



# Examination of Physiological Changes Seen in Workers Using Breathing Masks During COVID-19 Pandemic

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## Abstract

**Background:** There are very few studies in the literature evaluating the effects of mask use on physiological parameters.

**Objectives:** This study aims to examine physiological changes due to masks in healthcare workers who use respiratory masks for long hours in the emergency room during the pandemic process.

**Methods:** Cross-sectional and prospective study was carried out with healthcare professionals with an FFP2 type valve mask. The participants' transcutaneous oxygen saturation, pulse, and respiratory rate were measured before wearing the respirator mask and at 30 and 60 minutes after wearing the mask.

**Results:** SPO2 values of the participants decreased gradually at 0th, 30th, and 60th minutes and respiratory rate increased gradually at 0th, 30th, and 60th minutes. The statistically significant difference arises from the 0 and 60 minutes values. Higher SPO2 values were found at 0 and 30 minutes in non-smokers. SPO2 value gradually decreased in non-smokers at 0, 30, and 60 minutes, but no significant decrease was observed in non-smokers. Pulse rate was found to be higher at 60th minute compared to 0th minute in non-smokers. No significant difference was found between smokers and non-smokers. The respiratory rate gradually increased in smokers at 0th, 30th, and 60th minutes. SPO2 values were lower at the 60th minute compared to the 0th minute in both women and men. There was no significant difference in pulse rates. Respiratory rate was found to be higher at 60th minute in men than at 0th minute.

**Conclusion:** It is recommended to follow the physiological parameters and to regulate the working conditions when necessary.

**Keywords:** COVID-19 Pandemic, Pandemics, N95 FFRs, Respiration, Vital Signs

## 1. Background

The coronavirus disease 2019 (COVID-19) pandemic, which started at the end of 2019 and was caused by a new type of coronavirus, continued throughout 2020.<sup>1,2</sup> The World Health Organization (WHO) declared this disease with the 2nd highest contagiousness of the 21st century as a pandemic on March 11, 2020.<sup>3</sup> Clinically, the disease often presents with lower and upper respiratory tract infections such as cough, sore throat, and fever. Respiratory tract infections are transmitted by contact and droplets, causing rapid effects on large masses and significant losses. Acute lower respiratory tract infections are among the top three causes of death and disability globally, both among children and adults.<sup>4</sup> Clinical studies and animal studies on the transmission mechanism of COVID-19 disease show that it can be transmitted by sneezing, coughing, respiratory secretions, droplet tract, direct body contact, and surface

contact; showed that close contact poses a risk.<sup>5</sup>

In the prevention of the spread of diseases, there are cases with the reverse-transcriptase polymerase chain reaction (RT-PCR) test, quarantine practices, closure of schools, distant education, not leaving home except for critical situations, travel restrictions, hand hygiene, use of masks and social isolation.<sup>6,7</sup> Although masks are not considered a measure alone, they are recommended because they contribute to social isolation and prevent droplets that can be spread by coughing and sneezing.<sup>8</sup> Provided that certain criteria are met, the masks have two commonly used types: medical-surgical masks and respiratory protective masks (FFP, N95).<sup>9</sup>

For healthcare professionals dealing with patients with or suspected COVID-19. While, WHO considers medical masks sufficient except for medical interventions that droplets may contaminate, the European Center for

Disease Prevention and Control (ECDC) and the United States Center for Disease Control and Prevention (CDC) recommend that FFP masks be worn in all routine care.<sup>10-12</sup> The mask is worn to protect the environment as a preventive barrier against the respiratory spread of droplets from the wearer. Before the COVID-19 pandemic, healthcare workers used medical masks mostly during interventional surgical procedures. However, after the pandemic, many centers use it as additional protection for employees in daily practice.<sup>13</sup> During the COVID-19 pandemic, all healthcare professionals use surgical masks during non-COVID-19 patient examination and treatment processes. FFP and N95 masks are used in diagnosis, treatment, and follow-up processes of diagnosed or suspected COVID-19 patients and interventional procedures with transmission risk. Studies argue that masks are a mechanical barrier that makes respiratory work difficult and has physiological effects.<sup>14-16</sup> In our clinic, it has been observed that some healthcare professionals stated that they experienced breathing difficulties due to the use of masks.

## 2. Objectives

This study examines physiological changes (respiratory rate, heart rate, transcutaneous oxygen saturation) due to masks in healthcare workers who use respiratory masks for long hours in the emergency room during the pandemic process.

## 3. Methods

### 3.1. Study Design

This cross-sectional and prospective study was carried out with healthcare professionals working in Turkey's emergency department and practice hospital and pandemic polyclinic. Informed consent was taken from all participants.

### 3.2. Data Collection

Healthcare workers were informed about the study, and written consent was obtained from those who volunteered. Participants' age, gender, smoking, and chronic diseases were questioned. All participants participated in the study with Wogl brand FFP2 NR EN-149: 2001+A1: 2009 model FFP2 type valve mask. The participants' transcutaneous oxygen saturation, pulse, and respiratory rate were measured before the respirator mask (0 minutes) and at 30 and 60 minutes after wearing the mask.

Participants with a known chronic respiratory disease, acute upper and lower respiratory tract symptoms, anatomical problems that made breathing difficult in the upper airways, and who had to remove their masks due to increased discomfort were excluded from the study. In addition, participants who did not have the measurements taken at the specified times; removed the mask during the study were also excluded from the study.

A study in the literature was used to determine the minimum sample size to be included in this study.<sup>15</sup> Accordingly, the minimum number of individuals,

sampled at 60% statistical power with a 95% confidence interval and 5% type 1 error, was detected 58. The simple random sampling method was performed for the sample selection.

### 3.3. Statistical Analysis

The compliance of the data to normal distribution was tested with the Shapiro-Wilk test. Student *t* test was used to compare normally distributed features in two independent groups, and the Mann-Whitney U test compared non-normally distributed features in two independent groups. Repeated ANOVA and Bonferroni post hoc test for features showing normal distribution at repetitive times, Friedman test for non-normally distributed features, and Wilcoxon test corrected as Post-hoc test. As descriptive statistics, mean  $\pm$  standard deviation for numerical variables, minimum-maximum values, and number and % values for categorical variables are given. SPSS Windows version 23.0 package program was used for statistical analysis, and  $P < 0.05$  was considered statistically significant.

## 4. Results

A total of 60 healthcare workers were included in the study. The median age of the participants was 26 (25-29), 3% ( $n=5$ ) had comorbid disease, 40% ( $n=24$ ) were smoking and 58.3% ( $n=35$ ) were male (Table 1).

The transcutaneous SPO2 values of the participants decreased gradually at the 0th, 30th, and 60th minutes ( $P=0.001$ ). There was no significant difference in pulse rates. However, the respiratory rate increased gradually at the 0th, 30th, and 60th minutes. The statistically significant difference arises from the 0 and 60 minutes values ( $P=0.002$ ) (Table 2).

Participants' smoking status and physiological parameters were compared. Higher SPO2 values were found at 0 and 30 minutes in non-smokers ( $P < 0.05$ ). SPO2 values gradually decreased in non-smokers at 0, 30, and 60 minutes ( $P=0.001$ ), but no significant decrease was observed in non-smokers ( $P=0.055$ ). Pulse rate was higher at 60th minute compared to 0th minute in non-smokers ( $P=0.029$ ). However, no significant difference was found

**Table 1.** Descriptive Data

Parametre	Value
Age [Median (Q1-Q3)(min-max)]	26 (25-29) (22-41)
<b>Gender (n,%)</b>	
Male	35 (58.3)
Female	25 (41.7)
<b>Comorbidity (n,%)</b>	
Yes	3 (5.0)
No	57 (95.0)
<b>Smoking (n,%)</b>	
Yes	24 (40.0)
No	36 (60.0)

SD: Standard deviation; min: Minimum; max: Maximum

**Table 2.** Comparison of Physiological Parameters at the 0th, 30th, and 60th Minutes

		Min- Max	Mean ± SD	P
SPO2	0	94-99	<sup>a</sup> 97.23 ± 1.23	0.001
	30	94-99	<sup>b</sup> 96.53 ± 1.16	
	60	93-99	<sup>c</sup> 96.05 ± 1.34	
Pulse	0	60-122	78.95 ± 11.18	0.252
	30	58-125	79.37 ± 10.61	
	60	55-102	79.21 ± 7.60	
Respiratory rate	0	12-22	<sup>a</sup> 15.46 ± 2.58	0.002
	30	12-28	<sup>ab</sup> 16.07 ± 3.01	
	60	13-30	<sup>b</sup> 16.64 ± 2.93	

SD: Standard deviation; min: Minimum; max: Maximum. *P* was obtained from the Friedman test, and within each row, different letters superscript indicate significant differences ( $P < 0.05$ ) according to the Wilcoxon test *P* values subject to finner adjustment.

between smokers and non-smokers. The respiratory rate gradually increased in smokers at the 0th, 30th, and 60th minutes ( $P = 0.002$ ) (Table 3).

Physiological parameters were compared with gender. SPO2 values were lower at the 60th minute than the 0th minute in both women and men ( $P < 0.05$ ). There was no significant difference in pulse rates. However, the respiratory rate was higher at the 60th minute in men than at the 0th minute ( $P = 0.003$ ) (Table 4).

## 5. Discussion

A mask is used to protect against respiratory diseases transmitted by droplets. Whether masks provided effective protection before the COVID-19 pandemic was controversial, and there was little or no evidence that it was effective.<sup>17,18</sup> At the beginning of the COVID-19 pandemic, there were opinions that the use of masks would not be

**Table 3.** Comparison of the 0th, 30th, and 60th-Minute Values of Smoking Factor and Physiological Parameters

		Smoking		Non-smoking		<i>P</i> <sup>a</sup>	<i>P</i> <sup>b</sup>
		Min-Max	Mean ± SD	Min- Max	Mean ± SD		
SPO2	0	94-98	96.46 ± 1.4	96-99	<sup>a</sup> 97.75 ± 1.00	0.001	0.122
	30	94-98	95.91 ± 1.11	95-99	<sup>b</sup> 96.92 ± 1.02	0.001	
	60	93-98	95.59 ± 1.47	94-99	<sup>c</sup> 96.34 ± 1.19	0.038	
	<i>P</i> <sup>c</sup>	0.055		0.001			
Pulse	0	60-108	80.13 ± 9.75	65-122	<sup>a</sup> 78.14 ± 12.14	0.508	0.110
	30	58-103	77.86 ± 9.93	68-125	<sup>ab</sup> 80.31 ± 11.06	0.401	
	60	55-102	79.45 ± 10.40	68-90	<sup>b</sup> 79.06 ± 5.23	0.851	
	<i>P</i> <sup>c</sup>	0.195		0.029			
Respiratory rate	0	12-22	<sup>a</sup> 14.96 ± 2.79	12-22	15.79 ± 2.41	0.232	0.133
	30	12-28	<sup>ab</sup> 15.68 ± 3.76	12-22	16.32 ± 2.42	0.442	
	60	13-30	<sup>b</sup> 16.77 ± 3.57	14-26	16.56 ± 2.48	0.792	
	<i>P</i> <sup>c</sup>	0.002		0.295			

SD: Standard deviation; min: Minimum; max: Maximum.

<sup>a</sup> Comparison within groups (Mann Whitney U tests); <sup>b</sup> Comparison between a subject (Two ways repeated ANOVA); <sup>c</sup> Comparison between groups (repeated ANOVA).

**Table 4.** Comparison of 0th 30th, and 60th-Minute Values of Gender Factor and Physiological Parameters

		Male		Female		<i>P</i> <sup>a</sup>	<i>P</i> <sup>b</sup>
		Min-Max	Mean ± SD	Min-Max	Mean ± SD		
SPO2	0	95-99	<sup>a</sup> 97.14 ± 1.02	94-99	<sup>a</sup> 97.36 ± 1.28	0.504	0.279
	30	94-98	<sup>ab</sup> 96.65 ± 1.07	95-99	<sup>ab</sup> 96.38 ± 1.28	0.383	
	60	93-99	<sup>b</sup> 96.15 ± 1.35	94-99	<sup>b</sup> 95.91 ± 1.35	0.523	
	<i>P</i> <sup>c</sup>	0.001		0.002			
Pulse	0	60-95	76.09 ± 7.59	65-122	83.13 ± 14.12	0.016	0.351
	30	58-103	77.29 ± 8.23	68-125	82.43 ± 12.98	0.072	
	60	55-97	77.97 ± 7.94	72-102	81.14 ± 6.76	0.126	
	<i>P</i> <sup>c</sup>	0.354		0.334			
Respiratory rate	0	12-22	<sup>a</sup> 15.49 ± 2.68	12-22	15.41 ± 2.46	0.914	0.041
	30	12-28	<sup>a</sup> 15.88 ± 3.25	12-22	16.36 ± 2.66	0.564	
	60	13-30	<sup>b</sup> 17.06 ± 3.47	14-20	16.00 ± 1.66	0.186	
	<i>P</i> <sup>c</sup>	0.003		0.070			

SD: Standard deviation; min: Minimum; max: Maximum.

<sup>a</sup> Comparison within groups (Mann Whitney U tests); <sup>b</sup> Comparison between a subject (Two ways repeated ANOVA); <sup>c</sup> Comparison between groups (repeated ANOVA).

## Research Highlights

### What Is Already Known?

The mask is worn to protect the environment as a preventive barrier against the respiratory spread of droplets from the wearer. Healthcare professionals work long hours in closed environments with these masks. However, the use of masks is a mechanical barrier that makes respiratory work difficult and has physiological effects.

### What Does This study Add?

This study showed that physiological values remained within normal limits, but there was a decrease in SPO<sub>2</sub> and an increase in the respiratory rate due to a mask. While the respiratory rate increased in smokers, pulse and SPO<sub>2</sub> values did not change. In non-smokers, the pulse rate increased, while SPO<sub>2</sub> values decreased. Therefore, planning breaks to remove masks in clean areas for healthcare workers who have to wear breathing masks for a long time under pandemic conditions. Considering the complaints of the healthcare professionals who cannot tolerate, it is recommended to follow the physiological parameters and regulate the working conditions when necessary.

effective.<sup>19,20</sup> However, the aggravation of the pandemic has led to the need for reconsideration of prevention methods. New studies have strengthened the view that the mask is protective.<sup>21-23</sup> It is especially recommended that healthcare workers work with respirator-type masks, and healthcare professionals work long hours in closed environments with these masks.<sup>22</sup>

The use of breathing masks for long hours is a situation that can be considered as a mechanical barrier for air intake and exit from the upper airways. Discomfort and respiratory distress due to prolonged use of respirator masks have been emphasized in some studies, and their effects on vital signs have been studied.<sup>24-26</sup> In the study of Biçen et al, healthcare workers who used breathing masks for a long time (>180 minutes) developed respiratory distress; a significant increase in heart rate and decrease in SPO<sub>2</sub> have been reported.<sup>26</sup> In the study of Roberge et al, it was shown that using a respiratory mask does not affect physiological parameters (such as respiratory rate, heart rate, SPO<sub>2</sub>).<sup>27</sup> Epstein et al showed that the use of masks (surgical and respiratory type) during exercise does not make a significant difference on physiological parameters (respiratory rate, heart rate, SPO<sub>2</sub>).<sup>28</sup> Our study found that the SPO<sub>2</sub> values of emergency healthcare workers using breathing masks decreased, and their respiratory rate increased. Moreover, our study included participants who did not feel uncomfortable with the mask. This study suggests that breathing masks create respiratory resistance in healthy individuals.

The adverse effects of smoking on respiratory functions are well known. One of the crucial causes of cardiovascular

and respiratory diseases and loss of function is smoking.<sup>29</sup> It can be thought that functional losses caused by smoking can trigger physiological changes by contributing to the mechanical barrier created by masks. However, there is not enough data in the literature on this subject. In the studies of Biçen et al, it was found that using masks did not affect the physiological values of smokers.<sup>15</sup> In our study, when the 0th and 60th-minute values of the non-smoker participants were examined, it was observed that their respiratory rate did not change ( $P>0.05$ ), but their pulse rate increased and SPO<sub>2</sub> values decreased ( $P<0.05$ ). On the other hand, in smokers, it was observed that the respiratory rate increased ( $P=0.002$ ), but the pulse and SPO<sub>2</sub> values did not change ( $P>0.05$ ). Participants who smoked did not have a known respiratory disease, but it is known that lung damage due to smoking starts in the small airways and affects respiratory functions in the long term.<sup>30</sup> The increase in the respiratory rate of smokers can be explained by the fact that the damage that started in the lung can still be compensated. Although SPO<sub>2</sub> values were within normal limits in both groups, smokers were lower than non-smokers at 0, 30, and 60 minutes ( $P<0.05$ ) explains this situation.

### 5.1. Limitation

The most important limitations of our work; (1) the small number of participants, (2) the inability to perform respiratory function tests on smokers before the study, (3) the participants who had breathing difficulties and could not tolerate the use of masks for a long time and removed their masks were excluded from the study.

## 6. Conclusion

There are very few studies in the literature evaluating the effects of mask use on physiological parameters. Although physiological values remained within normal limits in all participants; there was a decrease in SPO<sub>2</sub> and an increase in the respiratory rate due to mask. There was a decrease in SPO<sub>2</sub> and an increase in the respiratory rate due to mask. While the respiratory rate increased in smokers, pulse and SPO<sub>2</sub> values did not change. In non-smokers, the pulse rate increased, while SPO<sub>2</sub> values decreased. Suggestions, planning breaks to remove masks in clean areas for healthcare workers who have to wear breathing masks for a long time under pandemic conditions. Considering the complaints of the healthcare professionals who cannot tolerate, it is recommended to follow the physiological parameters and regulate the working conditions when necessary.

### Authors' Contributions

HS and MB developed the study concept, HS and MB performed testing, and data collection, data analysis, and interpretation were performed by HS, MB, TES, and HBA. All authors contributed to the study design and approved the final version of the manuscript for submission.



**Conflict of Interest Disclosures**

The authors report no known conflict of interest.

**Ethical Approval**

All procedures performed in studies involving human participants were following the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The local institutional ethics committee approved the study (Decision no: 2020/98; Date: 1 June 2020). Informed consent was taken from all participants.

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