Blood Oxygen Saturation and Prolong Face Mask Use in Healthcare Workers in Port Harcourt Nigeria, in the COVID 19 Pandemic Era

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Authors' contributions

This work was carried out in collaboration between both authors. Author PNT designed the study, wrote the protocol and wrote the first draft of the manuscript while author UO performed the statistical analysis and literature search. Both authors read and approved the final manuscript.

Review Article

ABSTRACT

Introduction: The World Health Organization (WHO) declared the Corona Virus disease 2019 (COVID 19) caused by Severe Acute Respiratory Syndrome Corona Virus 2(SARS-Cov-2) a pandemic in March 2020. Aerosolized infected droplets and airborne transmission have been proffered as means of transmission, and as such, the use of face masks has been advocated as a key strategy in the disease control - more so in health care workers who are at the fore-front of the pandemic. However, the use of face masks for prolonged periods has raised concerns on possible adverse effect on blood oxygenation, potentially affecting compliance.
Aim: To monitor the blood oxygen saturation (SPO_2) of healthcare workers wearing facemasks for 8-hours in the course of their duties, in a tertiary institution in Port Harcourt, Nigeria.
Methods: A cross-sectional study of healthcare workers wearing face masks while working. Baseline pre-face mask use SPO_2 was done at Zero hour. Subsequently, serial hourly SPO_2 were recorded until completion at the eight-hour. The respiratory and pulse rates were recorded at zero and eight hours. The results were analysed and presented as Means, Medians, Graphs and Tables.

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Results: There were 220 participants with more females 147(66.8%). Doctors constituted 133(60.5%). The baseline pre-facemask Mean SPO_2 was 97.9% ±0.75. The Median SPO_2 was 98%. The overall SPO_2 trend across 8 hours was maintained above 97.7% for all participants. Age was significantly associated with differences in SPO_2 trend (P=0.032) (P=006); while Type of Facemask use had no significant effect on mean SPO_2 trend (p=1.00). There was no significant difference in respiratory and pulse rates pre and post 8-hours face mask use.
Conclusion: Healthcare workers using facemasks continuously over eight hours maintained normal SPO_2 level, with physiologic adaptation of respiratory and pulse rates.

1. INTRODUCTION

With the onset of the COVID 19 pandemic declared by the WHO on March 11th 2020 [1], one of the guidelines for reducing the risk of transmission is the wearing of face masks, as aerosolized infected droplets and airborne transmission have been postulated as means of transmission of the causative agent - SARS-CoV-2 [2-5]. As such, the universal use of face masks has been advocated as a means to control transmission in public places [2], and a high degree of compliance is expected to maximize the impact and effectively control the pandemic. This strategy is complementary to social distancing and hand hygiene [6-8].

The use of facemasks as an essential part of Personal Protective Equipment (PPE) have been practiced by healthcare workers over time as necessitated by their duties [9]. However, this has become more pertinent in the current era of the COVID 19 pandemic as they are at the frontline of combating the pandemic especially in the direct care and treatment of infected persons [7]. As such, all categories of healthcare worker are necessitated to use facemask for prolonged period during the course of their work. There are different types of face masks such as surgical, N95 medical mask, and cloth mask which may be cotton or nylon/synthetic; and they have been noted to provide different degrees of protection against the disease [10,11]. However, the use of face mask has generated several safety-related issues and anxieties about its effect on blood oxygen levels especially when worn over prolonged periods as may occur with healthcare workers [12-15]. This concern if not addressed, may potentially adversely affect adherence with the preventive guidelines for COVID 19 and escalate the pandemic.

This study thus aims to monitor the blood oxygen saturation (SPO_2) of health care workers working at the University of Port Harcourt Teaching Hospital (UPTH) to determine the effect of prolonged continuous and proper use of face mask on their SPO_2.

2. METHODS

This was a cross-sectional study of doctors and nurses and other healthcare workers at the University of Port Harcourt Teaching Hospital (UPTH) in Port Harcourt, Rivers State, in the Niger-Delta region of Nigeria, conducted over six weeks from the 1st July to the 12st of August 2020. The study participants had their baseline respiratory rates, baseline pulse rates and baseline SPO_2 taken at the onset before adorning their mask (zero hour). The SPO_2 was done using a pulse Oximeter (Omron® Fingertip Pulse Oximeter LOT 1028003). Subsequently, the face masks were properly worn ensuring that both nostrils and the mouth are well covered, and their blood oxygen saturation (SPO_2) was recorded every hour for eight hours. The respiratory and pulse rates were recorded again at the 8th hour. The types of face masks used and pre-existing chronic medical illness (if any) were also documented.

Details demographics of the recruited study participants are shown in the table below

Study population Variable	Frequency n=220(%)
Age (years)	
20 - 30	41(18.6)
>30 - 40	87(39.6)
>40 - 50	61(27.7)
>50 - 60	31(14.1)

Study population Variable	Frequency n=220(%)
Gender	
Female	147(66.8)
Male	73(33.2)
Job Description	
Doctors	133(60.5)
Consultants	31
Senior Registrar	18
Junior Registrar	33
Interns	51
Nurses	77(35.0)
Other health workers	
Nursing assistant	4(1.8)
Pharmacist	4(1.8)
Radiographer	2(0.9)
Departments	
Paediatrics	82(37.3)
Obstetrics & Gynaecology	33(15.0)
Surgery	30(13.7)
Internal Medicine	20(9.1)
Dentistry	18(8.2)
Ophthalmology	11(5.0)
Radiology	10(4.5)
ENT	10(4.5)
GOPD	4(1.8)
Community medicine	2(0.9)
Underlying medical illness	
No	213(96.8)
Yes	7(3.2)
Hypertension	4(1.8)
Diabetes	1(0.5)
Arthritis	1(0.5)
Seizure disorder	1(0.5)
Mask type	
Surgical	162(73.6)
Cloth	43(19.6)
N95	15(6.8)

Data was entered into excel spread sheet. Statistical analysis was done using SPSS version 23. The proportion of categorical variables was expressed in frequencies ad percentages while the median, mean and standard deviation of continuous variables were expressed. One-way repeated analysis of variance of the SPO_2 levels over time (SPO_2: 0,1,2,3,4,5,6,7,8,) was done, with assessment for within the subject effects of factors, to identify any overall significant difference between the SPO_2 levels at different time points. Level of significance was set at 0.05. Bonferroni Post hoc testing was done to identify which specific Means significantly differed. Effect size was represented in 95% Confidence Interval and a graphical plot of significant mean was drawn.

3. RESULTS

Table 1 shows the base line Mean SPO_2, respiratory and heart rates of the study participants before the use of facemask. The Mean SPO_2 was 97.9% ± 0.75.

3.1 Over All SPO_2 Trend of Study Population Over 8 Hours

The median SPO_2 was consistently 98% at baseline to the end of 8 hours. The minimum SPO_2 recorded (only once, and in only one subject) was 87%, and the maximum was 99%. The overall Mean SPO_2 was 97.90%. There was an initial gradual increase in the Mean SPO_2 levels in the first 2 hours which peaked at 97.92%, and a second peak was seen at 4 hours (97.93%), before a gradual decrease in SPO_2

levels that settled at 97.87% at 8 hours. There was however no significant statistical difference in the overall trend or pattern of SPO_2 (P= 0.3). This is illustrated in Fig. 1.

3.2 Comparison of SPO_2 Trend with Variables in the Study Population

Table 2 shows the comparison of the SPO_2 with different variable in the study population. Specifically, Age (P= 0.02) and Type of face mask (0.01) were significantly associated with differences in SPO_2 trend.

Pairwise comparisons show that even though the saturation for all age groups were above 97%, people >50 to 60yrs had significantly lower Mean values of SPO_2 compared to those aged >20 to 30yrs (mean difference -0.379, 95%CI, -0.736 to -0.021, p=0.032) and those aged >30– 40years (Mean difference -0.392, 95% CI, -0.706 to -0.77, p=0.006) this is illustrated in Fig. 2.

Table 1. Baseline mean-value parameters of study population

Parameter	Mean value
Baseline SPO_2 Mean (SD)	97.9 ± 0.75
Base line Respiratory Rate - Mean (SD)	19.68 ± (2.17)
Baseline Pulse rate - Mean (SD)	72.55 ± (6.4)

3.3 SPO_2 Trend with Use of Different Types of Facemasks

Overall, the comparison of the SPO_2 trend according to the type of face masks used showed that there was no significant difference in the Mean SPO_2 using the various mask P =1.00 (Fig. 3). All participants irrespective of type of face masks used maintained SPO_2 levels above 97%.

However, among those using the N95 face masks, there was an initial drop in Mean SPO_2 level at 2 hours to 97.2%; with a rise to 98.3% by 3 hours. This difference between the 2nd and 3rd hour SPO_2 among those using N95 face mask was significant (Mean difference -0.370, 95% CI, -0.726 to -0.013, p=0.034). Thereafter, the SPO_2 level in those using N95 remained comparable to those wearing other types of face mask.

3.4 Comparison of Respiratory and Pulse Rates Pre and Post Facemask Use

The mean respiratory and pulse rates of the participants were within normal values both at baseline and Post-8 hours face mask use. There was no significant difference in the Pre (baseline) and Post 8-hours face mask respiratory rate (RR) and pulse rate (PR) across the different variables in the study participants except in Gender (Table 3). Males had significantly lower RR and PR when compared to females (Mean difference -0.243 (95% CI: -0.443 to -0.044, P=0.017) at baseline. However, after 8hours of face mask use, there was an increase in respiratory rate for males while the females had a decrease in respiratory rate, although the difference in trend according the gender was not statistically significant. Pulse rate was also significantly lower for males when compared to females (mean difference -0.765 (95% CI: -1.123 to -0.407, P= 0.0001) Table 3; Figs. 4. and 5.

3.5 Factors Associated with having SPO_2 ≥ 98% Over 8 Hours of Face Mask Use

The SPO_2 of the participants was consistently greater than 98% in all measurements in 80(36.4%) of our participants. The likelihood of consistently maintaining SPO_2 at ≥ 98% at all readings was decreased among those age 50-60yrs (OD: 0.29, 95% CI: 0.10, 0.79. P=0.012) and doctors (OD: 0.3, 95% CI: 0.17, 0.54. P=0.00003) when compared to their younger counterparts and other health care workers respectively (Table 4).

4. DISCUSSION

The study shows that the Mean blood oxygen saturation (SPO_2) of the study population was maintained well within the normal values of 95 to 100% [16] across the eight hours duration of consistent use of any type of face mask. This finding is important because it shows that the continuous use of face mask by health care workers does not pose an adverse risk to their blood oxygen saturation; and as such, adherence to the WHO guidelines on use of face mask for prevention of COVID 19[2] can be practiced without anxiety of its effect on blood oxygenation. More so, the most recurring (Median) SPO_2 recorded in this study was 98% suggesting a normal, steady maintenance of SPO_2 similar to findings in a study done by Nku et al. [17] in Calabar, Southern Nigeria where normal controls were found to have a Mean SPO_2 of 98.11%. When used as cut-off for value, over one-third of our study participants had SPO_2 level consistently at, or above 98% especially in the younger age group and health workers other than doctors. The reason for this is likely

physiological as older individuals have lower SPO_2 levels compared to younger age groups [18] and doctors are more represented in the older age groups in this study.

Although there were isolated SPO_2 readings less than normal for few of the participants at some point in the course of the 8 hours, the lowest reading of 87% recorded in a single participant at a single point was surprising and may be spurious as subsequent readings for the said participant were normal, and no underlying chronic illness was disclosed by the participant.

Despite the overall Mean SPO_2 trend being normal throughout the duration of the 8-hours, there were subtle significant differences in the SPO_2 trends for the different age groups and for type of face mask used. However, when subjected to further analysis, the trend specifically for the type of facemask used showed a slight deep in the SPO_2 levels among those using N95 face masks at 2 hours with a recovery by 3 hours, compared to other types of facemask. This may be due to the fact that the N95 face mask have a better air seal and this may affect initial physiologic adaptation compared to others types of face masks. Similar

adaptations have been noted with use of N95 and other face masks for prolong periods in health workers [12,13]

The prolonged use of face masks had no significant effect on the respiratory and heart rates of the participants as their respiratory and heart rates were maintained within normal levels both at baseline and after 8 hours of face mask use. However, male had significantly lower baseline respiratory and heart rates compared to females even though by the 8th hour of face mask use, there was an insignificant rise in respiratory and heart for the males while the females had a slight reduction in rates. These variations are most likely due to normal body physiology adaptations as have been noted in a commentary by Scheid et al. [12] which stated that the prolonged use of different types of face mask had no impact on respiratory rate and heart rate. Other studies have documented similar adaptive mechanisms [19,20]. These findings suggests that the heart and lungs adapted to the use of face masks for prolong period quite well; as such, adherence to face mask use in COVID 19 prevention may have no adverse effect on heart and respiratory function.
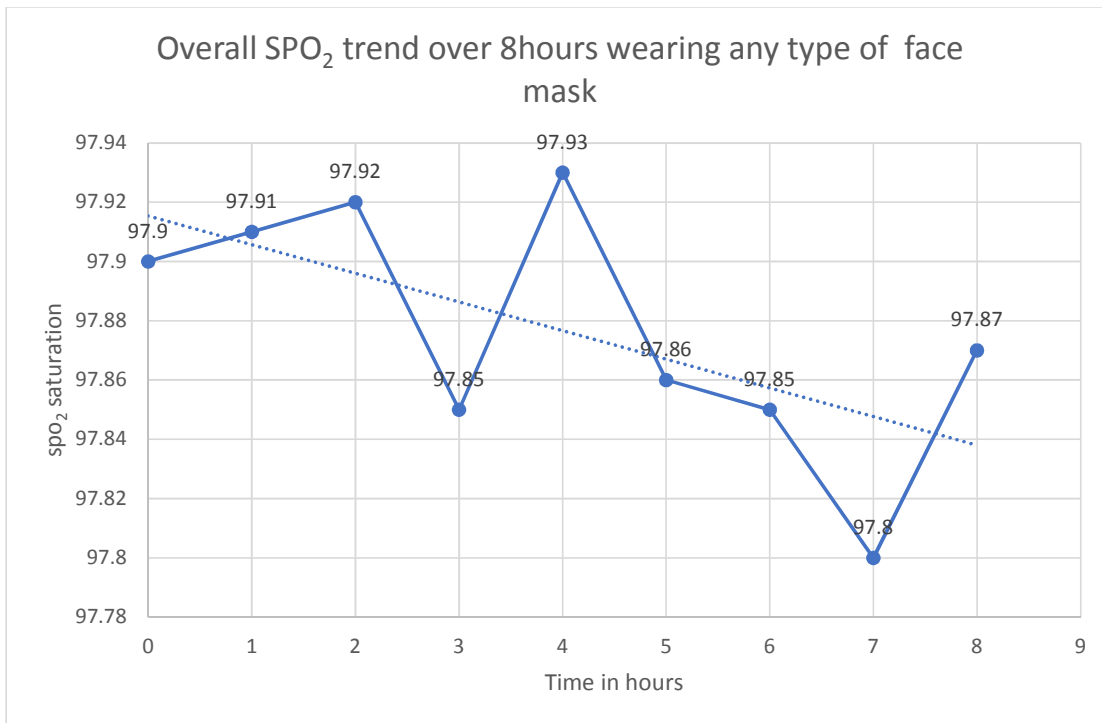

Fig. 1. Overall SPO$_2$ trend over 8 hours wearing any type of face mask
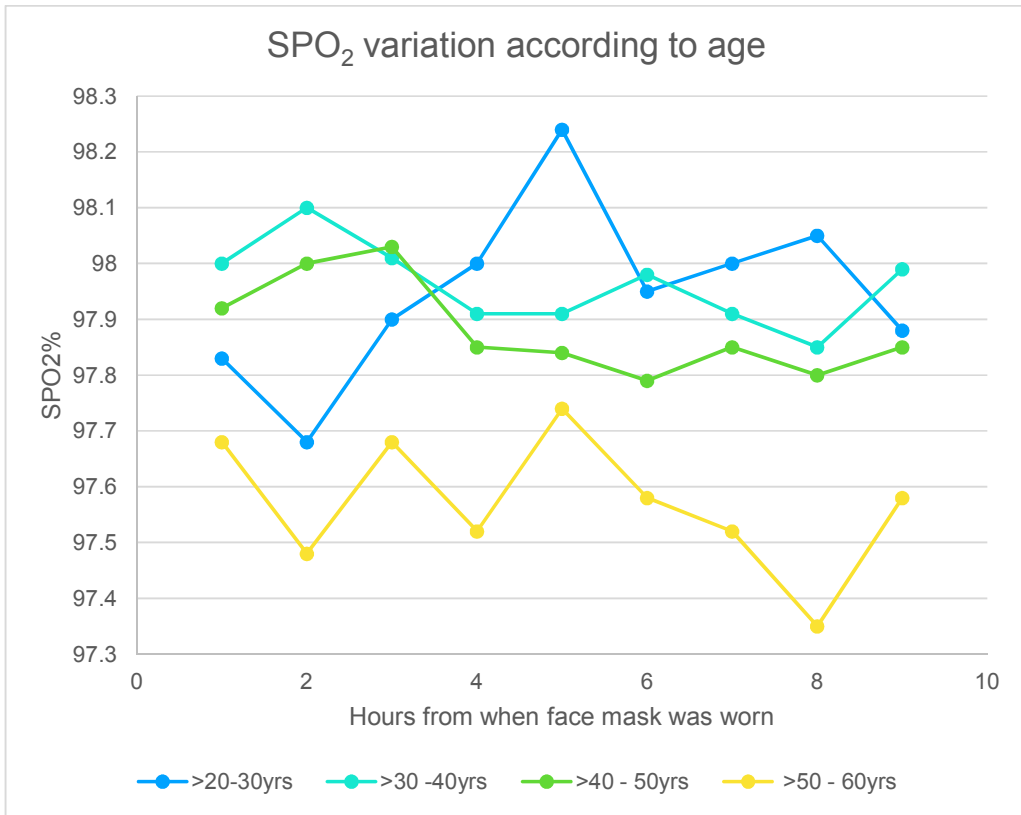*Greenhouse-Geisser sig= 0.300*

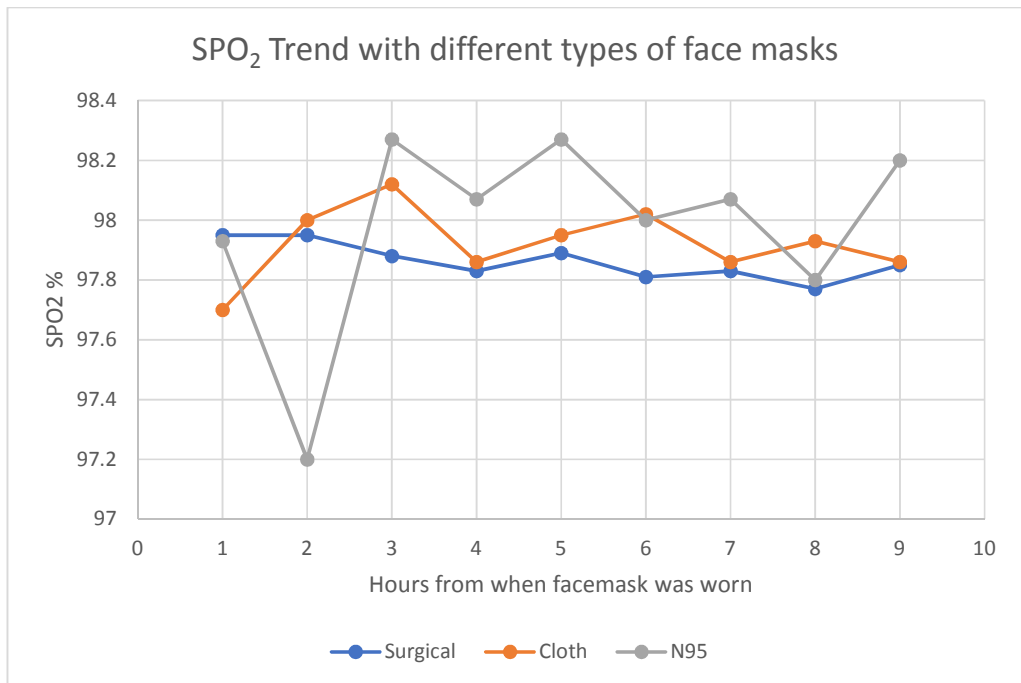**Fig. 2. SPO$_2$ variation according to age**

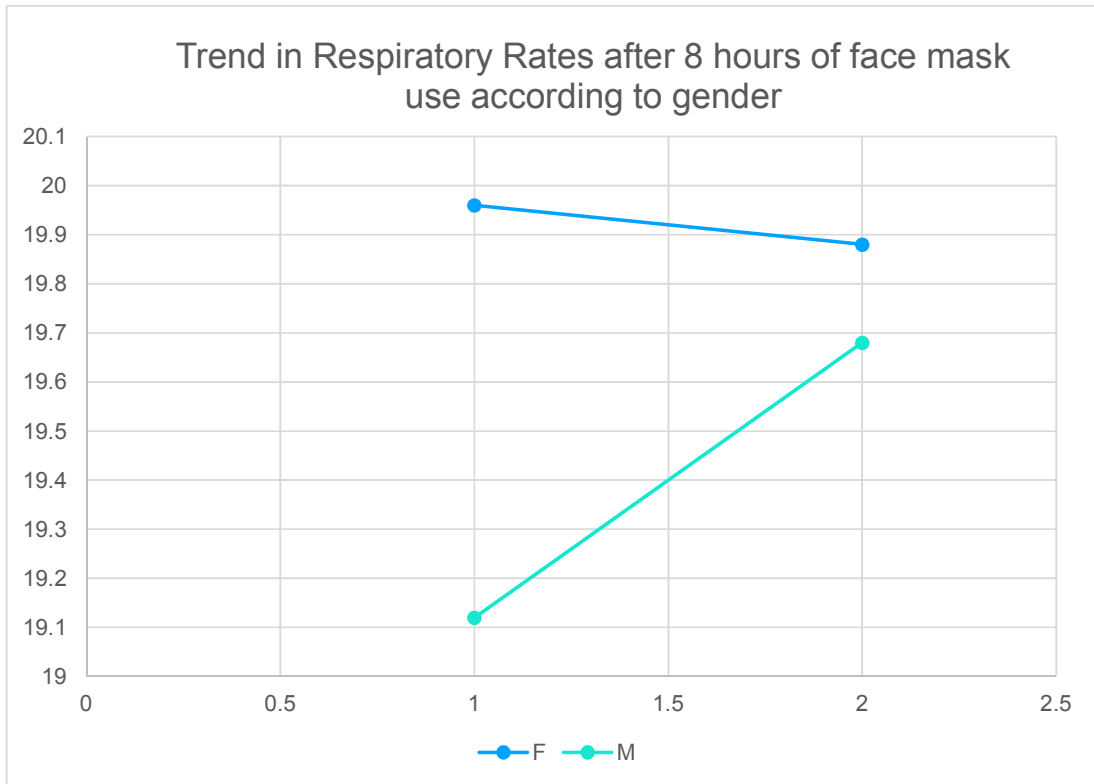**Fig. 3. SPO$_2$ Trend with different types of face masks**

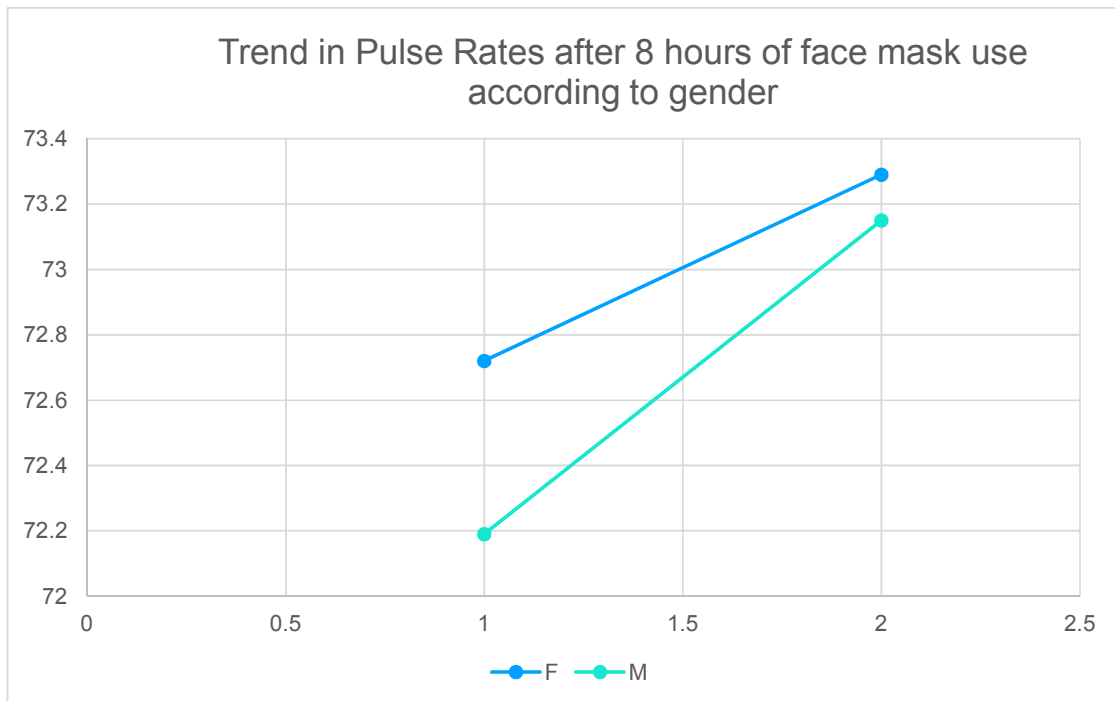**Fig. 4. Trend of respiratory rate according to gender after 8hours of face mask use**

Fig. 5. Trend of pulse rate according to gender after 8 hours of face mask

Table 2. Comparison of SPO$_2$ Trend over 8 hours with variables

Variable	Oxygen Saturation SPO$_2$ (%)									Mean	SD	P-value
Hours	0	1	2	3	4	5	6	7	8			
Age(years)												
20 - 30	97.83	97.68	97.9	98	98.24	97.95	98	98.05	97.88	97.95	0.16	0.02
> 30 - 40	98	98.1	98.01	97.91	97.91	97.98	97.91	97.85	97.99	97.96	0.07	
> 40 -50	97.92	98	98.03	97.85	97.84	97.79	97.85	97.8	97.85	97.88	0.08	
> 50 - 60	97.68	97.48	97.68	97.52	97.74	97.58	97.52	97.35	97.58	97.57	0.12	
Sex												
Female	97.91	97.93	97.92	97.85	97.91	97.86	97.85	97.76	97.9	97.88	0.05	0.67
Male	97.88	97.86	98.01	97.86	97.96	97.88	97.86	97.89	97.82	97.89	0.06	
Work												
Doctor	97.86	97.81	97.85	97.79	97.91	97.85	97.79	97.77	97.78	97.82	0.05	0.45
Nurse	97.96	98.01	98.12	97.95	97.95	97.84	97.95	97.81	98.01	97.96	0.09	
OHW	98	98.4	98	98	98	98.2	98	98.2	98	98.09	0.15	
Mask												
Surgical	97.95	97.95	97.88	97.83	97.89	97.81	97.83	97.77	97.85	97.86	0.06	0.01
Cloth	97.7	98	98.12	97.86	97.95	98.02	97.86	97.93	97.86	97.92	0.12	
N95	97.93	97.2	98.27	98.07	98.27	98	98.07	97.8	98.2	97.98	0.33	
Illness												
Yes	97.57	97.71	97.43	97.57	97.57	97.57	97.57	97.43	97.57	97.89	0.05	0.08
No	97.91	97.92	97.97	97.86	97.94	97.87	97.86	97.82	97.88	97.55	0.08	

OHW= Other health workers

Table 3. Comparison of Respiratory Rate (RR) and Pulse Rate (PR) pre and post 8hours of face mask use

Variables	Pre- face mask RR	Post-face mask RR	P-Value	Pre-mask PR	Post-mask PR	P-Value
Age years						
20 – 30	19.39	19.59	0.769	71.2	72.15	0.331
>30 – 40	19.77	20		72.38	73.36	
>40 – 50	19.52	19.51		73.52	73.84	
Gender						
Female	19.96	19.88	0.002	72.72	73.29	0.0001
Male	19.12	19.68		72.19	73.15	
Designation						
Doctor	19.33	19.65	0.058	72.15	72.94	
Nurse	20.14	20		73.51	74.12	
Others	20.8	20.6		70.4	70.6	
Chronic Illness						
No	19.7	19.84	0.8	72.5	73.29	0.26
Yes	19.14	19.14		73.86	72	
Face Masks						
Surgical	19.54	19.67	0.519	72.77	73.39	0.718
Cloth	20.26	20.3		72.42	73.33	
N95	19.53	20.07		70.47	71.47	

Table 4. Factors associated with having $SPO_2 \geq 98\%$ over 8-hours of wearing face mask

Variable	SP02 ≥98% 80 (%)	SPO_2≤ 98% 140(%)	Total n (%↓)	OD	95% CI	P-value
Age 50 – 60yrs						
Yes	5(16.1)	26(83.9)	31(14.1)	0.29	0.10, 0.79	0.012
No	75(39.7)	114(60.3)	189(85.9)			
Gender						
F	56(38.1)	91(61.9)	147(66.8)	1.25	0.69, 2.26	0.44
M	24(32.9)	41(67.1)	73(33.2)			
Health worker						
Doctors	34(25.6)	99(74.4)	133(60.5)	0.3	0.17, 0.54	0.00003
Others	46(52.9)	41(47.1)	87(39.6)			
Chronic illness						
Yes	1(14.3)	6(85.7)	7(3.18)	0.21	0.03, 2.39	0.21
No	79(37.1)	134(62.9)	213(96.8)			
Surgical mask						
Yes	57(35.2)	105(64.8)	162(73.6)	0.82	0.45, 1.5	0.54
No	23(39.7)	35(60.3)	58(26.4)			
Cloth Mask						
Yes	18(41.9)	25(58.1)	43(14.6)	0.60	0.31, 1.16	0.12
No	137(54.3)	115(45.6)	252(85.4)			
N95 Mask						
Yes	5(33.3)	10(66.7)	15(6.8)	0.86	0.28, 2.63	0.86
No	75(36.6)	130(63.4)	205(93.2)			

5. CONCLUSION

The continuous use of face masks for 8 hours irrespective of age and type has no significant effect on the blood oxygen saturation of health care workers (p=0.3). Although, the Mean SPO_2 trend was maintained above normal throughout the duration of the 8-hours for all, there were subtle significant differences in the SPO_2 trends for the different age groups as older age group had comparatively lower Mean SPO_2 (p=0.032). Among those using the N95 mask, there was a

significant drop in Mean SPO_2 at the 2nd hour with a recovery by the 3rd hour (p= 0.34). Respiratory rates, pulse rates and SPO_2 trend were maintained within normal limits over the course of face mask use, suggesting adequate physiologic adaptation.

6. RECOMMENDATIONS

The study recommends the continuous use of face masks by health workers in the course of their normal duties, as a precaution in the face of the COVID 19 pandemic.

7. LIMITATIONS

The study is limited to health care workers and as such generalization to the public should be applied with caution. Also, the pulse oximetry (SPO_2) is not an exact reflection of the arterial - oxyhemoglobin saturation (SaO_2) in all situations.

ACKNOWLEDGEMENT

ETHICAL APPROVAL AND CONSENT

Permission for the study was obtained from the hospital administration and informed consent was obtained from the participants, which included House Officers, Postgraduate Resident doctors, Consultants, and Nurses/Midwifes, Pharmacist, Physiotherapist in the four clinical departments of Medicine, Surgery, Paediatrics and Obstetrics & Gynecology.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World Health Organization. Coronavirus disease (COVID-19) pandemic.
Available:
https://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/novel-coronavirus-2019-ncov
2. World Health Organization. Modes of transmission of virus causing COVID-19: implications for IPC precaution recommendations.
Available: https://www.who.int/news-room/commentaries/detail/modes-of-transmission-of-virus-causing-covid-19-implications-for-ipc-precaution-recommendations
3. Wang J, Du G. COVID-19 may transmit through aerosol. Ir J Med Sci. 2020;1–2.
DOI: 10.1007/s11845-020-02218-2. (1971–)
4. Morawska L, Cao J. Airborne transmission of SARS-CoV-2: The world should face the reality. Environ Int. 2020;105730 .
DOI: 10.1016/j.envint.2020.105730.
5. Shiu EYC, Leung NHL, Cowling BJ. Controversy around airborne versus droplet transmission of respiratory viruses: Implication for infection prevention. Curr Opin Infect Dis. 2019;32: 372–379.
DOI: 10.1097/QCO.0000000000000563.
6. Kwok YLA, Gralton J, McLaws ML. Face touching: A frequent habit that has implications for hand hygiene. Am J Infect. Contr. 2015;43:112–114.
DOI: 10.1016/j.ajic.2014.10.015.
7. World Health Organization (WHO). Infection prevention and control during health care when novel corona virus (nCoV) infection is suspected. Interim guidance; 19 March 2020. WHO 2020.
8. Sjodin H, Wilder-Smith A, Osman S, Farooq Z, Rocklov J. Only strict quarantine measures can curb the corona virus disease (COVID-19) outbreak in Italy. Euro Surveill. 2020;25.
9. Siegel JD, Rhinehart E, Jackson M, Chiarello L. Health care infection control practices advisory committee. Guideline for isolation precautions: Preventing transmission of infectious agents in health care settings. Am J Infect Control. 2007 Dec;35(10 Suppl 2):S65-164.
10. Washington DC. Institute of Medicine (IOM) National Academy of Sciences. Preventing transmission of pandemic influenza and other viral respiratory diseases: Personal protective equipment for healthcare personnel update 201 : The National Academies Pres; 2010.
11. FDA. Masks and N95 Respirators.
Available:
https://www.fda.gov/MedicalDevices/ProductsandMedicalProcedures/GeneralHospitalDevicesandSupplies/PersonalProtectiveEquipment/ucm055977.htm
12. Schied JL, Lupien SP, Ford GS, West SL. Commentary: Physiological and psychological impact of face mask usage during the COVID-19 pandemic. Int J

Environ Res Public Health. 2020;17(18): 6655.
Available:https://doi.org/10.3390/ijerph171 86655

13. Beder A, Büyükkoçak U, Sabuncuoğlu H, Keskil ZA, Keskil S. Preliminary report on surgical mask induced deoxygenation during major surgery. Neurocirugia (Astur). 2008;19(2):121-126.
DOI: 10.1016/s1130-1473(08)70235-5

14. Parsons J. Do masks cause lower oxygen levels? The Ohio State University Wexner Medical center.
Available:https://wexnermedical.osu.edu/bl og/masks-oxygen-levels

15. Dattel AR, O'Toole NM, Lopez G, Byrnes, KP. Face mask effects of CO2, Heart rate, respiration rate, and oxygen saturation on instructor pilots. Collegiate Aviation Review International. 2020;38(2):1-11.
Available:http://ojs.library.okstate.edu/osu/i ndex.php/CARI/article/view/8038/7412

16. World health Organization (WHO). Pulse oximetry training manual.
Available:https://www.who.int/patientsafety /safesurgery/pulse_oximetry/who_ps_puls e_oxymetry_training_manual_en.pdf?ua=1

17. Nku CO, Peters EJ, Esheit I, Oku O, Osim EE. Lung function, oxygen saturation and symptoms among street sweepers in Calabar, Nigeria. Nigerian Journal of Physiological Sciences. 2005;20(1-2):79-84.

18. Doyle GR, McCutcheon JA. Clinical procedures for safer patient care. British Columbia Institute of Technology.
Available:https://opentextbc.ca/vitalsign/ch apter/what-are-normal-oxygen-saturation-levels/

19. Roberge RJ, Coca A, Williams WJ, Powell JB, Palmiero AJ. Physiological impact of the N95 filtering facepiece respirator on healthcare workers. Respir. Care. 2010;55:9.

20. Kenney WL, Wilmore JH, Costill DL. Physiology of Sport and Exercise, 7th ed, Human kinetics: Champaign, IL, USA; 2020.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/62680