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Reduction of Oxygen Saturation and Increase of Heart Rate in Hospital Workers Wearing Face Mask during Routine Shift

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Abstract

***Background & Aims*:** The COVID-19 pandemic forced healthcare workers to use Personal Protective Equipment (PPE) or at least wear gowns, gloves, and face masks during their working shifts. Previous research reports some problems such as headaches and itching due to the new working conditions. The present study was conducted to determine the possible physiological changes related to wearing face masks, in the current ongoing situation, among healthy hospital workers.

Materials & Methods: A questionnaire was administered to hospital personnel requesting them to measure their oxygen saturation level (SpO_2) and heart beats per minute (BPM) before and after their shifts. They used a pulse oximeter available in their hospital. Eighty-two hospital workers completed their forms, reporting their pre- and post-SpO_2 and BPM measurements.

***Results*:** Statistically, the comparison of data (before and after shifts) indicated a significant decrease in SpO_2 (98.68±1.56 versus 97.57±1.76, $p<0.01$) and an associated significant increase in BPM (82.86±7.21 versus 93.14±5.00, $p<0.001$). Also, there was no significant difference ($p>0.05$) between the mentioned responses for those who used N-95 masks (10 persons) and those who used surgical masks (72 persons).

***Conclusion*:** Although these changes were all in the reference range for healthy subjects, these fluctuations in the long term can cause physiological and psychological stress among hospital staff during the COVID-19 pandemic.

***Keywords*:** COVID 19, Face masks, Heart beats per minute, Hospital staff, long working shifts, Oxygen saturation level

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Introduction

In December 2019, an outbreak of the coronavirus disease (COVID-19) was reported in China. Scientists in the field described that the virus replicated in the upper respiratory tract with symptoms beginning in 5–14 days. The virus spread into many countries, including Iran in early 2020. Initial studies in China suggested that 20% of the total infected patients will require medical care, with 14% having severe illness and 5% showing critical condition, while the overall case-fatality rate was 2.3% (1).

Available evidence indicated that the virus is transmitted between people through close contact and droplets, not airborne transmission (2, 3). The individuals most at risk of infection are those who are in close contact with a patient or those who take care of infected patients (4). Since the COVID-19 pandemic has already infected millions of individuals worldwide and with no vaccine so far available, interventions to mitigate transmission are urgently needed (5). Travel restrictions, social distancing, washing hands regularly, and using face masks are valuable in limiting the spread of the virus (5). Some or all of these factors were imposed on the public by many governments, as suggested by the World Health Organization (WHO).

Healthcare workers are the first group that can get infected by the virus. For this reason, they use PPE such as gowns, protective eyewear (goggles or face shields), gloves, and different face masks to reduce the risk of transmission throughout their shifts (6, 7). Currently, working for longer hours with PPE may cause some health problems and stress for hospital workers. Migraines and headaches were reported among healthcare workers due to the prolonged use of face masks (6). Another problem, such as itching was reported due to the use of face masks by the general public (8). Scheid et al. (9) reported that transcutaneous CO_2 levels increased significantly during a 12-hour shift in nurses wearing either an N95 or surgical mask. However, this was not clinically important as CO_2 remained within healthy reference ranges (37-45 mmHg) (6). Different types of masks have different efficiency, usage time, alongside expiration dates (10). N95 masks, expired or not, have the best efficiency (over 95%) but can also cause suffocation for symptomatic patients by their secretions (10, 11). The lowest efficiency for masks are for homemade, cotton masks and loosely tightened surgical masks, which have an efficiency of one-third compared to fitted surgical masks (10, 11).

Normal oxygen saturation (SpO_2 measured by pulse oximeters) for a healthy person is usually between 95-100 percent (12). Oxygen levels between 90-95percent are still considered safe for healthy subjects, but severe for chronic obstructive pulmonary patients. It is reported that amounts below 90% become dangerous, and if the oxygen level drops below 80%, it would harm vital organs (4, 13). Overall, research conducted on mask usage and oxygen levels showed that although there is usually a decrease in the oxygen level, this level remains in the safe zone (14).

The normal heart rate is between 60-100 beats per minute (BPM) for adults in their resting state. The heart rate increases during exercise or heavy activities (15). This increase is a body response to maintain its efficient function and provides different organs with sufficient nutrition and oxygen (16). This indicates that the body is in times under stress and tension.

Our literature review did not show any publication about oxygen consumption and heart rate of healthcare personnel before and after long hour shifts while forced to always wear a face mask as a precautious step, during the COVID-19 pandemic. To illustrate the effects of these factors, the present study was conducted.

Materials & Methods

A questionnaire including name, age, occupation, duration of shift, and type of face mask used was administered to hospital workers in Tabriz and Kerman public hospitals. Hospitals' matron distributed the questionnaire among volunteer hospital staff and invited them to participate in this study. In the given form, the participants were requested to measure their oxygen saturation (SpO_2) and heart rates (BPM) using a general fingertip pulse oximeter available in their departments, before and after finishing their shift, using a 5-minute

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relaxation time for stabilisation of their oxygen consumption and heart rate. The proposed 5-minute relaxation time (17) helped reduce stress due to routine workload. In addition, we suggested fingertip pulse oximetry in this study, because it is a non-invasive mode of measuring oxygen saturation and heart rates (BPM) that is available in all hospitals and has the same working mechanism with a standard error of 1%, for all brands. Furthermore, all of participants were familiar with the use of an oximeter, and could use it, or record the reading data.

Two hundred questionnaires were distributed in hospitals in two cities of Iran: Kerman and Tabriz. The questionnaires were collected by the hospital's matron and given to us. The uncompleted forms were discarded, due to required missing information or necessary data. Eighty-two complete forms were included in the present study.

Statistical Analysis:

Data were analyzed using IBM SPSS (version 23) windows software. Different statistical tests such as frequency distributions, descriptive statistics, independent-sample t-test, and paired t-test were used, as needed. Significant differences were mentioned when p-values were less than 0.05.

Results

Since data were collected from two different states of Iran, first we analyzed the information of each province separately. In Tabriz, 34 nurses with an age range of 23-52 years (31.50±6.23) participated in the study. Nine of them were male and the remaining were female (n=25). Twenty-six subjects used surgical masks and 8 used N-95 masks. Analysis of collected data showed a significant ($p<0.01$) decrease in SpO_2 (98.21±1.43 verse 97.21±1.53) while their BPM increased significantly ($p<0.001$) from 82.33±7.51 to 92.08±3.68.

Kerman's hospital workers were 48 subjects with an age range of 22-58 years (34.35±7.87). Eighteen subjects were male and 30 were female. Among them, 2 used N-95 (2 subjects that worked in Hospital information system), while remaining used surgical face masks. Table 1 illustrates the occupation and gender of the participant in Kerman. Gathered data of this group also indicated a significant ($p<0.01$) decrease in SpO_2 (98.92±1.60 verse 97.83±1.88) while their BPM increased significantly ($p<0.001$) like the increase detected in Tabriz (83.50±7.17 verse 94.40±6.22).

Table 1. Summary of occupation, gender and age, SpO_2 and BPM of the participants in Kerman state. The values for ages are means ± SD, while values of SpO_2 and BPM are pre- and post-means according to their occupation

Occupations	Frequency	Percent	Male	Female	Age	SpO2	BPM
Nurse	11	22.9	0	11	39.45±3.36	97.82-96.64	84.25-97.50
Doctor	6	12.5	5	1	39.0±11.26	96.83-96.00	81.00-92.00
Operating Room Worker	13	27.1	7	6	33.23±8.65	99.85-98.38	83.23-92.75
Anaesthesiologist	8	16.7	2	6	29.75±1.98	100.00-99.25	82.43-93.24
Paramedic	7	14.6	4	3	31.29±8.41	100.00-99.43	84.41-94.26
Hospital Information System	3	6.3	0	3	30.67±7.37	97.67-96.00	87.00-93.00
Total	48	100.0	28	30	34.35±7.87	98.92-97.63	83.50-94.40

Due to the resemblance of fluctuation in SpO_2 and BPM among two groups of hospital workers in two cities, we recalculated the collected data of all participants as one group. Among the 82 participants in this study, 27 were male (32.9%) and 55 were female (67.1%). The average (mean ± standard deviation) of their age was 33.17 ± 7.34 years. Statistically, there was not a significant difference between the average age of males (34.63± 8.62 years) and females (32.45± 6.59 years) ($p>0.05$). Forty-five of the participants were nurses (8 males, 37 females), 6 of them were medical doctors (5 males, 1 female), 13 of them were operating

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room staff (7 males, 6 females), 8 of them were anesthesiologists (2 males, 6 females), 7 of them were paramedics (4 males, 3 females), and 3 of them were working in the hospital information department (1 male, 2 females).

Participants were not working in intensive care units (ICU) or were not in contact with COVID-19 patients. Due to the endemic of the coronavirus, they used face masks all the time, during their working hours. Three participants (one nurse and two doctors) were on 24-hour shifts; the remaining 79 participants worked for 6 to16 hours. The breakout of data indicated that nurses worked for 6-12 hours (8.30 ± 2.04), while doctors worked for 6-16 hours (10.50 ± 4.44). The operating room workers' shift was 10-12 hours (10.31 ± 0.75), and the anesthesiologist worked for 10 hours. Similarly, staff working in hospital information stations and paramedics worked for 10-14 hours (11.71± 1.38). Figure 1 shows working hours for all 82 participants according to their genders.

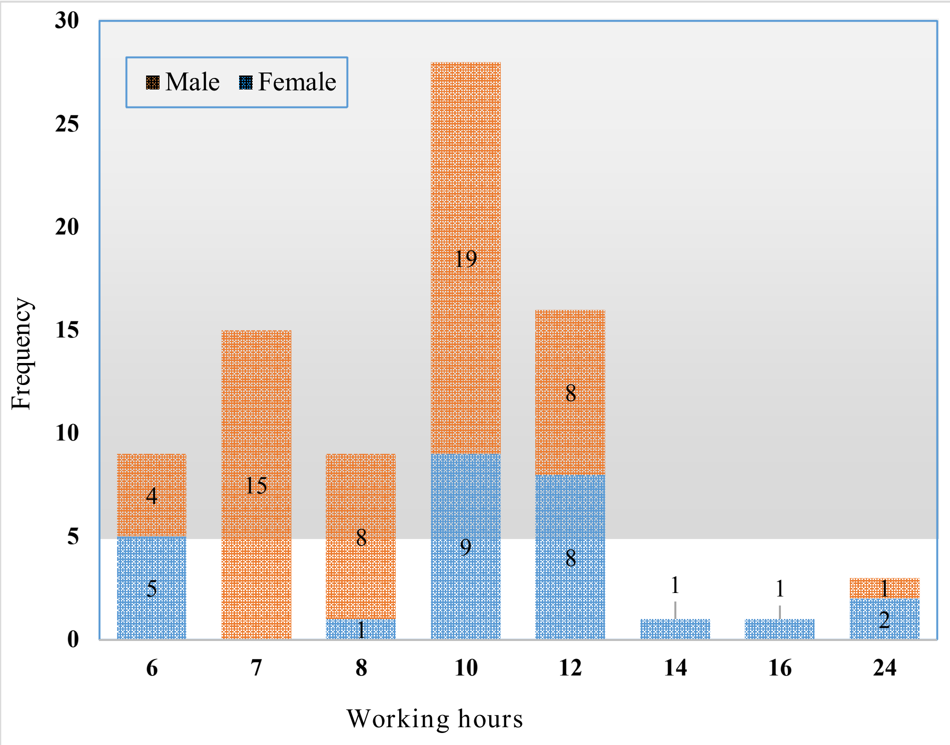

Fig 1. Working hours of 82 hospital workers that participanted in this study according to their gender. Forty-five of the participants were nurses (8M, 37 F), 6 participants were medical doctors (5 M, 1 F), 13 participants were operating room staff (7 M, 6 F), 8 of them were anesthesiologists (2 M, 6 F), 7 participants were paramedics (4 M, 3 F), and 3 participants were working in hospital information department.

Ten participants used N95 masks, and 72 participants used surgical masks during their shifts. Surgical masks used were tight, three-ply, paper-like, and disposable masks that are provided in hospitals and are manufactured locally in Iran (API Group, Shiraz, Iran). Statistically, pre- and post-oxygen consumption, and BPM were compared according to the type of masks used. Analyzed data showed that the oxygen saturation level of those who used surgical masks was 98.76%±1.58% before their shift, while it was 97.74%±1.78% after their shift. Corresponding data for those who used N95 masks were 97.6% ± 0.97% before their shift and 96.4 ± 1.17% after their shift. A two-tailed paired t-test also showed a significant reduction in oxygen saturation for both groups ($p<0.01$). The BPM for surgical mask users was 81.64 ± 6.73 that changed to 93.36 ± 5.54 after their shift. Corresponding data for N95 users were 85.0 ± 7.96 before their shift and

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92.75±4.23 after their shift. Statistically, a comparison of pre- and post-BPM showed a significant increase for both groups ($p<0.001$). On the other hand, there were no significant differences ($p>0.05$) between SpO_2 and BPM for those who used N95 masks (10 subjects) or surgical masks (72 subjects). Table 2 shows the breakdown of responses according to type of face masks.

Table 2. Comparison between surgical (n=72) and N-95 (n=10) masks did not indicate significant differences, while comparison of pre- and post-tests for both types of the masks were significant

	Mask type	Means ± SD	Comparison of face masks (p values)	Pre- and post-tests (p-value)
Pre-oxygen saturation	Surgical	98.76±1.58		
	N-95	97.60±0.97	0.20	
Post-oxygen saturation	Surgical	97.74±1.78		<0.001
	N-95	96.40±1.17	0.11	<0.004
Pre-heart rate per minute	Surgical	81.64±6.73		
	N-95	85.00±7.97	0.31	
Post-heart rate per minute	Surgical	93.36±5.54		<0.001
	N-95	92.75±4.23	0.77	<0.006

Discussion

The outbreak of the coronavirus disease in 2019 has spread rapidly and is now a global pandemic in 2020. Healthcare workers are among the first groups that may be infected by the virus. That is why they use heavy PPE to reduce the risk of transmission. Unfortunately, the use of such PPE during working hours may cause health problems for these staff (18). Our data indicate that wearing face masks during long working hours reduced oxygen saturation and increased heart rate among hospital workers. The association of hypoxia and increases in heart rate are well documented before in healthy subjects (15, 19-21) which could support our present results.

Statistically, responses to the different mask types did not show significant differences ($p>0.05$) between groups who used N95 masks (10 persons) and those who wore surgical masks (72 persons). We recalculated data for SpO_2 and BPM of all participants. Pre- and post-average values for SpO_2 were 98.62%±1.56% and 97.57%± 1.76%, respectively. Corresponding values for BPM were 82.86±7.21 and 93.14±5.0. Both changes with a 95% confident interval of difference were statistically significant ($p<0.001$). Reference oxygen saturation read by pulse oximeters usually ranges from 95-100 percent (12) and the reference range for heart rate of adults is 60-100 beats per minute (22). Both deviations we detected were within physiological ranges for healthy subjects. The reduction in oxygen saturation may be due to deterioration of mask worn for long period, by exhalation water and CO_2 (9). Other reasons may be tiredness or anxiety of getting infected by coronavirus, or stress of workload. To clarify the reason, further investigation is necessary.

The mean increase in heart rate beat was irretrievable even after 5-minute rest before taking the readings. Though part of this increase could be due to work stress and tiredness, some may be the effect of wearing face masks for a long period. These changes might lead to excessive personal stress and anxiety in long-terms that may be the reason for symptomatic headaches or other physiological problems mentioned before (6, 9). Other factors such as anxiety of being contaminated by the virus, work stress, dehydration, hypoglycemia, and fatigue (23, 24) could reduce SpO_2 and increase BPM among hospital workers.

In addition, our results indicate that there is no significant difference between N95 and surgical masks, while both of them may cause a reduction in oxygen uptake after 7–14-hour shifts. This statement is also

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supported by the published work that compared the filtration efficiency of N95 and surgical masks (25).

Results of the present study may be the first report showing reduction in SpO_2 and increase in BPM among hospital workers during a long shift. This study has some drawbacks due to the limited number of cases and self-reporting data by the participants, although all of them were familiar with the measurement of oxygen saturation by the figure oximeter. Another deficiency is the lack of corresponding data from hospital workers without the face mask, which is impossible due to pandemic of COVID-19 at present time. By conducting such research in future, it is possible to identify the reasons for changes detected in present study.

In conclusion headaches (6), itching in the face (26), work stress during the COVID-19 pandemic and other physiological changes that occur during 10–16-hour shifts may be the consequences of wearing masks by hospital workers, as reported before. The present study found a mild but significant reduction in oxygen consumptions and a recognizable increase in the heart rate among hospital workers, irrespective of the ward or department they work.

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Declaration of Competing Interest:

All authors report no conflicts of interest relevant to this article.

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