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Original Research

An Observational Study of the Respiratory Effects of the N95 Mask During the Covid-19 Pandemic

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ABSTRACT:
Aim: An Observational Study of the Respiratory Effects of the N95 Mask During the Covid-19 Pandemic. **Method and material:** Pulse oximetry was used on 50 students from both sexes who were 21-26 years old, non-smokers, and did not have any chronic lung illness and were studying at Dental College and Hospital. During the research, the blood oxygen saturation was measured using the same pulse oximeter. The pupils were then advised to don a mask and not remove it until the completion of an assessment. After 5 hours, each student's blood oxygen saturation was tested again using the same pulse oximeter. Results: Total 50 students with mean age of 22.59±3.69 years were recruited in this study, among which 36 were females and 14 were males. It was discovered that before wearing the N95 mask at 8.30 am, the mean of SpO2 values was 97.02±0.21, however after removing the N95 mask at 1.30 pm, the mean of SpO2 values was 96.14±0.33 (p=0.000). When SpO_2 values of males and females were compared, it was observed that males have 0.41 and females have 0.34 of standard error of mean (p=0.52). A statistically non significant difference was seen for the values between the groups (p>0.05). **Conclusion:** Blood oxygen saturation levels have dropped due to prolonged usage of a N95 mask by COVID-19 patients. Finding ways to mitigate these consequences is crucial for future pandemic preparedness.
Keywords: COVID-19, SpO2, N95 mask

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INTRODUCTION

A number of local health officials reported clusters of patients with pneumonia of unclear aetiology in late December 2019, which were epidemiologically connected to a seafood market in Wuhan, China. The pathogen, a new coronavirus (SARS-CoV-2), was found by local hospital utilising a monitoring method for "pneumonia of uncertain aetiology". The World Health Organization (WHO) named CoViD-19 a "public-health emergency of worldwide significance" on January 30, 2020.[1] The viral epidemic quickly became a public health issue and expanded rapidly to other regions of the globe.[2]

In this perilous condition, the WHO and CDC have advised using a N95 respirator mask as a prophylactic step.[3] COVID-19 virus, according to research, spreads by respiratory droplets and contact routes.[4] As a result, the use of masks is advised in order to prevent and restrict the spread of respiratory virus illnesses.

The N95 respirator is a respiratory protection equipment authorised by the National Institute of Occupational Safety and Health (NIOSH) that is primarily used to reduce aerosol exposure. The word "N95" denotes that the respirator blocks at least 95% of 300 nm test particles.[5] The N95 respirator is a "respiratory protection equipment intended to provide an extremely tight face fit and highly effective filtration of airborne particles," according to the FDA (N95 Respirators, Surgical Masks, and Face Masks.[6] However, there are certain drawbacks to wearing the N95 masks for extended periods of time, such as nausea, shortness of breath, complaints of vision difficulties, headache, lightheadedness, and trouble communicating .[7]

The amount of oxygen carried by red blood cells is indicated by the blood oxygen level. Blood oxygenation is critical in ensuring that muscles, the brain, and other organs get the energy they need to operate effectively. An observational research including 52 surgeons using surgical masks revealed a reduction in arterial O2 saturation from roughly 98% before surgery to 96% after surgery lasting 1-4 hours.[8]

Although statistically significant, these results were not clinically significant.

Typical pulse oximeter values range from 95 to 100%. Values less than 90% are considered low and signal the need for more oxygen. This is known as hypoxemia, and its symptoms include severe shortness of breath, an elevated heart rate, and chest discomfort. According to a research conducted by Rebmann et al., prolonged (12 h) usage of masks (N95 respirator or N95 respirator with a surgical mask overlay) is related with headaches, lightheadedness, shortness of breath, and a drop in blood oxygen saturation.[7]

The major goal of this research was to determine if wearing a N95 mask for 5 hours influenced blood oxygen saturation levels.

METHOD AND MATERIAL

Pulse oximetry was used on 50 students from both sexes who were 21-26 years old, non-smokers, and did not have any chronic lung illness and were studying at Dental College and Hospital. They were afebrile, hemodynamically stable, and breathing room air. They had no history of Corona virus infection or positive contact history.

Students were given disposable sterile valve-less N95 masks, and the mask position remained constant during the assessment (never below the nose). During the research, the blood oxygen saturation was measured using the same pulse oximeter. Participants were urged to talk and act normally during the assessment session. The pulse oximeter was placed on the second finger of the right hand for all measurements. The experiment lasted five days in a row. Before donning a mask, each student's temperature and blood oxygen saturation were monitored. The pupils were then advised to don a mask and not remove it until the completion of an assessment (approximately 5 hrs). After 5 hours, each student's blood oxygen saturation was tested again using the same pulse oximeter. Students were shown how to put on and remove a N95 mask while using correct sanitization techniques.

The data was statistically analysed using the Statistical programme for social sciences (SPSS v 25.0, IBM). Descriptive statistics such as frequencies and percentages for categorical data, as well as mean and standard deviation for numerical data, have been displayed.

The normality of numerical data was tested using the Shapiro-Wilk test, and it was discovered that the data followed a normal curve; hence, parametric tests were utilised for comparisons. The paired t test was used for intragroup comparison (upto 2 observations). $p<0.05$ was deemed statistically significant for all statistical tests.

RESULTS

Total 50 students with mean age of 22.59±3.69 years were recruited in this study, among which 36 were females and 14 were males.

Table 1 Gender and age of the participants

Gender	Number	Percentage
Male	14	28
Female	36	72
Age		
below 20	7	14
20-22	16	32
22-24	17	34
above 24	10	20
Mean age	22.59±3.69	

Table 2 compares the SpO2 levels of all students before and after wearing the N95 mask. It was discovered that before wearing the N95 mask at 8.30 am, the mean of SpO2 values was 97.02±0.21, however after removing the N95 mask at 1.30 pm, the mean of SpO2 values was 96.14±0.33 (p=0.000). For all 50 students, there was a statistically significant difference in values between time intervals ($p<0.01$), with higher values at 8.30 am and lower values at 1.30 pm.

Table 2.comparison of SpO_2values of all students before and after wearing N95 mask

	Before wearing N95 mask	After removing N95 mask	P value
SpO_2values	97.02±0.21	96.14±0.33	0.001

Table 3 compares the SpO2 levels of male students before and after wearing the N95 mask. It was discovered that before wearing the N95 mask at 8.30am, the mean of SpO2 values was 96.74±0.31, whereas after removing the N95 mask at 1.30 PM, the mean of SpO2 data was 96.07±0.44 (P=0.000). For 14 male students, there was a statistically significant difference in values across time periods (P0.01), with greater values at 8.30 am and lower values at 1.30 pm.

Table 3 Comparison of SpO_2values of male students before and after wearing N95 mask

	Before wearing N95 mask	After removing N95 mask	P value
SpO_2values	96.74±0.31	96.07±0.44	0.001

Table 4 compares the SpO2 levels of all female students before and after wearing the N95 mask. It was discovered that before wearing the N95 mask at 8.30 am, the mean of SpO2 values was 97.58±0.26, however after removing the N95 mask at 1.30 pm, the mean of SpO2 data was 95.87±0.18 (p=0.001). For 36 female students, there was a statistically significant difference in values across time periods (p<0.01), with higher values at 8.30 am and lower values at 1.30pm.

Table 4 Comparison of SpO_2values of Female students before and after wearing N95 mask

	Before wearing N95 mask	After removing N95 mask	P value
SpO_2values	97.58±0.26	95.87±0.18	0.001

When SpO_2 values of males and females were compared, it was observed that males have 0.41 and females have 0.34 of standard error of mean (p=0.52). A statistically non significant difference was seen for the values between the groups (p>0.05).

DISCUSSION

In this investigation, we discovered a substantial fall in blood oxygen saturation levels after wearing a N95 mask for 5 hours. Data showed that there was a significant difference in blood oxygen saturation reduction between males and females. However, when the blood oxygen saturation levels of males and females were compared after 5 hours, there was no significant difference. Filtering face piece respirators (FFRs) are protective devices used to reduce airborne particulate exposure in a variety of workplaces.[9]

An N95 respirator is a respiratory protective device that is designed to provide a very close facial fit while also filtering airborne particles very efficiently. The respirator's edges are meant to produce a seal around the nose and mouth. Surgical N95 Respirators are a subset of N95 Filtering Facepiece Respirators (FFRs), which are commonly used in healthcare settings.[6] N95 filters are constructed from several layers of woven synthetic material that has been electrostatically charged. N95 filters provide adequate protection from most airborne pathogens in the healthcare setting.[10] Even though these devices are designed to minimise breathing resistance as much as possible, a N95 respirator user will experience some level of breathing resistance. Hypoventilation can occur when there is enough breathing resistance, resulting in a reduction in the frequency and depth of breathing due to decreased oxygen levels and increased carbon dioxide (CO2).

The primary cause of significant discomfort while wearing a N95 FFR is hypoventilation.[11]

However, Roberge et al2010 .'s study found that this hypoventilation did not pose a significant risk to healthcare workers after less than one hour of continuous N95 use.[12] When healthcare workers work for longer periods of time without rest while wearing a N95 mask, blood CO2 levels may rise above the 1-hour mark, which may have a significant physiological effect on the wearer.[13]

Among the known physiological effects of increased CO2 concentrations are:

1. Headache; increased intracranial pressure;
2. Nervous system changes (e.g., increased pain threshold, decreased cognition - altered judgement, decreased situational awareness, difficulty coordinating sensory or cognitive abilities and motor activity, decreased visual acuity, widespread sympathetic nervous system activation that can counteract the direct effects of CO2 on the heart and blood vessels);
3. Increased frequency of breathing;
4. Increased "work of breathing," caused by breathing through a filter medium.
5. Cardiovascular effects (e.g., decreased cardiac contractility, peripheral vasodilation);
6. Less tolerance for lighter workloads.

To avoid such negative effects, the balance between the protection provided by N95 respirators and the burden imposed by these respirators must be met with a plan to reduce the burden. Healthcare workers should find a safe place to remove their respirators in order to reduce CO2 buildup and the negative physiological effects that come with it. Individuals' health and safety depend on taking breaks during work shifts. The potential physiological burden caused by PPE use is an unfortunate side effect that can be easily remedied with some fresh air and proper self-care. Dehydration can be a significant issue when working in high-risk environments while wearing PPE. Dehydration may contribute to the experience of physiological burdens such as headache, dizziness, intense thirst, and reduced cognition. As a result, healthcare workers must be aware of the importance of proper hydration, especially if their PPE causes significant sweating due to heat exposure. Drink 1 ml or 1 oz of fluid for every 1 ml or 1 oz of body weight lost as a rule of thumb. Similarly, eating healthy food is necessary in part because calories are required to provide energy for healthcare workers to continue their work.[14] Various alternative respirators have been made available to prevent the spread of airborne infections. Because of their reusability, Elastomeric Respirators (EHMRs) may be a viable alternative to N95 FFRs.[15] However, the physiological burden on the wearer when wearing an EHMR is more likely to cause anxiety than when wearing FFRs.[16] The increased breathing resistances found in EHMRs can cause a decrease in breathing frequency and an increase in tidal volume. Another reusable alternative to N95 FFRs is the Powered Air- Purifying respirator (PAPR). The physiological benefit of PAPRs is that they have a fan that blows fresh air through the filter; therefore, there should not be any sense of breathing resistance as experienced with a N95 FFR or an EHMR. However, there may be other psycho physiological effects resulting from the constant noise produced by the PAPR motor, such as headache, distraction, anxiety, difficulty communicating with others in the room to mention a few.[14]

CONCLUSION

Blood oxygen saturation levels have dropped due to prolonged usage of a N95 mask by COVID-19 patients. Finding ways to mitigate these consequences is crucial for future pandemic preparedness. Future care of adverse effects associated to continuous use of masks should include scheduled breaks, enhanced hydration and rest, and maybe newly designed comfortable masks.

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