

A plethora of opportunities and design innovation in personal protective equipment segment for dental professionals

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Abstract: Around the world, various reports have brought the focus on the vulnerability of healthcare professionals in the dentistry. Dental professionals are more prone to the catching the virus during an outbreak like this as their work exposes them to aerosols and droplets from the patient. The need to provide the people actively involved in providing dental care with appropriate Personal Protective Equipment (PPEs) is evident. An interview schedule was developed and through random sampling method, 50 dentist professionals were interviewed for assessment of needs. The statistical findings from the study indicate the perception of the protective wear from the wearer's interpretations. It was observed that the pandemic is generating a risk to the environment with rise of disposable PPEs. Thus, the PPEs developed for the dental professionals were made from anti-corona fabrics/fabrics with anti-viral finishes that can be home laundered and used up to 30 washes. The PPE developed promotes a feeling of well-being and has the potential for a multi-disciplinary functional approach. The designed protective wear met the functional, technical and aesthetic concerns of the wearer.

Keywords: covid19, dental professionals, functional clothing, personal protective equipment, protective textiles

1. Introduction:

“Necessity is the mother of invention”. - Plato

This quote by the visionary philosopher Plato is the basis of human evolution which rightly states that we as humans have used every necessity situation as an opportunity to innovate and invent. The Corona virus pandemic has provided the global fashion industry with an opportunity to “reset and reshape”. The pandemic has changed the life as it was before pre-pandemic¹. It wasn't until December 2019, when the first record of outbreak of this virus was noted in Wuhan, China. It is a highly contagious disease which spreads primarily from person to person through small droplets from the nose or mouth, which are expelled when a person with COVID-19 coughs, sneezes, or speaks. These droplets are relatively heavy, do not travel far and quickly sink to the ground. People can catch COVID-19 if they breathe in these droplets from a person infected with the virus. Thus, social distancing, washing hands regularly with soap and water or use of alcohol-based hand rub have been recommended as precautionary measures to curb the spread of corona virus by the Centers for Disease Control and Prevention (CDC)³.

1.1. Personal Protective Equipment

One of the more unexpected side effects of the pandemic was to forever alter our relationships with personal protective equipment (PPE); to make medical garments, at least in the mask sense, a new accessory of self-expression and a part of almost every wardrobe². The term PPE refers to Protective clothing (PC), including gloves, face shields, eye wear, face masks and/or other equipment designed to protect the wearer from injury or spread of infection. Most commonly used in healthcare settings, PPE acts as a barrier between infectious materials and wearer's skin, mouth, nose, or eyes. It is essential, however, that PPE is used with other infection control practices such as hand washing, using alcohol-based hand sanitisers, and consistent enforcement of infection prevention practices. Thus, making Protective Clothing for healthcare workers, the unexpected big market with high growth potential⁴.

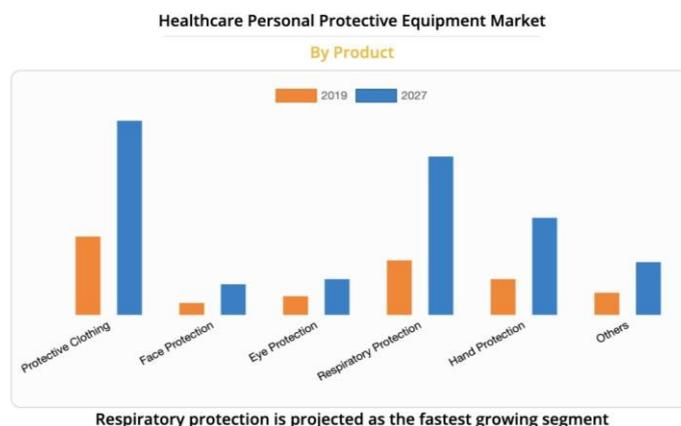


Chart 1: Market for PPE for healthcare workers⁴

1.2. Personal Protective Equipment for Dental Professionals

As part of the healthcare workers, the dental professionals help their patients protect, restore and maintain their oral health. The dental professionals are required to diagnose, treat and provide care for injuries, malformations and diseases associated with

teeth, oral tissues and mouth. As these dental professionals' work in close proximity of their patients, they are vulnerable to catching the infection through aerosols and droplets from the patient. The use of drills during dental treatment carries fine water particles in the air, which could carry the coronavirus for up to three hours. This vulnerability in times of a pandemic is a reminder that equal importance needs to be given to the profession of dentistry⁵. During the first noted wave of Covid pandemic, a study⁶ by Muhammad A.A. and his team reported about a large number of dental professionals were fearful of contracting the infection by their patients and staff and hence have been skeptical of providing treatment. A news report⁷ in Visakhapatnam highlighted how it is going to cost more for a common man to visit a dentist. The reason being that besides the regular expenses of the dental clinic; dentists in private practice will need to buy PPE and disinfectants to protect patients, staff and themselves from the spread of the infection, thus providing dental care became more expensive. It is also important to note that India enjoys a worldwide market share of 14% in dental tourism⁸, which might be affected due to travel restrictions and increased cost of care. One also needs to understand that there is direct correlation between oral health and general health of the public. This is extremely significant for prevention of various chronic diseases. It all the more shows the need for timely recognition and redressal of susceptibility of dentistry by healthcare system of each nation. This is needed to be able to provide dental care to the population while controlling the spread of the virus. Thus, there is a need to provide the people actively involved in providing dental care with appropriate PPEs for enabling them to provide services and continue their practice in times of this pandemic.

1.3. Need for Reusable Dental Protective Clothing:

Our environment is currently facing decay and the facts are there. We are over-consuming beyond the capacity of earth where an equivalent of 1.5 earth's resources is consumed. It is predicted that by 2025 this will double and we will be consuming three times the resources of earth to sustain us if we continue using and generating waste at the same pace. This has brought a rise and awareness about being mindful and conscious about the consumption and impact on environment. The businesses are looking for new ways and business models to curtail consumption and waste. The pandemic brought the focus of this consumption and waste issues in fashion, clothing, uniforms and personal protective equipment market. During the coronavirus pandemic, PPE and protective uniforms have never been more important. More have been manufactured, used, and disposed of than ever before, which is having an environmental impact⁹.

It was observed that during the first six months of the pandemic, the estimate of carbon footprint of PPEs was 106,478 Tonnes of carbon dioxide emissions. There was shortage of PPEs for the healthcare workers and some of the governments even advised healthcare workers to reuse certain items of PPE which even included the masks and respirators. This was widely criticized for risking the lives of healthcare workers. Apart from the spread of virus during covid pandemic, PPE and uniforms have been vital part of surgeries and some other key sectors like retail. The use of single use PPE is known to have harmful impact on the environment. Thus, a need was observed to provide a design solution of reusable PPE for dental professionals that reduced the carbon footprint and yet protects the wearer.

1.4. Anti-viral Fabrics:

The pandemic brought focus on the medical textiles and anti-viral properties in the fabrics. The pandemic has also accelerated more than one trend in the fashion industry, including the textile sector's crucial role in spearheading innovation.

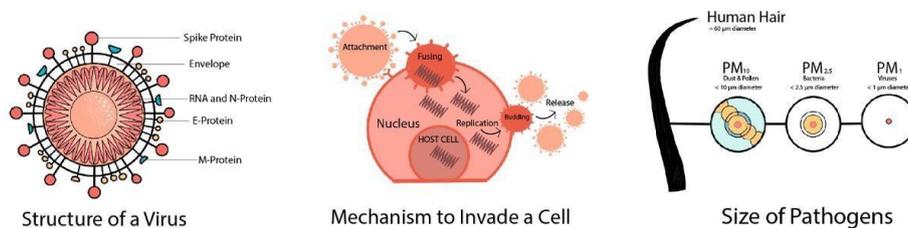


Fig 1. The structure, mechanism and size of the virus and pathogens

The development of anti-viral fabrics and finishes was possible by studying the structure and mechanism of the virus. A major development with respect to the anti-viral fabrics was seen as leading textile industries collaborated with international technology to develop shirting and suiting fabrics with anti-viral properties¹⁰. Arvind Ltd. Collaborated with HeiQ to create Viroblock fabric. Donear group developed GRADO – anti bacterial and anti-viral fabric. Birla Cellulose launched their Liva fabric with anti-microbial properties. Living Guard group is providing antiviral finishes using the EFM-7 technology. These fabrics and finishes provide effective protection against contamination and transmission of viruses that use textiles as a hosting surface.

2. Aim and Objectives of the study

To design and develop personal protective equipment for the healthcare workers in the dentistry department.

To adhere to the standards and requirements of PPE for dental professionals as published in National Guidelines for Safe Dental Practice During Covid-19 pandemic by the Ministry of Health and Family Welfare, Government of India¹¹.

The objective of this PPE is as follows:

- SAFETY –
- To protect the dental care worker from aerosols as well as contact with infectious material
- COMFORT
 - Easy donning, doffing and disposal of PPE
 - Ability to wear the PPE for longer hours
- FUNCTIONALITY
 - Ability to carry out routine procedures with ease.
 - PPE that allows easy communication between the dental care worker as well as patient.
- AESTHETICS
 - The look should give comfort and confidence to the patients instead of making them more anxious

- Use of color psychology and personalization of PPE

3. Methodology and Sample selection:

The target audience for designing the PPE was for dental professionals in India. This included the dentists and their assistants in a dental clinic. Through snowball sampling method, 50 dental professionals were identified in India. An interview schedule was developed. The team of researchers visited and interviewed various dental professionals. Through observation and qualitative analysis of the interview schedule the requirements and needs of the dental professionals were understood.

A review of various anti-microbial and antiviral fabrics available with textile manufacturers and companies in India was done. The varied functional finishes and their efficacy was reviewed across the companies providing antiviral fabrics in India. These industries were contacted to understand their developments with anti-viral finishes and scope of using these fabrics with finishes which show good efficiency towards laundry washes were studied. A conceptual framework for designing of PPE for dental professionals was developed. This framework was based on the interview schedule, market survey and global trend analysis. The conceptual framework developed was as follows:

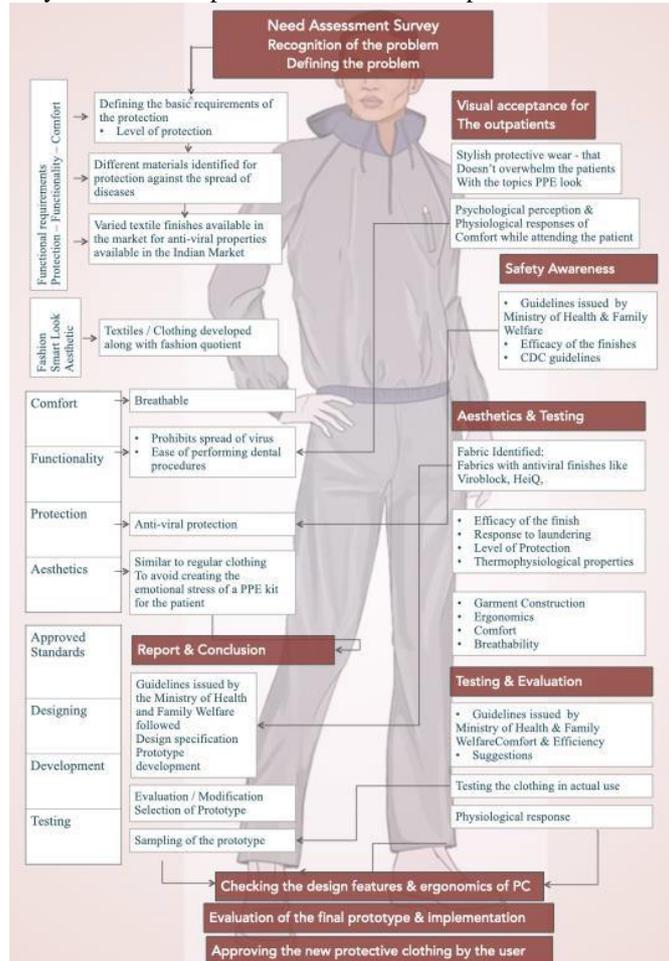


Fig2: Conceptual Framework for design and development of personal protective equipment for dental professionals.

4. Results and Discussions:

The research team visited dental clinics to interview and observe dental professionals, observe the work conditions, environment and ergonomics of functioning while wearing a PPE and performing the dental procedures. The space and environment of dental clinics was observed.





Fig3: Set of images from the clinic of the chairs for dental professionals and patients.

The observations and the conceptual framework resulted in narrowing down the key features for designing of Dental Protective Equipment listed as below:

- Two-piece PPE – consisting of top wear and bottom wear, instead of over-garment
- Accessories as part of PPE - anti fogging glasses, face masks, Face shield, Nitrile gloves, caps, shoe covers are optional
- The face masks, as per MHFW suggests N95 respirator masks, however communicating with patients gets difficult so a design of mask with same protection level but easier to carry out their procedures is preferred.
- The main concern with existing PPE is that it doesn't allow the sitting position for the dental care workers to carry out their procedures, as they need to sit with spread legs. The separate bottom wear that accommodates this ergonomic posture is required.
- Preferred concealed closures
- A chest pocket for holding a pen, no extra pockets for tools needed
- Use of breathable fabric to avoid heat stress and enable wearing for long hours
- The PPE should resemble regular/civilian clothing. The dental patients are already anxious, so not to add to that and keep PPE which is not too bulky or resembling the same in a Covid ward.
- Exploring colour psychology, prints and patterns for ensuring comfort of patients.
- A hood style attached to PPE that can be easily worn or put down during the procedure and while interacting with patient as required.

Based on the listed features, preliminary designs were developed. These designs were evaluated with discussions with the stakeholders of the research. The designs developed were as follows:



Fig4: Design Developments for PPE for Dental Professionals for Men

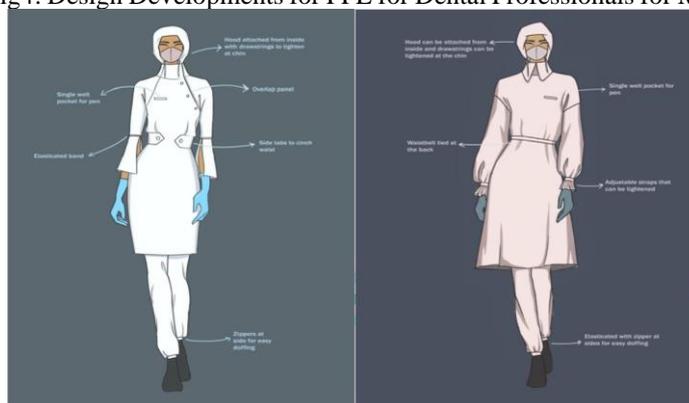


Fig5: Design Developments for PPE for Dental Professionals for Women

The fabrics were sourced from Siyaram's, Birla Cellulose and Living Guard to create the prototypes. These prototypes were given to the respondents to understand the practicality and feasibility of the same. The suggestions were for minor changes like having a stitched hood instead of detachable hood. In place of elastic at cuff and hem bands, ribbed knit was preferred. The suggestions

and observations were noted to make the final designs. The selected designs were developed with the necessary changes.

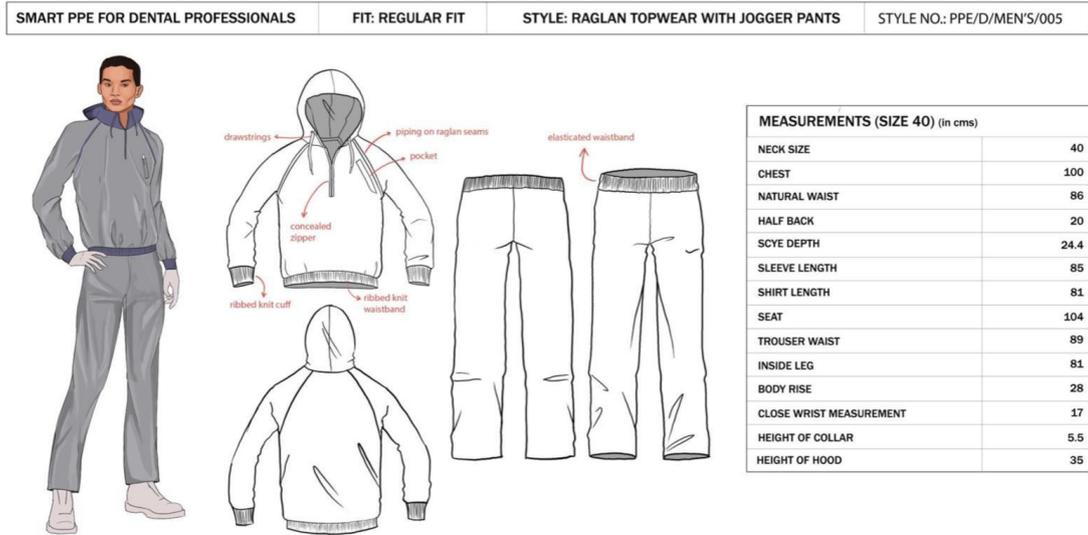


Fig6: Final Tech pack of PPE designed for Dental Professionals (menswear)



Fig7: Final Tech pack of PPE designed for Dental Professionals (womenswear)

The final prototypes were developed for male dental professional. It was very well received by the respondents.



Fig8: Fittings of final prototype on respondent.

5. Conclusion:

The pandemic may have shaken the belief of normal, but it created a plethora of opportunities for design interventions, setting up better practices for a more sustainable future. The research resulted in developing smart personal protective equipment

for dental professionals, which not only looked closer to regular/civilian clothing but served its primary function of protection. This was one of the most important features that helped these dental professionals provide dental care to their patients without causing any emotional stress which the disposable PPEs would cause in the times of pandemic. The developed prototype was found to be comfortable to work for long hours and was reusable. Thus, reducing the carbon footprint and adding to the disposable PPE waste that is being generated in the past two years almost.

The research sets a precedent for future scope of sustainable design solutions in the field of protective clothing across various sectors. The idea to provide protective wear that is similar to regular clothing and yet meet the functional needs of the wearer while caring for the environment will form the basis of future of this industry. What right fully resonates the present situation is a tweet by science writer Ed Yong, that we await returning to the pre-covid normal however the present was an outcome of the past normal. And to avert future pandemics, we as humans need to build something better.

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