Mask Policy Webinar

McILVAINE

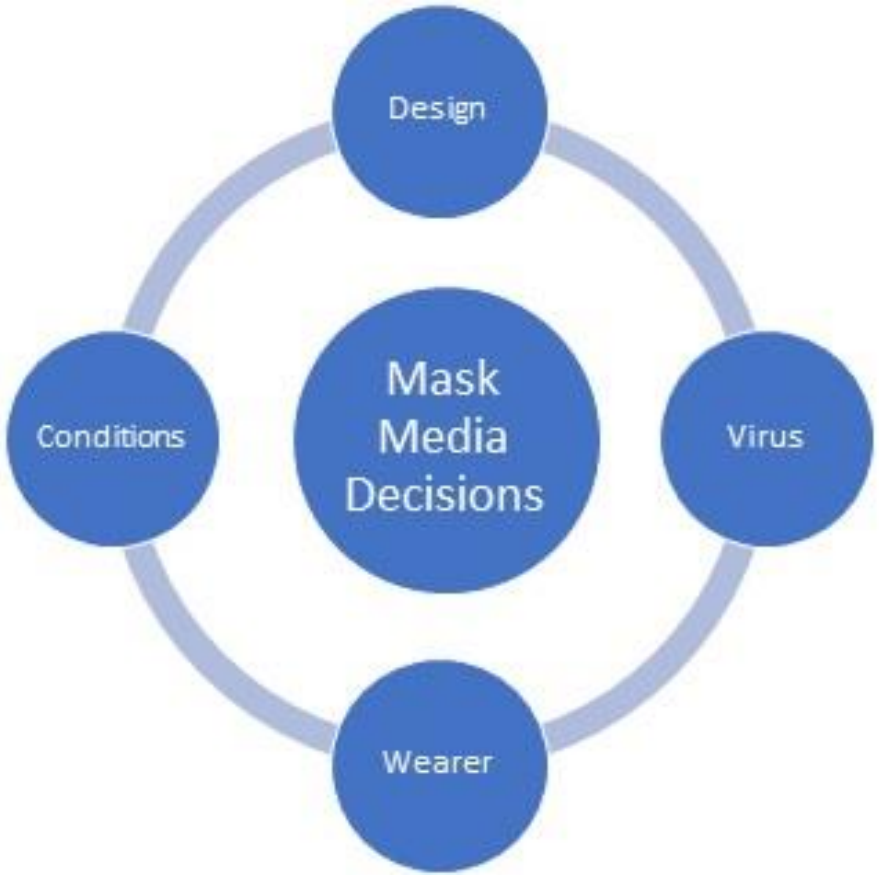
Mask Media Considerations

Virus Factors

- The size and proliferation of aerosols
- The percentage of virus in aerosols versus larger droplets
- The viral load
- Minimum infectious dose
- Life of virus
- Virus rejuvenation from dormancy
- Creation of aerosols from viruses leaving surfaces

Mask Factors

- Efficiency of various masks in removing viruses
- Various mask media options
- Wash ability
- Efficiency reduction over time or with washing
- Mask fit
- Comfort
- Breathability and oxygen deprivation
- Valve options
- Killing as well as capturing viruses



McILVAINE

Virus Factors

Size and proliferation of Aerosols. *We breathe in millions of particles per minute but must avoid just 10 viral particles.* Small particles such as virus aerosols are invisible. This can provide a false sense of safety. In every cubic meter of air we inhale we also inhale 35 million particles greater than or equal to 0.5 microns in diameter. We inhale even more smaller particles in the 0.1 to 0.2 micron range which is the size of the virus.

There are some reports that the minimum infectious dose for COVID-19 can be as low as 10 viral particles. This means that if just a tiny fraction of the particles we inhale every minute are COVID we can become infected. For comparison purposes a pharmaceutical cleanroom typically is ISO 5. The cleanest operating theaters in hospitals are ISO 4. The semiconductor industry spends billions of dollars per year to reach ISO 3. The task of keeping small particles such as viruses from occupying space is very difficult.

Many of the particles we inhale are long distance travelers. For example mercury emitted from gold mines in Brazil has been traced to the Artic. When a volcano erupted in Iceland the skies turned dark in Europe for weeks. Italian researchers have found COVOD on air pollution particles in the Lombardy region. Another takeaway is that social distancing has limited effectiveness. Viruses travel on cigarette smoke sized particles. So one way to view the task is to think that everyone you encounter is puffing away and you have to avoid even inhaling a few of his smoke particles.

McILVAINE

The percentage of virus in aerosols versus larger droplets: Viruses attach to droplets or particles. They are only 0.1 microns in diameter but may be in droplets 20 microns in diameter or larger. Droplets in the 5 micron range can also be generated or can be the result of evaporation of larger droplets. In medical changing rooms in China higher viral loads have been noted. Viruses are also being aerosolized by cleaning the floor or from other surfaces.

Viral Load: The viral load varies by individual and activity. A lusty super spreader singer was able to generate many thousands of aerosols and infect 45 people in just two hours.

Minimum Infectious Dose: There are reports that only 10 viral particles is enough to cause an infection. Other views are that it generally requires a large number of particles over a period of time. Since large cough or sneeze droplets don't travel far, social distancing is therefore the best way to avoid infection. However, if small numbers of airborne viruses can cause an infection then a whole different approach is needed.

Life of Virus: The virus is known to remain viable for hours in the air and for days on various surfaces.

Virus Rejuvenation from Dormancy: It has now been documented that viruses are not necessarily dead but just dormant as they travel through the air. They can then penetrate the lungs where the moisture revives them.

Creation of Aerosols from Viruses Leaving Surfaces: There are numerous cases tracking aerosols which were originally on surfaces such as floors or clothing.

McILVAINE

Mask Factors

Efficiency of Various Masks in Removing Viruses: Masks vary in efficiency depending on the media and the fit. Viruses average 120 nm in diameter but can be entrained in droplets larger than 300 nm. In general the efficiency improves with more media which means higher pressure drop. The meltblown media used with most N95 masks is electrostatically charged which improves capture efficiency.

The pressure drop impacts breathability. It increases as the square of velocity. So where there is lots of leakage such as the surgical mask with the gap below, the actual pressure drop is much lower than 2.5 Pa. this is because much of the air is bypassing the media. It is clear that surgical masks with gaps do not remove a big percentage of small particles. Most homemade masks are even more inefficient. In some cases a heavy cotton fabric is by itself quite efficient but with high resistance it will cause more air to bypass the mask. The takeaway is that the masks being worn by the public do not protect against virus aerosols.

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

	flow rate: 1.2 CFM		
	filter efficiency (%)		**pressure differential**
sample/fabric	**<300 nm average ± error**	**>300 nm average ± error**	**Δ*P* (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

McILVAINE

Various Mask Media Options

Surgical masks are made mostly with meltblown polypropylene. The meltblown is sandwiched between two layers of spun bond media. There is an electrostatic effect which improves on the already high efficiency due to the fine fiber matrix. There are some new meltblown designs with claims of even higher efficiency at a given pressure drop.

There are a number of alternative materials which are now available commercially. They include nanofiber membranes which are claimed to have higher efficiency at a given pressure drop. They are also washable. The media is available in large quantities. In the case of Cummins the offering is based on media originally designed for filtering engine air intakes. In the case of Ahlstrom it is the use of surgical drapes. Berry is another supplier diverting media used from other applications.

McILVAINE

Efficiency: Some of the newly available media has efficiencies rated at N99 or better. 3M already offers a range of options higher than N95 using meltblowns. The question of a carbon layer and its impact on efficiency also needs to be addressed.

Washability: N95 masks with meltblown media can be decontaminated with UV light, H_2O_2 , or other means. Battelle reports ten time successful reuse of masks decontaminated with H_2O_2. Masks made with membrane materials can be washed by various means and reused many times. This reuse ability results in a better tight fitting mask with an affordable cost per use.

McILVAINE

Efficiency reduction over time or with washing: The support structure as well as the mask media can deteriorate. The ability to separate the media and support structure means that the structure can provide longer term use.

Mask Fit: The mask fit is critical to providing protection. The more expensive reusable masks can provide that fit.

Comfort: N95 masks without valves but with a tight fit are uncomfortable to wear for long periods. The medical worker can endure the discomfort for a shift but it is unrealistic to think that people will wear N95 tightfitting masks without valves throughout the day without serious negative impacts.

Breathability and oxygen deprivation: With a tight fitting N95 mask the quantity of air inhaled is down as much as 25%. Some CO2 is re-entrained in the new breath. Two Korean 14 year olds who were required to run in 1000 meter tests with their masks on died last month on the track. The government has since suspended the requirement.

Valve options: There is a large industry which has flourished for many years. Masks with valves are purchased by those wanting to protect themselves from air pollutants. In China there are Vogmask stores where all they sell are dozens of varieties of highly efficient designer masks. They are equipped with one way valves which allow the air to be exhaled through the valve

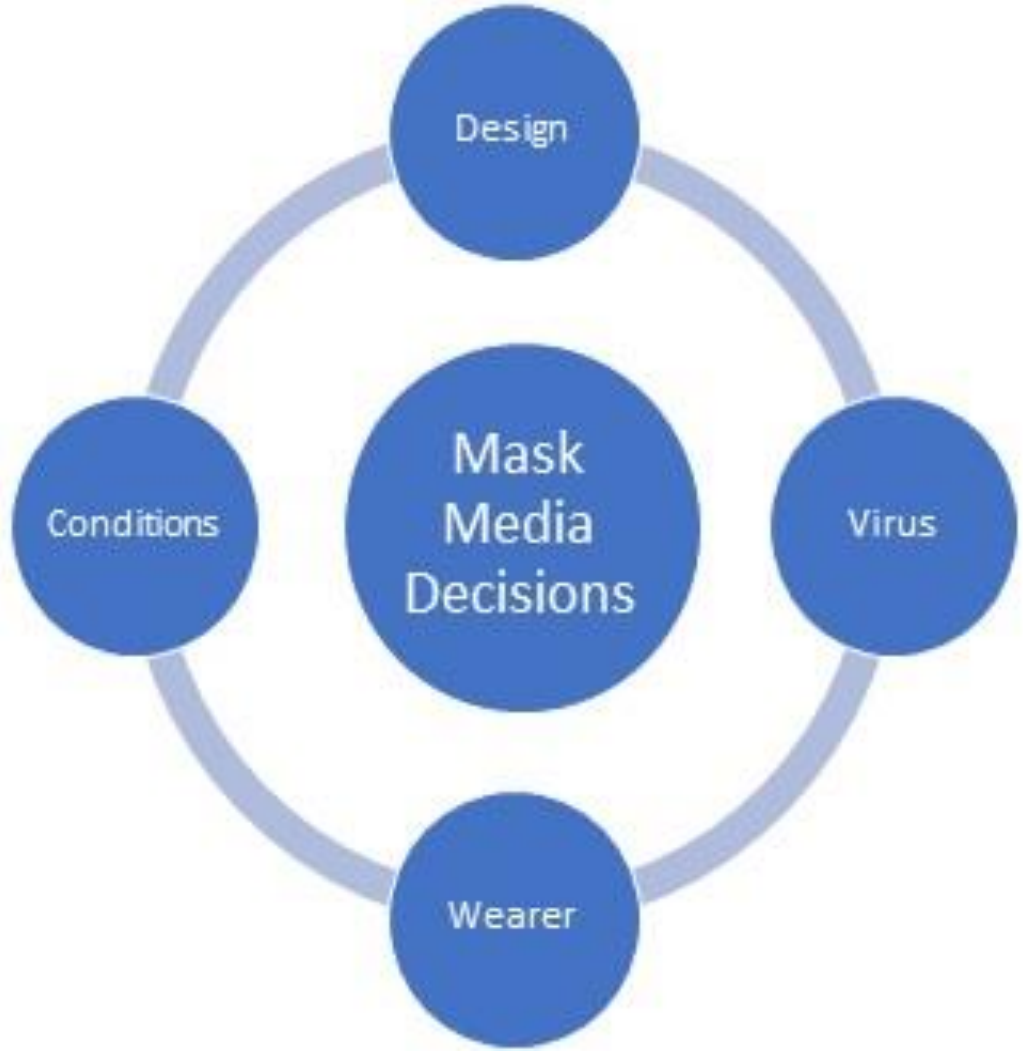
McILVAINE

Conditions

- Virus load
- Percentage of aerosols
- Humidity
- Air flow patterns
- Benefits of capturing other contaminants

Wearer factors

- Age and immune response
- Other medical conditions
- Lung function
- Activities



McILVAINE

Environment

Virus load: The wearing of masks can be tailored to the viral load and therefore the risk. There is a movement to develop a N-80 mask which would be less efficient than the N95 but more efficient than the typical surgical mask. Individuals could have all three mask options available. They could decide where it is most appropriate to not wear a mask or to wear the N80 or N95.

Percentage of aerosols: The danger at any point in time is a function of the percentage of the total viral load which is in the form of aerosols.

Humidity: In general higher humidity deters the virus when it arrives. The virus travels shorter distances in humid air than in dry air where the droplet size is smaller.

Air Flow Patterns: The viral load is in part determined by air flow. This important subject is dealt with in a separate analysis.

Benefits of capturing other contaminants: The coronavirus pandemic will subside at some point in time. There will be uncertainty about when and if it will return. Wearing an N90 mask may become as much a habit as drinking bottled water. Everyone is subjected to high air pollution levels at some point in time during the year. In some countries this is a daily occurrence. But even in others the mask will be justifiable. St Louis was meeting its particulate ambient emission goals and was assumed to be meeting its toxic metal goals which had been shown to track the total particulate. However, when the city installed monitors to directly measure toxic metals, they found spikes on days when the wind blew from the direction of a lead refinery.

Hospital acquired infections cause 1.7 million illnesses and 99,000 deaths per year in the U.S. Patients would be well served to wear N95 masks

McILVAINE

Wearer Factors

Age and immune response: The use of masks by the elderly is conditioned on breathability. It is unlikely that anyone with reduced lung function or heart problems could wear an N95 mask without a valve. Shouldn't the type of mask be dictated by this need? Should the elderly be deprived of efficient masks because valves are prohibited? Sacramento says: Masks with valves are prohibited. Let's consider mask recommendations by segment and not as one.

Other medical conditions: Those with impaired immune systems can probably justify an N99 Mask and tight fit. This will require use of a valve. The tight fit is also a function of the valve. If you are blowing air out around the edges of the mask you tend to expand the opening.

Lung function: The lung functions vary among individuals creating an important variable in mask selection.

Activities: Any job function involving physical labor including many meat processing jobs needs to take into account the importance of wearing a mask which does slow down oxygen intake.

McILVAINE

Supplier Products

Media and Masks which are Unique

McILVAINE

KAU Researchers funded by King Abdullah University of Science and Technology have developed a membrane that can be attached to a regular N95 mask and replaced when needed. The filter has a smaller pore size than normal N95 masks, potentially blocking more virus particles.

FiberExtrusion Technology (FET) We've done a lot of work with sustainable polyamides and polyesters, as well as with PHAs and a range of PLAs," Slack says. "In the longer term, there has to be a more sustainable option than polypropylene in these products and the opportunity to explore potential alternatives — drawing on the know-how from the extensive body of tests and trials we've carried out in the past, as well as the machines run commercially by our customers — is something I believe makes us pretty unique in the services we can offer nonwovens manufacturers.

NXTNano capacity available for manufacturing N95 rated face mask material. Materials are nanofiber coated PET in ranges from 29 to 70 GSM depending on the needs of individual manufacturing line.

Tustar Teams with **Neatrition** to Introduce High Efficiency Masks to the U.S. Market. With the help of Ann Arbor, Michigan-based TusStar, Chinese nanotechnology company Neatrition is introducing new KN95 safety masks to the U.S. market. These easy-to-clean, multiple-use masks will shield users from respiratory droplets and other particulate matter during the current COVID-19 crisis and beyond.

McILVAINE

Nexera made the decision to develop a N95 respirator mask constructed from Foss Performance Materials' Agion Antimicrobial treated polyester fiber. Sciessent is its supply partner.

Ahlstrom-Munksjö is supplying facemask material from its plant in Tampere to Teho Filter for the assembly of masks. The masks will be available in May-June in the stores of Finland based retailer S Group. The filtration efficiency of the face mask material of 88% is substantially higher than the roughly 20-40% efficiency of masks made from cloth; the company claims. The filtration efficiency of a mechanical filter media remains intact over time compared to electrostatically charged materials.

O2 Nano Mask is sold at $35.99 consists of two components: the reusable skin and the replaceable filter. Each filter features three layers: two layers of PET and one embedded with nanofiber material. The fibers are on the order of 85 ± 20 nm in diameter. This nanoscopic morphology creates uniquely small pores and drastically increases the membrane surface area while leaving open-air travel paths in 99% of the membrane volume.

McILVAINE

Cambridge has an N99 efficient and comfortable mask but with valve. The pro mask uses a unique triple filter system which has been tested by Nelson and reaches N99 efficiency levels.

The first layer of the filter system catches larger pollution particles such as dust and PM10. It's then backed up by the Three-Ply Micro Particulate which stops nearly 100% of smaller particulate matter such as PM2.5 and PM3.0. The inner filtration layer is made from 100% pure activated carbon cloth, originally developed by the UK Ministry of Defense for chemical, biological, and nuclear warfare protection.

Draeger says its N95 mask design offers superior comfort and breathability and is certified to the NIOSH standard for particle respiratory protection.

CDC Approves Powered Air Purifying Respirators
NIOSH-approved respirators are available in many types, models, and sizes from many manufacturers for a wide variety of uses in many occupational settings. The most common types of respirators in healthcare are N95 filtering facepiece respirators (FFRs), surgical N95 FFRs, and PAPRs.

IQ Air has a Multi-layer HyperHEPA for PM2.5 and fine particles - Non-woven glass microfiber, medical-grade HyperHEPA material.

McILVAINE

Armbrust American, is currently ramping to produce 1.2 million masks per day, and plans to scale production to billions annually if needed. Armbrust American says it can offer masks cheaper than Chinese suppliers. Individuals can purchase Austin, TX made medical masks for $0.50 on Armbrust's website, with plans to bring prices down as production increases.

W.L Gore has engineered prototype reusable mask covers to supplement clinicians' primary face masks. These covers, developed by a cross-divisional team, are made from a material that:

- is a proprietary Gore high-flow filtration laminate
- provides greater than 99% aerosolized virus particle protection
- is water repellent yet air permeable, and
- can be reused after autoclave or EtO sterilization

MOTEX offers N80 masks. This designation is being used by those who are offering a mask for the general population which is higher efficiency than most masks being worn by the public but would be 80% efficient on 0.3 micron particles in contrast to the 95% N95.

Midwest Textiles and Hollingsworth & Vose (H&V) are collaborating on a new ready-to-sew face mask kit for the general public. The new collaboration between Midwest and H&V offers an improvement to the everyday consumer by adding a layer of Nanoweb FM to the mask. Nanoweb FM is new filtration media made by H&V, designed for use in homemade face masks.

McILVAINE

Bondex developed a polypropylene nonwoven that is used in both mask and isolation gown applications, as well as hydroentangled polyester that is also used in the construction of mask materials.

Asiatic Fiber Corporation mask filter has three layers, and each layer has its unique purpose. The outer layer is air-droplets blocker, that can preliminarily filter the majority of particles and air-droplets. The second layer is an AFC® filter pad, it embraces air-in area and air-out valve, to create an PM 2.5 filtration effect.

Start X Med developed a small personal air purifier that is really the world's smallest N90 filter. When coupled with a surgical or cloth mask, it provides a lot of protection, along with sophisticated health monitoring.

Lumen Couture $95 LED Matrix Face Mask allows wearers to write their own text: draw designs or use a phone's microphone or music tracks for equalizer effects. The construction is a Dual-layer cotton and mesh material with LED Flex Panel. It is washable. Electronics are removable for cleaning and sanitation.

McILVAINE

Alpha Pro Tech N-95 Particulate Respirator face mask's unique flat-fold design features a Positive Facial Lock (PFL). The N-95 face mask filters at least 95% of airborne particles. The integrated Magic Arch technology creates a comfortable breathing chamber within the N-95 face mask by holding it away from the wearer's nose and mouth.

22 Mask offers a $5 mask with filtration efficiency not less than 95%. Five layers of protection, disposable dust mask, activated carbon layer, non-woven fabric layer, double electrostatic absorption cotton and soft non-woven fabric layer.

Exxon Mobil has a new industrial-style mask being fast-tracked for production. The design improves coverage of a health care worker's nose and mouth and will use a replaceable cartridge system that includes a filtration fabric to prevent contact spread of the virus from the saturated filter. In this design, the filters are disposable while the main component of the mask can withstand repeated sterilization, thus prolonging the life-cycle of the product and addressing shortages of N95 masks.

SWM Delnet™ apertured film, a lightweight nonwoven that is extruded, oriented, and uniquely embossed for use as a flexible surface layer for medical facemasks.

McILVAINE

Berry is launching an extension to its Synergex range of products, Synergex ONE, a new media for face mask applications. Developed to initially meet the new face mask categories for general population, the aim is to quickly bring the media up to EN 14683:2019 standards for surgical masks. The newly introduced Synergex ONE provides a multilayer nonwoven composite product in a single sheet, as an alternative to traditional face mask layer structures.

SpectraShield™ Series of antimicrobial respirator masks formally passed penetration and resistance in multiple testing at numerous independent testing laboratories in the European Union. These tests require the SpectraShield™ masks to be subject to exposure of a quantity of particulate aerosols at 0.3 micron in size at a specific velocity rate. Upon the exposure of the aerosols, the amount of droplets that penetrate the mask are measured. In the European Union, for the masks to be rated a FFP2 it must meet a minimum of a 97% filtration rate, and for a FFP3, it must meet a minimum 99% filtration rate.

NC State University created unique filters that have excellent filtering capability and can potentially be reused after cleaning with peroxide, or potentially alcohol solution Because these materials are strong, unlike classical meltblown filters, they can also be cut and sewn by traditional techniques.”

McILVAINE

MSA P100 masks, which are not typically used in health care settings but are approved for industrial use by the National Institute for Occupational Safety and Health (NIOSH), cover a person's nose and mouth, and are equipped with two removable filter cartridges.

Sindat has developed a comfortable cotton mask with a replaceable membrane with high virus capture efficiency. The mask is washable.

Cummins' NanoNet® and NanoForce® Media technology, which uses DuPont's Hybrid Membrane Technology (HMT), can typically be found in air, fuel and lube filtration products used in heavy-duty diesel engines but also can be used in the N95 respirator masks.

Fibertex Nonwovens has introduced a new fully synthetic non charged HEPA 13 filter media based purely on mechanical filtration by nanofibers and with near to half the pressure drop of glass media.

Superior Felt and Filtraton offers Technostat® Plus – a triboelectric media of needle-punched felt that offers 20% improvement in filtration efficiency over standard electrostatic filter media.

McILVAINE