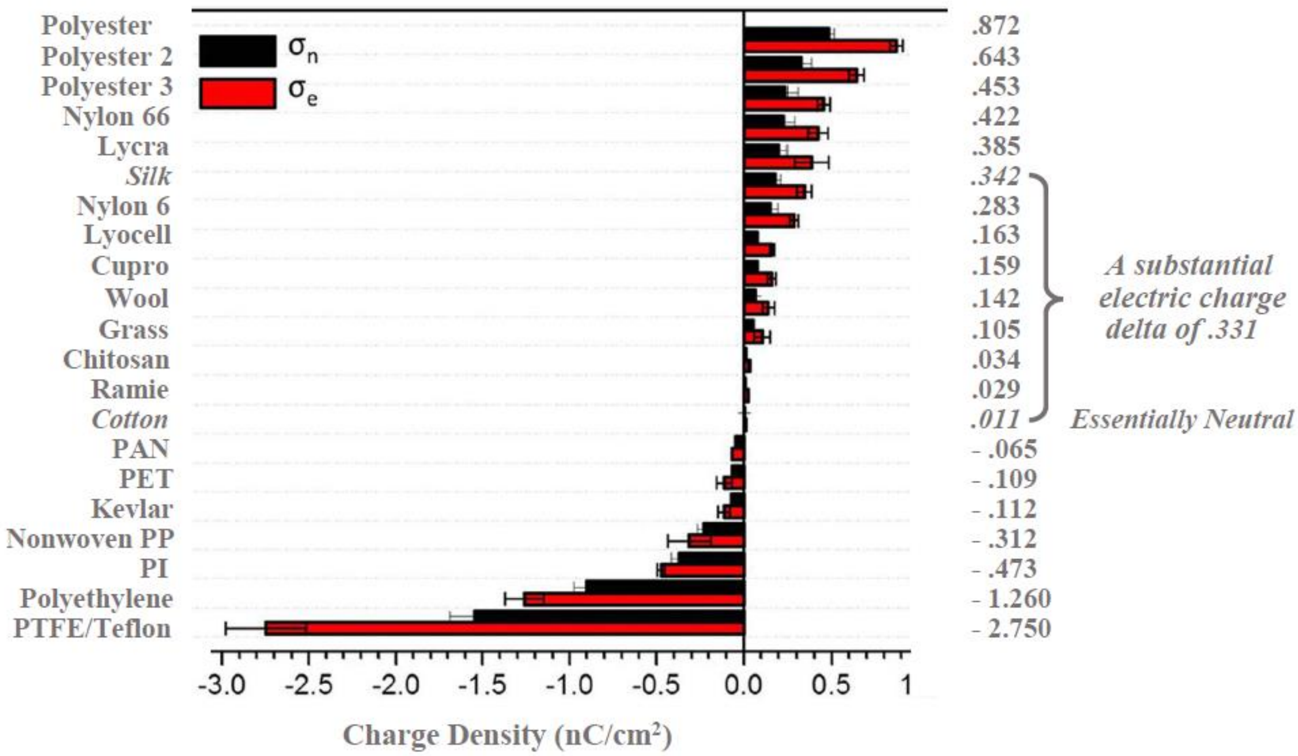
The ability for an electric charge to inactivate viruses derives from the structure and electrical polarity of the virus itself. COVID-19 has mass, and it travels on air and surfaces, it has electrons, protons, a core and an electrical charge. A characteristic that makes it so virulent is its ability to survive without a host for long periods until it finds one. Why it is able to sustain itself for different periods of time on various surfaces is very revealing to physicists/scientists like Ron Kurtus who reason: "If we compare the electrostatic nature of the surfaces that the new corona virus sustains a longer life on, and analyze the static nature of these surfaces, the theory that the virus lives longer on surfaces with a negative charge becomes apparent and cannot sustain itself on surfaces that retain a positive charge *such as silk*…" [39]

Indeed, scientist have known for decades that many viruses have outside hulls (or envelopes or capsids) that are largely made up of protein and that these protein coverings typically exhibit negative polarity. This is often referred to as being "gram negative". When a gram negative virus comes in proximity to positively charged material it is attracted to it through the process of electrostatic induction and then it is essentially electrocuted as the viral cell's protein capsid gives up its charge and fails, thereby inactivating the virus.

Most people are familiar with what is commonly known as "static electricity". It can occur, for example, when a person wearing socks walks across a carpet and then touches a door knob. What actually occurs is that the person gives up electrical charge to the door knob which is grounded. The feeling that is experienced is that of the person "shorting out". This same phenomenon can be replicated when two fabrics are made to rub against each other to create a triboelectric charge, *assuming that the fabrics have different polarity*. The key to making this process effective in the context of creating face mask protection is the correct selection of the face mask's materials. Clearly, the scientists at the Argonne National Lab and the University of Chicago knew this when they set about to evaluate face mask materials. This is why the study they published in *ACS Nano* found that the combination of cotton and silk in a face mask performed at a level that *exceeded that of the N95 mask for <300 nm (viral-size) particles* and was near on par with it for >300nm sized particles.

The use of electrostatic charges in face mask for filtration dates back to 1972 when 3M Company developed the first "single use respirator" with an electrostatic charge to attract smaller particles to it. The reason why N95-type respirators are effective is because the center layer is charged upon manufacture. As described above and elsewhere however, while effective, the limitations of respirators for daily extended use are plentiful. This concept can be replicated in cloth masks with the correct selection of materials, proper layering, etc.

Almost all materials exhibit the triboelectrification effect, from metal, to polymer, to silk to wood. As any of these materials can be used to fabricate a triboelectric charge, material selection is critical, especially when the ability of a material for gaining/losing electrons depends on its polarity. The exhibit below (created from data provided by Mr. Kurtis) illustrates the charge tendencies of various fabrics. Note the substantial charge delta between cotton and silk: this makes them an excellent pair of fabrics for this purpose due to their polarity.



Natural silk is a superior electronegativity biomaterial that evidences exceptionally reliable energy harvesting performance owing to its mechanically super-strong material properties; it also dissipates electrostatic charge easily. Silk is one the very best fabrics for use in electrostatically filtering particles <100 nm owing in part to its sheerness and effectiveness at charge transfer with nanoscale particles.

Cotton is one of the very few materials that do not tend to readily attract or give up electrons when brought in contact or rubbed with other materials. Cotton has the advantage of being subject to only minimal antistatic build-up and its natural tendency is to be hygroscopic – i.e. draw in moisture from the air, thereby increasing its static dissipative capacity. Supima® cotton's extraordinarily longer fibers enhance its electrostatic value owing to its strength and ability to facilitate a tighter weave, an attribute noted by Argonne Lab researchers.

Chiffon produces frequent and powerful jolts of static electricity when used, in great part, due to its "bumpy" texture. This propensity to create a greater amount of friction, which enhances the triboelectrification process.

The University of Chicago and Argonne National Laboratory researchers concluded that a combination of masks made of high thread-count cotton with natural silk fabric or a chiffon weave can be essentially equally effective at filter out aerosol particles at a level equivalent to, or better than, N95-type respirators.

Given the attributes of Supima® cotton, natural silk and chiffon described above, it only stands to reason that the ideal face mask composition would be a Supima® cotton/silk chiffon combination.

Chemical Antibacterials

Some face masks manufacturers make claims that the various antibacterial or antimicrobial technologies they use enhance their product's safety and effectiveness. Others claims that it extends the mask fabric's useful life. Regrettably, many of these claims are not founded in science and lead to a false sense of security.

Antibacterials and antimicrobials differ regarding the microorganisms they act upon and how they work:

- An *antibacterial* is an antibiotic that, as its name implies, can only effectively target bacteria. Antibacterial technologies typically incorporate an active silver, copper or zinc ingredient that is destructive to, or inhibits the growth of, a broad spectrum of harmful bacteria (e.g., E. coli, MRSA).
- The term *antimicrobial* is derived from the Greek words anti (against), mikros (little) and bios (life) and refers to all agents that act against microbial organisms. Antimicrobial technologies destroy (kill), and inhibit the growth of, all types of microorganisms: bacteria, viruses, fungi and protozoa.

Most people have confidence in the effectiveness of antibacterials as they have been around for decades and are widely used. However, with the emergence of the coronavirus, and all the ensuing information and misinformation that it generates, many are suspect as to the effectiveness of various measures against it. Understanding this, it is worthwhile to discuss exactly how viruses work.

In simple terms, there are essentially five stages involved in how a virus hijacks cells and causes infection.

1) *Attachment*: Target and attach to a cell and make it a host.
2) *Penetration*: Inject the host cell with its noxious genetic material.
3) *Synthesis Viral Components*: Copy viral DNA/RNA to make viral proteins with host cell materials.
4) *Assembly*: Create additional viral particles from newly synthesized viral components.
5) *Release*: Break away from the host cell and search for new cells to infect.

Although COVID-19 is a novel virus, it is a *betacoronavirus*, part of the *coronaviridae* family and related to the commonly known MERS-CoV and SARS-CoV viruses. The SARS-CoV-2 genome is ~30kb in size. It is an enveloped, positive-sense (positive +) single-stranded RNA virus. The viruses' human receptor is an angiotensin-converting enzyme 2 (ACE2) that impacts the regulation of blood pressure and the cells of the heart, lungs, kidneys and intestines. The coronavirus binds to these enzymes through the mushroom-shaped surface proteins called spike proteins with which we have all become familiar, and which give the virus its crown (corona)-like appearance. This is why many of the symptoms associated with COVID-19 are caused by impairment of the patient's immune system, and not the virus itself. [40]

The primary function of antimicrobials is to fend off microorganisms from attaching to the fabric's surface, and killing them if they do. Because microorganisms can live on a fabric's surface and grow, antimicrobials are very effective as they prevent their growth and spread within the fabric. Face masks can be a particularly inviting site for microorganism's propagation because it is in extended close contact with the wearer's skin which provides a very conducive environment for microorganism growth. Indeed, the combination of nutrient sources, temperature and moisture provided optimal condition for microbial growth on a face mask's surface.

Understanding this, it's easy to appreciate that antimicrobials offer a face mask wearer a greater level of protection versus antibacterials by killing the virus and continuously inhibiting the growth and spread of microorganisms on its surface for an extended period of time. Indeed, there is good evidence that these types of viruses are actually some of the easiest virus types to deactivate, although specific CODIV-19 data is lacking as scientists are still researching its exact nature and how large a role surface transmission plays in its spread. Notwithstanding this, it is advised that face mask purchasers carefully research and scrutinize the often exaggerated claims made by mask manufacturers and marketers as to the efficacy of the anti-microbial substances they employ. Below is a detailed review of the more commonly used antimicrobial technologies.

An essential element of any antimicrobial solution is its ability to remain affixed to the treated fabric and continue to kill microorganisms as they come in contact with the surface over time. To remain effective, it must maintain durability and not "leach" (wash away) over time. Antimicrobials work by physically stabbing and electrocuting the microorganism on contact to kill it. [41] Leaching anti-microbials are often effective early on, but not over time because, like an arrow shot from a quiver, or a bullet shot from a gun, they are used up in the process of working and wasted by random misses. To extend the useful life of the antimicrobial agent, some makers build leaching mechanisms into them, at the expense of its effectiveness. As face masks treated with a leaching antimicrobial are washed, the treatments are removed thereby reducing their effectiveness.

What's more, this leaching process can actually lead to an increased risk to the face mask wearer. Like any other living organism, microbes will take extreme measures to survive. If they are exposed to sub-lethal doses of an antimicrobial agent – and not killed – the microorganism can genetically mutate or be enzymatically induced into adapting to the potential toxicant and become a tougher "super-strain". [42] This phenomenon is similar to that which occurs when patients discontinue taking antibiotics once their symptoms subside instead of continuing through to the end of the period prescribed by the physician. This is yet another reason why the antimicrobial agent used on a face mask should be of concern to the buyer when selecting one.

Superior antimicrobial technology does not leach (wash away or diminish over time) but instead remains permanently affixed to the face mask's fabric. This is accomplished because it "attaches" to the fabric through a two-stage chemical reaction whereby a one- molecule deep ion exchange occurs that replaces protons on the fabric's surface and, through polymerized chemical absorption, creates a bond that is virtually irremovable. Unable to migrate, the antimicrobial does not cross the skin barrier, does not affect normal skin bacteria, and does not causes rashes or skin irritations. This "organofunction" does not seek to poison the microorganism but physically rupture it with a sword-like action and then electrocute it with a positively charged nitrogen molecule. [43] This proven antimicrobial technology has been substantiated and used on both consumer and medical goods in the US, Europe, Asia and elsewhere throughout the world, for more than four decades, without any human health or environmental problems in actual end-use situations.

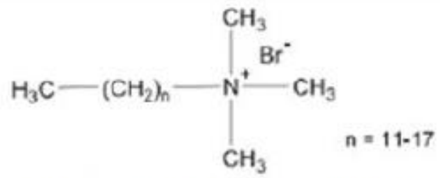
The ability for an antimicrobial to chemically bond to a face mask's fabric *and* remain safe, is crucial. The antimicrobial agent must be tested against oral, ocular, dermal and vapor inhalation irritation, reactions and toxicity; surface and percutaneous (through the skin) dermal absorption; and be absent of exogenous metabolic activation (chemical reactions of a relatively benign substance into a more hazardous one by normal biochemical processes in cells and tissues). The antimicrobial treated fabric must be assured to be non-toxic, non-irritating and non-sensitizing, and, no other untoward health effects should be notable.

Given that a face mask must be durable, the fabric with which it is constructed must also be as durable. As such, the antimicrobial treatment used on face mask fabric must be able to survive abrasion, sterilization, wet and dry cycles, freeze and thaw cycles, alcohol rinses and other physical and chemical stresses.

Chemical Antimicrobial Approaches

There are many antimicrobial approaches to treating fabrics used for face masks. The following is a brief discussion of the pros and cons of the two most common ones: Quaternary Ammonium Compounds - QACs and Metals / Metallic Salts. The exhibit below is a modified version of one that was used in a piece entitled "Antimicrobial Approaches for Textiles: From Research to Market" that was in *Materials Journal* (June, 2016), [44] the source of the information used in the technical discussion that follows. Essentially, it describes how the method works (the "action mode") and on what fabrics it can be applied.

A *quaternary ammonium compound* (or QAC) is a surface active agent that stirs up a chemical reaction on the surface upon which it is applied. It is cationic, meaning it is positively charged (produces electrically positive ions in solution) and therefore becomes effective as an antimicrobial agent. Usually applied to cotton, polyester, nylon and wool, QACs are effective against a wide range of microorganisms including gram-positive and gram-negative bacteria, fungi and certain types of viruses. They work as a result of an interaction of surface positive charges and cell membrane negative charges that create a membrane permeability and leakage in the targeted microbe's cell that is triggered by electrical interactions between the ammonium active agent and the negatively-charged cell membrane of the microbe. This results in various antimicrobial actions may include damaging the microbe cell's membranes, the denaturation (i.e., killing) of the cell's proteins and the inhibition of DNA production to prohibit multiplication. Notwithstanding their effectiveness as an antimicrobial, the one disadvantage of some QACs is that they leach (become detached) from the fabric due to

Biocide	Chemical Structure	Action Modes	Fibers
QACs	 (Example: monoquaternary ammonium salt: alkyltrimethylammonium bromide)	•Damage cell membranes; •Denature proteins; •Inhibit DNA production, avoiding multiplication [7,12,26].	Cotton Polyester Nylon Wool
Metals and metallic salts	Examples: TiO_2 and ZnO	Generate reactive oxygen species, damaging cellular proteins, lipids and DNA [31,32].	Cotton Wool Polyester Nylon

the lack of adequate physical bonding, resulting in the antimicrobial's effectiveness diminishing over time. In fact, for some lesser quality antimicrobial products, the QAC can be exhausted under near boiling conditions when washed. However, other commercial QAC-based antimicrobials (e.g., the Aegis® Microbe Shield) utilize an isolated active agent that is purer and therefore more durable and effective over time. To increase the antimicrobial's durability by creating a stronger bond between with the fibers' surface, some QAC may be polymerized to act as a bio-barrier against microorganisms by a non-leaching contact action that makes them less vulnerable to multiple washings. Lastly, in studies performed by multiple laboratories, no significant effect on human health was observed with antimicrobials that are QAC-based.

Metal-Based Antimicrobials

The other antimicrobial technology that is commonly employed on face masks are based on the use of various metals that have been found to be toxic against many microorganisms, at low concentrations, either in their free state or in salts or compounds. As a result of their biocidal (e.g., poisonous, destructive to life) qualities, these metals, oxides and salt compounds are fairly widely used as antimicrobial agents in some textiles. Although copper, zinc and cobalt are used for this purpose, most of the antimicrobials used on face masks are silver based. The use of silver to control infections dates back centuries as silver's antibacterial properties have long been known. Silver does however have many toxicity issues with which to contend. Since the antimicrobial agents used in many masks are silver based, a critical assessment of this topic is relevant and warranted. Because silver has long been known for its ability to neutralize many of the nasty microbes that can make people sick, healthcare professionals have used it to treat burn victims, germs on medical devices (e.g., catheters and bone prostheses) and even to effectively combat dangerous "superbugs" that have become resistant to traditional antibiotics. In each of these instances, the use of silver has been shown to be effective

Silver, for use as an antimicrobial agent base in the form of ultra-fine metallic particles, can only be added to fabrics at the finishing stage. Most recently however, advances in technology have made it possible for consumer products companies to add tiny, powerful silver nanoparticles for antibacterial purposes to an ever expanding array of items as diverse as cutting boards, underwear, yoga mats, running shirts, gloves, shoe insoles, socks, toothbrushes and other goods. As of late, this list has been expanded to include non-medical COVID-19 cloth face masks. This more expansive and widespread use of nanosilver has caused concern on the part of a growing number of scientists and environmental watchdog groups however as the long-term effects of chronic exposure to these particles on humans, and to our ecosystem environment, are not well known. This has led researchers at the US Geological Survey to warn against the overuse of silver and fear the explosion of its use on products where we do not know it to be effective; noting that it is important to evaluate the risk of using silver before putting it into the environment. [45] Indeed, nanosilver manufacturers must now register their products with the EPA citing the risk they pose. And, while it is true that most experts agree that fairly high doses of silver can be safely tolerated by humans, what is of concern to them is the fairly recent manipulation of these nanoparticles and their use for applications where silver has never before been used (e.g., face masks).

Product Name	Company	Description
agion® [36]	Sciessent	Additive based on silver and zeolite
AlphaSan® [37]	Milliken Chemical	Additive based on silver
BioGuard® [38]	AEGIS Microbe Shield™	Finishing agent based on 3-trimethoxysilylpropyldimethyloctadecyl ammonium chloride
Biozac ZS [12]	Zschimmer & Schwarz Mohsdorf GmbH & CoKG	Finishing agent based on PHMB
Cosmocil CQ™ [39]	Lonza	Additive based on polyaminopropyl biguanide
Eosy® [12]	Unitika	Finishing agent based on chitosan
Irgaguard® 1000 [12]	BASF (Ciba)	Finishing agent based on triclosan
Irgasan [12]	Sigma Aldrich	Finishing agent based on triclosan
Microban® [40]	Microban International	Agent based on triclosan
Reputex™ [41]	Lonza	Finishing agent based on PHMB
Sanigard KC [42]	L.N.Chemical Industries	Finishing agent belonging to the QAC group
Saniguard Nano-ZN [42]	L.N.Chemical Industries	Finishing solution based on an aqueous nano-dispersion of zinc oxide
Sanitized® [43]	SANITIZED	Finishing agent based on 3-trimethoxysilylpropyldimethyltetradecyl ammonium chloride
Silpure® [44]	Thomson Research Associates	Finishing agent based on fine silver particles
Silvadur™ [45]	The Dow Chemical Company	Interpenetrating polymer network with silver ions
SmartSilver® [12]	Nanohorizon Inc.	Agent based on silver nanoparticles
Silvérion 2400 [46]	PURE Bioscience, Inc.	Agent based on a stabilized silver complex

We have only recently come to better understand how the molecular mechanisms of silver kill bacteria and how resistance to silver develops in microorganisms. University of Calgary biological scientists have helped to enhance our understanding of silver's antibacterial properties with research intended to explore how the genes of various strains of bacteria show either resistance or sensitivity when exposed to silver; and the mapping of genetic cell response that indicates the many ways in which silver acts on bacteria. [46]

Despite the many benefits of using silver and nanosilver as an antimicrobial agent, what environmentalists, public health officials and Duke University researchers fear is the negative impact the disposal of various silver treated medical (e.g., gloves) and consumer products (e.g., disinfectant wipes, cleaning detergent) has when they end up in sewage treatment systems and, ultimately, in the environment. This is because there are presently no effective means by which to filter out silver nanoparticles and the large-scale release of them into the atmosphere may lead to not only disturbances of the microbiological ecosystem but also our bacterial resistance to silver. [47] As such, they content that the use of silver-based products should be avoided unless justified (e.g., for needed medical interventions) and when it can be both immobilized and contained, recognizing the ample evidence exists that there may be adverse long-term effects from the consumption of, or exposure to, silver. [48]

While normal concentrations of silver in human tissues are fairly low…if there is overexposure, silver can accumulate in the skin, liver, kidneys, corneas, gingiva, mucous membranes, nails and spleen…with serious health consequences: this according to Dr. Kenneth Rosenman, Distinguished Professor of Occupational and Environmental Medicine at Michigan State University. Exposure to silver ions may pose a risk of neuro-toxicity; may interact with skin flora, causing the detachment of the cell membrane of healthy bacteria thereby weakening the skin's defense barrier; and lead to skin discoloration. His four decades of research has shown that the exposure to, and inhalation of, silver compounds, dust or fumes can cause or contribute to upper and lower respiratory tract irritation; bronchitis, emphysema and reduced pulmonary volume. [49]

Many strategies exist to enhance the uptake and durability of metals as an antimicrobial agent to treat fabric. As it relates to natural fibers (e.g., cotton) this can only be undertaken at the finishing stage. Exhaust or pad applied, silver-based antimicrobial finishes and coatings adhere to fiber surfaces and deliver silver ions each time organisms land or form on the treated fabric, thereby inhibiting microbe growth and buildup on the fabric's surface. Although the active agent used in these products has been proven to be effective on viruses in general, its impact against viruses like COVID-19 has not been established in clinical studies. Fabric treated with silver-based agents boast of being able to withstand up to 50 high-temperature wash cycles, but no tests exist to support this claim. Given the potential harmful health effects of silver-based technologies, face masks employing alternative antimicrobial technologies are not recommended.

Antimicrobial Fabrics

Very few (if any) face mask manufacturers actually create the fabric that they use in their masks: typically, they purchase a commercially available antimicrobial textile. The global antimicrobial textile market is a $10 billion one and most of these textiles are used in the healthcare industry which in known for high standards of hygiene and the need for a bacteria-free environment. Unfortunately, as the accompanying exhibit shows, most commercial antimicrobial fabrics are synthetic, not eco-friendly, toxic and can cause adverse effects on human health. [44] Moreover, of the sixteen commonly used commercially available antimicrobial fabrics noted, not one is natural or cotton-based: the material best suited for face masks (as detailed above).

Product Name	Company	Description
ACTICOAT™ [107]	Smith & Nephew	Textile structure composed of 3 layers: 2 layers of polyethylene mesh coated with high density nanocrystalline silver; 1 layer of rayon and polyester
Amicor/Amicor Plus [12]	Acordis, Ltd.	Acrylic fibers containing triclosan or a combination of triclosan and tolnaftate
Bactekiller® [12]	Fuji Chemical Industries, Ltd.	Fibers containing metal ions
Bactershield® [108]	Sinterama	Polyester yarn containing a bacteriostatic agent
Bioactive® [109]	Trevira	Polyester fibers containing silver
BiofresH™ [12]	Sterling Fibers, Inc.	Acrylic fibers containing triclosan
Chitopoly® [12]	Fuji-Spinning	Fiber made by kneading chitosan into polynosic fiber
Crabyon® [110]	SWICOFIL AG	Composite fiber of chitin/chitosan and cellulose viscose
FeelFresh® [111]	Toyobo	Acrylic fibers endowed with antibacterial metal ions
Kendall™ [112]	Medtronic	Textile foam dressing containing PHMBs
Microfresh® [7]	O'Mara, Inc.	Polyester yarns containing silver particles
Rhovyl'As® [12]	Rhovyl	Fibers containing triclosan
SeaCell® *active* [113]	Smartfiber AG	SeaCell fibers (based on cellulose) enriched with silver ions
Silfresh® [7]	Novaceta	Cellulose acetate yarn containing triclosan
SoleFresh® [7]	O'Mara, Inc.	Polyester yarns containing silver particles
Thunderon® [12]	Nihon Sanmo Dyeing Company, Ltd.	Acrylic fibers containing copper ions

Aegis® Microbial Shield

One QAC-based antimicrobial technology that distinguishes itself from the rest is the Aegis ® Microbe Shield. A breakthrough product created by Dow Corning, and having a 30-year safety and efficacy profile unmatched by any other commercial product, the Aegis® Microbe Shield is a unique bonded antimicrobial technology for textiles that provides effective control of airborne microbes while eliminating the potential for their growth.

Conventional QAC-based antimicrobials penetrate living cells and kill by way of poisoning the organism or disrupting a vital life process. They are designed to act and dissipate quickly. Most antimicrobials used for treating surfaces do an adequate job of killing microbes, although they have a limited range of effectiveness. The Aegis ® technology takes a totally unique approach. It provides an effective initial microbial kill when applied, but, unlike conventional methods, it also provides long-term control of growth on treated surfaces, often for the life of the product as the surface itself is modified to make it antimicrobial active.

The AEGIS® Microbial Shield is infused into the mask's fabric to bond and become a part of it	Microbes are attracted to the treated fibers	AEGIS® punctures/electrocutes the microbe's envelope, which eliminates its ability to sustain life	Absent a healthy envelope, the microbe dies and becomes inactive

The Aegis ® Microbe Shield's active ingredient forms a positively-charged polymer that molecularly bonds to the treated surface and, metaphorically, creates a layer of electrically charged swords. A cationic anti-microbial, it neutralizes the cell wall's natural protection by interacting with cellular proteins needed to maintain their integrity. When a microbe makes contact with the treated surface, the sword punctures the cell and the electrical charge shocks the microbe's negatively charged membrane to kill it. Since nothing is transferred to the dead cell, the antimicrobial doesn't lose strength and the sword is ready for the next cell. [51]

Available on a few select premium commercial fabrics, the Aegis ® Microbe Shield is chemically applied to fabrics during its manufacturing in the rinsing stage after the fabric has been knit or woven. Because the treatment's chemistry polymerizes when it is applied to form a permanent bond with the protected fabric, it actually becomes a part of it, won't diminish in effectiveness over time and will last for the life of the fabric. Normal cleaning should not remove the treatment; although it can be abraded away. A test of hospital blankets treated with the Aegis® Microbe Shield demonstrated its enduring effectiveness after 180 washings. [52]

The Aegis® Microbe Shield has a long history of safe and effective use. Unlike many other QAC-based antimicrobials, it has no unwanted side effects, including damage or discoloration on product surfaces, toxicity to living organisms or environmental damage. It does not volatilize, dissipate, or leach onto other surfaces or into the environment or give off any gases after application. Globally recognized for its superior antimicrobial protection, it is one of the very few safe and effective antimicrobials. Its safety, utility, performance and durability for medical use has been confirmed by dozens of independent private, public and academic laboratory studies and risk assessments. It has received OEKO-TEX® certification and is proven to be compatible with the stringiest Restricted Substance List's and sustainable textile manufacturing processes. Its biocidal active components are registered with the EU Biocidal Products Regulation [53] and the US EPA. [54] NASA's Spaceflight and Life Sciences Training Program verified its effectiveness on cotton. [55] Canada's Western University ImPaKT Facility Biosafety Level-3 Lab found it reduces the risk of microbial transmission by up to 99%. [56] The American Hospital Supply Corp. studied the use of antimicrobials on medical non-woven products where virtually all medical antimicrobials were screened for toxicity, effectiveness against the types of microbes encountered in surgery and compatibility with the physical, chemical and biological contaminants found on fabrics. This study eliminated *all* other antimicrobials except the Aegis® Microbe Shield.

A test performed several years ago to demonstrate the effectiveness of the Aegis® Microbial Shield against Methicillin Resistant Staphylococcus Aureus (MRSA) [57] was performed by Robert A. Monticello, Ph.D., who now serves as the Senior Scientific Consultant to the International Antimicrobial Council (a not-for-profit whose "mission is to protect the public from the potential abuses of antimicrobials by educating antimicrobial users, producers and laboratories regarding the appropriate use and development of appropriate test methods, procedures and standards"). Conforming to ASTM E2149-01 guidelines, the study found that the fabric treated with the Aegis® Microbial Shield reduced the total population of MRSA bacteria 99.99 % after one hour simulated dynamic contact. Independent research testing conducted by the Malaysian & Thailand Government research laboratory, proved the efficaciousness of the disinfectant biocides used in the Aegis® Microbial Shield against the highly pathogenic H5N1 Avian Influenza virus. [58] To see a short video that describes why the Aegis® Microbe Shield is different from, and more effective than, other antimicrobial agents, click here.

Bio-Burden Elimination

Another distinctive advantage of an antimicrobial approach to face mask protection pertains to the safety of the protected face mask as it relates to wearing, removing and storing it. Even when they are properly used, ordinary face masks create "bio-burdens" or large populations of viable viral microorganisms. [59] This is a result of the wearer breathing and coughing germs and viruses into them and coming into contact with others who carry and transmit germs and viruses to the mask surface. Since the Aegis® Microbial Shield actually continuously *kills*, rather than simply *filters*, dangerous microbes, the issues of cross-contamination and bio-burdens are effectively addressed. Due to the elimination of the microbe, a perfectly airtight seal is not as necessary for the mask to be effective in use; there is little risk of mask-to-hand-to-body transmission when removed; and, relative to ordinary masks, it is safer to transport and store (as it is not covered with active pathogens). This is critically important as when the wearer touches, adjusts and discards a mask, each action potentially spreads disease and possibly infects the wearer, others in the vicinity and any surfaces it contacts.

Warning about Antimicrobial Claims

The EPA has strict rules regarding marketing claims made about the capabilities of antimicrobial products. Among them are prohibitions against making claims beyond that of the "treated article" itself. Without specific EPA approval, claims cannot be made about an antimicrobial's protection/prevention against specific organisms infectious to humans (e.g., COVID-19) or that of the treated fabric. These prohibitions cover the product's packaging, advertising and communications.

As it relates specifically to face masks, unless authorized by the EPA, any claim as to the antimicrobial's capability must be limited to the face mask itself; be specific and not unqualified; not reference health-related microbes, and; refrain from denoting personal (e.g., "for skin, wound, or respiratory") protection. Further, graphic representations of the mask's antimicrobial protections can't include or imply protection of public health significance or take prominence above other normal product claims. The above, from an article appearing in WWD (April, 2020) [60] by Terry Walmsley, Director of Regulatory Affairs and Sustainability at *Noble Biomaterials*. While these prohibitions apply to foreign textile technology companies that sell products in the US, face mask purchasers should be aware that many make unsubstantiated claims about their product's anti-COVID-19 capabilities.

COVID-19 Antimicrobial Claims

Although many claims are made by established and emerging antimicrobial and anti-viral pathogens perceived to kill the COVID-19 causing virus, no organization can justly make such a claim as, to date (July, 2020), there has been no approval, or any form of government-sanctioned testing performed to prove the effectiveness of any antimicrobial agent against the coronavirus. The Aegis® Microbial Shield is certainly among the world's leading antimicrobial agents and it has a proven track record of effectiveness against a plethora of microbes. And, while its built-in active antimicrobial biocide technology is indeed effective against viruses in its pure state, it has not currently been proven to have any antiviral properties when built-into products.

Graphene-Based Antibacterials

Still thought to be very much in its infancy for real world applications, *graphene* has nonetheless been described by as the most exciting material of the 21st century. Graphene is the world's first two-dimensional material made from carbon. A nanomaterial comprised of sheets of carbon atoms in a honeycomb pattern it is essentially graphite oxide (GO) in one layer. In that graphene oxide is less expensive and easier to manufacture than graphene, it is likely that it will enter mass production and practical use sooner however.

Having amazing properties, graphene (the thinnest and lightest object ever made) is a million times thinner than human hair yet three-hundred times stronger than steel. Flexible, transparent and a better conductor than copper many scientists believe that graphene could one day enhance, or replace, metals and plastics in our daily lives as a one-atom-thick sheet of it can be applied to a variety of materials in many ways (e.g. composites and coatings, water filtration, sensors, electronics and biomedical applications). [61]

Understanding this, with the emergence of COVID-19, graphene producers, application developers and researchers from throughout the world are exploring the use of both graphene and graphene oxide in the fight against this pandemic. Chief among this research is a focus on the potential to create a graphene (oxide)-based antibacterial cotton as graphene is reported to exhibit strong antibacterial activity. In the US, this study is being undertaken by several university researchers who believe that it could help make face masks repel bacteria owing to its bacteriostatic properties that inhibit bacterial replication due to its atomic structure. [62]

One such incarnation is a rather futuristic face mask that employs a portable battery pack that sends a low-level electrical charge through its surface which repels particles trapped in the graphene. Initial tests claim that this graphene-based filtration technology is 99% effective against particles that are more than 0.3 micrometers and 80% effective against smaller particles (which is not very reassuring considering that the coronavirus is 0.12 microns in diameter). The masks power pack employs a USB port and an at-home docking system that sterilizes the unit for future re-use. It is noteworthy to mention that, despite it being believed to be non-toxic, the long-term effects of wearing such an electrically charged graphene-based device so closed to a mask wearer's skin for an extended period has not been fully researched or adequately tested. [63]

Some Asian-based companies are taking orders for face masks that are graphene-enhanced, looking to leverage the material's bacteriostatic/antimicrobial characteristics. By applying a coating that contains one, or a combination of, graphene, graphene oxide and other carbon nanomaterials to the mask's outer layer, these masks claim to create a bacteria-resistant surface that effectively repels, reduces and/or inactivates between 90 – 98% of various bacteria. [64] [65] Because the coatings are applied by various direct adsorption, exposure to radiation or chemical bonding processes their laundering durability is important as most claim they may be washed from ten to more than twenty times without color fading or loss of the mask's graphene coating's antibacterial or antistatic properties. This appears to indicate that these masks don't last very long and need to be replaced often, thereby contributing to the high cost of using such a mask on a regular basis

While the promise of graphene is certainly encouraging, the author does not believe that it is ready-for-prime-time as it relates to face mask applications. In large part, this has to do with various challenges inherent in the material and its limited use in textiles, especially those that are intended to be worn for an extended period next to the skin, and breathed through (as studies indicated it could be toxic to the liver, kidneys and lungs). [66] [67] By example, while animal tests are reputed to evidence that GO-modified cotton fabrics cause no irritation to rabbit skin, we know of no similar testing having been done on humans. [68] There is some concern as to the porosity of graphene-treated fabric when it gets wet. [69] It is still a reasonably high-cost material fraught with uniformity, transport and handling issues and not subject to the standards that are customary in most industries. Lastly, according to a study published in the (June, 2018) American Society for Microbiology's *Journal of Antimicrobial Agents and Chemotherapy* "…their possible ecological effect must be properly evaluated before their widespread use". [70] Given the other alternative proven and tested means by which to imbue antimicrobial characteristics in face masks, we believe that the use of carbon-based (e.g., graphene) materials in face masks should be delayed until further evidence of their effectiveness and safety is better understood.

The Importance of Proper Fit

There are seven basic face shapes (oval, round, square, diamond, heart, pear and oblong) and a good face mask must accommodate each of them as a mask is only as effective as its fit. Per the *ACS Nano* study, a 1 - 2% gap can reduce a mask's filtering effectiveness by half. A well-fitting mask must fit snuggly, have no gaps along its side, around the nose or under the chin that would allow air or virus particulates to bypass it, or it will compromise its effectiveness by enabling aerosolized air to escape (or enter). A factor that critically impacts a mask's comfort and effectiveness is the ear mechanism that secures it to the wearer's face. Essentially, there are three approaches to this: an elastic ear loop, cloth ties or a cloth ear straps with an adjustable holder.

Putting aside for the moment those cheap (uncomfortable and barely wearable) masks that have simple cut outs for your ears, most face masks use elastic ear loops. In great part, this is because they are inexpensive and easy to manufacture and install. They also make it easy for the wearer to put on and take off the mask. But that is where the advantages end. In general, elastic ear loops typically pull the wearer's ears forward thereby making the mask very uncomfortable for most within a half hour. [71] Elastic ear masks also often don't facilitate a good fit, resulting in the sides flaring in and out with one's breadth. They can make it difficult for those having small, large, thin or wide heads to achieve a good fit. Elastic ear loops can interfere with wearing earrings; they often don't last very long after multiple machine washings and some contain latex.

There are two types of mask ties: those that tie behind each ear and those that tie together behind the wearer's neck and head. Very adjustable, they do make it fairly easy to obtain a good fit on all face sizes and shapes, and can make a mask comfortable. Masks with ties take longer to put on and take off (and necessitate the ability to tie a knot behind one's head). They cost more, and take longer, to manufacture and install. [72]

The ideal mask-securing ear mechanism incorporates a simple solution that is easily adjustable to ensure a snug fit while at the same time enhancing a masks' long-term comfort: ear straps used with a cord stop, loop lock or buckle clamp, an apparatus that is quick and convenient to use, durable and reusable. This simple device keeps each of the mask's ear straps in place with a push-button locking slider that secures the mask around the ears to minimize friction, pressure, skin irritation, leakage and make it comfortable. Plastic, with a protective nylon cover to maintain strength while under resistance, it is costlier, but more effective than the alternatives, with no drawbacks. [73]

Another way to ensure a snug mask fit is with an adjustable nose piece. Found on N95 respirators, an adjustable nose form is a means to ensure a 360-degree seal. It helps to tighten the mask to prevent gaps and to mold over the wearer's nose. It also stops it from pushing into the bridge of the nose. A plastic encased, stitched-in, padded corrosion resistant aluminum nose form (that doesn't kink or break when adjusted) will help seal the mask and prevent eye glass fogging. It will help the mask to maintain its shape over time and facilitate a snug, comfortable fit understanding that a mask must be fidget-proof as touching even a masked face is not good. [74]

Moisture Control

An improperly designed face mask can trap moisture that develops from the wearer's perspiration and breath. The moisture and humidity can both generate dangerous bacterial build-up and lead to chafing of the skin around the mouth as well. [75] A correctly-designed mask however will automatically regulate humidity within the mask and draw moisture and perspiration away from the wearer's skin and onto the exterior of the mask's fabric, enabling it to evaporate or dry rapidly so that it doesn't saturate it. This process is called "moisture wicking". Man-made polyester, a synthetic, is hydrophobic and typically has a low level of wicking. It tends to repel water and polyester fabrics don't absorb perspiration leaving the wearer with a moist, clammy feel. [76] Of all natural materials, cotton is the most efficient moisture wicking fabric because it transmits heat and absorbs moisture well…especially tighter weave, high (200 - 500) thread count varieties. The result is that the fabric touching the mask wearer's skin is dry, non-sticky and bacteria free.

Breathability / Adequate Airflow

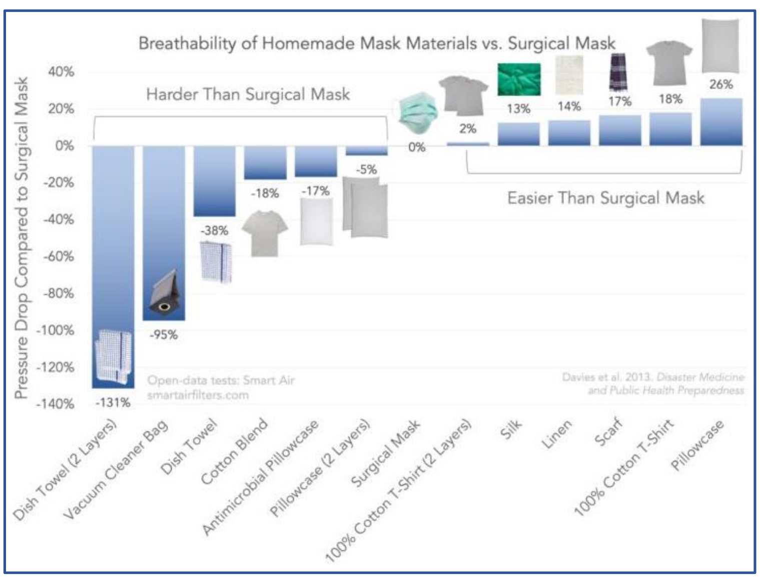
For a face mask to be effective, and able to be worn for an extended period of time, it has to satisfying two competing requirements: filtration and breathability. Ultimately, the form of "filtration" that would ensure that not even a single germ or virus could be inhaled would be to wrap one's head in "Saran Wrap®," but of course, the mask wearer would be unable to breathe and suffocate. In that this isn't practical, in addition to having excellent particle filtration capability, a face mask must be breathable and allow for adequate airflow.

In non-technical terms, breathability, or the ability to realize adequate airflow, as related to face mask wearing, is defined as the measure of how well the fabric allows the passage of air through it. Permeability is the rate at which substances pass through the mask's porous medium. A face mask needs air, water and vapor permeability; to be properly ventilated enough to be able to breath comfortably, especially for the elderly and those with breathing difficulties. If breathability is inadequate, the mask will not be able to be safely or comfortably worn for an extended period and the wearer will not be able to speak normally and be heard clearly. [77] If the wearer can't be heard clearly, he or she will get closer to the person with whom they are communicating, which may inadvertently encourage noncompliance with important physical distancing norms.

Why N95 Respirators Aren't the Answer

N95 respirators are regarded as the gold standard for viral protection for healthcare workers. Unfortunately, many falsely believe that they would be ideal for everyday use. Nothing could be further from the truth. Despite their overall effectiveness, respirators have inherent problems that make them difficult to wear for more than the short periods of time for which they are intended. To begin, they require a tight fit to be effective as a gap of 1 – 2% can reduce their effectiveness by half. As such, this makes the mask hot and humid on the face which causes discomfort. More importantly, they are difficult to breathe through for extended periods. Stanford University researchers have shown that N95 wearers actually breathe in 5% to 20% less oxygen (O^2) than normal unfiltered air and they also breath in a higher proportion of the carbon dioxide (CO$^{2)}$ they exhale (neither of which is good, as described below). [78] [79] Unfortunately, this lack of O^{2,} and surplus of CO^2, is uncomfortable by nature and often leads to the wearer adjusting the mask often which can increase their ability to become infected or inadvertently break the N95's required air-tight seal. Healthy wearers can typically adapt to the CO^2 difference after an hour or so, however the reason for the wearer's blood oxygen and CO^2 levels returning to normal may be because they begin to take longer, deeper breaths. [80] Some N95 masks have inhale or exhale valves, but they defeat their purpose by allowing infected particles to enter it.

Below is an exhibit that details the relative breathability of materials often used in face masks. The data is from an article entitled "Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?"



The study, which appeared in the (May, 2013) *Cambridge University Press*, was conducted by Public Health England. [81] The findings shown here were reformatted by *Smart Air*. [82]

As N95 respirators are not appropriate for non-medical applications, it wasn't included in the study. Had it been, due to its poor breathability, it would have been at or near the bottom of the range. Interestingly the surgical mask was used as the baseline measure of a mask's breathability.

Note that those mask fabrics found to be most breathable are also natural, found to be more effective at microbe filtration and less likely to be a bio-burden, e.g., linen, silk, and 100% cotton items (e.g., t-shirts, pillowcases).

Prolonged Mask Wearing Myths

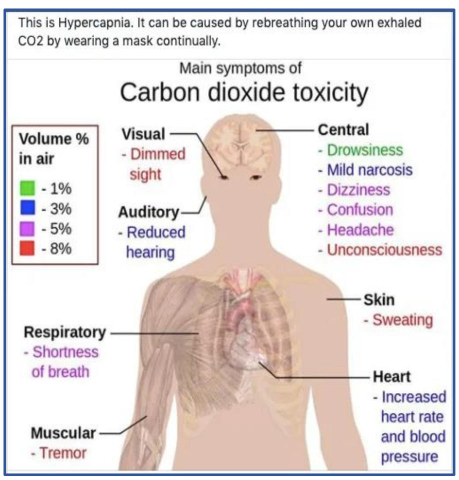
With regard to the relative breathability of face mask fabrics, it is important to note that the number of layers in the mask and thread count of a fabric will impact breathability. Thread count is the metric used to indicate the relative density of a fabric and a factor with respect to breathability. As it relates to fabric density, there is a delicate balance to be reached between barrier effectiveness (i.e., higher thread count) and breathability.

Legitimate concerns that have been raised as to how healthy prolonged face mask use may be as it relates to breathing in too much of one's own exhaled carbon dioxide (CO^2), especially for mask wearers with preexisting respiratory illnesses. These claims suggest that the prolonged use of face masks causes hypoxia, arguing that the extended breathing of exhaled air turns into CO^2, which makes the mask wearer feel dizzy. [83] This intoxication would increase if the wearer moves about causing discomfort, loss of reflexes, conscious thought and great fatigue. Prolonged mask usage could also cause hypercapnia, a condition arising from too much CO^2 in the blood. [84] Common hypercapnia symptoms include dizziness, drowsiness, fatigue, headaches, feeling disoriented, flushing of the skin and shortness of breath whereas severe symptoms include hyperventilation, twitching muscles, a loss of consciousness, coma and seizures among others things. For people with preexisting respiratory illnesses like COPD extended mask use could cause both hypercapnia and hypoxia.

Some masks cause oxygen ($O^{2)}$ deficiencies that are unhealthy. According to the Mayo Clinic, a healthy O^2 intake level (the amount of O^2 circulating in your blood), ranges from 95 - 100% and anything less than 90% is considered low. [85] Over time, O^2 deficiency would cause glucose breakdown and promote lactic acid rise. It is noteworthy to mention that hypoxia is a condition in which the tissues of the body are starved of O^2. [86]

Medical masks are created with non-woven fabrics that are relatively porous although this material does affect air permeability. Recent studies indicate that many healthcare workers are able to tolerate wearing a medical mask only slightly better than a N95 respirator over an 8-hour period, with breaks. [87] [88] While medical masks may impose some measurable airway resistance, it is unlikely that they significantly increase the process of breathing. Though it is likely that hypoxemia may result from the increased CO^2 content of the inspired air resulting from the exhaled CO^2 trapped beneath the mask, the author found no research on the effect of medical masks on blood oxygenation levels. One clinical investigation did however note a decrease in blood O^2 saturation and an increase in pulse rates of surgeons after performing operations due to surgical mask use. [89]

Despite claims to the contrary, cloth face mask wearers are in little danger of breathing in unhealthy amounts of CO^2, even for extended periods of time. Physicians explain that such extreme symptoms are unlikely to occur in most people as the risk of hypercapnia or hypoxia are unlikely with cloth masks because they are not very tight-fitting. Although the use of tight-fitting N95 respirators for extended periods of time could cause some people with pre-existing respiratory illnesses to encounter breathing difficulty, this use would be against the intended purpose of that type of mask. [90] Using an N95 respirator for a long period of time isn't recommended and could cause dizziness, light-headedness and even lung damage for those with respiratory issues.



If CO^2 should slowly build up in a cloth face mask over time the level of buildup will be tolerable for most. Some, may get a headache or become uncomfortable but they would most likely not suffer the symptoms observed by being subjected to much higher levels of CO^2. It is unlikely that wearing a cloth face mask will cause either hypercapnia or hypoxia.

Little research exists on the impact of face masks on wearers. Ultimately, it will depend on the wearer's health, any pre-existing respiratory illnesses, the mask type and length of time it's worn. For most, the effects of prolonged cloth mask usage are small however cloth masks shouldn't be worn for long periods by anyone who has trouble breathing or who can't remove it without assistance. When driving a car with a mask on cracking a window is needed or the car's stale air could make the driver lose consciousness over an extended period.

Hypoallergenic / Latex Free

The designation "hypoallergenic" is not a scientific, legal or a regulatory term. There are no formal standards, definitions or requirements that authorize or govern its use. Indeed, the US Food & Drug Administration does not require manufacturers of cosmetics, toys, clothing or other products labeled as hypoallergenic to submit substantiation of their hypoallergenicity claims. [91] Essentially a marketing claim, the term hypoallergenic is intended to designate that a product contains or harbors fewer potential allergens and is relatively less likely to trigger an allergic response in most people versus other products. Further, no product is allergy proof as there are myriad potential allergens and what people may be allergic to can vary greatly.

With no government standard, the word hypoallergenic on a label provides little to no protection. An NIH-funded study carried out in Brazil found that more than nine in ten children's products marked hypoallergenic contained at least one ingredient that could cause an allergic reaction. [92] In a study reported in the *Journal of Allergy and Clinical Immunology*, a test of 187 products sold in California stores − and labelled hypoallergenic and safe for use in children − found that nearly nine in ten contained at least one allergen and more than six in ten contained two or more. [93] In a *JAMA Dermatology* (Nov, 2017) study of 174 best-selling whole-body moisturizers sold by Amazon, Target and Walmart only 12% were free of allergens. [94]

Notwithstanding the aforementioned, the following discussion is intended to provide support for the contention that 100% cotton is naturally hypoallergenic, and polyester is not. Cotton is a natural, breathable, absorbent and sustainable fabric. Polyester, a man-made synthetic fiber, does not breathe well, repels water and isn't sustainable. These characteristics affect how they are used in clothing and face masks and their ability to be hypoallergenic. This is important because a hypoallergenic face mask is far less likely to throw off the delicate PH balance of the wearer's facial skin. [95] And, while those having sensitive skin may have more of reason to seek out a genuine hypoallergenic mask, the fact is that all skin types stand to benefit from a mask being allergen free. In part, this is because even if the wearer does not believe that his/her skin is sensitive, it still reacts to the face mask's fiber (and chemicals within) which can lead to inflammation, acne, itchiness and general uncomfortableness, all of which can lead to undesirable and avoidable mask adjustment. [96]

An allergy is the immune system's reaction to something that's typically not otherwise harmful. According to the *American College of Allergy, Asthma & Immunology*, skin allergies drive five million office visits a year. A hypersensitivity disorder that affects more than one in four individuals, it is the 6th leading chronic disease in the US. [97] While most allergies are triggered by dust, dust mites, mold, pet dander, grass and pollen (as well foods, drugs, insects) many people are allergic to common fabrics, metals and chemicals.

In fact, there's something called "polyester allergy" and it's a lot more common than most realize. Indeed, contact textile dermatitis affects some six million adult Americans. [98] This is because polyester, a type of plastic, is created by a chemical reaction involving petroleum, air, water and antimony − a carcinogen that is toxic to the heart, lungs, liver and skin. [99] Likewise, rayon is made from wood pulp that is treated with caustic soda and sulphuric acid. Polyester allergy occurs when skin reacts to the textile's fibers or to the dyes, resins or other chemical additives used to process or treat them. A study in *Current Treatment Options in Allergy* (February, 2019) explains that different color dyes are used for synthetic versus natural fabrics. [100]

While the rate of sensitization to reactive dyes used to natural fabrics (e.g., cotton, silk, wool) is extremely low (< 1%) those used to color synthetic textiles (e.g., polyester, nylon, rayon) have a frequency of sensitization rate up to seven times higher; [101] enough for some international textile research/test institutes to classify them as allergenic and their use restricted noting that "polyester materials are known to cause significant allergic reactions among some people". [102] Moreover, the body heat generated by wearing synthetic clothes (and, presumably, a face mask) releases these chemicals into the air, to be absorbed by the wearer's skin. [103]

Lastly, an estimated 8% of Americans suffer from latex (and spandex) allergies owing to an over-sensitive immune system. Patients having a latex allergy may experience reactions ranging from minor rashes to nausea, vomiting, difficulty breathing, chest tightness and even shock; symptoms that can occur upon exposure. [104] Unbeknownst to many, certain materials used in some face mask may contain traces of the natural rubber that cause the reaction (e.g., elastic ear loops). Knowing this, a face-mask must be latex free.

Comfort

Face mask comfort isn't a mere luxury as it can greatly influence how long a person will wear it…and how frequently it will prompt (dangerous) adjustment. In that an employment-related mask will likely be worn for an extended time, it must be comfortable, easy to breathe through and feel good against the wearer's skin. [105] Regular mask wearers say that the friction and pressure of a mask often causes skin irritation as it grips the cheeks, under-eye area and chin to achieve the good fit needed. [106] To be comfortable, a mask should have a very soft interior lining and a design that enables a variety of adjustments to mold it around the wearer's face.

Odorless

Smells are usually gases or vapors. Some materials that are used in certain masks have a distasteful odor. Likewise, odor can emanate from certain chemicals that are added to fabrics for various purposes. Indeed, the internet abounds with consumer complaints about new masks that smell. [107] These odors can come from the actual fabric the mask is made from; filter layers and filter cartridges; ozone and organic vapors; melted polymers that are air-blasted into the fabric's tiny fibers; chemically infused bacteria-killing nanomaterials; and polymer-containing silver-based anti-microbial treatments and coatings. Sadly, those who are sensitive to even nuisance levels of disagreeable smells might find wearing their mask unpleasant. And, while many odors will go away if the mask is aired out for a day or two, some won't. In order not to impede their regular use, a good face mask should be made by processes and of materials that are unscented and odorless.

Reusability / Durability

While many face masks are designed for one-time use, consumers buying them for work-related purposes prefer reusable ones. A mask's ability to be reused depends upon the durability of its materials; the quality of its construction; its ability to be washed multiple times; and its ability to avoid dangerous bio-burden build-up.

Cotton is the optimal mask material, but not all cottons are created equal. Those with longer staple fibers are far stronger and resilient than typical cottons; resisting pilling, breaking and tearing. Double layer construction adds considerable body to the mask for added support, strength and ability to keep its form longer. As discussed above, some masks are chemically treated with antibacterial/antimicrobial coatings that have fairly short half-lives before the coating wears off or is no longer effective. With very few exceptions, these treatments are applied post-construction and can only withstand ten to twenty home laundering cycles.

Beyond design, material and construction factors, the length of time a mask can be safely worn is also dependent upon the number of people with whom the wearer comes in contact. This is because the mask's outer layer not only serves as its barrier or filter against particulates, it accumulates viral pathogens, without killing them. As noted in the discussion below, a study that appeared in *The Lancet* (April, 2020) indicated that COVID-19 can last on a surgical mask for a long time noting "a detectable level of infectious virus could still be present on the outer layer of a surgical mask on day seven". This evidences just how crucial it is to properly remove and store a face mask after wearing it. [31] As such, the longer a mask is worn and exposed to others, the more concentrated the infectious load it builds up becomes. For this reason, the CDC recommends routine daily washing. [108] As a practical matter, most masks that are advertised as "long-lasting", are not as they can't withstand multiple home launderings. This is why it is recommended that wearers have several reusable masks to rotate during the week, so they don't make the poor decision to reuse a mask that isn't clean.

Beyond this, other factors can detract from a masks effectiveness over time that are not obvious. These have to do with the mask's ability to "operate" as intended relative to airflow. If the mask's pores become clogged over time, for whatever reason, more air will be inhaled or exhaled from around its edges, and that air is obviously unfiltered. [109] This is because airflow follows the path of least resistance. As such, it is worth articulating the reasons why a mask's primary air route can be impeded. These include the humidity and moisture level of the place in which the wearer lives and/or works (e.g., Arizona or Houston or Seattle); the wearer's breathing rate (e.g., stationary vs. active); the amount the wearer talks (impacting the airflow volume); the environmental dust level and even the nasal discharge (e.g., post-nasal drip, runny nose) of the wearer.

COVID-19 Survival on (Face Mask) Surfaces

Since the emergence of the COVID-19 pandemic we have learned a great deal about the properties and characteristics of the virus, including to what degree it can survive on various objects and surfaces. This is important as it pertains to face masks as one of the purposes of a face mask is to act as barrier against coronavirus-infected droplets and aerosols that it may encounter understanding that some of those particles will remain on the face mask, possibly for some time. As noted in a later discussion below, even when they are properly used, ordinary face masks create "bio-burdens" or large populations of viable microorganisms. This is a result of the wearer breathing and coughing germs and viruses into them and coming into contact with others who in turn carry and transmit germs and viral particles. This makes taking off and storing the mask a task that is critically important to master in order to not amplify the risk of self-contamination.

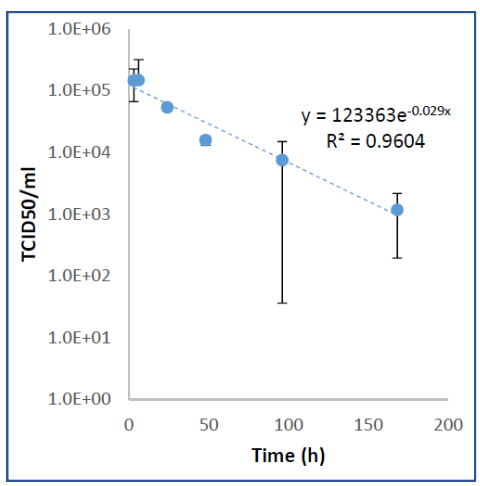
There have been a few studies on the surface survivability of COVID-19, the most comprehensive one being the study conducted by researchers at the School of Public Health at The University of Hong Kong that was published in *THE LANCET – Microbe Edition* (April, 2020) one of the world's oldest and best-known general medical journals. The study, entitled "Stability of SARS-CoV-2 in Different Environmental Conditions" [31], looked at how long aerosolized COVID-19 lived at various temperatures and measured the extent to which it remained active on several surfaces. It found that although the virus is highly stable over an extended time period (14-days) at a temperature of 40 ° F, it was sensitive to heat. With the incubation temperature increased to ~ 160° F, the time it took for the virus to become inactive was reduced to only 5 minutes.

The study also looked at the activation period on various surfaces including paper, tissue paper, wood, cloth, glass, a banknote (paper currency), stainless steel, plastic, and the inner and outer layer of a surgical mask. An exhibit from the study that illustrates its key findings appears below.

Time	Virus titre (Log $TCID_{50}$/ml)									
	Paper		Tissue paper		Wood		Cloth		Glass	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
0 min	4.76	0.10	5.48	0.10	5.66	0.39	4.84	0.17	5.83	0.04
30 mins	2.18	0.05	2.19	0.17	3.84	0.39	2.84	0.24	5.81	0.27
3 hrs	U	-	U	-	3.41	0.26	2.21*	-	5.14	0.05
6 hrs	U	-	U	-	2.47	0.23	2.25	0.08	5.06	0.31
1 day	U	-	U	-	2.07*	-	2.07*	-	3.48	0.37
2 days	U	-	U	-	U	-	U	-	2.44	0.19
4 days	U	-	U	-	U	-	U	-	U	-
7 days	U	-	U	-	U	-	U	-	U	-
Time	Banknote		Stainless steel		Plastic		Mask, inner layer		Mask, outer layer	
	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
0 min	6.05	0.34	5.80	0.02	5.81	0.03	5.88	0.69	5.78	0.10
30 mins	5.83	0.29	5.23	0.05	5.83	0.04	5.84	0.18	5.75	0.08
3 hrs	4.77	0.07	5.09	0.04	5.33	0.22	5.24	0.08	5.11	0.29
6 hrs	4.04	0.29	5.24	0.08	4.68	0.10	5.01	0.50	4.97	0.51
1 day	3.29	0.60	4.85	0.20	3.89	0.33	4.21	0.08	4.73	0.05
2 days	2.47	0.23	4.44	0.20	2.76	0.10	3.16	0.07	4.20	0.07
4 days	U	-	3.26	0.10	2.27	0.09	2.47	0.28	3.71	0.50
7 days	U	-	U	-	U	-	U	-	2.79	0.46

As noted, the degree to which COVID-19 remained active was measured at several intervals ranging from 30 minutes to seven days. For the sake of keeping it simple and not getting technical, the appearance of the letter "U" indicates that the virus is "Undetectable" at that measurement point.

Note that COVID-19 is undetectable on (cotton) cloth on the second day. This supports the finding of infectious disease doctors from the Johns Hopkins Health System that COVID-19 survives better on less porous "artificial fibers" like polyester (and spandex) versus cotton.



The exhibit at right, from the same study, is a more detailed illustration in support of the exhibit above. It shows the measure of the half-life of COVID-19 on the non-woven outer surface of a surgical mask; the surface with the greatest chance of infectious bio-burden development. Strikingly, a detectable level of infectious virus could still be found to be present on day seven. Surgical masks are for very limited exposed use; not for extended (all-day) use. Because they are readily available and inexpensive, people purchase and wear them for many days. This is *very ill-advised due to their ability to develop a bio-burden build up.*

Made in the USA

Given the COVID-19 crisis, current political climate and uncertainty in the global markets, many Americans may prefer American-made products, such as the face masks companies are now being required to provide their employees. Indeed, beyond simple patriotism, if there was ever a time to resist the urge to purchase foreign-made goods based on their relatively lower prices, it is now, especially when an employee's health and well-being hangs in the balance. Here are some solid reasons to consider "buying American".

Domestic purchasing will enable the US to regain its independence. Once the world's manufacturing powerhouse, the emergence of this pandemic has made it all too evident that the US has become needlessly reliant on imports of vital products, thereby putting our nation's security in jeopardy. Many believe this as short-term thinking, counterintuitive and dangerous. Supporting local businesses strengthens our economy from the bottom up by reinforcing the stability of our local communities, both saving existing jobs and creating new ones. It drives more money into our manufacturing sector to enable it to sustain itself and grow. Buying American also increases domestic investment in manufacturing, keeps that money in the US and reduces our trade deficits. All of this fortifies our country and our national security.

Whatever may have been true in the past, decades of advances in manufacturing processes, technologies and logistics now make buying American not only cost-effective but environmentally sound, as our manufacturers have embraced and widely implemented cleaner, renewable and eco-friendlier practices that contribute to a cleaner environment. Relatedly, sweatshops remain commonplace in many less advanced countries. Buying foreign-made goods can have the effect of promoting poor working conditions, unfair wages, unreasonable work hours, child labor and deficient worker benefits. In the US, a plethora of laws and regulations − and an environment of relative transparency − serve to control working conditions, promote worker safety and ensure fair wages for our valued domestic workforce.

Delivery reliability is not just a key factor in logistics and supply-chain management: it is critical when you really, really need to get something on time. While imports from China are characteristically late, and defective products arrive far too often, US companies are well-known and respected worldwide for keeping their commercial promises. Comparatively-speaking, no other companies meet their on-time delivery commitments more than those made in the US.

A hallmark of American manufacturing, our record for "getting it right the first time" is simply unparalleled. Further, there is no other designation that possesses more international cachet − or that is more synonymous with quality, excellent craftsmanship, precision, reliability, durability and value − than the "Made in the USA" label. Indeed, international perceptions of that term are rooted in the well-deserved favorable perception of our country itself. For many, buying American simply evidences one's commitment to quality.

While it is true that the price tags for domestically-made products may often be somewhat higher than those that are imported, in terms of value and cost per use, US-made products are often ultimately less expensive due to their quality, durability and reliability − all of which contribute to their longer useful life. Consumers throughout the world know this, especially your fellow countrymen. In fact, a recent *Consumer Reports* survey found that given a choice between a product made domestically and an identical one made abroad, eight in ten Americans would rather buy the US-made product [110]. What's more, a recent American Marketing Association report indicates that six in ten US consumers will pay at least 10% more for a US-made product: and this is a phenomenon that is not at all limited to domestic consumers. [111]

Lastly, consider this quotation that supports all of the sentiments above: "The bitterness of poor quality remains long after the sweetness of low price is forgotten." It was penned some 250 years ago by an individual known worldwide as being one of the most brilliant men to have ever walked the face of the Earth: *Benjamin Franklin*. Let us all pay tribute to his wisdom and patriotism by striving to buy American whenever we are able. Let's play the long game, which strengthens our industries, our economy and the American worker, and resist the temptation to purchase foreign goods based only on their price, without considering the bigger picture.

Stylish

Unless you go by the name Zorro, Lone Ranger, Batman, Joker or Darth, most agree: masks are fundamentally unattractive and not a fashion accessory, per se. Understanding this, in that masks do take up a fair amount of facial real estate, there's no reason to wear an ugly one. Some may desire a grouping of masks in a variety of colors, designs, patterns and prints to match various outfits. Ergo, "stylish" could be a mask attribute for some.

Customizable

An organization's logo makes its product/service recognizable, and brand promotion helps to leave a deep positive impression about the brand in a buyer's mind; builds the trust of customers; and makes them believe that the quality of the product/service the brand provides is the best choice on the market. This all helps to reinforce the customer's purchase decision and build a loyal and long-term customer base. Some face masks can be customized with an organization's color, name, logo, motto, tagline or favorite saying. Though not essential, many organizations see the ability to customize a face mask for promotional value to be desirable.

A Good Value

While reusable face masks vary greatly in price (from $5 to $75), price alone does not always reflect "a good value" …which has been defined as the difference between the benefit received and price; the worth, usefulness or importance of something; the most advantageous combination of cost, quality and sustainability to meet customer requirements; or the purchase of high quality, quantity or worth for a low or reasonable price. Like anything else, the purchase of a face mask should represent a good value…up front and over its extended use.

Readily Available / Easy to Obtain

Generally speaking, there is a shortage of non-medical, cloth face masks and many of the companies that supply them can only do so in limited quantities, often with long lead times. Most ask for full payment upfront, even for large orders (>100,000 units). Purchasers should keep this in mind when considering placing an order.

Seller Reputation / Reliability

Generally speaking, there is a shortage of medical and non-medical face masks throughout the world and, with increased demand for these products, face mask scams are on the rise. US and European authorities (including the FBI, Europol and Interpol) have foiled dozens of cases of both domestic and international fraud involving hundreds of millions of dollars. Better Business Bureaus throughout the country are reporting thousands of cases of fraud being lodged with them. [112] Many companies that market (medical and non-medical) face masks have been shown to be illegitimate, or making false product claims, prompting companies like eBay, Amazon, Etsy, Target, Walmart and Facebook to curtail, or entirely stop, the promotion or sale of face masks.

For the most part, these scammers offer facemasks that don't exist; or sell masks, take money and don't deliver. Many involve fake email addresses or cloned websites. They often "ghost" the buyer post-purchase, cutting off all contact, refusing to answer questions, or closing or deactivating their online storefronts. Of particular note are attempts to tug at consumers' heartstrings by claiming to donate one mask for every mask they sell. Many put up phony online stores after a trusted outlet (like Amazon) has sold out of a particular face mask.

Given this, buyers would be wise to take these precautions. Buy only from a reputable seller. Check out the seller and product online to see what others say about it. Be certain the seller is legitimate (e.g., real street address, working customer service number and email). Check the seller's website domain registration at www.whois.com (e.g., for country of registration and date). Review the product's description for unfounded claims, clues about substandard materials, use of stock photos (use *Google Image* to do a reverse search). Carefully examine the terms of sale (e.g., purchase price, taxes, shipping, and handling fees). Identify, and become comfortable with, the product's manufacturing country. Establish a delivery date or timeframe and take notice of any return and refund policies and fees. Pay by credit card (for federal law protection) or consider using an escrow agent for very large purchases. These measures will reduce the chance of being scammed.

Face Mask Comparison Grid

Attribute / Feature	Measure / Metric	Option 1	Option 2	Option 3	Optimal
Protection Objective					
Purpose for Wearing Mask	Cut Spread / Protect Wearer / Both				**Both**
Protection Level					
Argonne Lab Test (No Gap) > 300 nm	< 85% / 85 - 98% / > 98%				**> 98%**
Argonne Lab Test (No Gap) < 300 nm	< 85% / 85 - 94% / > 94%				**> 94%**
Added Antimicrobial Protection	Yes / No				**Yes**
Construction Design					
Outer Layer	Poly / Cotton / Supima / Poly Blend				**Supima**
Middle Layer(s)	Poly / Cotton / Silk Chiffon / Poly Blend				**Silk Chiffon**
Inner Layer	Poly / Cotton / Supima / Poly Blend				**Supima**
Filtration Mechanism					
Flow Valve(s)	None / Single / Dual				**None**
Activated Charcoal Filter	None / Single / Dual				**None**
Melt-Down Layer	Microfiber / Polypropylene / HEPA				**None**
Antimicrobial Layer Only	Yes / No				**Yes**
Antimicrobial Defense					
Metal-Based Method	None / Silver / Copper /Zinc Base				**None**
QAC-Based Method / Application	Post-Construction / Molecular Bonding				**Molecular Bonding**
Metal / QAC Treated Fabric Type	Cotton / Polyester / Poly Blend				**Cotton**
Commercial Treated Fabric	None / Chemical / Graphene				**None**
Electrostatic Antimicrobial	Silk / Chiffon / Silk Chiffon				**Silk Chiffon**
No Antimicrobial Agent	Yes / No				**Yes**
Proper Fit Features					
Non-Adjustable Elastic Ear Band	Yes / No				**No**
Adjustable Cloth Ear Ties	Behind Ears / Behind Head				**Behind Ears**
Adjustable Ear Cord / Sliding Stop	Yes / No				**Yes**
Adjustable Nose Piece	Yes / No				**Yes**
Moisture Control					
Polyester Layer (No Wicking)	Yes / No				**No**
Cotton Layer (Wicking)	Yes / No				**Yes**
Airflow Adequacy					
Thread Count Suitability	Moderate (Breathable) / Too High				**Moderate**
Too High Thread Count Cotton	Yes / No				**No**
Insertable Filter Obstruction	Yes / No				**No**
Four or More Layer Construction	Yes / No				**No**
Hypoallergenic					
Natural Fibers (High Probability)	Yes / No				**Yes**
Synthetic Fibers (Low Probability)	Yes / No				**No**
Latex Free					
Body of Mask	Yes / No				**No**
Ear Band / Ties / Cord	Yes / No				**No**
Comfort Potential					
Inner Layer Softness	Pima Cotton / Supima Cotton / Other				**Supima**
Padded Ear Loops	Yes / No				**Yes**
Odor Factor					
Fabric Odor	Yes / No				**No**
Filter Odor	Yes / No				**No**
Reusabe / Durability					
Construction Quality	Low / Medium / High				**High**
Two or More Layers	Yes / No				**Yes**
Antimicrobial Longevity Extension	Low / Medium / High				**High**
Country of Origin					
Manufactured in USA	Yes / No				**Yes**
Materials Sourced in USA	Yes / No				**Yes**
Stylishness					
Appealing Design	Yes / No				**Yes**
Available in Multiple Colors	Yes / No				**Yes**
Customizablity					
Ability to Imprint Logo, Etc.	Yes / No				**yes**
Ability to Custom Color Match	Yes / No				**Yes**
Good Value					
Acquisition Cost	Low / Medium / High				**Medium**
Estimated Useful Life in Days	10 / 30 / 60 / 90 / 120				**120**
Added User Costs (e.g., Filters)	None / Low / Medium / High				**None**
Availability					
Days to Delivery (Not Customized)	< 15 / 15 / 30 / 45 / > 45				**<15**
Source Reliability					
Company Verifiability	Low / Medium / High				**High**

Face Mask Liability Considerations

You may have heard Shakespeare's most controversial line, "The first thing we do, let's kill all the lawyers", or of the fictional law firm of Dewey, Cheatem & Howe. Lawyers: we all hate them, until we need one. That said, many employers fear that the COVID-19 pandemic may bring about the Lawyers Full Employment Act. All joking aside, all one has to do to understand how potentially legally precarious this crisis may be for employers is do a web search with the terms: "COVID-19", "employer" and "liability". It will be sobering.

The author is not a lawyer and the following discussion is not intended to constitute legal advice, and should not be taken as such. *The information provided is only intended to provide the reader with an appreciation of the legal and regulatory compliance issues attendant to the subject of employers furnishing face masks to their employees. In that laws or regulations are subject to interpretation and change, and vary by jurisdiction, the reader should seek the advice of legal counsel or the regulators in their jurisdiction.* Notwithstanding this, the following information will provide a framework for becoming aware of, and understanding, the issues at hand.

In addition to any state or local laws and regulations that may pertain to employer requirements and liabilities related to employee face mask use, these federal agencies and statutes may impose requirements on employers: the Occupational Safety and Health Act (OSHA), Equal Employment Opportunity Commission (EEOC), Americans with Disabilities Act (ADA), Whistleblower Protection Act (WPA), Federal Drug Administration (FDA) and United States Department of Agriculture (USDA)…for issues ranging from discrimination to proper food handling. A discussion of the employer impact of each of these agencies and statues follows.

A host of questions come to mind as it relates to employer responsibility and liability with respect to the wearing of face masks by employees in the workplace in the context of COVID-19. Some of these include:

- Is it legal for an employer to require its employees to wear a face mask?
- Should/must an employer require employees to wear a face mask? Who should pay for them?
- Which employees should we required to wear them? Under what circumstance? For how long?
- What type of face mask should be used? Ones to protect the wearer, those around them or both?
- Should a company have a *standard* mask or should homemade/non-standard masks be allowed?
- What legal liability could an employer have if it allows homemade/non-standard masks to be worn?
- Could liability arise for providing a lesser quality mask when a higher quality one is available?
- What if an employer requires the use of a mask and an employee refuses to wear it?
- Does OSHA provide guidance with regard to face mask use in this context, or impose any requirements?

These risk, safety and liability topics may be answered by a corporate attorney, workers' compensation advisor, risk manager and/or worksite safety professional. The following will help to frame such a discussion.

Passed, Proposed and Pending Federal COVID-19 Legislation: Coronavirus Aid, Relief and Economic Security (CARES) Act and Health and Economic Recovery Omnibus Emergency Solutions (HEROES) Act

As a preface to the discussion below on employer legal liability related to the development and implementation of employer face mask policies to maintain compliance with the various government regulatory responsibilities impacted by CONVID-19, the following is a discussion on recent activity taken by the US Congress in this area. Federal legislative action in this environment is a dynamic one and these measures are important to be aware of as they often directly impact, preempt or supersede actions by state and municipal authorities.

As more state and local governments move to re-open their communities for commerce, and businesses develop plans and take measures to reopen in a safe orderly and responsible way, a great deal of uncertainty exists as the exact steps required to reopen the economy remain unclear. What has become all too clear however is that while the emergence of COVID-19 necessarily creates new requirements, responsibilities and demands on employers, lawmakers remain split as to how to address the many issues attendant to this challenge.

In a rare act of bipartisanship (albeit hard fought), on March 25, 2020 both chambers of Congress unanimously passed the $2.2 trillion Coronavirus Aid, Relief and Economic Security (CARES) Act. [113] Including a variety of stimulus-related measures it did not contain any mandated worker protections or monies for essential workers. Provisions in the bill, put forth by the House of Representatives' Democrats, would have created an emergency regulation to protect healthcare employees and other workers deemed by the CDC and OSHA to be at elevated risk of exposure to respiratory illnesses, including COVID-19. This provision was ultimately removed from the final legislation through the efforts of Treasury Secretary Mnuchin, Senate Republicans and lobbyists for the American Hospital Association, the latter arguing that enforcement would be too costly for hospitals and that complying with a new standard amid a severe respirator shortage might limit hospitals' ability to adequately provide patient care. These measures were to be handled later.

On May 15, 2020 the Health and Economic Recovery Omnibus Emergency Solutions (HEROES) Act [114], a second COVID-19 relief package, was passed by the House. Among other items, this legislation does in fact address bonus payments to essential workers and a many worker protections, including the following:

- The establishment of a $200 billion HEROES' fund to reimburse employers for their payment of hazard incentive compensation to a defined group of essential workers in accordance with a specified schedule.
- A requirement that OSHA promptly issue an enforceable emergency temporary standard (followed within two years by a permanent comprehensive infectious disease standard) that would require employers to "develop and implement a comprehensive infectious disease exposure control plan to protect workers from exposure to the SARS-CoV-2 virus that causes COVID-19." With respect to enforcement, OSHA would have discretion to determine if an employer cannot feasibly meet certain requirements as long as it is implementing alternative methods and measures to protect employees.
- A requirement that OSHA forbid employers from retaliating against workers for reporting infection control problems to their employer, any public authority, to the media or on a social media platform as well as a standard that would also forbid employers from retaliating against workers.
- Measures that would prevent hospital managers and other employers from locking up personal protective equipment or providing incorrect protective equipment, as well as ones that would ensure that employees receive the education and training needed to use PPE safely.
- Provisions that provide OSHA with the discretion not to issue citations to employers due to shortages of equipment if they can show that they are making a good-faith effort to purchase personal protective equipment, come into compliance and are implementing alternative methods to protect their employees.
- A new presumption of worksite illness standard whereby employees who must interact with the public, who have been quarantined, or who have been diagnosed with COVID-19 during the performance of their duties will be given a presumption that they contracted the virus at work. This will serve to define these illnesses as being covered by workers' compensation insurance and expediting the claim process.

It is important to understand that while the Senate will likely consider the bill passed by the House, it is extremely unlikely that it will be passed in its current form and unlikely that the ultimate legislation passed by the Senate will include all of the provisions detailed above or in the form described above. In great part, this is because there exists significant disagreement on how to address several of these issues. By example, both Senate and House Republicans are united in their demand that employers be shielded from responsibility for the healthcare workers and others working on the front lines of fighting COVID-19. They want to protect businesses with strong protections from "frivolous" COVID-19 lawsuits while Democrats in both chambers are equally united in their concern that such protection would lead to employers not taking proper steps to safeguard their workers. Appreciating that it takes both chambers of Congress to make law, it is likely that some of the provisions in the House bill will be watered down or even eliminated to reach a compromise as there are other elements of the legislation that they want. Nonetheless, these provisions inform us of what might lie ahead for employers as our thinking about how to deal with the ramifications of COVID-19 evolve.

Despite the enormous authority of the Occupational Safety and Health Administration, and the responsibility it has for ensuring the workplace health and safety of more than 130 million workers, it's actually a small agency having ~ $550 million in annual funding for its entire nationwide operation (which amount to ~ $3.75 per year to protect each worker). [115] Since its inception 45 years ago, it's never had more than 2.500 federal and state inspectors; today it has about 2,1000 inspectors (that's about one inspector per 60,000 workers). It would take 165 years for it to inspect the 9.8 million workplaces under its oversight with this staffing level (though, to be fair, it concentrates its inspections on the manufacturing and construction industries). [116]

According to the 2019 report "*Death of the Job: The Toll of Neglect*", the 28th edition of an annual AFL–CIO study [117], in 2017 these were the fatality, injury and illness statistics for the US workforce:

- Some 5,147 workers were killed on the job;
- Approximately 275 workers died each day from hazardous working conditions;
- An estimated 95,000 workers died from occupational diseases;
- Private-sector employers reported 2.8 million injuries and illnesses;
- State and local government employers reported an additional 664,000 injuries and illnesses; and
- The national injury and illness rate for the private and public sector in 2017 was 3.1 per 100 workers.

On average, the consequences of an OSHA inspection/fine in 2017 were hardly enough to be impactful:

- The average penalty for a serious violation was $3,580 for federal OSHA;
- The average penalty for a serious violation was $1,985 for OSHA state plans;
- The median penalty for killing a worker was $7,761 for federal OSHA;
- The median penalty for killing a worker was $2,700 for OSHA state plans;
- Only 99 worker death cases have been criminally prosecuted under the OSHA since 1970;

Despite the nominal average fines recently paid as noted above, OSHA is not an agency to be taken lightly if an employer is a prolific, serious, willful or stubborn violator. Below are the 2020 penalties levied against employers for safety violations by the federal OSHA. [118]

- Other than Serious violations, $13,260 (up from $12,675 in 2018);
- Serious violations, $13,260 (up from $12,675);
- Repeat violations: $132,598, (up from $126,749);
- Willful violations, $132,598 (up from $126,749);
- Failure to abate (per day), $13,260 (up from $12,675 last year).

Federal OSHA expects states with their own programs to align their penalties with theirs, but some do not. By example, Kentucky and North Carolina still maintain a $7,000 maximum fine for serious violations and $70,000 for willful or repeat violations. Despite this, over the years OSHA has levied some very substantial fines when the violations were serious. It levied $22 million and $87 million penalties against BP; more than a dozen penalties of $5+ million against companies like US Steel, Citgo, Dayton Tire and Samsung; dozens of $1+ million penalties; and hundreds of six-figure ones. [119]

In 2019, ***respiratory protection*** and ***personal protective equipment*** claims were the 6th and 10th most frequent violation types, respectively according to OSHA Information System data from Oct. – Sept, 2018 as reported in *Safety+ Health Magazine* (November, 2019). [120]

	STANDARD	TOTAL VIOLATIONS
1	Fall Protection (1926.501)	5,677
2	Scaffolding (1926.451)	2,939
3	Hazard Communication (1910.1200)	2,754
4	Ladders (1926.1053)	2,463
5	Lockout/Tagout (1910.147)	2,415
6	Respiratory Protection (1910.134)	1,902
7	Machine Guarding (1910.212)	1,737
8	Powered Industrial Trucks (1910.178)	1,593
9	Fall Protection – Training Requirements (1926.503)	1,584
10	Personal Protective and Life Saving Equipment – Eye and Face Protection (1926.102)	1,449

Lastly, according to Northeastern University School of Law Professor Emily Spieler, there are impediments related to an employee's actual ability to effectively lodge a whistleblower complaint against his or her employer owing to the claim filing process. To begin, the period within which an employee can file a whistle-blower claim is only a short thirty-days from the subject action; which often results in a significant number of whistleblower complaints never even getting docketed. If an employee files a formal complaint within that time period, despite the anti-retaliation provisions of OSHA, the employee often does face retaliation. If retaliatory action is taken, the employer has no private right of action, and must instead rely on OSHA to prosecute its whistleblower complaint. As a result, in 2019, there were 2,084 OSHA whistleblower complaints lodged and, although 545 of the cases were settled *only fourteen were resolved on the merits*. Between 2005 and 2012 the average settlement was for less than $7,000. Since many of these settlements include no employer admission that an OSHA regulation was violated, they do virtually nothing to protect other employees. (121)

Occupational Safety and Health Act (OSHA) Challenges

As a side note, it should be noted that the author was *one of the first corporate "OSHA officers"* back in 1971.

OSHA is a federal statute and each new standard is typically adopted by each state. Nonetheless, there are some 22 states that operate OSHA-approved plans having provisions that vary with the federal statue. In such cases, employers must comply with the regulations and standards of only the state plan if there is one. As it relates to this discussion, any reference to "OSHA" will refer to the federal plan, unless otherwise noted.

OSHA's *general duty clause* states "employers shall furnish to each of his employees' employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees". [122] If worker equipment qualifies as personal protective equipment (PPE) under OSHA several employer obligations ensue as OSHA has been regulating the use of PPE (including respirators and face masks) almost since it was established. [123] Its requirements have involved their usage in industrial, healthcare, food services and certain of other workplace environments. These regulations are all encompassing and very specific and include a requirement for employers to have a respiratory protection program in place if it is required that employees use respirators and certain face protection in the workplace.

Typically, employers and employees look to OSHA for clear direction as it relates to workplace safety matters. While in March of 2020 OSHA did in fact issue temporary COVID-19 guidance for employers of healthcare workers it is merely advisory and admittedly "creates no new legal obligations" for employers. This guidance on PPE is very general, suggesting the obvious, that face masks may be needed in some workplaces, depending upon the exposure risk faced by employees. [124] It has yet (July, 2020) to propagate any specific standards for employers not in the healthcare industry who are providing essential services nor has it published definitive and clear guidance as to whether cloth face masks constitute PPE. Thus, it is unclear whether employers must comply with OSHA's PPE requirements when they take steps to comply with state, city and municipal face mask requirements and other directives and recommendations from government agencies such as the CDC.

OSHA's inability or unwillingness to issue specific guidance on the treatment of face masks has created some very real issues and challenges for employers…largely as a result of unintended consequences. By example, OSHA's guidance as it relates to COVID-19 clearly lists face masks as an example of what it considers to be PPE. If face masks are PPE − and provided to comply with a state, city or municipal face mask requirement − does that trigger OSHA's PPE hazard assessment and training requirements? [125] On one hand, an argument may be made that OSHA's and the CDC's suggestions with regard to the reasons for requiring and providing a cloth face mask may be distinguishable from more typical PPE use based on *whom the equipment is intended to protect.* Clearly, the intended use of face masks by these agencies is to protect the general public from asymptomatic carriers of COVID-19 whereas PPE is generally intended to protect the wearer. If the intended purpose of requiring face mask usage is to protect the wearer, could the employer be required to then meet all of OSHA's other requirements with respect to PPE? It could very well be that the *employer's stated purpose* in requiring the use of a face mask may have a direct impact on how it must address OSHA's various requirements in this regard. The courts will likely have the last word on this.

An employer's requiring its employees to use of a face mask at work, regardless of the reason, could however trigger a host of other OSHA requirements with respect to an employer's broader obligations under OSHA's general duty clause to maintain a safe and healthy workplace, as well as OSHA's PPE-specific obligations. If an employer compels all or certain high-risk employees to wear face masks it could be viewed under OSHA as a form of "administrative control". [126] OSHA's requirements are set by statute, standards and regulations and administrative controls are workplace policies, procedures and practices intended to minimize the exposure of employees to risk conditions. They can include training, shift designs that lessen the threat of a hazard to an individual, hours of service regulations for commercial vehicle operators, safety signage for hazards and measures to ensure the regular maintenance of equipment. What this means is that when an employer requires employees to wear a mask they need to carefully consider the obligations this might create for them to ensure that the mask is effective and provides the proper protection (for the wearer and others) as a safe work practice.

To be clear, if the mask is intended to only meet CDC recommendations or other governmental requirements aimed at lessening community spread, this may or may not be considered to be an administrative control. If, however, the intent in requiring wearing a mask is as a means by which to ensure workplace safety, under this OSHA standard the employer could possibly be expected to ensure that they are safe and that employees use them safely. Understanding this, if an employer's intention in requiring its employees to wear a mask is solely to reduce community spread, as opposed to requiring a mask to be worn as a part of the employer's OSHA hazard assessment, this should be clearly communicated to avoid potential OSHA obligations. Notwithstanding this however, a question arises as to whether requiring mask wearing for the purpose of reducing community spread is not *ipso facto* a part of the employer's overall strategy to create a safe workplace? Isn't an intent to reduce community spread within the workplace not a part of an effort to ensure a safe work environment?

Given the discussion above, the least risky course of action that an employer can take to accommodate the CDC's recommendations to reduce community spread would be to consider that their requiring employees to wear a mask amounts to a form of administrative control that falls under the general dominion of OSHA and to generally follow all of the pertinent requirements that would pertain to PPE.

The tasks needed to meet these requirements are the provision of a written respiratory protection program; the performance of a hazard assessment; the consideration of other options to protect employees; identifying and providing appropriate personal protective equipment for employees at the employer's expense; providing NIOSH-certified equipment and ensuring proper sizing and fit; training employees in the use, care, cleaning, maintenance and appropriate replacing of damaged PPE; and periodically reviewing all of the aforementioned.

Employee Risk Classification in the Context of COVID-19

Exposure Risk	*Work Conditions and Job Classifications*	*PPE & Face Mask Guidance*
Very High	*Health care, laboratory, morgue and funeral employees with a high potential for known or suspected exposure to COVID-19 via specific medical, laboratory or post-mortem procedures including the collection and handling of specimens of known COVID-19 patients or performing aerosol generating procedures.*	*Provide gloves, gown, face shield or goggles, a face mask or respirator, depending on job tasks and exposure to COVID-19.*
High	*Health care delivery and support staff; medical transport and mortuary workers; and other involved with preparing bodies; and jobs having high exposure to known COVID-19 patients.*	*Provide gloves, gown, face shield or goggles, a face mask or respirator, depending on job tasks and exposure to COVID-19.*
Medium	*Jobs that require frequent and/or close contact (≤ six feet) with the general public (schools, retail settings) or work in high population density environments or with persons who may be infected with COVID-19, but who are not known or suspected COVID-19 patients and are in areas of ongoing community transmission.*	*Consider offering face masks to all employees and customers until they are able to leave the workplace.*
Low (Caution)	*Jobs that do not require contact with people known to be, or suspected of being, infected with COVID-19, nor close contact (≤ six feet) of the general public.*	*Monitor Centers for Disease Control and local guidelines.*

Many factors will influence an employer's decision to require the use of face coverings, face masks and/or other respiratory protection. This exhibit was prepared by the author with consideration given to OSHA's guidance for employers with regard to assessing the level of exposure of each workplace based on factors such as community spread, cases of COVID-19 in the workplace and the exposure levels employees face.

Many factors will influence an employer's decision to require the use of face masks. OSHA's guidance is for employers to consider the level of exposure of each workplace based on factors such as community spread, cases of COVID-19 in the workplace and the exposure level employees face. [127] As it relates to ensuring a safe workplace in a COVID-19 world (as required by OSHA's general duty clause), it is necessary to determine the relative risk level of each employee's specific situation. The exhibit above provides assistance in this regard and is based on OSHA guideline used to determine the need to provide personal protective equipment. It may be used by employers as the basis upon which to develop job risk assessments in the context of COVID-19.

The following discussion provides guidance with respect to answering the questions enumerated above. To begin, it is legal for employers to require that their employees wear face masks. Notwithstanding any outright requirements imposed by any applicable state, city or municipal entity, it would be wise for employers to establish written parameters as to which employees must wear a face mask and which may not necessarily need to wear one, and under what circumstances and conditions these policies would apply. Indeed, employers may wish to embrace strategies and develop guidelines based on their company's particular tolerance for risk, financial position, labor relations status, public image, etc. Below, are some thoughts and insights about this.

- *Very High Exposure*, and *High Exposure*, employees both have a high chance of COVID-19 exposure. Employers should follow industry-specific guidelines re: N95 mask use *while employees perform the tasks noted above*. Understanding that N95 masks are not designed for other than short-duration use, when performing other less risky tasks, the other guidelines noted below should apply.
- *Medium Exposure* employees are routinely in close proximity to large numbers of potentially infected persons. Face masks are highly recommended for these employees, *while they are in such proximity*.
- *Low Exposure* employees are not regularly required to be in close proximity to customers or co-workers. At the very least, face masks are recommended for entry to, exit from and in any common areas.

An employer that considers requiring the use of a cloth face masks the creation of a form of administrative control should provide general information on their safe usage. Being certain to emphasize the inherent limitations of most cloth face masks to make it clear to employees that − unlike N95 respirators − these masks lack a sophisticated filtration system that prevents particles from entering the lungs (unless the face mask is otherwise designed and constructed with features that enable it to protect the wearer, as detailed above).

Another consideration that has to be addressed by employers is whether or not to require the exclusive use of a company standard face mask or to allow employees to provide their own face mask. In either case, as with any PPE, it is ultimately the employer that will be held responsible to assure that the face mask worn is adequate, safely designed and constructed, safely used, properly maintained, clean, etc. Appreciating this, any face mask used has the capability of creating a safety hazard and a challenge to employers. As such, as a practical matter, establishing a company standard face mask, and requiring all employees to use it exclusively, would create a level of uniformity that would make it easier for employers to ensure greater reliability consistency and dependability as it relates to maintaining a uniformly high safety level enterprise-wide.

Permitting the wearing of homemade or other commercial face masks would thwart that effort. By example, the wearing of bandannas, neck gaiters, handkerchiefs, balaclavas, scarves, shawl scarfs, matos and hash-scarf head wraps are not designed to be face protection under OSHA's PPE standard and would likely create undue safety hazards that employers would need to address. If a face mask other than a company standard one is allowed, employers would have to assess, evaluate and approve each to ensure that they meet whatever minimum requirements the employer establishes for an acceptable mask. This will only add another step and degree of complexity to the process of ensuring ongoing face mask safety, etc. In establishing a standard for face masks, employers need to consider the following safety challenges:

- *Entanglement Hazards*: The wearing of certain masks may create a risk of becoming caught or tangled in machinery, resulting in serious injury. Similar to an employer's ability to prohibit the wearing of other items in the interest of ensuring safety (e.g., jewelry, hooded sweatshirts, very long hair) they should not allow the wearing of homemade masks and require the exclusive use of a company standard face mask.

- *Vision Concerns*: The wearing of certain face masks may obstruct the wearer's vision or "fog-up" their glasses or safety glasses and adversely impact their ability to perform their work tasks safely. For this reason, the use of a company standard face mask is recommended. Further, employees should be advised of these risks and trained in the correct use of the face mask to achieve a proper fit, eliminate fogging and condensation buildup, etc. In those very few situations where wearing a face mask creates a hazard that may not be adequately mitigated, the face mask should not be worn.

- *Bio-Burden/Transmission Vector Threats*: Even when they are properly used, most ordinary face masks create "bio-burdens" or large populations of viable pathogenic microorganisms, as a result of the wearer breathing and coughing germs and viruses into them and coming into contact with others who may carry and transmit infected germs and viruses. There are several means by which employers can mitigate these risks including the use of a face mask that employs antimicrobial technology (e.g., the Aegis® Microbial Shield, electrostatic layer) that continuously *kills*, rather than simply *filters*, dangerous microbes, thereby reducing the risk of cross-contamination and bio-burdens. The use of an effective antimicrobial reduces the need for such a tight face mask fit and wearer's need to constantly readjust the mask (which heightens the risk of transmission). It also reduces the risk of mask-to-hand-to-body transmission when removed; and, relative to ordinary masks, it is safer to transport and store (as it is not covered with active microbes). This is important as when the mask wearer touches, adjusts and discards a mask, each action potentially spreads disease and possibly infects the wearer, others in the vicinity and any touched surfaces.

  Regardless of what company standard face mask they choose to adopt, employers are advised to train employees to safely put on, fit, wear, remove, clean, maintain, handle and store their face mask to reduce mask-to-hand-to-body transmission and to establish protocols for their proper and timely replacement.

- *Breathing Impairment Risks*: While common sense dictates that wearing any face mask necessarily impairs a wearer's ability to breath relative to not wearing one, the benefits of face mask use have been deemed to outweigh the nominal risk associated with wearing masks that are correctly designed and constructed to support extended use. Homemade masks that are often tight and constructed of relatively impermeable materials, and commercially available masks that are not correctly designed or constructed, may excessively limit an employee's breathing, as well masks that become covered with saliva, mucous, face oils, makeup, dust and dirt that may accumulate over time. As detailed elsewhere in this document, this can cause the wearer to rebreathe his/her carbon dioxide ($CO^{2)}$ or other infectious material; exacerbate breathing problems of those having underlying respiratory or cardiac health conditions; and, in extremely limited circumstances, cause severe headaches, hypercapnia or hypoxia.

  To address this risk, employers are well advised to train employees on the correct fitting, wearing, cleaning and maintenance of their face mask and to establish protocols for their proper and timely replacement. Moreover, to better reduce this risk, employers should not allow the wearing of homemade mask and require the exclusive use of a company standard face mask.

- *Furthering a False Sense of Security*: it is possible that some employees may presume that they cannot spread, or become infected by, COVID-19 as a result of face mask wearing by others or themselves.

  Regardless of what company standard mask they choose to adopt, employers are advised to train and clearly communicate to their employers that no cloth face mask is intended to be a substitute or replacement for medical-grade personal protective equipment; that face masks are an imperfect supplemental protection and not intended to replace other recommended or required measures to stop the community spread of COVID-19 (e.g., social distancing, hand washing, refraining from touching the face, sheltering-in-place, etc.); and that face mask wearers should consult with their trusted medical professional to determine compatibility with their personal medical situation regarding face mask use in relation to their particular health issues.

ADA, FFCRA and EEOC Challenges

The author believes that most professional business advisors will agree that, in the context of a pandemic such as COVID-19, it is more important than ever for employers to prepare and understand the various laws that may indirectly impact them. Among these is the Americans with Disabilities Act (ADA) of 1990. [128]

The ADA is a civil rights law that prohibits discrimination based on disability. It affords similar protections against discrimination to those having disabilities as the 1964 Civil Rights Act, which made discrimination based on race, religion, sex, national origin, and other characteristics illegal. Covered disabilities include a very inclusive group of mental and physical medical conditions, which do not need to be severe or permanent. To meet its requirements, the ADA obliges covered entities (e.g., employers with ≥15 employees, etc.) to provide *reasonable accommodations* to employees with disabilities and imposes accessibility requirements on public accommodations. A reasonable accommodation is a change in the way things are typically done to meet the specific needs of a disabled employee and can include, among other things, special equipment to allow the employee to perform a job, scheduling changes, changes to the way work assignments are chosen, etc.

The ADA does not interfere with employers following advice from the CDC and other public health authorities on appropriate actions relating to the workplace. The Equal Employment Opportunity Commission (EEOC) is the agency that enforces workplace anti-discrimination laws, such as the ADA. In 2009, the EEOC issued guidelines to help employers deal with H1N1 virus (which it recently updated for the current COVID-19 pandemic) entitled "*Pandemic Preparedness in the Workplace and the Americans with Disabilities Act*". [129] These guidelines address how employers can deal with the realities of a pandemic while complying with the ADA. As a point of clarification, while the discussion below details various ways in which employers may need to prepare to respond to certain requirements of the ADA as they relate to employee *physical* disabilities, the ADA covers discrimination based on a wide expanse of disabilities including mental health disorders (e.g. depressive, bipolar, post-traumatic stress, obsessive compulsive) and religious beliefs.

One question that is answered by the ADA is the need for employers to make accommodations for employees with a disability who need a related reasonable accommodation under the ADA (e.g., non-latex gloves, or gowns designed for individuals who use wheelchairs): the employer should provide these, absent undue hardship. Likewise, employees with compromised immune systems and respiratory conditions, who may be at heightened risk from community transmission of COVID-19, must be provided a face mask if they request one in those workplaces that do not permitted voluntary use of face masks (as is the case with many employers). On the other hand, what if a disabled employee maintains that he or she has a medical condition that makes it impossible for he or she to wear a face mask? This situation would trigger what is known in ADA-speak as the *interactive process*, [130] a very specific procedure that involves the medical assessment of this situation and the exploration and evaluation of various appropriate and reasonable accommodations. [131] If, in fact, the employee does provide a legitimate medical reason for not being able to wear a face mask at the workplace where it would otherwise be required, reasonable accommodations could include the following:

- Providing the employee an unpaid leave of absence until face masks are no longer required at work;
- Allowing the employee to work remotely; or
- Providing an alternative face mask or covering that is consistent with the employee's medical condition.

Relatedly, the recently enacted Families First Coronavirus Response Act (FFCRA) requires certain employers to provide their employees with paid sick leave, or expanded family and medical leave, for various reasons related to the COVID-19 pandemic. [132] The author's understanding is that any unpaid leave of absence based upon the employee's inability to wear a face mask at work would likely not be covered by the FFCRA. Further, the author believes that under these conditions the employee likely would not be eligible for either paid sick leave or emergency paid Family and Medical Leave Act (FMLA) leave. [133] That being said, the author wants to reiterate that he is not an attorney and that these matters should be reviewed carefully with a qualified attorney as the employee may in fact qualify for some of these benefits under certain circumstances.

Notwithstanding the above, when all is said and done, there may be times when certain employees, for valid health conditions, may not be able to easily wear a face mask. In these circumstance, the employer would be advised to excuse them from high-risk and medium-risk roles. However, in all other circumstance it is the author's recommendation that an employee should never be permitted to work onsite without the required face mask as, in the case of COVID-19, it is not only about the safety of the subject employee but also about the safety of their colleagues and the communities in which the work and reside.

It is noteworthy to mention that the courts have ruled it is not a violation of the ADA for an employer to require an employee to wear PPE to address a safety hazard as part of an essential function of his or her job where the business is seeking to address a safety concern in cases where the employee's objection to wear the PPE was based on a disability. [134] Indeed, the Eighth Circuit Court of Appeals recently affirmed a dismissal of a legal claim brought under the ADA against an employer that terminated an employee who was unable to use PPE that was required under an American Society for Testing and Materials (ASTM) standard. [135]

Other examples of situations that may require an ADA accommodation might be an employee who may need a modified face masks for those who communicate with them, if that employee is deaf and relies on lip reading to communicate. Or, an employee may also request a religious accommodation for a modified face mask due to their need to wear religious garb. An employer's flat refusal to consider reasonable requests for modification of the company face mask policy to accommodate such circumstances may create a legal or regulatory liability.

The question has come up as to whether or not an employer can terminate an employee for wanting to wear a face mask when the employer has a policy *against* wearing a face mask. This was actually a case that was tested in Kansas during the early days of the COVID-19 crisis (March, 2020) when there was little known about the virus. At the time, there were mixed and confusing directives coming from the CDC and other public health agencies as to whether or a not a mask was effective for either the wearer or those nearby for persons thought to be healthy; and certain public-facing employers were concerned about how masked employees would appear to their customers. A couple of short months later (July, 2020), with new evidence, and the CDC and virtually all other public health agencies, in support of the premise that wearing face masks is an effective means by which to reduce the risk of community spread, this would appear to be a rather moot case…however, that's not the case. Indeed, as more states open up and allow non-essential businesses to resume operations, this topic has reemerged and, to some extent, become a political issue and taken a front and center place with those who do not believe that it is effective, essential or valuable to wear a face mask, in public or at the workplace. In fact, this sentiment appears to be held by certain employers, employees and policymakers alike. Understanding the reality of this situation, the topic of whether or not an employer can prohibit or terminate an employee for wanting to wear a face mask is worth contemplating.

The case of the Kansas City barista fits nicely into this discussion. [136] The employee had been working at this high-end coffee shop for some time when in early March of 2020 the COVID-19 outbreak was characterized as a pandemic by the WHO. Taking the severity of the situation seriously, the employee went to work one day wearing a face mask only to be told by her employer that the CDC was not mandating that face masks be worn by healthy people and that she could not wear one as the business owner was concerned about how a masked employee, especially a customer-facing one who was preparing coffee for customers, might appear. He contended that wearing a face mask might convey the impression that the establishment may not be a safe place for the customer to be. (It is important to remember that, at the time, there were a great number of people who did not believe that restaurants, bars and coffee shops were necessarily safe places to frequent, which is evidenced by the fact that attendance at these types of establishments fell off dramatically far before they were shut down by various government authorities.) The employee was told that she could either take the mask off or go home. Not wanting to be put in harm's way, the employee believed that she had to leave her job, and she did. The question is "Was the employer within his legal rights to deny the wearing of a face mask?"

OSHA's general duty clause remains in force during the pandemic and an employer is required to provide a work space free from hazards that are likely to cause death or grave physical harm. According to OSHA's standards for determining employee risk exposure (see graphic above), a barista is a "medium" exposure position and entitled to a face mask in the workplace. Also in full effect are OSHA's regulations that provide for an employee's right to refuse hazardous work. Indeed, an employee may refuse to perform work unless each of the four following conditions are met:

- When asked to eliminate the danger, the employer failed to do so; and
- The employee, in "good faith", genuinely believes that an imminent danger exists; and
- A reasonable person would agree that the situation presents a real danger of death or serious injury; and
- Due to the urgency of the hazard, there isn't time to get it corrected via regular enforcement channels.

The fundamental issue at hand is whether or not a real danger is present and, in the context of the COVID-19 pandemic, what authority can be relied upon to determine if the situation poses an imminent threat to the work-place such that wearing a face mask would not be found to be unreasonable. [137] In the US, the presumptive controlling authority on the use of (medical and non-medial) face masks in the workplace is the CDC and the NIH's National Institute of Allergy and Infectious Diseases (NIAID). Referencing the requirements, guide-lines or recommendations of these entities would likely constitute adequate enough authority to support a claim that a workplace environment is, or is not, a real danger or hazard as it relates to issues related to immunology and infectious disease transmission. The determination could either support a claim that wearing a face mask would be appropriate if there was a real danger of hazard of becoming infected by COVID-19 or that there was no such danger, thereby supporting an employer who didn't want employees to do so, on the basis that it might unnecessarily alarm or frighten customers. Given the progression of the disease, and the changing perspectives of the aforementioned authorities over time, in the past, it is likely that an employer would be victorious in keeping his/her workplace free of mask wearers. However, now that it is well known that wearing a mask does in fact reduce the spread of infection, and in some instances actually protect the employee from exposure to the virus, it is likely that the employee would be victorious in winning the right to wear a mask. Presently, the CDC's guidance supports the OSHA claims made by thousands of hospital workers who wanted to wear a face mask only to be told that they couldn't due to a global shortage [138] or that they couldn't wear one as, in doing so, they might hurt the feelings of patients [139] or otherwise cause "unnecessary" alarm.

In recent months however, public sentiment has been changing and it is likely that more and more employers will encounter employees who may not wish to wear a (non-medical or non-PPE caliber) face mask on the belief that they are either not effective at reducing the spread of disease or for protecting themselves from infection. The question then becomes: "Can an employer fire an employee for not wearing a face mask?". There is certainly an abundance of evidence to support the reasonableness of an employer requiring the wearing of a face mask in the workplace, not the least of which is reducing the spread of infection to other of the employees it is required to protect. [140] And, with few exceptions, they can institute reasonable safety policies and terminate employees for refusing to comply (typically under the at-will employment provisions of most states). As detailed above, those exceptions would be the limited instances in which wearing a mask presented a hazard itself or if the employee could not wear a mask due to health reasons.

Lastly, there is the topic of how employers should handle employees who refuse to wear a mask at the work. Unfortunately, unlike some countries in Asia that have more experience with serious epidemics, and where there exists a more community-minded culture, people who are sick routinely wear a face mask when they are sick, to benefit those around them. This impulse to be more collective about disease management is one of the reasons why wearing face masks has never really caught on in the US. With this in mind, employers are beginning to find themselves having to deal with a small number of employees who view wearing a mask as an infringement of their perceived First Amendment right to express who they are. [141] It may not be a coincidence that this small minority can often be very vocal, and sometime aggressive, and simply not able to fully grasp that the First Amendment does not endow upon them the constitutionally limitless right to be heard and seen by everyone all the time, or the unfettered right to say whatever they wish without consequence. [142]

To some, refusing to wear a mask is seen as an emblem to overtly display their disregard for, and diminution of, experts and expertise. To others, the refusal to wear a mask is a form of macho messaging intended to minimize the COVID-19 risk and to appear manly. Still others may view wearing a mask as submitting, a form of muzzling and the showing of weakness. Regardless of the reason, given the current social and political climate, it is likely that an employer will encounter at least one employee who will want to exercise his or her right to breathe unobstructed into the face of anyone in their path in open defiance of the authoritative guidance and unequivocal evidence that suggests that wearing a mask is not only of value to the wearer but in the best interest of those around the wearer. There is no easy way to handle situations like these. In the event that an employee refuses to wear a mask against an employer's stated workplace safety policy for any of the reasons discussed above, the employer would be well advised to begin a discussion with the employee by asking questions that would lead to a better understanding of their reason for refusal. [143] Of course, none of the aforementioned reasons is adequate enough to justify putting an employer's workplace at risk, in violation of OSHA's general duty clause. Further, in the absence of a legitimate claim under the ADA, possibly for a psychiatric reason, there is likely no protection for the employee under the ADA. Under such circumstances, the author believes that the employer would be well within his/her rights to terminate the employee for cause.

As to the volume of activity spurned by COVID-19, OSHA reports that there are thousands of pending complaints under its general duty clause that requires employers to provide a safe, hazard-free workplace. [144]

OSHA Whistleblower / Retaliation Liabilities

While many employers are familiar with the general provisions of OSHA, what is not commonly known or understood is that OSHA's Office of the Whistleblower Protection Program (OWPP) is not only responsible for enforcing whistleblower protection under ten other laws but has jurisdiction over all state whistleblower complaints under Section 11(c) of the Act. [145] This section prohibits employers from terminating, or in any manner discriminating against, any employee because the employee has (1) filed a complaint under or related to the OSHA; (2) instituted or caused to be instituted any proceeding under or related to the OSHA; (3) testified or is about to testify in any proceeding under the OSHA; or (4) exercised on his own behalf or on behalf of others any rights afforded under the OSHA. As to protected activity, employees may complain or bring claims for retaliation under this section if they are not allowed to wear a face mask; if they refuse to perform functions where they work in close contact with others without face masks; or are sent home or terminated for refusal to wear a company-provided face mask. Employees have thirty days of the adverse employment action in which to file a whistleblower claim with OSHA; an agency investigation will be conducted; and there is no private cause of action under the act. Employees generally do not have the right to refuse to attend work entirely on account of a safety concern once the employer demonstrates that it has a program to protect the employee against the hazard however, the employee may refuse to perform specific tasks for which he or she has an objectively reasonable safety concern that the employer has not yet addressed. Employees generally do not have the right to walk off the job. Given this, employers implementing company face mask policies are advised to be aware of these potential retaliation issues and to discuss them with their attorney or professional advisor.

National Labor Relations Act (NLRA) Challenges

It is worth mentioning that an employer that arbitrarily or systematically refuses to provide for a safe workplace in the context of the COVID-19 pandemic runs the risk of being on the wrong side of a group of employees armed with the protections afforded by Section 7 of the National Labor Relations Act (NLRA). [146] Indeed, this was exactly the case that occurred early on in the crisis, on many occasions, when groups of front-line healthcare workers lodged claims against their respective hospital employers when they refused to provide a safe workplace by denying them the opportunity to avail themselves of safe face mask protection.

- In one case, a hospital didn't want to scare its patients or visiting family members, when that was allowed. The hospital was not providing adequate PPE and the workers wanted to use their own homemade face masks. They were told that doing so would violate hospital policy. When one veteran nurse requested to see that policy the hospital administrator threatened her with disciplinary action or termination. [147]

- In a second instance, a hospital's policy was to allow nurses to wear a mask only while attending to patients in their rooms; not in hallways or other common areas, again for fear of scaring patient visitors. When a senior nurse challenged the policy by wearing her mask everywhere, on the basis that the hospital was not providing a safe workplace, management told her that if she continued she would be fired. [148]
- In yet another situation, a hospital was allowing its nurses to where N95 masks however being in short supply, they were asked to wear them for several days. N95 masks are designed to be used for only one patient and then discarded. During the early days of the pandemic, when supplies were very low, it was not too unusual for healthcare workers to be asked to wear them for an entire day or shift. Being asked to wear them for more than one day was well outside of the parameters of safe usage. Knowing this, several of the nurses at this particular hospital, who had a supply of donated high-quality, US-made N95 masks decided that they would use them while working at the hospital, to reduce their risk of exposure. Again, the first nurse that did no was threatened with termination if she were to continue. [149]

In each of the cases above, one brave employee organized a group of her colleagues, discussed their lack of protection, the unsafe working environment in which they were placed, and then lodged an NLRA claim on behalf of the group. In one case, the group participated in a group refusal to continue to work at the hospital under the circumstances and they were all terminated both for wearing a face mask and for their communicating amongst themselves about the relative safety of the hospital workplace. Section 7 of the NLRA protects workers who undertake "protected concerted activity for mutual aid or protection" related to the terms and conditions of their employment. Employers should be cognizant of the risk of becoming entangled in such situations (if they pursue policies along these lines) and try to avoid them at all costs.

The employer consequence for getting caught up in one of these actions is hardly inconsequential. Several months ago (August, 2019) a US federal judge awarded more than one million dollars in lost wages and punitive damages to two former employees when their employer was found guilty of firing them in retaliation for their participation in a federal OSHA safety investigation. The court's award of $500,000 in punitive damages is the largest punitive award under the anti-retaliation provision. Moreover, the judge also required the employer to post an anti-retaliation notice at the worksite. [150]

United Stated Department of Agriculture (USDA) and
Federal Drug Administration (FDA) Safety Compliance Issues

Employers in the food processing and manufacturing industries may be subject to additional liability pertaining to federal and state regulatory agencies (e.g. USDA and FDA) that may prohibit, restrict or prescribe the types of face masks that can or cannot be worn by employees at the workplace. Employers in these industries are advised to become familiar with these specific requirements. [151]

Civil and Criminal Legal Actions

In addition to employer liability resulting from regulatory compliance violations, employers could face civil or even criminal legal action as a result of face mask issues pertaining to COVID-19. The family of a veteran Walmart employee recently (April, 2020) filed suit against the employer charging it with negligence and wrongful death in one of the first COVID-19 lawsuits filed by an employee against an employer. [152] Among other things, the suit alleges that Walmart failed to provide workers with face masks and other protective equipment. The plaintiff is one of two Walmart employees to die from complications related to COVID-19.

Workers' Compensation Challenges

Workers' compensation is a publicly sponsored, state-mandated form of insurance program that pays monetary benefits to workers who become injured or disabled in the course of their employment in exchange for the mandatory relinquishment of the employee's right to sue his or her employer for the tort of negligence. This bargain is intended to benefit both employees and employers ensuring reliable insurance coverage with predictable, timely payments and reduced legal costs. Although every state has its own unique workers' compensation system, in most states, workers' compensation claims are handled by dedicated administrative law judges. Each state employs varying coverage requirements and standards that are typically based on industry, occupation and the size and structure of a business. In addition to providing for medical treatment at no cost to the employee, workers' compensation also provides wage replacement benefits for lost wages resulting from time away from work as well as a financial death benefit if applicable.

The emergence of the COVID-19 pandemic has created myriad challenges for policymakers at all levels of government and has not excused those who are responsible for establishing and interpreting workers' compensation policy. Several questions therefore arise as to whether or not COVID-19 is compensable under workers' compensation coverage? Is coverage impacted by the increased risk or greater likelihood of an employee contracting the condition due to the employee's occupation (e.g., essential worker)? What about arguments that might question the source of the disease and posit that the virus may have been contracted in other than a work-related location? The answer to all of the questions is a definitive "don't' know" as the issue is indeed a complicated one. In great part this is because although most workers' compensation programs inherently exclude "ordinary diseases of life" or routine community-spread illnesses (e.g., the common cold or flu) from their definition of an "occupational disease" a compelling counterargument may be made that certain occupational groups (e.g., healthcare workers) have a higher probability for exposure and that the workplace contraction of the disease should be compensable. [153] This is certainly not unheard of as some states have amended their statues for workers in certain industries and job positions to include coverage for the development of various chronic illnesses, like cancer, that result from repeated exposure to harmful materials and environments while on the job. [154] Some twenty or more states cover various lung and respiratory illnesses for firefighters and other first responders when those conditions are presumed to be work-related [155] (although it is unclear as to whether or not these provisions would extend to COVID-19 illnesses).

Unlike other states, Texas allows employers to opt out of its workers' compensation system in favor of taking their chances in court and facing potential liability under tort law. This could be particularly problematic as, in doing so, they become subject to much greater risk in today's COVID-19 environment as they will not enjoy the benefit of workers' compensation's preclusive effects and thereby face the substantial risk that simple negligence will be enough to support employee claims arising from COVID-19 exposure.

Absent specific provisions to the contrary (see below), the question of whether or not an employee adversely impacted by COVID-19 at the workplace can meet the eligibility requirement for proving an occupational diseases vary from state to state. In most states however, an employee typically needs to demonstrate that:

- the job's particular nature caused the illness or greater risk of viral exposure than the general public, and
- the employee contracted the illness as a result of a specific exposure that happened while doing their job.

Under normal circumstances, it would likely be particularly difficult for an employee to meet both of the requirements above when an infectious disease like COVID-19 becomes widespread in the community and a general hazard to everyone worldwide, irrespective of employment. This is because all persons are exposed to COVID-19 both at the workplace and virtually everywhere else (including at home). Moreover, workers' compensation law does not typically compensate employees just because they become hurt, injured or contract COVID-19 on the job as work has to be the prevailing cause as to why the employee contracted COVID-19. To lodge a successful claim, the employee would be required to prove that there was something specific about the employee's work that increased the risk of contracting COVID-19 even if the employee were to have been able to successfully establish successfully that COVID-19 was in fact contracted at, or as a result of, work. However, not only are these not normal circumstance, there is no assurance that we will ever return to normal.

The recent development of the construct "essential worker" as it relates to the COVID-19 pandemic presents some unique circumstances to address in the context of workers' compensation coverage. There is no common definition of this term, as this designation is being determined by the states and various government agencies.

To be sure, the term can be very broadly interpreted and defined, as evidenced by the fourteen initial employment categories created by the Department of Homeland Security (DHS). [156] These include:

1. Healthcare employees.
2. First responders.
3. Food and agriculture employees.
4. Energy employees.
5. Water and sanitation.
6. Transportation and logistics.
7. Public workers.
8. Manufacturing.
9. Communications and information technology.
10. Community-based government operations.
11. Financial services.
12. Hazardous material management.
13. Defense industrial base.
14. Chemical management employees.

Each of these categories is then further defined such that, by example, within the category of "healthcare employees" are not only hospital employees, laboratory workers and direct caregivers but also COVID-19 researchers, funeral and cemetery workers, social service workers, medical equipment warehouse operators, healthplan administrators, etc. to name but a few. The definition included within the recent (May, 2020) legislation passed by the House of Representatives (known as the "The Heroes Act") is more expansive. This bill proposes the funding of $200 billion in "pandemic premium" aka hazard pay for "vital workers". [157] The author makes mention of this to convey the context within which workers' compensation policymakers may take their cues as it relates to expanding their programs to address COVID-19 concerns.

With this in mind, it is not at all surprising that many states have already begun to take action to extend workers' compensation coverage to include some grouping of job categories deemed to be essential or vital and to include COVID-19 infection as a presumed work-related illness or disease. In most cases, this presumption places the burden on the employer (and insurer) to prove that the infection was not work-related making it easier for those impacted employees to file successful claims; a move that will unfortunately likely increase employer insurance / claim costs at a time when businesses are already facing significant financial challenges. These presumption policy changes are being made by legislatures [158] although some are being implemented by executive fiat. [159] Some states have extended coverage to employees who are quarantined by a doctor and consider eligibility for coverage on a case-by-case basis for those who test positive for COVID-19. [160] In a few states, an employee might be able to qualify for coverage even if the employee's job isn't considered particularly high risk, as long as the employee has strong medical evidence of workplace exposure. [161]

Another interesting aspect of this COVID-19 workers' compensation coverage discussion is related to employer liability arising not out of the risk of exposure that emanates from the nature of the employee's *occupation* but rather simply the contraction of the disease by virtue of being exposed to the virus as aa result of dangerous or hazardous conditions at the employee's *workplace*. As we have been witnessing on the news, such a situation has already been proven to be the case at the many meat processing plants. There, social distancing measures have not been implemented for many employees, face masks have not been provided, and workers' compensation claims have already been lodged in large numbers by employees who allege that they contracted COVID-19 (and likely did, in many instances) after being exposed to a fellow infected employee at work. [162] Although the treatment of these types of claims has yet to be addressed by state workers' compensation systems, existing statutes and court opinions provide some insight as to the various approaches states may take. In some states, workers' compensation coverage is extended to occupational diseases that are materially caused by conditions that are particular to the employee's place of employment, in addition to the employee's particular trade or occupation. [163] In other states, courts have held that the sick employee only needs to show a probable link between the workplace conditions and the occupational disease. [164] These do no portend well for employers who will inevitably foot the added expense of this extended coverage.

The extension of workers' compensation coverage to include those employees who become infected with COVID-19 will yet increase the financial consequences of an employer that fails to implement and execute a company face mask policy that successfully mitigates these risks (for the mask wearer and other workers alike).

COVID-19 Waivers / Releases / Disclaimers

In the ever-changing landscape of the COVID-19 era, employers have become more proactive in trying to limit their risks and taking steps to protect themselves against possible future liability for COVID-19 exposure claims. In this regard, liability waivers, releases and disclaimers are a simple, familiar and cost-effective first step that an employer can take to protect against potential liability for virus-related exposures. [165]

Liability waivers and releases are essentially forms of a contract. Employers often use them in an attempt to excuse or relieve themselves for illnesses or injuries to an employee that arise out of the known and unknown risks of an employment activity, and possibly, the inherent risks that arise from employment owing to the employer's ordinary negligence. As contracts, they are interpreted by the courts using contract law principles. A disclaimer is a statement whereby an employer can refuse to accept liability, or limit it, entirely or in specified circumstances. It usually arises in the context of a contractual relationship and requires a degree of acceptance by the employee (because the employee entered into the relationship on terms which include the disclaimer).

Even though liability waivers, releases and disclaimers are routine and well-known, it is still unclear whether such documents seeking to relieve an employer of liability for virus-related exposure claims would be enforceable. In part, this is simply due to the practical reality that as of this writing (July, 2020) no court has yet analyzed one in this context. That said, basic legal principles should provide guidance on such, and those seeking to employ a liability waiver, release or disclaimer should consider the following general principles.

Typically, a liability waiver or release will be successfully upheld only if all of these conditions are satisfied:

- The injury or illness arises from known, unknown or inherent risks that are specifically stated in the waiver/release or from the employer's simple negligence,
- The waiver/release is properly worded according to the state law in which the employee works, and
- The contract does not violate any state laws or public policy.

If all of these conditions are met, the waiver/release's use may result in the lawsuit being dismissed. Indeed, in most jurisdictions throughout the country, courts will enforce liability waivers that insulate an employer from liability arising out of the employer's negligent conduct. Despite their widespread use, liability waivers, releases and disclaimer have some limitations. [166] By example, as it relates to the liability associated with an employer's policy on wearing a face mask, a waiver (release or disclaimer) may be of little value to employers for workers' compensation purposes, as employees typically can't waive their rights to file such claims based on injuries or illnesses arising in the course of their employment.

Most jurisdictions will also not enforce waivers of liability that purport to prospectively waive liability arising from intentional, reckless, or grossly negligent conduct and an employer cannot successfully claim immunity from suit if it engages intentionally or recklessly in conduct that caused the harm. Similarly, with gross negligence being defined as an extreme deviation from the ordinary standard of care, or a conscious disregard for the rights and safety of others, an employer that knowingly fails to take the precautions necessary to maintain a safe and hazard-free workplace in today's COVID-19 environment would not be contractually immune from liability to an exposure claim as exposing employees to a known risk of contracting COVID-19 would most likely be considered reckless or grossly negligent conduct.

Another limitation of liability waivers, releases and disclaimers is the court's reluctance to enforce them if they are contrary to public policy. [167] In some states, a waiver could evoke public policy implications if it involves a matter of interest to the public, such as an employment relationship (contract). By example, courts have ruled against waivers, releases and disclaimers purporting to release an employer from liability for negligence if its employees violated public policy (e.g., refusing to wear a face mask in a high-exposure job position). [168] This is because both workplace safety and the employee-employer relationship are subject to numerous public statutes and regulations, and the employer generally has such superior bargaining power that it makes a waiver inherently unfair. Understanding this, as COVID-19 affects the general public, it is highly likely that liability waivers for exposure claims would be considered contrary to public policy, and therefore unenforceable.

Company Face Mask Policies and Proactive Employee Communications

Employers would be well served to launch their COVID-19 safety, risk management and liability mitigation efforts by establishing a comprehensive corporate face mask policy, initiating a face mask training program and engaging in a proactive communication initiative, along the following lines:

Company Face Mask Policy

As you know, the world is currently taking measures to respond to the COVID-19 pandemic. The Company is focused on protecting the health and safety of all its employees, contingent workers and facility visitors. As such, it is taking measures to protect our employees, business associates and customers and following guidance from the Centers for Disease Control and Prevention and other public health authorities. The Company believes that its response is fully compliant with all requirements and recommendations of all governing authorities and, while it may not be required to provide any type of Personal Protective Equipment (PPE) relative to COVID-19, the Company has decided to provide a very high quality company standard face mask intended to help ensure the safety of your work environment.

The CDC and other public health agencies continue to study and learn more about the spread and effects of the COVID-19 virus. We now know from numerous research studies that a very significant portion of individuals who are actively infected with the coronavirus lack symptoms ("asymptomatic") and that even those who eventually develop symptoms ("pre-symptomatic") can transmit the virus to others before there are any sign of symptoms. This means that the virus can spread between people interacting in close proximity; for example, speaking, coughing, sneezing or even breathing near a person − even if those people are not exhibiting symptoms. In light of this new evidence, the CDC believes that it is critically important to maintain 6-feet physical distancing to slowing the spread of the virus. Further, it advises the wearing of cloth face masks in all public settings (including work sites) where physical distancing measures are difficult to maintain and especially in areas where significant community-based transmission could occur.

Our knowledge of COVID-19 is rapidly expanding. This requires the periodic updating of our policies with respect to our efforts to manage this crisis and incorporating the best updated evidence about issues like viral transmission and face mask use. As such, our official Company face mask policy is intended to:

1. Protect our workforce should an employee have pre-symptomatic or asymptomatic COVID-19 infection;

2. Protect our employees should they come in close contact with an individual with either pre-symptomatic or mild COVID-19 infection or who has symptoms that have not yet been recognized;

To be successful, this approach will require enterprise-wide support from everyone. This will include observing all of the rules and requirements prescribed by the Company regarding correct face mask wearing, washing, maintenance, replacing, storage and disposal as detailed in *Face Mask Dos and Don'ts* (attached).

All full-time, part-time and temporary employees of the Company, as well as all visitors and on-site contractors, will be required to wear a Company standard face mask, *at all times*, while on Company property. All Company employees will be required to wear a Company standard face mask while representing the Company at off-site locales, in settings where physical distancing is difficult to maintain.

Wearing a face mask is one of many measures taken by the Company to ensure the safety of our worksites and employees by helping to reduce the spread of COVID-19 among our employees, contractors and visitors along with physical distancing (for the reasons detailed above). This is necessary to maintain compliance with the Occupational Safety and Health Act (OSHA), workers' compensation statues and other applicable public health and safety agencies. As such, given the importance of face mask wearing, the Company reserves the right to take disciplinary action against any (full, part-time or temporary) employee who refuses to follow the Company's face mask policy, including asking the employee to leave a worksite or, ultimately, suspension or termination. Visitors and on-site contractors who fail to abide by the policy may be asked to leave the worksite. Actions taken in this regard will be undertaken in accordance with applicable statutes.

A strong, comprehensive and effective company face mask policy should follow these guidelines:

- *A presentation of the facts and logic behind the company's strategy.* Employees want to know and understand why the company is implementing a new policy and why they are being asked to comply with it. Explain the facts of COVID-19 and how wearing a face mask helps to reduce the spread of the virus and make the workplace a safer, hazard free environment.
- *Describe the company's face mask policy including why, when and where employees must wear face masks.* This discussion should be as complete, specific and detailed as possible and include the logic and intention of the company's policy and the consequences of not abiding by the policy.
- *Explain exactly what types of face masks can and cannot be worn.* Provide an explanation as to why the company elected to have a *company standard* face mask, why it was selected, what its capabilities and limitations are; how employees may obtain one; that they are free and will be replaced as needed.
- *Instructions for correct face mask wearing, washing, maintenance, replacing, storage and disposal*. The effectiveness of a face mask policy has almost as much to do with its correct use as it does with the quality of the mask itself. Employees should be provided with detailed instructions and training (in person or via video) on COVID-19 hazards, the company's face mask policy and their correct use.
- *Document the face mask training process in writing*. This will serve to evidence its effectiveness.
- *Obtain employee sign-off*. Employers should ask employees to sign off as to their understanding of the company's face mask policy; their commitment to abide by it; and their agreement to hold the company harmless for their failure to follow it or their improper face mask use or care.

Company Standard Face Mask

The __________ face mask, manufactured by _________________, will serve as the Company standard face mask. Only this face mask will be allowed to be worn at Company worksites. Wearing any other commercial or homemade mask, of any type, is strictly prohibited. The Company standard mask will be furnished to all personnel required to wear one at no cost. It will be replaced as necessary, also at no cost.

Most of our employees have become familiar with the highly publicized N95 respirator. This form of face protection is specifically designed for use by healthcare workers and first responders. N95 respirators provide a very high level of filtration against microorganisms that is critically important in healthcare delivery situations where infectious droplets could become aerosolized in a clinical setting during patient treatment. Most people find that N95 respirators are hard to breathe through and difficult to wear for long periods of time and are impractical for generalized use. Indeed, they are not designed for this purpose. Further, the supply of N95 respirators is low and there is a general agreement that they must be reserved for use by medical professional, patients with known or suspected COVID-19 infection and high risk situations.

Similar to influenza and other respiratory viruses, COVID-19 spreads primarily through droplets and through aerosol particles in very close quarters. Droplets are *large* particles of liquid produced by a person who has coughed or sneezed. Because of their size, droplets usually do not travel very far before they fall onto a surface, thereby explaining how transmission occurs from a contaminated surface (e.g., a doorknob, keyboard, tableware). Aerosols are extremely small particles that are light enough that they can be suspended in the air for an extended period of time. They can not only be spread by coughing and sneezing, but also by be released by talking or simply breathing. In summary, droplets act like rain, while aerosols act like fog. If you walk under an overhang during the rain you won't get wet because gravity brings the raindrops straight to the ground (barring any wind). On the other hand, fog is so light it can float and occupy almost any space. This is an important distinct as it relates to a face mask's utility and its ability to protect the wearer and/or others in his or her vicinity. The Company wishes to provide protection for all its employees in each of these situations.

It is important to know that symptomatic people, those known to be infected with the virus, are not the only people who can spread COVID-19. In fact, studies have shown that the majority of community-acquired transmissions, and ~ 44% of all infections, emanated from *asymptomatic* people (who can transmit the virus for up to 5 days before symptoms become manifest). Further, researchers have found that the viral load of an infected person *increases* over time; that only 20% of coronavirus-positive people may be responsible for some 95% of the viral spread; and that infectious people come in all ages (although they all carry different levels of viral loads). In simple terms, people who do not know that they are infected are most likely to transmit the virus, in part, because people who know that they may be infected self-quarantine.

An N95 particulate respirator is a type of mask that is unique among face masks in that it is designed to not only reduce the risk of community spread (by reducing the volume of infected particles that exit the wearer's mouth by acting as a barrier) but to also protect the wearer (by killing the infected particles that are directed toward, and captured, by it). They have the ability to filter 95% of the airborne particles in the environment.

Particulate respirators employ two basic methods by which to block and kill inbound infected particles. In the first case, these masks are constructed of fine strands of plastic that are blown onto a screen to create a complex netting which are then formed into a mask. This acts as a physical barrier able to catch particles as they try to fly through the mask. In the case of N95 models, they are 95% effective at catching particles as small as 0.3 microns in size. In that the COVID-19 is considerably smaller in size (~ 0.125 microns), this method alone is not adequate enough to be effective against the virus. To make respirators effective against even the smallest of viral microbes, they employ a second technology based on "static electricity". They are built such that when the respirator's components "rub together", an electrostatic charge is created that attracts the infected particles much like a magnet and then electrocutes them.

We selected the Company standard face mask because, like the N95 particulate respirator, it is not only designed to reduce virus transmission from the wearer to others but also protect the wearer. Like the N95 particulate respirator it not only incorporates an inner layer of silk chiffon having keen electrostatic properties it is treated by a powerful antimicrobial that has a forty-year history of effectiveness against a wide variety of bacteria and viruses. It was developed by the world-renown Dow Chemical Company. This antimicrobial molecularly bonds with the face mask's fabric to become a part of its fibers and will withstand multiple washings while retaining its effectiveness. The face mask is made with Supima® cotton, the softest in the world, and it features an adjustable nose piece and ear loops to facilitate an all-important snug fit while ensuring maximum breathability. Lastly, this face mask is made right here, in the United States.

<u>A Note of Caution on the Effectiveness of Face Masks</u>

Although the Company wishes to do everything that it can to provide for a safe and hazard-free workplace by providing its employees and facility visitors with a top quality face mask, it is important to note that no cloth face mask is intended to be a substitute or replacement for good pandemic hygiene practices and other measures to reduce the community spread of COVID-19 (e.g., social distancing, hand washing, refraining from touching the face, sheltering-in-place, etc.). Further, all face mask wearers are advised to consult with their trusted medical professionals to determine compatibility with their personal medical situation regarding face mask use in relation to their particular health issues.

Lastly, and most importantly, although face masks have been proven to be effective at reducing community spread they are an imperfect supplemental protection against COVID-19 as it is a new and novel strain of the coronavirus and an emerging viral pathogen. As of today, there is not yet any acceptable method for claims against it and, according to the Environmental Protection Agency (EPA), no manufacturer can directly claim that it's product is effective against COVID-19. This includes the antimicrobial chemical treatments used in the fabrics from which the Company standard face masks is made. Understanding this, while the Company hopes that furnishing face masks will provide some degree of protection to you as the wearer, the exclusive specific intended purpose of our providing them is to help reduce the spread of COVID-19 at our worksites as no personal guaranty as it is person protection can be made at this time.

Face Mask Dos and Don'ts

Until the emergence of COVID-19, few people have had experience with face masks. This tutorial provides guidance on the correct wearing, care, maintenance, storage and disposal of a face mask (and tips to avoid).

Correctly Putting On a Face Mask

- Wash hands with soap and water (20+ seconds) or hand sanitizer before touching the mask.
- Identify the top of the mask. It typically has a stiff bendable edge meant to mold around the nose.
- Identify the front of the mask. It is typically the colored side as the white side touches your face.
- Secure the ear piece/mechanism
  - Mask with ear loops: Hold the mask by the ear loops. Place a loop around each ear.
  - Mask with ties: Bring mask to nose level; place the ties over the crown of the head; secure with a bow.
  - Mask with adjustable straps: Hold top of mask with fingertips, allowing ear straps to hang freely. Bring mask to nose level. Place straps around each ear. Adjust straps for snug fit. Press button to secure.
- Mold or pinch the stiff edge of nose form to the shape of your nose for snug fit.
- Be certain to fully cover nose and mouth. If mask allows, cover chin.
- Adjust accordingly to ensure snug fit with a minimum of gaps in between skin and the mask.

Correctly Wearing and Adjusting a Face Mask

- Whenever possible, refrain from touching your mask while you're wearing it, as anytime an adjustment is made and the face is touched the risk of infecting the wearer or transmitting the virus occurs.
- Avoid touching and fiddling with the mask as studies show that a contaminated finger will cross-contaminate the next seven surfaces it touches, e.g. phones, laptops, keypads.
- Don't pull the mask down to speak/take a drink; wear it around the neck or remove and then replace it.
- Don't let it obstruction your vision at work; or let it get tangled in machinery or equipment.
- Don't take the mask off or rest the mask under the chin or on top of the forehead as putting the clean part of the mask on parts of the body that might have pathogens on them potentially contaminates it.
- Always keep the mask covering the nose and mouth when in public. If it is necessary to remove it, go outside, at least 6 to 12 feet away from another person. Set it, front-side down, on a clean paper towel or in a paper bag. When put it on again, clean hands first and avoid touching the front of the mask.

Correctly Removing a Face Mask

- Wash hands with soap and water (20+ seconds) or hand sanitizer before touching the mask.
- Avoid touching eyes, nose and mouth during removal.
- Avoid touching the front of the mask as it may be contaminated and only touch the ear loops/ties/straps.
- Follow the instructions below for the type of mask you are using.
  - Mask with ear loops: Hold both of the ear loops and gently lift and remove the mask.
  - Mask with ties: Untie bottom bow, then untie top bow; pull mask away from face as ties are loosened.
  - Mask with straps: Press button to release and loosen each strap and gently remove the mask.
- If the mask involves the use of a disposable filter, throw it out.
- Place the mask where no one will touch it and where it won't touch other surfaces, such as countertops.
- Thoroughly wash hands after taking mask off, as it may be contaminated.

Correctly Washing a Reusable Face Mask

- To make sure a face mask remains most effective, regular washing is essential.
- Have a bag or bin to keep cloth face coverings/masks in until they can be laundered.
- Opinions vary as to the appropriate frequency that a face mask should be cleaned. Some experts suggest that reusable face masks must be washed after each use, largely due to their ability to accumulate infectious viral loads. Others believe daily washing is adequate. Disposable masks should not be reused.
- Opinions also vary as to how a face mask should be washed. Some manufacturers recommend that a mask be hand washed (in a sink, as you might wash delicates) using a non-allergenic laundry detergent.
- Many believe that dish washing detergent should be avoided as many contain natural or synthetic bleach that can fade the mask and/or neutralize any antimicrobial defense with which the mask has been treated.
- The CDC says chlorine, hydrogen peroxide, alcohol and detergent are all effective cleaning products.
- Some suggest *Woolite*® is the ideal cleaning agent as it's free of harsh ingredients (e.g., bleach, enzymes) and formulated to not only clean but prevent fiber damage, fading and shape loss during the wash cycle.
- Before hand washing, soak the mask in hot water and cleaner for 30 minutes to killed all the pathogens.
- When hand washing, wet the mask and rub it vigorously so as to build up a lather.
- The CDC states that cleaning a mask during a regular washing machine cycle is sufficient to clean it.
- The CDC's flu virus guidelines suggest masks be washed at a minimum temperature of 167° to kill any pathogens; others suggest that warm water is adequate and unlikely to weaken the mask's fabric.
- Rinse, and line-dry or dry, on a sanitized flat surface and make sure it is completely dry before wearing
- Rinse and allow the mask to line or air dry, on a sanitized flat surface, as dryer heat will cause the mask to shrink over time, and "slamming" any (heated) adjustable ear slides against the dryer's wall will cause them to break) and elastic loops may get damaged. Mask with only cloth ties may be placed in the dryer.
- Rinse, and line-dry or dry, on a sanitized flat surface and make sure it is completely dry before wearing.
- As the number of washing cycles is increased, the protection efficiency of some masks will decrease.
- Don't wear a face mask too long. The length of time it may be safely worn depends on the number of people a user encounters. This is because while the mask's outer layer acts as a barrier, ***those that are not treated with an effective antimicrobial, or an electrostatic inner layer*** not only filter pathogens they accumulate them as well, without inactivating or killing them. The longer a mask has been worn around others, the more concentrated the infectious load becomes. Even masks having an antimicrobial treatment, or electrostatic layer, should never be worn longer than a day without a thorough cleaning.
- Consider buying a few spare masks to keep in rotation to reduce washings and increase their longevity.
- To prevent eyeglass fogging, wash them with soapy water and let them air-dry; it leaves behind a thin film that reduces surface tension, causing the H_2O molecules to spread evenly into a transparent layer.

Correctly Storing and Disposing of a Face Mask

- Fold mask in half with (inner) mouth inside; store in a sealed paper bag or breathable container.
- Don't leave mask in a car or a place where it could get contaminated or cross-contaminate
- Replace mask if soiled with bodily fluids; on the inside (by wearer) or outside (through public exposure).
- Follow these instructions to properly dispose of a face mask:
  - Place mask in a plastic bag – a grocery shopping bag or a zip lock bag are ideal.
  - Secure bag containing face mask tightly.
  - Place bag with mask into the garbage can or waste disposal unit.
  - Wash hands with soap and water (20+ seconds) or hand sanitizer after disposing mask.
- Used face masks must be disposed of quickly and appropriately. If they are not, and they are left around, they can cross-contaminate previously clean areas as they may have concentrated infectious loads.

A Note of Caution on the Use of Face Masks

Employers want to do everything they can to provide for a safe and hazard-free workplace by furnishing their employees with an effective and safe face mask. Despite this, it is important to note that no cloth face mask is intended to be a substitute or replacement for good pandemic hygiene practices and other measures to reduce the community spread of COVID-19 (e.g., physical distancing, hand washing, sheltering-in-place, etc.).

Although face masks have been proven to be effective at reducing community spread, they are an imperfect supplemental protection against COVID-19 as it is a new and novel strain of the coronavirus, and an emerging viral pathogen. As of today (July, 2020), there is not yet an acceptable method for claims against it and, according to the Environmental Protection Agency (EPA), no company can directly claim that it's product is effective against COVID-19. [169] This includes the antimicrobial chemical treatments used in the fabrics from which face masks are made. Understanding this, while an employer might intend that furnishing face masks will provide some degree of protection to the wearer, at this juncture, the specific purpose of providing them can only be to help reduce the spread of COVID-19 at their worksites, and not for wearer protection.

Face mask wearers are advised to consult with their trusted medical professional to determine compatibility with their personal medical situation regarding face mask use in relation to their particular health issues.

Appendix A: Organic Cotton Regulation

In the United States, to be classified as organic, cotton plantations must meet USDA requirements that are enforced by the National Organic Program (NOP). [170] The NOP establishes the allowed practices for pest control, growing, fertilizing, and handling of organic crops. The use of genetically engineered seed for organic farming is also prohibited. Organic Supima® cotton is regulated in accordance with Global Organic Textile Standards (GOTS) [171], discussed in greater detail below.

There are numerous organizations around the world that verify the authenticity, safety and veracity of the claims made by producers of organic cotton materials and products. We start this discussion by noting that one analysis of the official sum of the volume of organic cotton for which certification declarations have been made actually *far exceeds* the world's production of organic cotton. Given this, it is not surprising to know that some certification organizations are more reputable, reliable and thorough than others and, as such, the value of their imprimaturs varies considerably. Below is a discussion of the most common of them and a cursory "assessment" of the value of each.

Uncertified Organic Cotton

There are some brands that sell uncertified organic cotton products, typically because the cotton is not actually organic. In some countries, the sale of uncertified organic cotton products is allowed. In others, cotton is sold as organic based on the cotton sellers "word" or a very weak supply chain transaction certificate system. The bottom line is, that certification of all stages of production is the only way to guarantee traceability and that a product is completely made with real organic cotton. Uncertified organic cotton is often purchased by small or emerging brands as they often cannot afford, or know to demand, a genuine certification process. [172]

OEKO-TEX® Certification

The OEKO-TEX® "label" is one of the most recognized and well-known in textile certification. [173] Consisting of 18 independent partner institutes in Europe and Japan, it offers a portfolio of services and certificates and claims to test every component of an article (e.g., thread, button and other accessory), in every stage of production (from the threads to the finished fabrics to the finished article) for harmful substances and certify that it is harmless in human ecological terms

The OEKO-TEX® standard is regarded as a very good one, based on reliable German criterion, despite the fact that very few batches of the subject product are checked each year. Critics of OEKO-TEX® typically start their censure by noting that its name in German, OEKO (ECO), is misleading as it infers an environmental reference when, in fact, the certification is only a health one. Indeed, the only known link between the entity's health certification and the environment is the founders' misplaced logic that if a product isn't harmful to humans, it isn't harmful to the environment (a secondary concern at the time). Because, since the time of its founding, it has been found that the textile sector is one of the most polluting industries in the world, the organization has expanded its certification scope to include more eco-oriented labels such as Made in Green, Eco-Passport and Standard 100…which are rarely used in the industry as there are more recognized ones that use higher standards to identify eco-friendly textiles. Unfortunately, although it does not typically guarantee that the products it certifies are ecological or good for the environment, it is alleged that the OEKO-TEX 100 label is used to certify certain conventional cotton textiles products, many of which are highly polluting and not eco-friendly (as discussed above). To its credit however, it obliges the certified brand to be responsible in the event of a health reaction from one of its user customers. In summary, as it relates to conventional cotton products, the OEKO-TEX® "label is better than nothing at all, but it cannot be relied upon in comparison, for instance, with GOTS certified organic textiles.

International Association of Natural Textile Industry (IVN)

The International Association of Natural Textile Industry (IVN) is an association of more than one hundred companies that offer certification of all processes performed by producers, distributors, manufacturers and suppliers in the textile industry. [174] Through its various quality seals its member businesses can evidence their commitment to sustainability in a credible, transparent and readily comprehensible manner, in accordance to strict and detailed definitions of ecological, social and quality standards. Its NATURTEXTIL BEST is currently regarded by many to be the strictest certificate in the industry relative to the ecological textile production supply chain. The regulations of the standard are higher than the current legal mandates within the European Union and covers not only the inspection of the entire textile chain in terms of ecological accountability, but social accountability as well. Further, it is considered by many to better than the GOTS label at it only certifies articles that are 100% organic.

Global Organic Textile Standard (GOTS)

The Global Organic Textile Standard (GOTS) is made up of four well-regarded member organizations - OTA (USA), IVN (Germany), Soil Association (UK) and JOCA (Japan) − and other international stakeholder groups with expertise in organic farming and environmentally and socially-responsible textile processing. [170] Going beyond all other vetting entities, it claims to ensure that the cotton it certifies is grown entirely organically and that all related processing and production along the entire organic textiles supply chain is environmentally friendly, and that social standards have been monitored at all stages. GOTS says that it's the only standard that guarantees the safety of human health, for cotton farmers, production workers and users.

Similar to the other certification standards, the GOTS label certifies that its cotton is grown without GMOs, without chemicals (fertilizers, pesticides and insecticides, and with full traceability along the entire supply chain from the farmer to the end user). While it allows cotton having only a minimum of 70% organic fibers to can become certified, it requires that all chemical inputs (e.g., dyestuffs) used must meet certain environmental and toxicological criteria; it mandates functional waste water treatment for any wet-processing; and requires all in the supply chain to respect every social working condition prescribed by the ILO (World Labor Organization) [174] and the United Nations.

GOTS goes further in distinguishing itself by being the only certification process to provide, during control audits, laboratory test reports proving that there is no trace of GMOs in the DNA of the cotton used, nor traces of pesticides and other toxic chemicals. Although these tests are complicated and expensive to perform, it is the only way to ensure that the cotton it certifies is natural and harmless. Given its expansive certification scope and criteria, and the demanding and thorough nature of its certification and audit process, the GOTS label is regarded as the gold standard for organic cotton.

Textile Exchange's Organic Content Standard (OCS)

The Textile Exchange [176] is a US-based, global non-profit that represents more than 200 member companies in 25 countries that include textile suppliers, service providers, manufacturers, brands, retailers and farmers.

The Textile Exchange's Organic Content Standard (OCS) is a chain of custody standard that provides companies with a tool to verify that one or more specific input material is in a final product. It requires that each organization along the supply chain take sufficient steps to ensure that the integrity and identity of the input material is preserved. Its Organic Content Standard (OCS) certification is limited in that it only certifies that the subject cotton is grown without genetic modification, without chemicals (fertilizers, pesticides and insecticides) and it provides traceability from the cotton farmer to the end user. Unfortunately, the certification suffers in a few ways in that it allows for some blending of non-organic cotton and polyester in the final product; doesn't take either social and environmental criteria into account; and relies on third-party (rather than internal) verification.

Appendix B: Antimicrobial Testing Standards and Test Results

Contamination of healthcare products by pathogenic microbes has been a major, decades-long concern among those in the healthcare and medical industries, affecting both patient morbidity and mortality. With the emergence of COVID-19, and subsequent interest in personal protective equipment, the effectiveness of face masks for personal and work-related use is a concern that has become foremost on the minds of many who wear them not only as a means by which to reduce community spread but also as a form of personal protection.

Regulatory Framework and Standards

To promote transparency and the public good, government regulators require those in the medical and healthcare industries to use products that are manufactured by companies that adhere to a variety of strict regulations and testing protocols. When properly followed, these regulations, processes and protocols prevent the manufacture, distribution and use of products that are unsafe (e.g., susceptible to contamination with objectionable microbes).

The following are the leading organizations that establish and issue standards on antimicrobial testing:

ISO	The *International Organization for Standardization* is a Switzerland-based independent, non-governmental international organization with a membership of 164 national standards bodies.
NIOSH	The *National Institute for Occupational Safety and Health* is the CDC agency that conducts research and makes recommendations for the prevention of work-related injury and illness.
ATCC	The *American Type Culture Collection* collects, stores and distributes standard reference microbes, cell lines and other materials for research and development; and it creates standards.
ASTM	The *American Society for Testing and Materials* develops research, environmental safety and production standards related to products manufactured from rubber, plastics and raw materials.
BSI	The *British Standards Institution* produces technical standards on a wide range of products and services and supplies certification and standards-related services to businesses in the UK.
AAMI	The *Association for the Advancement of Medical Instrumentation* develops consensus standards and technical information reports used worldwide throughout the healthcare field to ensure the safe and effective production, distribution and use of medical/healthcare technology.
EMAGMP	The *European Medicines Agency* is responsible for the scientific evaluation, supervision and safety monitoring of medicines – and the provision of scientific advice and protocol assistance – to foster scientific excellence for the benefit of public and animal health in the EU.
TGA	The Australian Government Department of Health's *Therapeutic Goods Administration* is responsible for regulating therapeutic goods including prescription medicines, vaccines, sunscreens, vitamins and minerals, medical devices, blood and blood products
OEKO-TEX	The *International Assoc. for Research and testing in the Field of Textile and Leather Ecology* consists of 18 independent worldwide research and test institutes that develop test methods that form the basis of product, production and chemical standards in the field of textile ecology.
CNS FZ/T	The *Chinese National Standards Administration* develops and issues standards and testing protocols in 26 industrial and commercial categories including spinning/textiles (FZ/T).
JISC	The *Japanese Industrial Standards Committee* establishes the standards used for industrial activities in Japan and performs certifications of various products and processes.

Applicable Standards

There are literally hundreds of international standards and tests that apply to the use and performance of anti-microbial agents on textiles. These standards address their effectiveness, efficiency, kill time, safety, bioburden capacity, longevity, durability, toxicity, environmental impact, etc. on germs, fungi, bacterial and viruses.

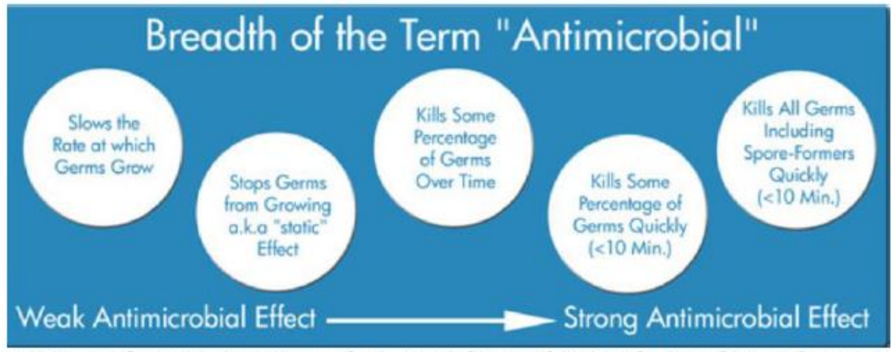
The following is a description of those standards that are applicable in the context of antimicrobial face masks.

ASTM E2180	The “Test for Hydrophobic Antimicrobial Surfaces” measures the antimicrobial effectiveness of incorporated antimicrobial agent(s) in polymeric or hydrophobic (water repelling) materials.
ASTM E2149	The “Standard Test Method for Determining the Antimicrobial Activity of Antimicrobial Agents Under Dynamic Contact Conditions” test evaluates the resistance of chemically-bonded, non-leaching antimicrobial-treated specimens to microbe growth under dynamic contact conditions.
AATCC 100	The “Antimicrobial Fabric Test AATCC 100” test is the industry standard for antimicrobial fabric performance in the US and quantitatively measures the ability of fabrics and textiles to inhibit the growth of microorganisms or kill them, over a 24-hour period of contact.
AATCC 90	The “Antibacterial Activity Assessment of Textile Materials: Agar Plate Method” test qualitatively detects bacteriostatic activity on products treated with antimicrobials and able to produce a zone of inhibition (the area where antimicrobial growth-inhibition activity occurs).
AATCC 147	The “Antimicrobial Fabric Zone of Inhibition Test: Parallel Streak Method” qualitatively evaluates the antibacterial activity of diffusible antimicrobial agents on treated textile materials and the ability of the treated textile to inhibit the growth and concentration of microorganisms.
ISO 20743	The “Determination of Antibacterial Activity of Textile Products” tests the ability of fabrics treated with antimicrobial agents to prevent microbial growth and to kill microorganisms, over an 18-hour to 24-hour period by measuring absorption, printing and transfer.
ISO 18184	The “Textiles - Determination of Antiviral Activity of Textile Products” test measures the antiviral activity (ability to replicate in the susceptible and permissive host cells) of the textile against specified viruses. It can be used on woven and knitted fabrics, fibers, yarns, braids, etc.
EN 14476	The “Chemical Disinfectants and Antiseptics” test quantitatively evaluates the virucidal activity of (ready-to-use) chemical disinfectant and antiseptic products in the medical area.
JIS L 1902	The "Testing Antibacterial Activity and Efficacy on Textile Products" test measures the ability of fabrics that have been treated with antimicrobial agents to prevent microbial growth and to kill microorganisms (over 18 hours), using one qualitative and two quantitative measures.
FZ/T 73023	The “Determination of Antimicrobial Efficacy of Antibacterial Knitwear” test assesses anti-microbial treated knitwear for intrinsic quality, appearance quality, antibacterial efficacy and consumer and environment product safety. It also takes into consideration washing durability.
ZHT110	The “Zone of Inhibition Test for Antimicrobial Activity” measures “leachable” antibiotic resistance and the ability of solids and textiles to inhibit an array of different microbial growth.
ATCC 9533	The test quantitatively determines that bacterial load of Trichophyton Mentagrophytes
ATCC 6538	The test quantitatively determines that bacterial load of Staphylococcus Aureus
ATCC 11229	The test quantitatively determines that bacterial load of Escherichia Coli

Tests performed in conformance with these standards are typically conducted by independent, privately-owned, state-licensed, certified or credentialed laboratories at the request of the textile manufacturer, as a means by which to meet regulatory guidelines, make certain claims and/or for promotional or competitive purposes.

Not All Antimicrobial-Treated Fabrics Act Alike

Not all chemical antimicrobials act alike. As the exhibit below illustrates, there are five effectiveness categories. In reviewing it, know that an antimicrobial's strength is a product of its concentration and the time that it is in contact with the microbe, i.e., the antimicrobial-treated fabrics that kill microbes faster are often the most potent.



Courtesy of Benjamin Tanner, Ph.D., President and CEO of Microchem Laboratory

At the low end of the antimicrobial-treated fabric spectrum are those that might retard the microbial growth rate, (possibly for one or just a few species). This might help with odor control, but it is unlikely to slow microbial spread.

Stronger antimicrobial-treated fabrics may retard the growth or kill more microbes, but over a much longer time.

Most antimicrobial-treated fabrics slow the growth, or kill, a greater percentage of microbes over a longer period (under certain circumstances). This, essentially, makes them useful for only aesthetic protection, but not for infection control proposes.

Few antimicrobial-treated fabrics kill an appreciable percentage of microbes quickly (defined here as being under ten minutes). This equates their impact to that of using a low-level surface disinfectant or sanitizer.

At the upper end of the antimicrobial-treated fabric spectrum are those that employ a strong sterilant chemical; few fabric technologies are able to deliver such a benefit. Some QAC-based antimicrobials achieve this goal.

Our Antimicrobial Approach: QACs

The "ideal face mask" described above would include two means by which to attract, secure and electrocute pathogenic microbes: a triboelectric air filtration (TAF) method and a chemical antimicrobial method. The chemical antimicrobial the author favors is the Aegis® Microbe Shield, originally developed by Dow Chemical. It uses a quaternary ammonium compound (QAC) method, meaning it is a surface active agent that creates a chemical reaction on the surface upon which it is applied. It is also cationic, meaning it is positively charged and highly effective at inactivating negatively-charged microbes with which it comes in contact. It does this by stabbing the target microbe's lipoprotein envelope (outer capsule or membrane) and electrocuting it. QACs are able to inactivate microbes (especially viral pathogens having an envelope) in part, as a result of an electrical interaction between the *ammonium active agent* and the microbe's negatively-charged cell membrane.

The AEGIS® Microbial Shield is infused into the mask's fabric to bond and become a part of it | **Microbes are attracted to the treated fibers** | **AEGIS® punctures/electrocutes the microbe's envelope, which eliminates its ability to sustain life** | **Absent a healthy envelope, the microbe dies and becomes inactive**

QACs are active ingredients in more than two hundred disinfectants currently recommended by the US EPA for use to inactivate the COVID-19 virus. The amounts of these compounds used in household, workplace and industry settings has increased, and usage will continue to be elevated given the pandemic's scope. The Aegis® product's active ingredient is Dimethyloctadecyl (3-trimethoxysilylpropyl) Ammonium Chloride (DTSACl).

QACs, especially those that use DTSACl as their active ingredient, have been found to be highly effective against *enveloped* pathogenic microbes, whether they are germs, fungi, bacteria or viruses.

Performance and Effectiveness Findings for DTSACl QACs

The Aegis® Microbe Shield, a breakthrough product created by Dow Corning, has a 30-year safety and efficacy profile that is unmatched by any other product. Other QAC-based antimicrobials *that use DTSACl as their active ingredient* act similarly and, for our purposes here - while there are dozens of private, public and academic studies of the Aegis® product - we are presenting test results from other QACs in addition to those of the Aegis® Microbe Shield to provide more data about its safety, utility, performance and durability.

Environmental and Sustainability Certifications

Unlike many other QAC-based antimicrobials, the Aegis® Microbe Shield has no unwanted side effects, including damage or discoloration on product surfaces, toxicity to living organisms or environmental damage. It doesn't volatilize, dissipate or leach onto other surfaces or into the environment or off-gas after application.

- Proven to be compatible with the most stringent restricted substance lists, the Aegis® Microbe Shield and its biocidal active components are registered with the EU Biocidal Products Regulation and the US EPA.
- The Aegis® Microbe Shield is *Bluesign®* approved. This verifies and guarantees the elimination of substances harmful to humans and the environment from the start of the manufacturing process to increase product safety through the entire supply chain; conserve valuable resources; minimize risk; and ensure sustainability.
- The Aegis® Microbe Shield is OEKO-TEX® STANDARD 100 certified, a coveted textile industry mark. Re-certified annually, STANDARD 100 labeled products are thoroughly tested for (regulated and non-regulated) harmful substances and guaranteed to be harmless in human and ecological terms through the supply chain

Aegis® Microbial Shield Product-Specific Tests

- Canada's prestigious Western University ImPaKT Facility Biosafety Level-3 Laboratory determined that the Aegis® Microbe Shield reduces the risk of microbial transmission by as much as 99%.
- NASA's Spaceflight & Life Sciences Training Program verified Aegis® Microbe Shield efficacy on cotton.
- Conforming to ASTM E2149 guidelines, a study performed by Robert Monticello, PhD (now serving as the Sr. Scientific Consultant to the International Antimicrobial Council) found that fabric treated with the Aegis® Microbial Shield reduced the total population of MRSA bacteria by 99.99%. While gram-positive, *MRSA's protein capsid has a net-negative charge (like COVID-19) that is vulnerable to QAC-antimicrobials.*
- Conforming to ATCC 9533/6538/11229 guidelines respectively, tests found the Aegis® Microbial Shield to be 99.95% effective against Trichophyton Mentagrophytes, Staphylococcus Aureus and E-Coli, *all of which have cell walls with a net-negative charge (like COVID-19) that is vulnerable to QAC-antimicrobials.*
- Tests conducted by the Malaysian & Thailand Government Research Lab proved the efficacy of the biocides used in the Aegis® Microbial Shield against the 2003 H5N1 Avian Flu, *an enveloped virus having a protein capsule that carries a net-negative charge (like COVID-19) that is vulnerable to QAC-antimicrobials.*
- Tests conducted by Hill Top Research (est. 1947) re: compliance with EPA pesticide guidelines, evidenced the solid virucidal activity of the Aegis® Microbe Shield against the HSV-1, *an enveloped virus having a protein capsule that carries a net-negative charge (like COVID-19) that is vulnerable to QAC-antimicrobials.*
- A landmark 1988 study of QAC-based antimicrobial agents performed by University of Michigan Professors Wang and Tsao noted the "excellent antimicrobial action" of the Aegis® Microbial Shield and demonstrated that fabrics treated with it adsorbed both the Bacteriophage T2 and HSV-1, enveloped viruses, which it inactivated by virtue of the disruption of the viral envelope, resulting in "an irreversible loss of infectivity".
- An American Hospital Supply Corp. (now Baxter International) study of virtually all antimicrobials agents, focused on their toxicity and effectiveness against microbes and chemical and biological contaminants found on surgery fabrics; it eliminated all other antimicrobial agents except for the Aegis® Microbe Shield.

Tests of QAC-Based Antimicrobial having the Active Ingredient DTSACl

- Conforming to the EN 14476 test standard, which quantitatively evaluates the virucidal activity of chemical disinfectant and antiseptic products in the medical area, tests performed by England's Microbial Solutions laboratory in February, 2020 determined that a QAC-based antimicrobial agent having the active ingredient DTSACl *showed a log reduction of 4.33 against the Feline Coronavirus, a member of the Coronaviridae Family and an enveloped virus having a protein capsule that carries a net-negative charge (like COVID-19). A log reduction of 4.33 means the antimicrobial was >99.99% effective against the virus. The Feline Corona-virus is a surrogate virus used in labs as a close, but safer, alternative to human pathogenic strains of Coronavirus, for which it shares an almost identical structure. Nonetheless, it cannot be known whether COVID-19 exhibits virulence properties that are impacted by the QAC-based antimicrobial agent without testing this strain.* This same QAC-based antimicrobial was also found to be very effective against many other viruses (e.g., H9N2, H1N1, Norovirus, Reovirus Type I and Influenzas A2 (Aichi and Asian) and B).
- Tests performed by the Southern Research Institute (est. 1941) found that surfaces treated with a QAC-based antimicrobial agent having the active ingredient DTSACl showed strong virucidal activity against a non-enveloped RNA enterovirus, Poliovirus Type 1 Strain MEF-1. Note that the EPA's Emerging Viral Pathogen Guidance mandates that disinfectants and antimicrobials used against SARS and COVID-19 must validate efficacy against viruses of this specific type in order to gain approval, among other requirements.
- Numerous other studies, tests and papers have been written on the antiviral activity of a QAC-based anti-microbial agents having the active ingredient DTSACl (both in solution and when immobilized) evidencing the inactivation of lipid-containing viruses, some non-lipid viruses, and bacteriophages. These results are encouraging regarding the utility of this treatment at reducing doses of viruses in a variety of applications.
- A study conducted by a team of researchers from US and South Korean textile colleges, published in 2004 in *Polymer*, tested the antimicrobial effectiveness of DTSACl. It found that "excellent anti-microbial action was demonstrated for all coatings". The specific antimicrobial studied was the Aegis® Microbial Shield.
- A study conducted by researchers from military universities in China and Augusta University in Georgia, published in 2017 in *Progress in Polymer Science*, studied the state-of-the-art of QAC-based antimicrobial agents including their anti*viral* resistance challenges, based on randomized human clinical trials. One of the study's finding was that, "in general, QACs are considered good disinfection agents for influenza viruses" and "we confirm virucidal effects of the IQACs tested against influenza viruses in our carrier tests". The study specifically noted the inactivation of the H5N1 flu virus in less than 2 minutes by (immobilized) QAC-coated surfaces. The Aegis® Microbial Shield is such an immobilized (or bonded) product.
- The CDC's 2009 publication entitled "Interim Biosafety Guidance for All Individuals Handling Clinical Specimens or Isolates Containing 2009-H1N1 Influenza A Virus (Novel H1N1), Including Vaccine Strains" notes that "several chemical disinfectants including...quaternary ammonium compounds, are effective against human influenza viruses if used at the correct concentration for the appropriate contact time as specified in the manufacturer's recommendations". Note that the H1N1 swine flu is *an enveloped virus having a protein capsule that carries a net-negative charge (like COVID-19), that is vulnerable to QAC-antimicrobials.*

Warning about Antimicrobials and COVID-19 Claims

The EPA has strict rules regarding marketing claims made about the capabilities of antimicrobial products. Without specific EPA approval, claims cannot be made about an antimicrobial's protection/prevention against specific organisms infectious to humans (e.g., COVID-19) or that of the treated fabric. As it relates specifically to face masks, unless authorized by the EPA, any claim as to the antimicrobial's capability must be limited to the face mask itself; be specific and not unqualified; not reference health-related microbes, and; refrain from denoting personal (e.g., "for skin, wound, or respiratory") protection. While these prohibitions apply to foreign textile technology companies that sell products in the US, face mask purchasers should be aware that many make unsubstantiated claims about their product's anti-COVID-19 capabilities. Further, *although many claims are made by established and emerging antimicrobial and anti-viral pathogens perceived to kill the COVID-19 virus, no organization can justly make such a claim as, to date (July, 2020), there has been no approval, or any form of government-sanctioned testing performed to prove the effectiveness of any antimicrobial agent against the coronavirus including, the Aegis® Microbial Shield.* While its active antimicrobial biocide is effective against viruses in its pure state, it has not currently been proven to have any antiviral properties when built-into products.

Bibliography / Sources / References

(1) Does a high viral load or infectious dose make covid-19 worse?
www.newscientist.com/article/2238819-does-a-high-viral-load-or-infectious-dose-make-covid-19-worse/

(2) WHO Report: Natural Ventilation for Infection Control in Health-Care Settings
www.who.int/water_sanitation_health/publications/natural_ventilation.pdf

(3) Factors involved in the aerosol transmission of infection and control of ventilation in healthcare premises
www.journalofhospitalinfection.com/article/S0195-6701(06)00286-6/fulltext

(4) Infectious virus in exhaled breath of symptomatic seasonal influenza cases from a college community
www.pnas.org/content/pnas/115/5/1081.full.pdf

(5) The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission
www.pnas.org/content/117/22/11875

(6) Aerosol and Surface Stability of SARS-CoV-2 as Compared with SARS-CoV-1
www.nejm.org/doi/full/10.1056/NEJMc2004973

(7) Aerosol emission and super-emission during human speech increase with voice loudness
www.ncbi.nlm.nih.gov/pmc/articles/PMC6382806/

(8) Temporal dynamics in viral shedding and transmissibility of COVID-19
www.nature.com/articles/s41591-020-0869-5

(9) SARS-CoV-2 Viral Load in Upper Respiratory Specimens of Infected Patients
www.nejm.org/doi/pdf/10.1056/NEJMc2001737

(10) Aerosol and Surface Distribution of Severe Acute Respiratory Syndrome Coronavirus 2 in Hospital Wards
https://wwwnc.cdc.gov/eid/article/26/7/20-0885_article

(11) Turbulent Gas Clouds and Respiratory Pathogen Emissions Potential Implications for Reducing Transmission…
https://lbourouiba.mit.edu/sites/default/files/images/2020-JAMA-Bourouiba-jama_bourouiba_2020_it_200011.pdf

(12) Coronavirus Disease Outbreak in Call Center, South Korea
https://wwwnc.cdc.gov/eid/article/26/8/20-1274_article

(13) COVID-19 Outbreak Associated with Air Conditioning in Restaurant, Guangzhou, China, 2020
https://wwwnc.cdc.gov/eid/article/26/7/20-0764_article

(14) Air, Surface Environmental, and Personal Protective Equipment Contamination by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) From a Symptomatic Patient
https://jamanetwork.com/journals/jama/fullarticle/2762692

(15) The Math Behind Social Distancing
www.visualcapitalist.com/the-math-behind-social-distancing/

(16) Simulation suggests that rapid activation of social distancing can arrest epidemic development due to a strain…
https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-9-117

(17) On coughing and airborne droplet transmission to humans
https://aip.scitation.org/doi/pdf/10.1063/5.0011960?download=true

(18) The airborne lifetime of small speech droplets and their potential importance in SARS-CoV-2 transmission
www.pnas.org/content/pnas/117/22/11875.full.pdf

(19) Reducing transmission of SARS-CoV-2
https://science.sciencemag.org/content/sci/early/2020/06/02/science.abc6197.1.full.pdf

(20) Social Distancing: Keep Your Distance to Slow the Spread
www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/social-distancing.html

(21) WHO: Advice on the use of masks in the context of COVID-19 (Updated June 05, 2020)
https://apps.who.int/iris/bitstream/handle/10665/332293/WHO-2019-nCov-IPC_Masks-2020.4-eng.pdf?sequence=1&isAllowed=y

(22) Fake news in the time of C-19
https://members.tortoisemedia.com/2020/03/23/the-infodemic-fake-news-coronavirus/content.html

(23) Speed Science: The risks of swiftly spreading coronavirus research
https://graphics.reuters.com/CHINA-HEALTH-RESEARCH/0100B5ES3MG/index.html

(24) The National Personal Protective Technology Laboratory (NPPTL) - Respiratory Protection Infographics
www.cdc.gov/niosh/npptl/RespiratorInfographics.html

(25) How to Ensure Your Water is Safe from Viruses like the Coronavirus.
https://h2ocoolers.com/news/water-safety/how-to-ensure-your-water-is-safe-from-viruses-like-the-coronavirus/

(26) UT Researcher's Nonwoven Fabrics Protect the Health of More Than a Billion People
https://utrf.tennessee.edu/ut-researchers-nonwoven-fabrics-protect-the-health-of-more-than-a-billion-people/

(27) Summary of FDA Guidance for Masks and Face Shields During the COVID-19 Outbreak
https://ibio.org/wp-content/uploads/MasksSUMMARY-OF-FDA-GUIDANCE-FOR-MANUFACTURING-FACE-MASKS-SURGICAL-MASKS-AND-RESPIRATORS-DURING-THE-COVID-19-OUTBREAK-4-8-2020.pdf

(28) Aerosol Filtration Efficiency of Common Fabrics Used in Respiratory Cloth Masks
https://pubs.acs.org/doi/pdf/10.1021/acsnano.0c03252

(29) Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?
https://www.cambridge.org/core/journals/disaster-medicine-and-public-health-preparedness/article/testing-the-efficacy-of-homemade-masks-would-they-protect-in-an-influenza-pandemic/0921A05A69A9419C862FA2F35F819D55/core-reader

(30) Filtration performance of common household materials for manufacturing homemade masks
https://docs.google.com/spreadsheets/d/17aJQn-zmhBWO9vlgfWQLAuRUNrxrUnE8Ftm2wUHlddI/edit#gid=0

(31) Survival of Enterococci and Staphylococci on Hospital Fabrics and Plastic
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC86187/pdf/jm000724.pdf

(32) Stability of SARS-CoV-2 in different environmental conditions
https://www.thelancet.com/action/showPdf?pii=S2666-5247%2820%2930003-3

(33) Does washing your clothes prevent the spread of the coronavirus?
.marketwatch.com/story/do-you-need-to-change-and-wash-your-clothes-after-visiting-the-grocery-store-2020-03-24

(34) Toxicity of Synthetic Fibers & Health
https://austinpublishinggroup.com/textile-engineering/fulltext/arte-v2-id1012.php

(35) DNA Testing Could Put an End to Fake Egyptian Cotton
https://www.bloomberg.com/news/articles/2016-09-22/dna-testing-could-put-an-end-to-fake-egyptian-cotton

(36) Are Your Sheets 'Egyptian Cotton'?
https://www.wsj.com/articles/more-u-s-retailers-probe-indian-supplier-of-egyptian-cotton-1472070815

(37) Supima Association of America
https://supima.com/

(38) WHO - IARC Monographs Volume 112: evaluation of five organophosphate insecticides and herbicides
https://www.iarc.fr/wp-content/uploads/2018/07/MonographVolume112-1.pdf

(39) Structurally Observed Electrostatic Features of the COVID-19 Coronavirus-Related Experimental Structures inside Protein Data Bank: A Brief Update (*See Comments by Ron Kurtis*)
https://www.preprints.org/manuscript/202003.0081/v1

(40) Genomic characterization of a novel SARS-CoV-2
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7161481/

(41) Chapter 2 – Nano-antimicrobials: Activity, Benefits, and Weaknesses
https://www.sciencedirect.com/science/article/pii/B9780323461528000020?via%3Dihub

(42) Antimicrobial Finishes
https://www.fibre2fashion.com/industry-article/1240/antimicrobial-finishes

(43) Controlling the Spread of Infections in Hospital Wards by the Use of Antimicrobials on Medical Textiles…
https://www.sciencedirect.com/science/article/pii/B978184569224750008X

(44) Antimicrobial Approaches for Textiles: From Research to Market
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5456784/pdf/materials-09-00498.pdf

(45) Silver Nanotechnologies and the Environment
www.researchgate.net/publication/221720677_Silver_Nanotechnologies_and_the_Environment

(46) Scientists seek a deeper understanding of how silver kills bacteria
https://www.ucalgary.ca/news/scientists-seek-deeper-understanding-how-silver-kills-bacteria

(47) Silver Nanoparticles May Adversely Affect Environment
https://ceint.duke.edu/news-events/silver-nanoparticles-may-adversely-affect-environment

(48) Nanosilver Weighing the Risks and Benefits
www.ncbi.nlm.nih.gov/pmc/articles/PMC3702006/pdf/ehp.121-a220.pdf

(49) Exposure-Related Health Effects of Silver and Silver Compounds: A Review
https://academic.oup.com/annweh/article/49/7/575/148203

(50) The Science Behind Aegis® Antimicrobial Technology
https://www.youtube.com/watch?time_continue=5&v=H3-vwlisL4I&feature=emb_logo

(51) Reducing Microbial Contamination in Hospital Blankets
www.aegisasia.com/wp-content/uploads/reducing_microbial_contamination_in_hospital_blankets.pdf

(52) Aegis Microbe Shield - Antimicrobial for Textile
www.go4worldbusiness.com/product/view/85920/aegis-microbe-shield---antimicrobial-for-textile.html

(53) ÆGIS EPA Registration & Gold Seal
http://www.microbeshield.co.uk/pdf/epa_goldseal_letter_aegis.pdf

(54) Evaluation of a Silane Quaternary Ammonium Salt as an Antimicrobial Fabric Treatment
http://www.microbeshield.co.uk/pdf/nasa_study.pdf

(55) How Aegis® Works
https://purepropertysolutions.ca/

(56) Certificate of Analysis – Aegis Microbe shield and MERS
www.microbedefence.com/support/pdf/MRSA.pdf

(57) Aegis ASIA® introduces two forward defense mechanisms against bird flu H5N1
www.microbeshield.co.uk/pdf/aegis_asia_introduces_two_forward_defense_mechanisms_against_bird_flu_h5n1.pdf

(58) Understanding the factors involved in determining the bioburdens of surgical masks
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6989980/

(59) Competitors, FTC, EPA Take Aim at Antimicrobial Ads
www.khlaw.com/710

(60) What Brands Need to Know About Antimicrobial Fabrics and Textiles
https://wwd.com/business-news/business-features/need-to-know-antimicrobial-fabrics-textiles-1203552002/

(61) Graphene Description
www.nanowerk.com/what_is_graphene.php

(62) Medium-Dependent Antibacterial Properties and Bacterial Filtration Ability of Reduced Graphene Oxide
www.ncbi.nlm.nih.gov/pmc/articles/PMC6835404/pdf/nanomaterials-09-01454.pdf

(63) Guardian G-Volt masks would use graphene and electrical charge to repel viruses and bacteria
www.dezeen.com/2020/03/06/guardian-g-volt-face-mask-graphene-coronavirus-bacteria/

(64) PlanarTECH IDEATI graphene mask - hands on review
www.graphene-info.com/planartech-ideati-graphene-mask-hands-review

(65) We are using our powerful graphene technology to fight COVID-19
www.bonbouton.com/graphene-mask

(66) Investigation into the toxic effects of graphene nanopores on lung cancer cells and biological tissues
https://reader.elsevier.com/reader/sd/pii/S2352940718302853?token=EE5D6317A7C82BF593082E6CDADA0743A3FB7B48B3FA593B455FFB93DC03EEA84D4F3FB2143D84660C4577C36CC59B7D

(67) An epigenetic signal…mechanism is activated by graphene oxide to inhibit its induced reproductive toxicity
https://www.sciencedirect.com/science/article/pii/S014296121500962X?via%3Dihub

(68) Graphene Oxide-Based Antibacterial Cotton Fabrics
https://www.thelancet.com/action/showPdf?pii=S2666-5247%2820%2930003-3

(69) Fabrics coated with hot-iron-treated graphene oxide for a self-cleaning and mechanically robust water–oil…
https://pubs.rsc.org/en/content/articlelanding/2017/ra/c7ra03127k#!divAbstract

(70) Antimicrobial and Antibiofilm Efficacy of Graphene Oxide against Chronic Wound Microorganisms
https://aac.asm.org/content/62/7/e00547-18

(71) Face masks hurting your ears? These easy solutions can help
www.today.com/style/how-make-face-mask-more-comfortable-ears-t180954#:~:text="Moisture%20and%20friction%20can%20cause,as%20well%2C"%20said%20Dr.

(72) If Your Face Mask Hurts Your Ears, Try These Genius Hacks to Prevent Irritation
www.health.com/condition/infectious-diseases/coronavirus/how-to-stop-face-mask-irritating-ears

(73) Adjustable Ear Loops for Face Mask
www.youtube.com/watch?v=xooPgVvLVdw

(74) Flexible Nose Wire Piece Materials for a DIY Face Mask
https://hellosewing.com/flexible-nose-piece-materials/

(75) Do these 5 things to protect your skin from the downsides of face masks, doctors say
www.cnbc.com/2020/05/13/rash-irritation-downsides-face-masks-how-to-protect-skin-according-to-doctors.html

(76) A cluster randomized trial of cloth masks compared with medical masks in healthcare workers
https://bmjopen.bmj.com/content/bmjopen/5/4/e006577.full.pdf

(77) What Actually Makes a Face Mask Effective? The Balance of Filtration & Breathability
https://stringking.com/face-masks/effective-face-masks-breathability-filtration/

(78) COVID-19 prompts Stanford engineers to rethink the humble face mask
https://news.stanford.edu/2020/04/14/stanford-researchers-reengineer-covid-19-face-masks/

(79) Physiological Impact of the N95 Filtering Face piece Respirator on Healthcare Workers
http://rc.rcjournal.com/content/55/5/569/tab-pdf

(80) Modified N95 Mask Delivers High Inspired Oxygen Concentrations While Effectively Filtering Aerosolized…
https://reader.elsevier.com/reader/sd/pii/S0196064406009425?token=EB25AF0F873C702937C6F99CA26AFA4A501DE07B96F1E8577B928F940D1ADFFEA6F9ECEE1338E06BD123E7720CBAA6A4

(81) Testing the Efficacy of Homemade Masks: Would They Protect in an Influenza Pandemic?
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7108646/

(82) What Are the Best Materials for Making DIY Masks?
https://smartairfilters.com/en/blog/best-materials-make-diy-masks-virus/

(83) Does Wearing a Face Mask Reduce Oxygen—and Can It Increase CO2 Levels? Here's What Experts Say
www.health.com/condition/infectious-diseases/coronavirus/does-wearing-face-mask-increase-co2-levels

(84) Partly false claim: Continually wearing a mask causes hypercapnia
www.reuters.com/article/uk-factcheck-coronavirus-mask-hypercapni/partly-false-claim-continually-wearing-a-mask-causes-hypercapnia-idUSKBN22H2H1

(85) Low Oxygen Symptoms: Signs You May Not Be Getting Enough Oxygen
www.inogen.com/blog/signs-your-loved-one-may-not-be-getting-enough-oxygen/

(86) Symptoms - Hypoxemia
https://www.mayoclinic.org/symptoms/hypoxemia/basics/definition/sym-20050930

(87) Physiologic and other effects and compliance with long-term respirator use among medical ICU nurses
https://www.ajicjournal.org/action/showPdf?pii=S0196-6553%2813%2900592-0

(88) Respirator Tolerance in Health Care Workers
https://jamanetwork.com/journals/jama/fullarticle/183158

(89) Preliminary report on surgical mask induced deoxygenation during major surgery
http://scielo.isciii.es/pdf/neuro/v19n2/3.pdf

(90) What to know about hypercapnia
www.medicalnewstoday.com/articles/320501

(91) "Hypoallergenic" Cosmetics
www.fda.gov/cosmetics/cosmetics-labeling-claims/hypoallergenic-cosmetics

(92) Evaluation of the presence of allergens in children's products available for sale in a big city
www.ncbi.nlm.nih.gov/pmc/articles/PMC6001089/

(93) Is there a risk using hypoallergenic cosmetic pediatric products in the United States?
www.jacionline.org/action/showPdf?pii=S0091-6749%2814%2901428-6

(94) Consumer Preferences, Product Characteristics and Potentially Allergenic Ingredients in Best-selling Moisturizer
www.ncbi.nlm.nih.gov/pmc/articles/PMC5710429/

(95) Device-related pressure ulcers: SECURE prevention
www.magonlinelibrary.com/doi/pdf/10.12968/jowc.2020.29.Sup2a.S1

(96) How to Care for Your Skin If You Wear PPE at Work, According to Dermatologists
www.allure.com/story/ppe-face-mask-skin-care-guide

(97) American College of Allergy, Asthma & Immunology - Allergy Facts
https://acaai.org/news/facts-statistics/allergies#:~:text=Allergies%20are%20the%206th%20leading,suffer%20from%20allergies%20each%20year.

(98) Contact Dermatitis: Synopsis
www.worldallergy.org/education-and-programs/education/allergic-disease-resource-center/professionals/contact-dermatitis-synopsis

(99) Textile Technology and Design
https://docplayer.net/54662208-Textile-technology-and-design.html

(100) Textile Contact Dermatitis: How Fabrics Can Induce Dermatitis
https://link.springer.com/content/pdf/10.1007/s40521-019-0197-5.pdf

(101) Textile Contact Dermatitis: How Fabrics Can Induce Dermatitis
https://link.springer.com/content/pdf/10.1007/s40521-019-0197-5.pdf

(102) Allergy Knowledge Database; Polyester Allergies
https://allergykb.org/polyester-allergies/

(103) Toxicity of Synthetic Fibers & Health
https://austinpublishinggroup.com/textile-engineering/fulltext/arte-v2-id1012.php

(104) Can’t touch this: “Latex-free” labels are misleading
https://www.health.harvard.edu/blog/cant-touch-this-latex-free-labels-are-misleading-201303135973

(105) Many of us are trying to figure out how to deal with this new normal….acknowledging the yuck factor of masks
https://www.chicagotribune.com/coronavirus/ct-coronavirus-the-misery-of-masks-0512-20200512-nz3nuv7uyngl7mczdmz2hjll2e-story.html

(106) We asked our medical expert to respond to the reasons why people don't wear masks
www.9news.com/article/news/health/coronavirus/doctor-responds-to-reasons-for-not-wearing-masks/73-d2c5c731-da4a-4fc0-b8d7-b0195e9abf50

(107) Is It Normal for Face Masks to Smell Bad?
www.refinery29.com/en-us/2020/05/9819442/face-mask-smell

(108) How to Wash Cloth Face Coverings
www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-to-wash-cloth-face-coverings.html

(109) Flow analyses to validate SARS-CoV-2 protective masks
www.unibw.de/lrt7/report_mask-investigation_unibw_lrt7_06_04_2020.pdf

(110) Consumer Reports: Made in America
www.consumerreports.org/cro/magazine/2015/05/made-in-america/index.htm

(111) Consumer Reports: Knowing Which Products Are Truly Made in America
www.consumerreports.org/cro/magazine/2013/02/made-in-america/index.htm

(112) BBB Scam Alert: Preparing for Coronavirus? That Face Mask Could be a Con
www.bbb.org/article/news-releases/21482-scam-alert-preparing-for-coronavirus-that-face-mask-could-be-a-con

(113) Coronavirus Aid, Relief and Economic Security (CARES) Act
www.congress.gov/bill/116th-congress/house-bill/748/text?q=%7B"search"%3A%5B"coronavirus+aid+relief+and+economic"%5D%7D&r=2&s=1

(114) Health and Economic Recovery Omnibus Emergency Solutions Act (HEROES) Act,
www.congress.gov/bill/116th-congress/house-bill/6800/text

(115) OSHA to Receive Increase in Budget for FY 2020
https://ohsonline.com/articles/2020/02/01/osha-to-receive-increase-in-budget-for-fy-2020.aspx#gsc.tab=0

(116) US Department of Labor: Commonly Used Statistics
www.osha.gov/data/commonstats#:~:text=Federal%20OSHA%20is%20a%20small,officer%20for%20every%2059%2C000%20workers

(117) AFL-CIO Report: Death on the Job: The Toll of Neglect, 2019
https://aflcio.org/reports/death-job-toll-neglect-2019

(118) EHS Today -OSHA Raises Employer Penalties for 2019
https://www.ehstoday.com/standards/article/21919985/osha-raises-employer-penalties-for-2019

(119) US Department of Labor – OSHA: Top Enforcement Cases Based on Total Issued Penalty
www.osha.gov/dep/enforcement/top_cases.html

(120) OSHA's Top 10 most cited violations for 2019
www.safetyandhealthmagazine.com/articles/19087-oshas-top-10-most-cited-violations

(121) National Law Review: Can OSHA Protect Coronavirus Whistleblowers?
https://www.natlawreview.com/article/can-osha-protect-coronavirus-whistleblowers

(122) OSHA's General Duty Clause
www.safetyandhealthmagazine.com/articles/19258-oshas-general-duty-clause#:~:text="Each%20employer%20shall%20furnish%20to,physical%20harm%20to%20his%20employees

(123) US Department of Labor – OSHA: Personal Protective Equipment
www.osha.gov/SLTC/personalprotectiveequipment/standards.html

(124) OSHA - Interim Enforcement Response Plan for Coronavirus Disease 2019 (COVID-19)
www.osha.gov/memos/2020-04-13/interim-enforcement-response-plan-coronavirus-disease-2019-covid-19

(125) OSHA PPE hazard assessment and training requirements
www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9777&p_table=STANDARDS

(126) OSHA Administrative Controls, Safe Work Practices, and Personal Protective Equipment (PPE)
www.osha.gov/SLTC/covid-19/controlprevention.html

(127) OSHA Employee Risk Categories – COVID-19 Potential Exposure Levels
www.osha.gov/Publications/OSHA3990.pdf

(128) Americans with Disabilities Act (ADA) of 1990 (Amended)
www.ada.gov/pubs/adastatute08.htm

(129) EEOC - Pandemic Preparedness in the Workplace and the Americans with Disabilities Act
www.eeoc.gov/laws/guidance/pandemic-preparedness-workplace-and-americans-disabilities-act

(130) An employer's duty to initiate the 'interactive process' without a request for accommodation from the employee
www.jdsupra.com/legalnews/an-employer-s-duty-to-initiate-the-38415/

(131) EEOC - Enforcement Guidance on Reasonable Accommodation and Undue Hardship under the ADA
www.eeoc.gov/laws/guidance/enforcement-guidance-reasonable-accommodation-and-undue-hardship-under-ada

(132) Families First Coronavirus Response Act (FFCRA)
www.dol.gov/agencies/whd/pandemic/ffcra-employer-paid-leave

(133) Family and Medical Leave Act (FMLA)
www.dol.gov/agencies/whd/fmla

(134) ADA Implications: I Don't Want to Wear a Mask
https://laborandemploymentlawupdate.com/2020/05/08/ada-implications-i-dont-want-to-wear-a-mask/#:~:text=In%20cases%20that%20have%20addressed,the%20job%2Fposition%2C%20where%20the

(135) Employer Not Required to Accommodate Employee's Inability to Wear Safety Shoes
www.parkerpoe.com/news/2018/09/employer-not-required-to-accommodate-employees-inability-to

(136) Kansas Barista Says She Was Fired for Wearing a Face Mask to Work
www.iheart.com/content/2020-03-27-kansas-barista-says-she-was-fired-for-wearing-a-face-mask-to-work/

(137) OSHA Workers' Rights and Protections / Workers' Right to Refuse Dangerous Work
www.osha.gov/right-to-refuse.html

(138) Thousands of OSHA complaints filed against companies for virus workplace safety concerns, records show
www.washingtonpost.com/business/2020/04/16/osha-coronavirus-complaints/

(139) Medscape Medical - News Amid PPE Shortage, Clinicians Face Harassment, Firing for Self-Care
www.medscape.com/viewarticle/927590

(140) Refusing to Wear a Mask at Work Could Get You Fired
https://news.bloomberglaw.com/daily-labor-report/refusing-to-wear-a-mask-at-work-could-get-you-fired

(141) Is going mask-less a rejection of science? A sign of freedom? Or none of the above?
www.deseret.com/indepth/2020/5/3/21239109/masks-symbol-statement-republican-democrat-polarized-trump-uncomfortable-constitutional-health

(142) Wearing a coronavirus mask isn't just a safety issue anymore. Now it's political
www.freep.com/story/news/local/michigan/2020/05/15/masks-coronavirus-politics/3081810001/

(143) Mask the rage: How to talk to people who don't wear face coverings
www.sfchronicle.com/bayarea/article/Mask-the-rage-How-to-talk-to-people-who-don-t-15273357.php

(144) Workers have filed 4,775 complaints to OSHA about exposure to Covid-19 on the job….only one citation….
https://thecounter.org/covid-19-osha-worker-safety-complaints/

(145) OSHA's Office of the Whistleblower Protection Program - Whistleblower Laws Enforced by OSHA
https://www.whistleblowers.gov/

(146) NLRB - Interfering with employee rights (Section 7 & 8(a)(1))
www.nlrb.gov/about-nlrb/rights-we-protect/the-law/interfering-with-employee-rights-section-7-8a1

(147) Doctors Say Hospitals Are Stopping Them from Wearing Masks
www.npr.org/2020/04/02/825200206/doctors-say-hospitals-are-stopping-them-from-wearing-masks

(148) Hospital Is Not Allowing Nurses to Wear Masks in Thick of COVID-19 Pandemic, Furious Nurse Says
https://chicago.cbslocal.com/2020/03/31/hospital-is-not-allowing-nurse-to-wear-masks-in-thick-of-covid-19-pandemic-furious-nurse-says/

(149) A Nurse's Hospital Wouldn't Let Her Wear an N95 Mask
www.propublica.org/article/a-nurses-hospital-wouldnt-let-her-wear-an-n95-mask-she-hasnt-been-back-to-work-in-weeks

(150) Federal Judge Orders…Company to Pay $1 Million to Employees Terminated for Assisting Safety Investigation
www.osha.gov/news/newsreleases/region3/08232019

(151) Guidance for the Food Industry: Coronavirus Outbreak III. Suggested Business Practices
www.fmi.org/docs/default-source/coronavirus/food-industry-suggested-business-practices---3.pdf?sfvrsn=455fcdaf_2

(152) Suing Walmart Over COVID-19 Deaths – A Viable Case?
www.vlaw.com/suing-walmart-over-covid-19-deaths/

(153) COVID-19 and Workers Compensation: What You Need to Know
www.ncci.com/Articles/Pages/Insights-COVID19-WorkersComp.aspx

(154) Workers' Compensation Benefits for Chronic Conditions
www.lawyers.com/legal-info/workers-compensation/a-chronic-illness-may-mean-long-term-workers-comp.html

(155) Workers' Compensation: Presumptive Coverage for Firefighters and Other First Responders
www.ncci.com/Articles/Documents/Insights-Research-Brief-Presumptive-Coverage.pdf

(156) Department of Homeland Security - Essential Critical Infrastructure Workforce
www.dhs.gov/coronavirus/cybersecurity-and-critical-infrastructure

(157) $200 billion for essential worker hazard pay included in Heroes Act pandemic aid package
www.ems1.com/legislation-funding/articles/200-billion-for-essential-worker-hazard-pay-included-in-heroes-act-pandemic-aid-package-57f2sfrm5oRchGBm/

(158) More States Push COVID-19 Claims to Work Comp; Potential Cost Anyone's Guess
www.claimsjournal.com/editors-picks/2020/05/19/297138.htm

(159) California Executive Order re Workers Compensation and COVID-19
www.gov.ca.gov/wp-content/uploads/2020/05/5.6.20-EO-N-62-20-text.pdf

(160) COVID-19: Workers' Compensation
www.ncsl.org/research/labor-and-employment/covid-19-workers-compensation.aspx

(161) Can I Get Workers' Compensation Benefits for Coronavirus (COVID-19)?
www.nolo.com/legal-encyclopedia/can-i-get-workers-compensation-benefits-for-coronavirus-covid-19.html

(162) As Colorado businesses reopen, coronavirus-related workers' compensation claims are piling up
https://coloradosun.com/2020/05/27/colorado-coronavirus-workers-compensation-liability/

(163) Meatpackers ordered back to work, but safety issues remain
www.businessinsurance.com/article/20200429/NEWS06/912334320/Meatpackers-ordered-back-to-work,-but-safety-issues-remain-COVID-19-coronavirus

(164) COVID-19 and the Law: Workers' Compensation Compensability in DE, FL, NJ, FL and PA
https://marshalldennehey.com/articles/covid-19-and-law-workers%E2%80%99-compensation-compensability-delaware-florida-new-jersey-and

(165) Liability Waivers Related to COVID-19 in the United States
www.bclplaw.com/en-US/insights/liability-waivers-related-to-covid-19-in-the-united-states.html

(166) Waivers of Liability in the COVID-19 Era: Proactive Steps Businesses Should Consider…..
www.mondaq.com/unitedstates/litigation-contracts-and-force-majeure/921578/waivers-of-liability-in-the-covid-19-era-proactive-steps-businesses-should-consider-to-protect-against-possible-future-liability

(167) Reopening the Economy and Getting Back to Business: Will Liability Waivers Protect My Business?
www.natlawreview.com/article/reopening-economy-and-getting-back-to-business-will-liability-waivers-protect-my

(168) Role for COVID-19 Liability Waivers in Employment Is Limited
www.law360.com/articles/1272374

(169) What You Need to Know Regarding Products Making Claims to Kill the Coronavirus Causing COVID-19
www.epa.gov/compliance/compliance-advisory-what-you-need-know-regarding-products-making-claims-kill-coronavirus

(170) About the National Organic Program
www.ams.usda.gov/publications/content/about-national-organic-program

(171) Global Organic Textile Standard
https://global-standard.org/

(172) Why Tutti Frutti Clothing is not a certified organic brand
https://tuttifrutticlothing.com/blogs/news/not-a-certified-organic-brand

(173) OEKO-TEX® Certification
www.oeko-tex.com/en/

(174) International Association of Natural Textile Industry (IVN)
https://naturtextil.de/en/home/

(175) ILO (World Labor Organization)
https://www.ilo.org/global/lang--en/index.htm

(176) Textile Exchange's Organic Content Standard (OCS)
https://textileexchange.org/matrix/organic-ocs/