Final Design Report

Redesign of mask
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**Problem Statement**

**SIZE OF CORONAVIRUS:** 50 nm to 140 nm.  
**SIZE OF RESPIRATORY DROPLETS:** Typically 5-10 micrometers (µm) in length; therefore, it can be inferred that an individual who ingests, inhales, or is otherwise exposed to SARS-CoV-2 positive respiratory droplets can be exposed to hundreds or thousands of virus particles which increases the probability of infection.

1. Difficulty in breathing  
2. Ineffective sound flow  
3. Bad grip- Entry of impure air, fogging of glasses and sliding down of masks  
4. Thread- breaking/ loosening; trouble to ears  
5. Pressing need for double masks for better filtration of air  
6. Development of facial skin lesions or worsening acne, when used frequently for long hours  
7. Difficulty wearing a mask in hot and humid environments  
8. Contamination of the mask due to its manipulation by contaminated hands  
9. Contamination that can occur if masks are not changed when wet, soiled or damaged.  
10. Cleanability and reusability  
11. High-filtration masks, which are a cut below N95s, can block much of the transmission but are not as effective against aerosols.
Primary Intended Beneficiaries

MISSION STATEMENT

To solve the existing problems of the COVID-19 masks currently in use, through redesigning.
Field Research Briefing

**Introduction :**

The coronavirus pandemic

COVID-19 long-haulers are showing early signs of neurological disorders: at least 1 in 5 still report brain fog after months.

The COVID-19 pandemic put such a strain on nurses on the frontlines that many are considering leaving the profession.

We just got our first evidence that Moderna's coronavirus booster shot works to fight variants.

Biden administration supports waiving intellectual property rights for COVID-19 vaccines — a big step in making vaccines more accessible to developing nations

Dr. Fauci explains why COVID-19 vaccines work much better than natural immunity to protect you from the coronavirus.

**PURPOSE OF USED OF CLOTH IN MASK DESIGN**

Cloth face masks may prevent the person wearing the mask from spreading respiratory droplets when talking, sneezing, or coughing. If everyone wears a cloth face covering when out in public, everyone's overall risk of exposure can be reduced. It's important to remember that you're not only wearing a mask for yourself, you're wearing it for others around you.

"If everyone wears a mask when in public, the ones who have illness in them, whether symptomatic or not, will not contaminate the environment," Chris Ziebell, an emergency medical director for US Acute Care Solutions, previously told Insider.

If you prefer to wear a surgical mask, it's still a great idea to wear a cloth face mask as an additional layer. Not only will it keep your single-use mask from getting contaminated and help it to last longer, but it can also improve the effectiveness. According to Dr. Anthony Fauci, director of the National Institute of Allergy and Infectious Diseases, doubling up on face masks is a good idea and "makes common sense."

Even if you've been fully vaccinated, you should continue to wear a mask in public as the CDC continues to learn more about the effectiveness against different variants of the virus. If it has been less than two weeks since your single-dose shot, or if you still need to get your second dose of a two-dose vaccine, you are not fully protected and should continue all safety precautions outlined by the CDC.

Below figure shows the use of different kind of mask by the peoples to protect from the infection of corona virus which are tested during the time of covid -19.
Preliminary Problem Analysis

The 28 best face masks tested during the pandemic
New design for the mask to protect against the covid-19 pandemic. Below figure shows the design of MASK here two point are introduced in the mask to release the CO₂ from the body.
so that respiratory system can work successfully. Further other new features are also added for the betterment of the respiratory system and inhaling the oxygen in the body.

Observations

Limitation of the existing mask

There are several are found in the current mask. After studying several existing mask of different model it is found that following limitation are exists which are as follows:

- Single point for entry and exit for inhaling of oxygen and exhaling the CO$_2$.
- Not a good grip facility
- Constant wearing will making burden in the both ears
- Not a good air flow facility exists.

Problems Identified

1. Functional Breathing capacity of the N95 mask

After studying the clinical practice its has been found that oral health professionals wondering if they can get used to wearing N95 mask for the all day and every day then they can easily suffer from reduced flow of oxygen due to breathing through these high-level masks and increased warmth from wearing additional personal protective equipment (PPE), many oral health professionals are struggling and suffering with tis problems..

Further use of an N95 mask or other approved respirator that offers a high level of protection during aerosol-generating procedures. If this level of mask is unavailable, then a surgical level III mask with face shield is the minimum recommended. However, fitted respirators are more effective against inhalation of airborne infectious agents, in part due to the snug fit against the face.

Further due to variety of personal air filtration devices/barriers in addition to ambient air sanitizing methods are in use, even as recommendations continue to change. For example, developing a way to run oxygen through N95 masks with this addition could be helpful, as the available oxygen inside N95 masks can be reduced up to 20%. Due to this oral health professionals are struggling to breathe with the following problems.

- With a lack of oxygen due to respirator use,
- Balancing loupes with a headlight,
- Seeing through face shields, and
- The warmth created by donning more PPE,
Clinicians are working up a sweat. Breathing gets more difficult with a Lack of oxygen, Resulting in higher pulse and blood pressure rates.

Mouths open to bring in more air, drying oral tissues and airways. The many benefits of nasal breathing are secondary to the need for air.

Problems

- Inhaling more carbon dioxide (CO₂) is another major consideration. CO₂ is necessary but breathing problems arise when proper oxygen/CO₂ ratio is disturbed. Hypercapnia occurs when exhaled CO₂ is continually inhaled from the dead space in the respirator, activating the sympathetic nervous system.
- Excessive CO₂ exacerbates this fight or flight response, causing the body to hyperventilate. CO₂ is a vasodilator, raising blood pressure and body temperature. Additionally, lack of adequate oxygen encourages open-mouth breathing in attempt to bring in more air.
- Individual tolerance to CO₂ exposure and its symptoms vary according to fitness level, comorbidity, and breathing pattern. The good news is tolerance can be increased. Those who have been medically cleared for the respirator fit test can take measures to decrease their CO₂ sensitivity. To learn your level of sensitivity to CO₂, measure your control pause or body oxygen level test (BOLT) score with these instructions.

Measure Your Sensitivity to CO₂

1. Rest for 5 minutes.
2. Sit straight without crossing your legs and breathe comfortably and steady.
3. After an exhalation pinch your nose.
4. Hold your breath and start stopwatch.
5. When you feel slight discomfort, resume your breathing and note the time.

This exercise measures the time it takes for your body to react to a lack of air. After the breath hold, the next inhalation should be calm. A healthy score is 25 to 40. A lower score indicates sensitivity to CO₂ and a greater breathing demand. At lower levels, the lungs have to work harder to remove excessive CO₂. Those with higher scores can maintain calmer, more relaxed breathing during rest and exertion.

Various breathing methods and exercises are available to reduce CO₂ sensitivity. Any that activate the parasympathetic (rest and digest) nervous system and support light, slow, and deep breathing can improve the control pause score.
Oral health professionals may want to implement functional breathing exercises on their days off when they are relaxed. Be sure to breathe through your nose, both in and out. Are you congested? Lower controlled pause scores correlate with congestion. As your breathing improves, so will your congestion. Try this exercise to immediately unblock the nose.  

2. Problems of Nose Unblocking Exercise

1. Take a small breath in through your nose and breathe out through your nose.
2. Pinch your nose and walk around or, if sitting, sway back and forth while holding your breath.
3. When the desire to take a breath is fairly strong, let go of your nose.
4. Breathe in only through your nose.
5. Repeat the cycle while breathing in and out only through your nose until your nose is unblocked.
6. Observe your breathing throughout the day. Good breathing during rest should not be seen or heard. A typical respiratory rate is around 10 to 20 breaths per minute.
7. A higher BOLT score correlates with fewer breaths/minute, which improves overall oxygen exchange. More efficient oxygenation of tissues improves energy and concentration.
8. In short, the lower the BOLT score, the greater the breathing volume, and the greater your breathing volume, the more breathlessness you will experience during exercise. To obtain an accurate measurement, it's best to rest for ten minutes before measuring your BOLT score.
9. Record the number of seconds you can hold before feeling the natural urge to breathe. Then, you release the nose and breathe through the nose. The inhalation at the end of this hold should be calm. The number of seconds is your BOLT score.
10. Additionally, a slower breathing pattern activates the parasympathetic nervous system, which, in turn, lowers pulse rate, helping to reduce anxiety and stress.

We can go weeks without eating and days without drinking, but only minutes without breathing; yet, we pay less attention to our breathing than what we eat and drink. The importance of healthy air and breathing cannot go unnoticed. We are learning as best practices evolve. Stay safe and listen to your body.

Popular N95 masks with respiratory valves which are as follows:

<table>
<thead>
<tr>
<th>N95 masks</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Onroad Co. Reusable Anti Pollution Mask with N95 Grade Filter.</td>
<td>With 2 valves</td>
</tr>
</tbody>
</table>
Urbangabru N95 Anti Pollution Mask | With 6 layers of filters
---|---
ASR Surgical N95 Anti Pollution Mask | Comfortable and lightweight

**Selected Problem Area**

Breathings problems and risk found in N95 masks

- Wearing high-grade filter N95 masks can help protect against the novel corona virus. But after a few hours, these tight-fitting devices can also make it *really hard to breathe.*
N95 respirators, for example, are famously good at blocking viral particles—but they can also reduce the amount of available oxygen by up to 20 percent.

For the above mentioned reason manufacturer guidance typically suggests that N95 respirators can be worn for 3-4 hours at a time.

Now some Stanford University researchers are addressing this problem with a portable device that pumps pure O₂ directly to the wearer.

Further because the more times people touch the mask and try to take it off in order to breathe better, the higher risk that they’re going to cross-contaminate their mask.
Design Iterations

Prototype Briefing: Breathing analysis of new designed mask

1. Flow rate of human breathing

- On average an 0.17 to 0.33 Hz adult human inspires and expires 10 to 20 cycle/min (the breathing frequencies or respiratory rate is 0.17 to 0.33 Hz) during normal quiet breathing.

- This can increase to 25 cycle/min (0.42Hz) during heavy exercise.

2. How much air do we breathe per minute?

- A normal human requires 50ml oxygen per seconds and per minute it requires 50*60 = 3 liter

- A normal minute volume while resting is about 3 to 5 liters per minute in humans. But Minute volume generally decreases when at rest, and increases with exercise.

- The average adult, when resting, inhales and exhales about 7 or 8 liters of air per minute with different heart conditions. That totals about 24*60*8=11,000 liters of air per day.

- Inhaled air is about 20-percent oxygen. Exhaled air is about 15-percent oxygen. Therefore, about 5-percent of breathed air is consumed in each breath.

- That air is converted to carbon dioxide. So, as far as how much air is actually used, human beings take in about 11000*0.5 =5500 or 550 liters of pure oxygen per day.
1. Moss layered air purification system to address the issue of breathing difficulty.

2. Mask strings to be replaced by knots, velcro or sliding fixtures.

3. Memory forms or masks designed in such a way so a to cover the nose perfectly would solve the problem of bad grip.

4. Cooling pads or opening near the lower jaw to address the problem of heat generation and sweating.

5. Provision of antiviral coatings on the mask.

Critical Analysis:

1. Besides of that following features are also provided in the new designed mask
2. 3D fit design
3. Comfortable inner knit layer
4. Adjustable & universal fit
5. Lightweight
6. Knot can be increased and decreased according to the face size.
7. A big misconception is used for considering that wearing just about any piece of cloth that covers your mouth will protect you during these times of crisis.
8. This new design mask which effectively filters out pollutants from the air, different masks work in different ways in catching and stopping bacteria and viruses from entering our body's airways.
9. ANTIMICROBIAL: Antimicrobial clothing keeps you protected from various microorganisms as well as keeps the odour away caused by excessive sweating. Stay protected yet very trendy.
10. WATER REPELLENT: eliminates the risk of diseases by blocking the penetration of any liquid.
11. SAFETY
12. Filtration: Masks have been efficiently designed to provide the highest grade protection. There are 6 layers, where 3 and 4th layers have been merged into one to prevent the transmission of airborne droplets.

Prototype Briefing:
• Besides of that following features are also provided in the new designed mask
  ❖ **3D fit design**
  ❖ **Comfortable inner knit layer**
  ❖ **Adjustable & universal fit**
  ❖ **Lightweight**
  ❖ **Knot can be increased and decreased according to the face size.**

*Prototype detailing:*
WORKING MILESTONES:

OBSERVATION:
Good grip for any size of face

The following features are used to provide better grip facility

- **Adjustable Head Loop**
  
  To ensure a snug fit and maximum face covering area to provide maximum protection against pollution, infection, dust, smog, virus & other particles in any type of environment.

- **Adjustable Ear Loop**
  
  To ensure a snug fit and maximum face covering for protection against pollution, infection, dust, smog, virus & other particles.

- **Breathable & Comfortable:**
  
  Masks are super comfortable for men and women and child of any age with any kind of face architecture and dimensions. These are for one time use-easily disposable. Good quality material allows for longer time wearing at office, home, cycling, traffic, school & travel according to his / her choice.
**CRITICAL ANALYSIS:**

New design mask Technical specification used for each layer

- **Layer-1** (inner layer) – Ultra-soft cloth Fabric provide better comfort ability and filtration capability during breathing.
- **Layer-2** (First filter layer) - BFE 99 PP based Polypropylene Fiber with mechanical width <=3200m fabric are used for better ultra-high filtration with more than 98% at 0.3 micron or less.
- **Layer-3** (Middle layer) Hot Air Cotton layer are used for extra comfort and easy breathability;
- **Layer-4** (second Filter layer) melt-blown technology based Superfine fiber, high porosity, smooth, soft, good wrinkle resistance with better filter system according to for ultra-high filtration greater than 95% at 0.3 micron
- **Layer-5** (Outer Layer) Spun bond technology based fabric layer for splash resistance and as initial layer of protection.
- **Layers 6** : Melt blown N series based fiber are used in the last layer for better protection and exhaling of CO₂ from the mask. This fiber is a high-quality filter material certified according to the NIOSH standard, which is an American standard nonwoven melt blown fabrics which are usually used to make facial protection with Particulate matter filtration efficiency is ≥95% or more with Inhalation resistance: ≤150pa.
- **Further Inhalation resistance testing flow rates range from 40 to 160L/min. Exhalation ...** Inhalation resistance – max pressure drop. ≤ 343 Pa. ≤ 70 Pa (at 30. L/min).
Hot cotton layer explained
<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td><strong>Brand</strong></td>
<td><strong>Indian</strong></td>
</tr>
<tr>
<td><strong>Number of Layers</strong></td>
<td>Multilayer</td>
</tr>
<tr>
<td><strong>GSM</strong></td>
<td>40 to 60 gsm</td>
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<tr>
<td><strong>Material</strong></td>
<td>Polypropylene(PP), Polyester</td>
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<tr>
<td><strong>Usage/Application</strong></td>
<td>Medical</td>
</tr>
<tr>
<td><strong>Type of Bonding</strong></td>
<td>Thermal</td>
</tr>
<tr>
<td><strong>Pattern</strong></td>
<td>Plain</td>
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Challenges:

Points to be Noted:
With the advent of a novel H1N1 influenza outbreak in spring 2009 and the expectation of a second wave during the 2009–2010 flu season, there has been considerable interest in the use of surgical masks (facemasks) and respirators as infection control measures. Although their appearance is often similar, respirators are designed and engineered for distinctly different functions than surgical masks. The amount of exposure reduction offered by respirators and surgical masks differs. The National Institute for Occupational Safety and Health (NIOSH) and the Centers for Disease Control and Prevention (CDC) recommend the use of a NIOSH-certified N95 or better respirator for the protection of healthcare workers who come in direct contact with patients with H1N1.

FINAL DESIGN DESCRIPTION

Flow diagram used for breathing analysis of the mask
If worn properly, a surgical mask is meant to help block large-particle droplets, splashes, sprays, or splatter that may contain germs (viruses and bacteria), keeping it from reaching your mouth and nose. Surgical masks may also help reduce exposure of your saliva and respiratory secretions to others.

While a surgical mask may be effective in blocking splashes and large-particle droplets, a face mask, by design, does not filter or block very small particles in the air that may be transmitted by coughs, sneezes, or certain medical procedures. Surgical masks also do not provide complete protection from germs and other contaminants because of the loose fit between the surface of the mask and your face.

Surgical masks are not intended to be used more than once. If your mask is damaged or soiled, or if breathing through the mask becomes difficult, you should remove the face mask, discard it safely, and replace it with a new one. To safely discard your mask, place it in a plastic bag and put it in the trash. Wash your hands after handling the used mask.

b) N95 mask with Respirators

An **N95 respirator** is a respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles. Note that the edges of the respirator are designed to form a seal around the nose and mouth. Surgical N95 Respirators are commonly used in healthcare settings and are a subset of N95 Filtering Face piece Respirators (FFRs), often referred to as N95s.

**General problems for the air filtration problems of N95 mask**
An **N95 respirator** is a respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles. Note that the edges of the respirator are designed to form a seal around the nose and mouth. Surgical N95 Respirators are commonly used in healthcare settings and are a subset of N95 Filtering Facepiece Respirators (FFRs), often referred to as N95s.

**General N95 Respirator Precautions**

- An **N95 respirator** is a respiratory protective device designed to achieve a very close facial fit and very efficient filtration of airborne particles. But peoples with chronic respiratory, cardiac or other medical conditions that make breathing difficult should check with their health care provider before using an N95 respirator because the N95 respirator can make it more difficult for the wearer to breathe.
- Some models have exhalation valves that can make breathing out easier and help reduce heat build-up. N95 respirators with exhalation valves should not be used when sterile conditions are needed.
- All FDA-cleared N95 respirators are labeled as "single-use," disposable devices. If your respirator is damaged or soiled, or if breathing becomes difficult, you should remove the respirator, discard it properly, and replace it with a new one. To safely discard your N95 respirator, place it in a plastic bag and put it in the trash. Wash your hands after handling the used respirator.

N95 respirators are not designed for children or people with facial hair. Because a proper fit cannot be achieved on children and people with facial hair, the N95 respirator may not provide full protection.

Respirators in Industrial and Health Care Settings

Most N95 respirators are manufactured for use in construction and other industrial type jobs that expose workers to dust and small particles. They are regulated by the National Personal
Protective Technology Laboratory (NPPTL) in the National Institute for Occupational Safety and Health (NIOSH), which is part of the Centers for Disease Control and Prevention (CDC).

However, some N95 respirators are intended for use in a health care setting. Specifically, single-use, disposable respiratory protective devices used and worn by health care personnel during procedures to protect both the patient and health care personnel from the transfer of microorganisms, body fluids, and particulate material. These surgical N95 respirators are class II devices regulated by the FDA, under 21 CFR 878.4040, and CDC NIOSH under 42 CFR Part 84.

N95s respirators regulated under product code MSH are class II medical devices exempt from 510(k) premarket notification, unless:

- The respirator is intended to prevent specific diseases or infections, or
- The respirator is labeled or otherwise represented as filtering surgical smoke or plumes, filtering specific amounts of viruses or bacteria, reducing the amount of and/or killing viruses, bacteria, or fungi, or affecting allergenicity, or
- The respirator contains coating technologies unrelated to filtration (e.g., to reduce and or kill microorganisms).

**Statistical approach for calculate efficiency and performance**
The following statistical experiments can be easily performed

- Water vapor condensation within the mask.
- Temperature and relative humidity presents inside the mask.
- Amount of heat generated within mask during breathing cycle.
- Measurement of bacteria distribution on the inner surface of the mask

**Statistical approach for measurement of bacteria distribution on the inner surface of the mask**

- A spread plate method was used for determining total bacterial and fungal counts.
- General bacteria are cultivated in a plate count agar (PCA) and
- General fungi are cultivated in a Sabouraud 4% dextrose agar (SDA).
- The plates were incubated at 37°C for 48 hours to get the bacterial counts, and
- incubated at room temperature for 5 days for fungal counts.
- Observation was done daily.
- After counting the isolated bacteria, fungi were preliminarily identified by Gram’s stain and microscopic morphology.
Future Aspects & Recommendations:

Above masks are also containing several new features which helps to run the respiratory system properly such as

**Features:**

1. It contains the liquid oxygen container to supply the oxygen continuously.
2. Outlet for release the internal heat and best breathability
3. Release of released of CO₂ from the body with good filtration facility.
4. Use of good and best quality of cloth in the mask so that it can be used continuously.
5. Better grip facility and easily set in the face.
6. Layers Three
7. Filter pocket No (could add when making)
8. Attachment type Ear loops
9. Nose wire Yes (it added when making for low of oxygen)
10. Glasses-compatible 1/5
11. Size adjustable No (could adjust to fit you when making)
12. Comfort while talking
13. If they will make your spectacles glasses less fog up.
REFERENCES


