

BLOOD OXYGEN SATURATION AND PROLONG FACE MASK USE IN HEALTHCARE WORKERS IN PORT HARCOURT NIGERIA, IN THE COVID 19 PANDEMIC ERA

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 (SPO₂) 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 SPO₂ was done at Zero hour. Subsequently, serial hourly SPO₂ 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.

RESULTS: There were 220 participants with more females 147(66.8%). Doctors constituted 133(60.5%). The baseline pre-facemask Mean SPO₂ was 97.9% ±0.75. The Median SPO₂ was 98%.

The overall SPO₂ trend across 8 hours was maintained above 97.7% for all participants. Age was significantly associated with differences in SPO₂ trend (P=0.032) (P=006); while Type of Facemask use had no significant effect on mean SPO₂ 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 SPO₂ level, with physiologic adaptation of respiratory and pulse rates.

KEYWORDS: Blood oxygen saturation, Face masks, Health workers, COVID 19 Pandemic.

INTRODUCTION

With the onset of the COVID 19 pandemic declared by the WHO on March 11th 2020¹, 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-2²⁻⁵. As such, the universal use of face masks has been advocated as a means to control transmission in public places², 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 (SPO₂) 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 SPO₂.

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. 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/Midwives, Pharmacist, Physiotherapist in the four clinical departments of Medicine, Surgery, Paediatrics and Obstetrics & Gynecology. The study participants had their baseline respiratory rates, baseline pulse rates and baseline SPO₂ taken at the onset before adorning their mask (zero hour). The SPO₂ 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 (SPO₂) 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)
Gender	
Female	147(66.8)
Male	73(33.2)
Job Description	
<i>Doctors</i>	133(60.5)
Consultants	31
Senior Registrar	18
Junior Registrar	33
Interns	51
<i>Nurses</i>	77(35.0)
<i>Other health workers</i>	
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 SPO₂ levels over time (SPO₂: 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 SPO₂ 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.

RESULT

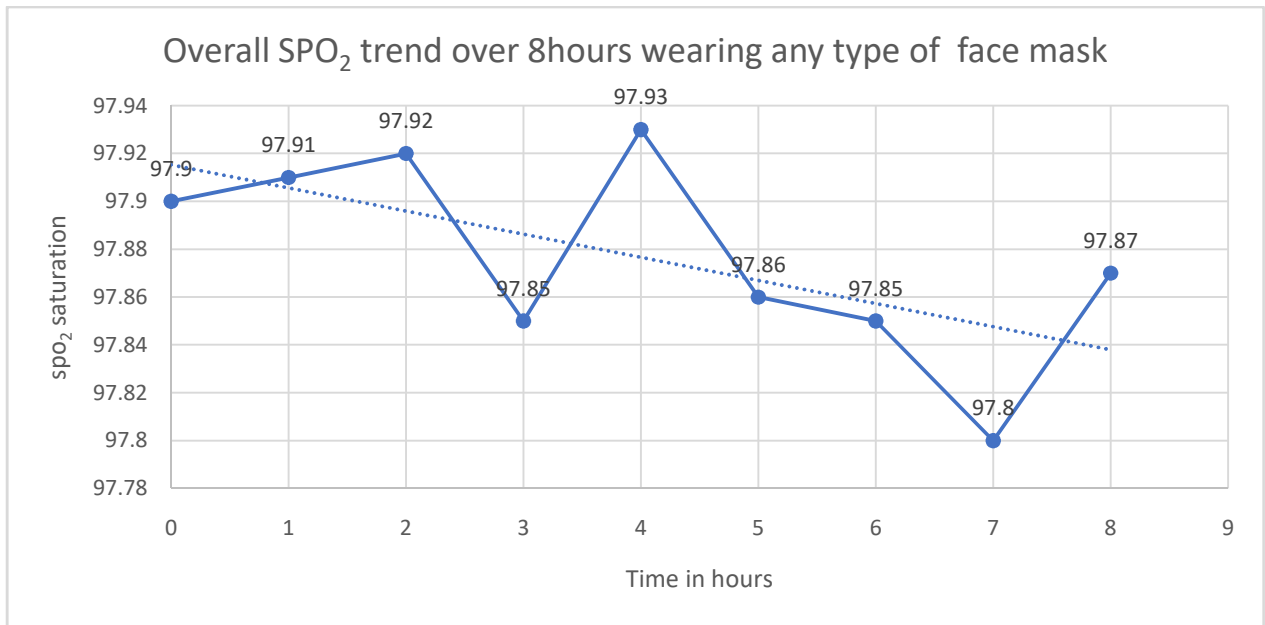
Table I shows the base line Mean SPO₂, respiratory and heart rates of the study participants before the use of facemask. The Mean SPO₂ was 97.9% ± 0.75.

Table I: 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)

Over all SPO₂ trend of study population over 8 hours

The median SPO₂ was consistently 98% at baseline to the end of 8 hours. The minimum SPO₂ recorded (only once, and in only one subject) was 87%, and the maximum was 99%. The overall Mean SPO₂ was 97.90%. There was an initial gradual increase in the Mean SPO₂ 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 SPO₂ levels that settled at 97.87% at 8 hours. There was however no significant statistical difference in the overall trend or pattern of SPO₂ (P= 0.3). This is illustrated in Figure 1.



Greenhouse-Geisser sig= 0.300

Figure 1: Overall SPO₂ trend over 8hours wearing any type of face mask

Comparison of SPO₂ Trend with variables in the study population

Table II shows the comparison of the SPO₂ 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 SPO₂ trend.

Table II: Comparison of SPO₂ Trend over 8 hours with variables

Variable	Oxygen Saturation SPO ₂ (%)									Mean SD		P-value
	0	1	2	3	4	5	6	7	8			
Hours												
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

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 SPO₂ 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 **Figure 2**

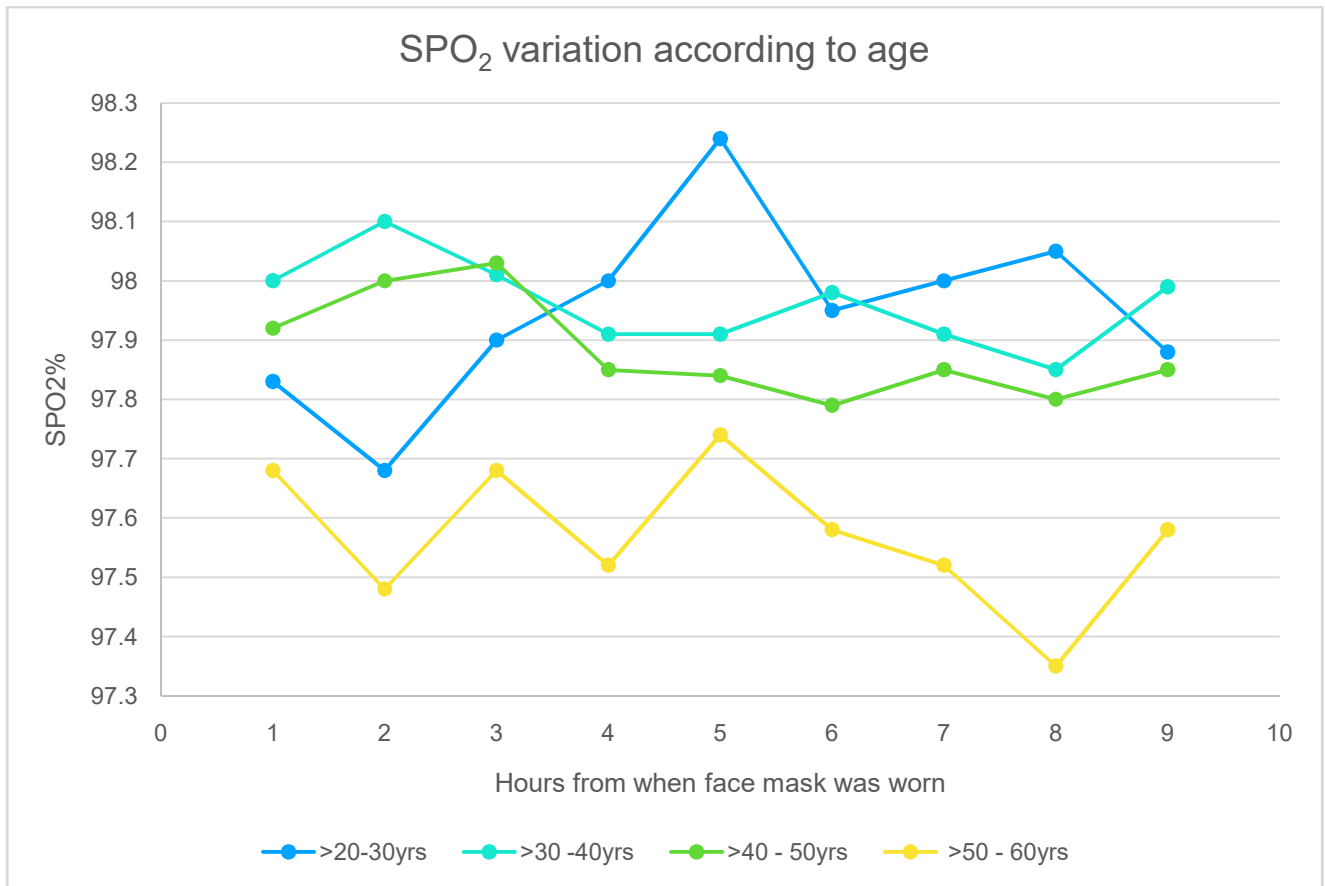


Figure 2: SPO₂ variation according to age

SPO₂ Trend with use of different types of facemasks

Overall, the comparison of the SPO₂ trend according to the type of face masks used showed that there was no significant difference in the Mean SPO₂ using the various mask P =1.00 (Figure 3). All participants irrespective of type of face masks used maintained SPO₂ levels above 97%. However, among those using the N95 face masks, there was an initial drop in Mean SPO₂ level at 2 hours to 97.2%; with a rise to 98.3% by 3 hours. This difference between the 2nd and 3rd hour SPO₂

among those using N95 face mask was significant (Mean difference -0.370, 95% CI, -0.726 to -0.013, p=0.034). Thereafter, the SPO₂ level in those using N95 remained comparable to those wearing other types of face mask.

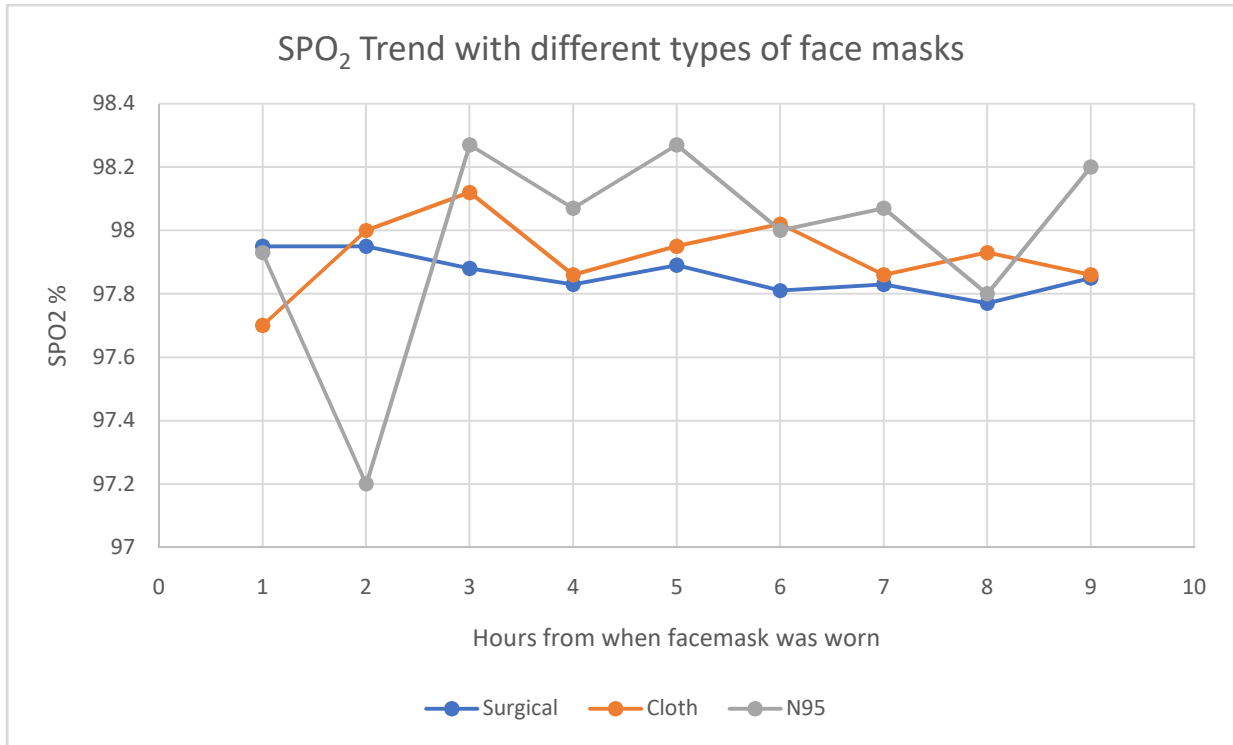


Figure 3: SPO₂ Trend with different types of face masks

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 III). 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 III; Figure 4 and 5

Table III: 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	
>50 - 60	20.13	20.23		72.87	73.23	
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	

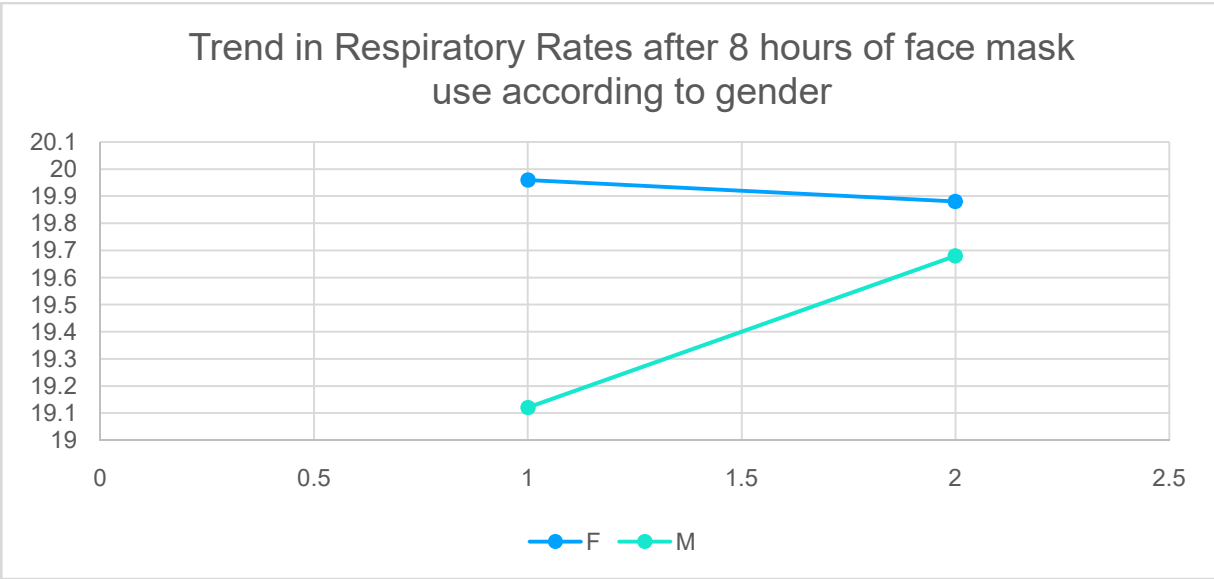


Figure 4: Trend of respiratory rate according to gender after 8hours of face mask use

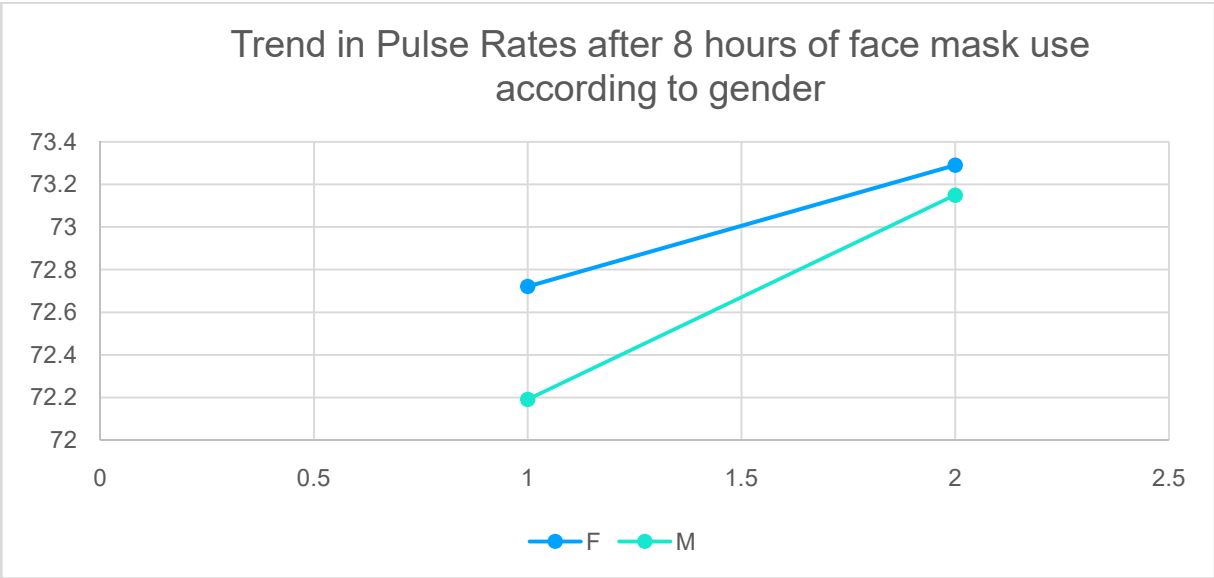


Figure 5: Trend of pulse rate according to gender after 8 hours of face mask

Factors associated with have SPO₂ ≥ 98% over 8 hours of face mask use.

The SPO₂ of the participants was consistently greater than 98% in all measurements in 80(36.4%) of our participants. The likelihood of consistently maintaining SPO₂ 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 IV)

Table IV: Factors associated with having SPO₂ ≥ 98% over 8-hours of wearing face mask

Variable	SPO₂ ≥98% 80 (%)	SPO₂ ≤ 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)			

DISCUSSION

The study shows that the Mean blood oxygen saturation (SPO₂) 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 19² can be practiced without anxiety on its effect on blood oxygenation. More so, the most recurring (Median) SPO₂ recorded in this study was 98% suggesting a normal, steady maintenance of SPO₂ similar to findings in a study done by Nku et al¹⁷ in Calabar, Southern Nigeria where normal controls were found to have a Mean SPO₂ of 98.11%. When used as cut-off for value, over one-third of our study participants had SPO₂ 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 SPO₂ levels compared to younger age groups;¹⁸ and doctors are more represented in the older age groups in this study.

Although there were isolated SPO₂ 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 SPO₂ trend being normal throughout the duration of the 8-hours, there were subtle significant differences in the SPO₂ 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 dip in the SPO₂ 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 al¹² 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.

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 SPO₂ trend was maintained above normal throughout the duration of the 8-hours for all, there were subtle significant differences in the SPO₂ trends for the different age groups as older age group had comparatively lower Mean SPO₂ ($p=0.032$). Among those using the N95 mask, there was a significant drop in Mean SPO₂ at the 2nd hour with a recovery by the 3rd hour ($p= 0.34$). Respiratory rates, pulse rates and SPO₂ trend were maintained within normal limits over the course of face mask use, suggesting adequate physiologic adaptation.

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.

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 (SPO₂) is not an exact reflection of the arterial - oxyhemoglobin saturation (SaO₂) in all situations.

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