Journal of Anatomical Sciences

Email:anatomicaljournal@gmail.com

J Anat Sci 12 (1)

Production of Covid-19 PPE for Frontline Health Workers and The University of Port Harcourt Community

[1]David LK, [2]Ebieto CE, [3]Asuzu-Samuel HO

[1]Department of Anatomy, Faculty of Medical Sciences, College of Health Sciences, University of Port Harcourt, Rivers State, Nigeria.

[2]Department of Mechanical Engineering, Faculty of Engineering, University of Port Harcourt, Rivers State, Nigeria.

[3]Department of Biomedical Technology, School of Science Laboratory Technology, University of Port Harcourt, Rivers State, Nigeria.

Corresponding Author: David LK
E-mail: lekpa.david@uniport.edu.ng**;** +2348035607640

ABSTRACT

The COVID-19 virus has been spreading across the globe since late 2019. Originally it was slower to reach Nigeria and Rivers State in particular, but advance more rapidly in 2020, and severely affected patients with difficulty breathing. Most rontline healthcare workers lack Personal Protective Equipment (PPE's) and ventilators are in extremely short supply in University of Port Harcourt Teaching Hospital and Lulu-Briggs Health Center. Our aim is to launch a wide-spread response and produce PPEs applying the 3D printing technology for the COVID-19 pandemic in University of Port Harcourt and Rivers State at large. Two Thousand (2000) face-shields were printed with University of Port Harcourt inscription on it and were distributed across the various health facilities in Rivers State, Nigeria and particularly, the University of Port Harcourt Community. One Hundred (50) N-95 Nose mask was also printed and distributed accordingly. Local production of PPE will protect health care workers and patients (University of Port Harcourt staff and students), improve delivery time and availability, reduce the spread of virus and save lives in our university community.

Key words: COVID-19, PPE, Pandemic, Healthcare, Frontline, University, Port Harcourt,

INTRODUCTION

The COVID-19 pandemic has placed an enormous strain on health care workers, and its potential impact has implications for the physical and emotional well-being of the work force. As the COVID-19 pandemic accelerates, global health care systems have become overwhelmed with potentially infectious patients seeking testing and care. Hospital systems run far over capacity, facing possible shortages of critical care medical resources and Personal Protective Equipment (PPE). Foremost on the minds of frontline health care workers working in conditions of possible contagion is personal safety.

WHO (2020)[1] recommends the appropriate use of PPE for the protection of health workers as paramount and these PPE include respiratory N95 masks, Face shield, eye protection, hand gloves, coverall and safety booth must be prioritized for health care workers and other caring for COVID -19 patients.
WHO as at April, 2020 shipped nearly a million sets of personal Protective Equipment to 47 containers, but the supplies was insufficient.

An epidemiological model developed by imperial college of London estimates that Africa will require 30,000 ventilators in a best case and 400,000 in the worst case scenario, characterized by zero mitigate measures[2]. Bloomberg (2020)[2] in a report noted that the demand for ventilator is ten times the current supply capacity which is as a result of the pandemic. Ventilators became very expensive, the prices ranges between USD 20,000 and USD 50,000 depending on the type.

The shortage of safety gear at one Manhattan Hospital is so dire that desperate nurses have resorted to wearing trash bags[3]. We don't want such situation in our University health centre. Preventing the spread of infection to and from health care workers (HCWs) and patients partially depends on the effective use of personal protective equipment (PPE) such as face masks, face shields, and sometimes ventilator[4]. A critical shortage of all of these PPE's is projected to develop or has already developed in areas of high demand. With the real possibility of insufficient amounts of PPE, such as N-95 nose masks, face shields and ventilators, health care workers have been expressing increasing concern in their daily work environment. Also school resumption has raised a lot of questions among lecturers and students in Nigeria.

African five priority actions to step –up Africa's response were first, to fast tract imports, exports and

movement of skilled personnel within Africa and globally. Secondly, to scale – up local manufacturing capacity. This is to enable local manufacturing and support effective industrial reconversion of PPE's. Thirdly, to manage supply chain effectively, implement a coordinated continental approach, leveraging on the African Union commission and to coordinate at the continental level, levering on regional economic communities. Fourthly, to bridge-short and long-term financial gaps; to fast track financing for companies involved in providing COVID – 19 related solution and finally, to ensure affordable access to technology knowledge, drug and vaccine South African government[5]. Bryan and Rick[6] reported plans to make more than a billion masks by the end of the year fight the pandemic and emphasized that localized supply chains are a secret weapon to achieve this goal.

In an official report in Egypt, the chairman of major state owned mental industries company says the first local made Medtronic's ventilator will be ready for mass production Ahmed[7]. The spread of this deadly respiratory disease which emanated from China in the late 2019 has led a global shortage of critical medical supplies of PPE's (ventilators and respirators) hence an Egyptian company believes that it should not wait for the situation in Egypt to get worse to come up with solution related to the production of ventilators. Bauchner *et al*[8] reported that ventilator demand in Africa is high hence called for a large increase in production and innovation. They recognizes the challenges, concerns, and frustration about the shortage of personal protective equipment (PPE) that is affecting the care of patients and safety of health care workers in the US and around the world.

There is need for the production of these PPE as we wait the reopening of the institution in Nigeria. The National Agency for Science and Engineering Infrastructure (NASEN), produced the first made in Nigeria ventilators. Nigeria received donated PPE from WHO and China since the COVID -19 outbreak on the 27th February 2020, but current statistics demand proactive measure in boasting the production of PPE locally. The Nigerian military reported its successful production of a ventilator using local content and also mass production of personal protective equipment and ventilator to cushion it's shortage in the country and boast the fight against the deadly COVID -19 (Coronavirous).
Disrupted supply chains are making it difficult to secure the necessary provisions. Local production of supplies will improve delivery time and availability of critical equipment. Access to proper PPE will protect healthcare workers; reduce the spread of the virus; and save lives.

To prepare for school resumption in our University, there is need to provide PPE to frontline health workers and students visiting the University of Port Harcourt Lulu-Briggs Health Centre. To address this concern, our team has worked diligently to track down and follow up all potential leads to produce and preserve adequate PPE for staffs and students, while keeping staff updated about PPE supply status.

Face shields come in various forms, but we produced customized face shield with University of Port Harcourt printed on it. This positioned the University properly as an entrepreneurial University. The face shield will provide a clear plastic barrier that covers the face. For optimal protection, the shield extend below the chin anteriorly, to the ears laterally, and there was no exposed gap between the forehead and the shield's headpiece[9].

Our team has been trained by a team at the Worcester Polytechnic Institute (WPI) to use 3D printing technology to produce various PPEs and ventilator assembly in response to the COVID-19 in Africa.
The aim of this research was to launch a wide-spread response in preparation for the COVID-19 pandemic in University of Port Harcourt, hospitals in Rivers State and other surrounding States.

MATERIALS AND METHODS

In the current research, 3D Printing Technology was applied to produce various PPE's (Face shield and N-95 nose mask), in response to the COVID-19 pandemic in Nigeria. This face shield protects the face by limiting aerosol and splatter exposure from the front and from above. It is a supplementary face shield created as an emergency action to provide backup personal protective equipment (PPE) options if the standard PPE is unavailable. This device has gone through a special verification process expedited strictly for the response to the COVID-19 pandemic.
The following materials are required for the production of the PPE's:

- 3D printing machines
- PLA filaments
- Transparent films
- 3-layer filters

The face shield and N-95 nose mask would be printed using the 3D printer and other accessories would be used for the finishing. The steps required for the production of the PPE's is shown in Figure 1.

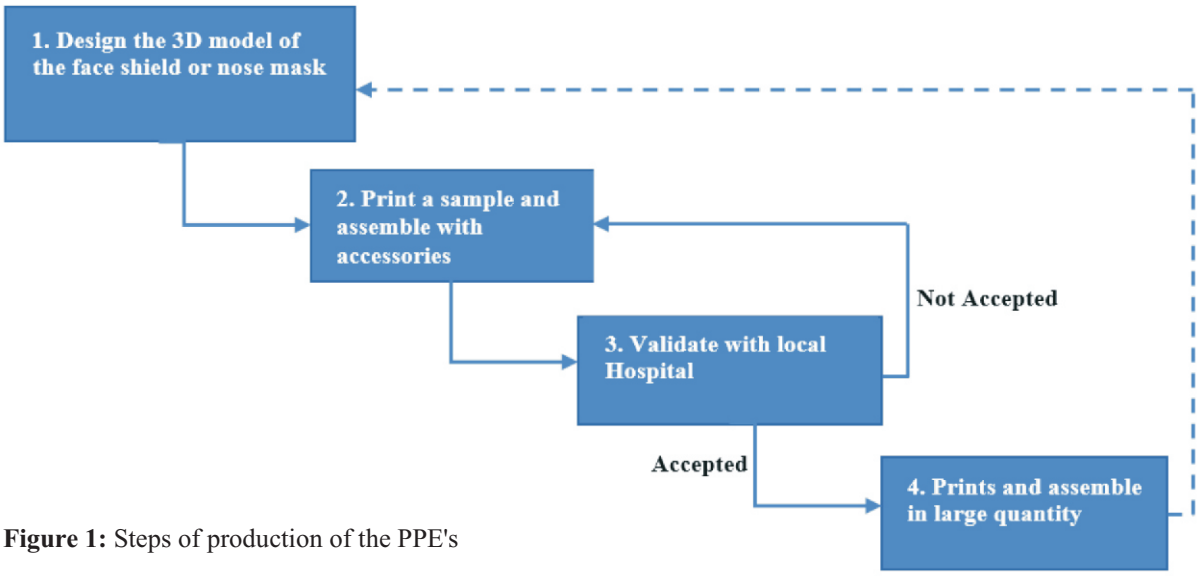

Figure 1: Steps of production of the PPE's

RESULTS

The face shield and N-95 nose mask was printed using the 3D printer and other accessories for the finishing. Two Thousand face shield was printed with University of Port Harcourt inscription on it and was distributed across the various health facilities in Rivers State, Nigeria and particularly the University of Port Harcourt community. Fifty N-95 Nose mask was also printed and distributed according.

Figure 2: 3-D printing of N-95 and face shield in University of Port Harcourt.

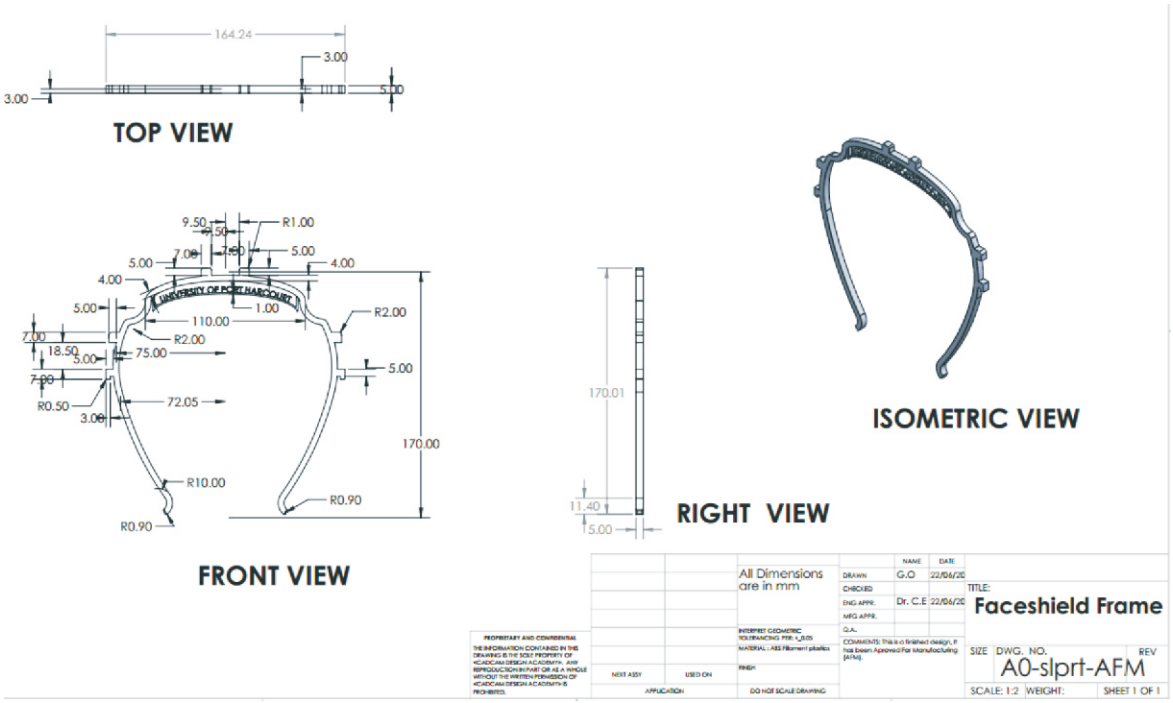

Figure 3: The design of University of Port Harcourt customized Face shield frame

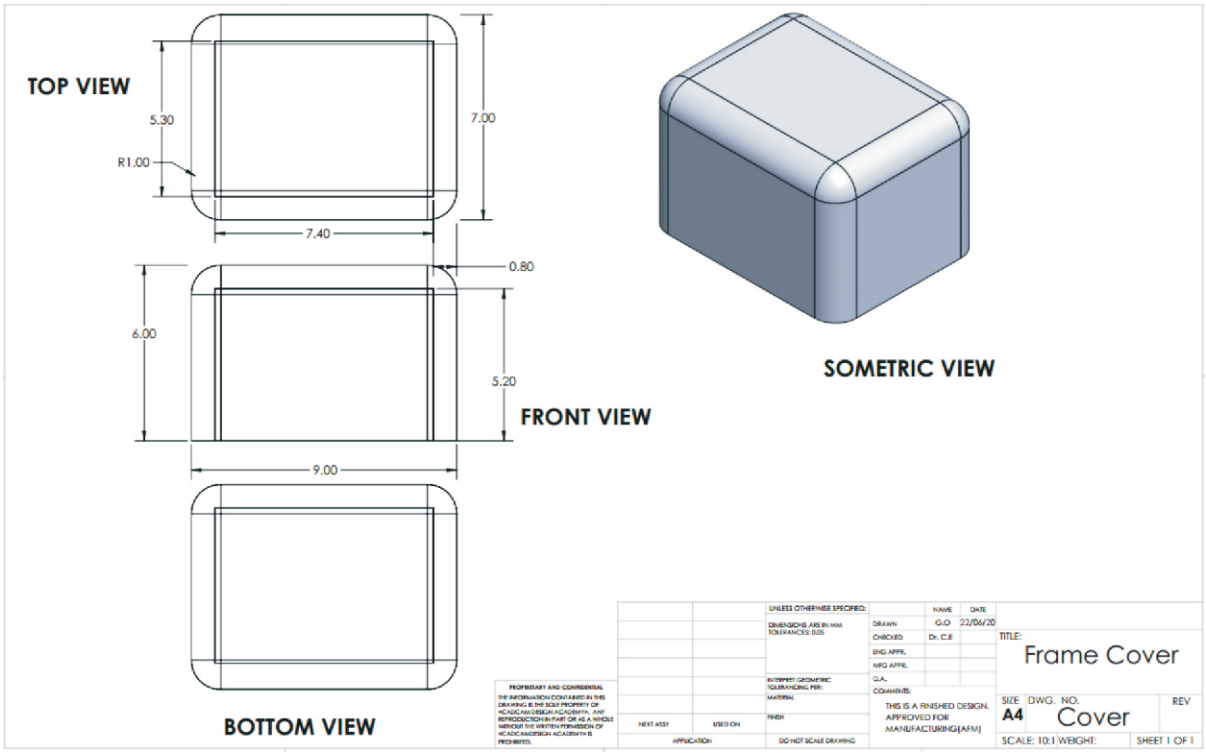

Figure 4: The design of University of Port Harcourt customized Face shield frame cover

DISCUSSION

In this work, we successfully printed several face shields and N-95 nose masks. The face shield frame (Fig. 2) took about 1h and 30 min to print each. N-95 nose mask (Fig. 2) took about 4 h and 10 min to be printed. All the models that we produced with our methodology presented a high detail and replicability, thus demonstrating the feasibility of this technology in the production of face shield and N-95 nose mask accuracy.

The single-frame design used <10 g PLA filament and took approximately 15 min production time to assemble the transparent shield to the frame. It took us less time compared to the work of Celik *et. al.,*[10] that the assembly of the transparent shield took them 35 min. Our design did not cause any pain around the ear as compared to the eyeglass design. We also design and added the inscription University of Port Harcourt on our face shield (Fig 2) These product features can be interpreted as the originality and advantages achieved for this product against competitors as seen in the countless of face shield on social media and distributed in our university community. Many approaches and concepts for face shield products produced using 3D technologies have been proposed during the COVID-19 pandemic to support the health services. Although all of them provide some level of functionality, many of their design features lack adherence to professional design principles, optimum structural topology, and ergonomics. One of our goal was to improve product quality, shorten the product development cycle.

This model can be printed as many times as needed without great expense of material and energy, thus revealing the efficiency of this method of manufacturing. The only associated disadvantage is the long printing time, which certainly should be overcome in the future with the advances of 3D printing technology. The present work also reveals the potential of using 3D printing technology for the creation of more customized PPE in our local environment to help us fight against COVID-19. Our study has shown that there is need for unique considerations for engineers in the design process for medical PPE. All engineering and medical concerns were addressed. An important issue in the use of PPE for medical purposes is biological consideration (including cleaning, sterilization, and biocompatibility). It has been reported by Jurischka *et. al.,*[11] that many filaments retain ambient moisture, which could pose a paradoxically increased risk for virus transmission during use or reuse.

Similar risks and concerns were also reviewed and reported by Clifton *et al*.,[12]. The authors reported that during this pandemic, the open distribution and propagation of PPE prototypes happened before validation and hypothesis formulation (in the context of both engineering and biological considerations) that emphasized on the fundamentally important factors for prototype testing, such as number needed to treat and reduce harm for patients, and the approval of health service authorities had not been considered.

We ensured that our PPE was clean and sterilized before distribution and usage by health workers and the entire university of Port Harcourt community. Expert design consideration and medical/health service authority approvals was also requested for validation before the field shield was distributed.

CONCLUSION

The COVID-19 virus has been spreading across the globe since late 2019. Most Frontline healthcare workers lack Personal Protective Equipment (PPE). As the country has resume schools, lecturers and students need PPE's and possible use of ventilators in severe cases. Our team has designed and produce PPEs (Face shield and N-95 nose mask) applying 3D printing technology in response to the COVID-19 pandemic. Two Thousand (2000) face shield was printed with University of Port Harcourt inscription on it and was distributed across the various health facilities in Rivers State, Nigeria and particularly, the University of Port Harcourt Community. One Hundred (50) N-95 Nose mask was also printed and distributed accordingly.

Local production of these PPEs will protect health care workers and patients (University of Port Harcourt staff and students), improve delivery time and availability, reduce the spread of virus and save lives in our university community. Though the products provides safety features as described by the WHO, the user is generally responsible for their safety while using the products in health service facilities and public areas.

ACKNOWLEDGEMENTS

This research study was supported/funded financially by TETFUND under the RNF research grant. We also acknowledged the Faculty of Engineering, University of Port Harcourt for providing the laboratory space where this printing work was carried out.

REFERENCES

1. World Health Organisations 2020 https://www.org/coronavirous/policy
2. Bloomberg World Ventilator Demand https://www.bloomberg.com/new/article/2020
3. Bowden E, Campanile C, Golding B. Worker at NYC hospital where nurses wear trash bags as protection dies from coronavirus. *New York Post*. March 25, 2020. Accessed March 27, 2020. https://nypost.com/2020/03/25/worker-at-nyc-hospital-where-nurses-wear-trash-bags-as-protection-dies-from-coronavirus
4. Livingston E, Desai A, Berkwits M. Sourcing Personal Protective Equipment During the COVID-19 Pandemic. *JAMA*. 2020;323(19):1912–1914. doi:10.1001/jama.2020.5317.
5. South African Government 2020, COVID–19/Noval Coronavirus https:ll www.gov.za/coronavirous
6. Bryan G, and Rick C. How 3M plans to Make More

Than a Billion Mask By the end of the Year. 2020**;** https://www.bloomberg.com/news/features/2020-03-25/3m-doubled-production-of-n95-face-masks-to-fight-coronavirus

7. Ahram. Egypt to produce prototype of first locally manufactured Medtronics ventilator in a week, http:llenglish.ahram.org/newsContent/1/64/366400/Egypt/Politic-/Egypt to produce – prototype of first locally manufactured. 2020.

8. Bauchner H, Fontanarosa PB, Livingston EH. Conserving Supply of personal protective equipment—a call for ideas. *JAMA*. Published online March 20, 2020. doi:10.1001/jama.2020.4770 ArticlePubMedGoogle Scholar

9. Perencevich, E.N, Diekema ,D.J, Edmond, M.B. Moving Personal Protective Equipment Into the Community: Face Shields and Containment of COVID-19. *JAMA*. 2020; 323(22):2252–2253. doi:10.1001/jama.2020.7477

10. Celik, H. K., Kose, O., Ulmeanu, M. E., Rennie, A., Abram, T. N., & Akinci, I. Design and Additive Manufacturing of Medical Face Shield for Healthcare Workers Battling Coronavirus (COVID-19) 2020. *International journal of bioprinting*, *6*(4), 286. https://doi.org/10.18063/ijb.v6i4.286.

11. Jurischka C, Dinter F, Efmova A, *et al.* , An Explorative Study of Polymers for 3D Printing of Bioanalytical Test Systems. *Clin Hemorheol Microcirc 2020;* 74:1–28.

12. Clifton W, Damon A, Martin AK, Considerations and Cautions for Three-Dimensional-Printed Personal Protective Equipment in the COVID-19 Crisis. *3D Print Addit Manuf* , 1:1–3. DOI: 10.1089/3dp.2020.0101.