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Adverse effects associated with the use of N95 mask among health-care workers at the COVID-19 care units: A cross-sectional study in Sulaimani city, Iraq

Saad Abdulrahman Hussain, Naza Mohammed Ali Mahmood[1], Trefa Mohammed Ali Mahmood[2], Neega Aras Mohammed Salih[3], Zainab Saad Abdulrahman[4]

Department of Pharmacology and Toxicology, Faculty of Pharmacy, Al-Rafidain University College, Baghdad, Iraq, [1]Department of Pharmacology and Toxicology, College of Pharmacy, University of Sulaimani, Kurdistan Region, Iraq, [2]Department of Periodontics, Orthodontics and Prevention Dentistry, College of Dentistry, University of Sulaimani, Kurdistan Region, Iraq, [3]Department of Emergency Medicine, Shar Teaching Hospital, Sulaimani, Kurdistan Region, Iraq, [4]Department of Clinical Pharmacy, Al-Kindy Teaching Hospital, Baghdad, Iraq

Address for correspondence:
Dr. Saad Abdulrahman Hussain, Department of Pharmacology and Toxicology, Faculty of Pharmacy, Al-Rafidain University College, Baghdad 10052, Iraq.
E-mail: saad.hussain@ruc.edu.iq

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Abstract:

BACKGROUND: Health-care workers have to use the N95 mask as a part of the protection kit during the COVID-19 pandemic. The adverse effects of such practice are not fully elucidated. The study aims to evaluate negative impacts of N95 face masks on health-care personnel at COVID-19 care units.

MATERIALS AND METHODS: One hundred and twenty-two health-care workers (aged 20–58 years) from various health-care settings in Sulaimani, Iraq, from January to August 2020, were enrolled in this prospective, cross-sectional study. The physiological variables (blood pressure, heart rate, and oxygen saturation) were recorded before putting on the N95 mask and postremoval of the mask. The incidence of adverse effects such as headache, difficulty breathing, redness, irritation, and dizziness were also reported as a number and percent at the end of the work shift.

RESULTS: There was a statistically significant difference in the physiological parameters after removal of the mask compared with baseline. Only diastolic pressure was significantly lower in those working >6 h when compared to those working 1–6 h. The changes in physiological markers were poorly and nonsignificantly associated with the duration of wearing the mask. Moreover, 67.2%–70.5% of the participants complain of headaches and breathing difficulties, while 45.9%–51.6% reported signs of itching, redness, and irritation. However, health-care workers who put on the face mask >6 h showed signs of headache, breathing difficulties, and itching at the exposed areas higher than those working for 1–6 h.

CONCLUSION: N95 mask negatively impacts the physiological variables of health-care providers. The adverse effects may lead to excessive exhaustion after long shifts in the intensive care unit during treatment of COVID-19 patients.

Keywords:

Adverse effects, COVID-19 pandemic, health-care workers, hemodynamic changes, intensive care units, N95 mask, work shifts

Introduction

During the second decade of the 21st century, a pandemic infectious disease caused by human coronaviruses (CoVs) has emerged. It is characterized as a novel coronavirus (SARS-CoV2 or nCoV-19). The outbreak was identified in December 2019 in Wuhan city, China.[1] The rate of transmission among humans seems to be higher than SARS-CoV1 and MERS-CoV.[2] During such a global health

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crisis, health-care providers were mandated to use personal protective equipment including goggles, gowns, surgical gloves, and close-fitting N95 masks during contact with patients suspected of having infectious diseases such as SARS-CoV2.[3,4] This approach was followed during the outbreak of influenza A H1N1 in 2009. Guidelines for the use of N95-masks were adopted despite the inadequate evidence for their appropriateness in different health-care settings.[5-7] This face mask has also been advised as a protective facility during the current pandemic of SARS-CoV. However, little data were available about the negative impacts of N95-masks on the healthcare workers subjected to prolonged daily use of these masks, especially on the respiratory function.[8] The N95 respirator represents a critical part of the personal protective equipment kit in addition to gown, eye shield, and gloves. However, feeling of discomfort and stress while using this personal protective equipment adds an extra burden on the healthcare professionals and limits their working capacity.[9] The tolerability of the N95-mask and its physiological impacts during prolonged daily use on the medical staff remains undeclared.[10,11] Many studies have demonstrated the negative dermatological impact of prolonged mask-wearing on healthcare workers.[12,13] They include irritation, erythema, pigmentation, and contact dermatitis in the contact areas.[14] Based on our knowledge, no study was conducted in Iraq about the negative physiological impacts of long-term daily use of N95-mask in Iraqi healthcare providers during the care of SARS-CoV patients. Therefore, in the present study, we evaluated the changes in respiratory function, blood pressure (BP), and skin manifestations from wearing the N95-mask over long daily shifts at the intensive care units.

Materials and Methods

Study design and setting

This prospective, multi-center observational study was conducted in various healthcare settings in Sulaimani City, Iraq, from January to August 2020.

Study participants and sampling

All participants were asked to provide written informed consent before enrolment. The participants were healthcare providers involved in the care of patients infected with SARS-CoV2; they include physicians, dentists, pharmacists, nurses, lab technicians, and administrative assistance aged between 20 years and 58 years. All participants are healthy, and those with cardiac or respiratory comorbidities and pregnancy were excluded. Based on a simple formula for the calculation of sample size in observational studies,[15] a total of 135 healthcare providers were enrolled; only 122 of them completed the study. The participants need to have a regular breakfast and adequate water, in addition, to avoid extra strenuous activity before enrollment in the study. The ambient temperature of their working environment varied from 25 to 28°C and the relative humidity from 30% to 50%.

Data collection tool and technique

After reporting the demographic characteristics, the baseline measurements were performed at the early morning shift, which includes the systolic and diastolic pressure, pulse rate (heart rate [HR]), and oxygen saturation (SpO_2). The parameters were recorded using a pulse oximeter (CONTEC®, China). For all measurements, the finger probe was applied to the second finger of the right hand. At the end of the work shift of each participant, the duration was reported, in addition to the other measurements that include systolic and diastolic pressure, pulse rate (HR), and oxygen saturation (SpO_2). Moreover, the signs of headache, dizziness, breathing difficulties, itching, redness, and irritation of the face were reported after removing the mask. The participants were also instructed to remove the masks before the end of the work shift when feeling any discomfort and breach of the personal protective equipment.

Data analysis

Statistical analysis was performed using the SPSS Statistics (IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY, USA). Demographic data were presented as mean ± standard deviation (SD) or percentages. The physiological variables were also represented as mean ± SD and percentages. The difference between variables at various time points (baseline and post-mask removal) was evaluated using paired *t*-test. Meanwhile, comparisons based on the different duration of work shifts were performed using an unpaired *t*-test. Person's correlation was performed to predict the association of changes with the time of the shift. A $P < 0.05$ was considered statistically significant.

Ethical consideration

The study was approved and registered by the Research Ethics Committee, Al-Rafidain University College, Baghdad, Iraq (approval number: REC-11-2021). Enrollment in the study was voluntary and all data were de-identified.

Results

A total of 135 healthcare workers were recruited in this study, and only 122 of them completed the evaluation steps. As shown in Table 1, the participants were 56.6% females and 43.4 males with an age range of 20–58 years; they include 29 physicians, five dentists, three pharmacists, 44 nurses, 25 laboratory technicians,

and 16 social services workers. Moreover, the mean duration they put on N95-mask was 6.7 ± 2.4 h. Table 2 showed that both systolic and diastolic BP were significantly (P = 0.0003) decreased at the end of work shifts and put-off the mask compared with baseline values (2% and 2.8%, respectively). Meanwhile, significant elevation of the pulse rate (7%) was reported in association with a highly significant reduction in the SpO_2 values (4.3%) compared with baseline values. When the participants were stratified according to the time of work shift, Table 3 shows that diastolic pressure was significantly lower in those working >6 h when compared with those working 1–6 h. However, none of the other parameters significantly differ between the two groups. Correlation between the physiological markers (BP, pulse rate, and SpO_2) with the duration of wearing the mask indicated poor and nonsignificant association (low r values) of these markers with the work-time while putting on the masks [Figure 1a-d]. In Table 4, 67.2%–70.5% of the participants complained of headaches and breathing difficulties, while 45.9%–51.6% reported signs of itching, redness, and irritation after putting on the N95-mask. However, only 8.2% of the participants complain of dizziness. When the participants were stratified according to the time of the work shifts, Table 5 shows that the healthcare workers who put on the face mask >6 h demonstrated higher signs of headache, breathing difficulties, and itching at the exposed areas, compared with those working for 1–6 h.

Table 1: Demographic characteristics of the participants (*n*=122)

Parameter	Value
Gender, *n* (%)	
Male	53 (43.4)
Female	69 (56.6)
Age (years)	30.74±8.4
Bodyweight (kg)	70.9±15.1
BMI (kg/m^2)	25.2±4.3
Profession, *n* (%)	
Physician	29 (23.8)
Dentist	5 (4.0)
Pharmacist	3 (2.5)
Nurse	44 (36.1)
Lab technician	25 (20.5)
Social	16 (13.1)
Duration wearing mask (h)	6.7±2.4
Smoking habit, *n* (%)	11 (9.0)
Alcohol consumption, *n* (%)	5 (4.1)

BMI=Body mass index

Table 2: Effects of long-term use of N95 mask on blood pressure, pulse rate, and oxygen saturation in healthcare providers during the care of patients with severe acute respiratory syndrome coronavirus 2 infection (*n*=122)

Parameter	Before using mask	After removing the mask	*P*
Systolic BP (mmHg)	114.9±13.9	112.6±12.2	0.0003
Diastolic BP (mmHg)	73.9±9.1	71.8±8.3	0.0003
Pulse rate (beet/min)	82.6±8.8	88.3±9.1	<0.0001
SpO_2 (%)	97.7±1.9	93.5±3.3	<0.0001

Values were represented as mean±SD. SpO_2=Oxygen saturation, SD=Standard deviation, , BP=Blood pressure

Discussion

The novel SARS-CoV2 pandemic mandates respiratory protection by using the N95 face mask as a part of personal protective equipment to limit exposure in healthcare workers. However, such a type of protection is not free from certain adverse physiological consequences. The present study evaluated the changes in BP, pulse rate, SpO2, and certain adverse reactions due to the use of the N95 masks in the healthcare workers providing care to the hospitalized patients with SARS-CoV2 infection. The results showed a significant elevation in HR from baseline after long-term use of the N95 mask. This finding may be due to the physiological response to hypoxia and hypercarbia caused by the dead space of the N95 filter, which may be associated with the accumulation of carbon dioxide.[9,11] The reduced availability of O_2 and an increasing amount of CO_2 lead to increased HR exponentially, even at low workloads. Although BP was significantly decreased, the 2% reduction may not be clinically significant. Another study reported no changes in BP during 12-h work shifts.[16] Therefore, N95 mask-associated increase in HR after long-term use can be attributed to many factors such as breathing resistance, stressful workload, physical fitness, mask-associated anxiety, and increased retention of CO_2.[17,18] A previously reported data showed a significant decrease in SpO_2 in surgeons performing procedures longer than 60 min,[19] which is in tune with those reported in the present study since the change in oxygen saturation from the baseline to the end of work-shift was around 2%. These results were comparable to those reported during qualitative respirator-fit testing performed for N95-Filter between controls and tested subjects.[20] Such reduction in SpO_2 from baseline to postremoval of the masks can be due to the increase in workload performed by the healthcare workers after donning personal protective equipment. A similar result was reported by Spurling *et al*. that indicated poor saturation of hemoglobin secondary to the increased partial pressure of CO_2 at higher exercise intensity.[21] Comfortable working conditions are a prerequisite for the healthcare workers carrying out their job while putting on N95-mask while working the intensive care units. However, the discomfort increases with the elevation of working periods during the pandemic of SARS-CoV2, especially when wearing a personal protective kit and N95 face masks. During long working shifts, the required exertion to perform

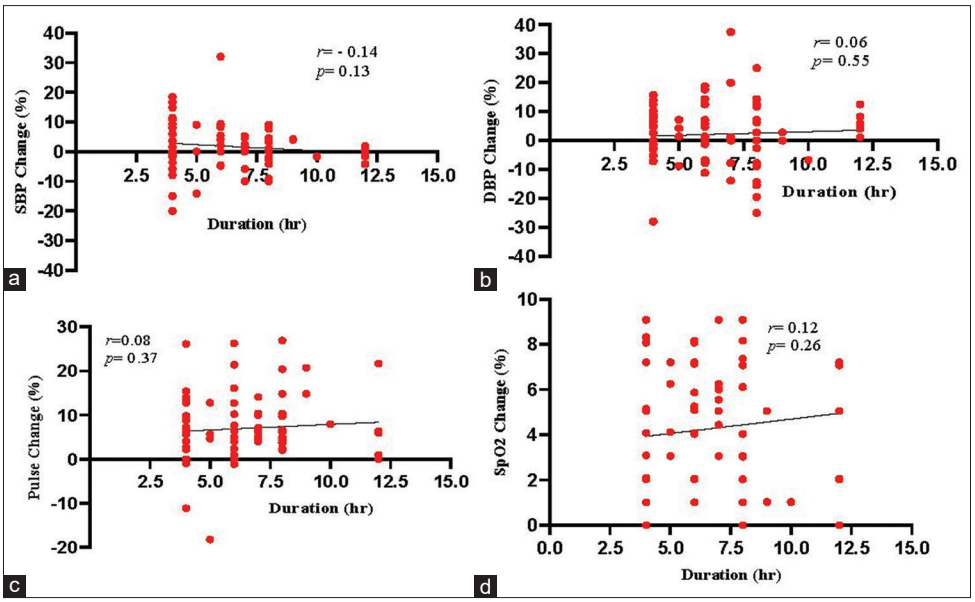

Figure 1: Correlation between duration on N95 mask with percent changes in SBP (a), DBP (b), Pulse rate (c), and SpO2 (d) after the end of the work session.

Table 3: Effects of long-term use of N95 mask on blood pressure, pulse rate, and oxygen saturation in healthcare providers during the care of patients with severe acute respiratory syndrome coronavirus 2 infection (*n*=122)

Parameter	1-6 h on mask (*n*=63)		>6 h on mask (*n*=59)	
	Before using mask	After removing mask	Before using mask	After removing mask
Systolic BP (mmHg)	118.7±15.7	114.5±14.4*,a	110.9±9.1	110.5±9.1[a]
Diastolic BP (mmHg)	75.4±7.8	73.3±6.9*,a	72.3±10.0	70.1±9.4[b]
Pulse rate (beet/min)	83.5±10.2	88.6±9.8*,a	81.7±6.8	87.9±8.4*,a
SpO_2 (%)	97.2±1.9	93.5±3.4*,a	98.2±1.7	93.5±3.1*,a

*Significantly different compared with the baseline values (P<0.05). Values with different superscripts (a, b) are significantly different. Values were represented as mean±SD. SD=Standard deviation, BP=Blood pressure, SpO_2=Oxygen saturation

Table 4: Incidence of adverse events among healthcare providers during the long-term use of N95 mask during the care of patients with severe acute respiratory syndrome coronavirus 2 infection (*n*=122)

Adverse event	Incidence, *n* (%)
Headache	82 (67.2)
Breathing difficulties	86 (70.5)
Redness and irritation	63 (51.6)
Dizziness	10 (8.2)
Itching	56 (45.9)

Table 5: Incidence of adverse events among healthcare providers with the time of using N95-mask during the care of patients with severe acute respiratory syndrome coronavirus 2 infection (*n*=122)

Adverse event	Incidence, *n* (%)	
	1-6 h on mask (*n*=63)	>6 h on mask (*n*=59)
Headache	30 (47.6)	52 (88.1)*
Breathing difficulties	35 (55.5)	51 (86.4)*
Redness and irritation	31 (49.2)	32 (54.2)
Dizziness	6 (9.5)	4 (6.8)
Itching	18 (28.5)	38 (64.4)*

*Significantly different compared with those working 1-6 h (P<0.05). Values were represented as *n* (%)

the work increased significantly after 4 h of wearing an N95-mask, leading to an increased fatigability and discomfort. In this regard, Meyer *et al*. suggested that the preferable duration of wearing the personal protective equipment with N95-mask is 1 h in an atmosphere of 18°C is the most suitable working environment.[22] In the present study, the mean duration of continued work with the personal protective equipment and the N95-mask was 6.7 h. Breathing difficulties and headaches were the most common adverse effect reported by the healthcare workers, followed by redness and irritation at the covered areas, itching, and dizziness, which can be the important causes of discomfort. The incidence of adverse events increased in those working longer than 6 h. It has been suggested that long-term use of the N95-mask with protective eye gear might lead to entrapment of exhaled moisture in the filters, resulting in increased breathing resistance. Meanwhile, the face mask represents a closed circuit for the inspired and expired air; meanwhile, rebreathing of the expired air increases arterial CO_2 levels and raises the chances of elevated acidity of the blood.[23] Thus, healthcare professionals working with an N95-mask

may experience signs similar to those shown in patients with chronic obstructive pulmonary disease, such as discomfort, headache, shortness of breath, fatigue, dizziness, muscular weakness, and drowsiness.[24] In the present study, most participants experienced breathing difficulties and headaches with a significantly higher rate in those working longer than 6 h. In this regard, Jyong *et al*. reported an elevation of 81% in the incidence of headache in frontline healthcare workers due to wearing personal protective equipment with N95-mask for >4 h/day.[25] It can be due to elevated PCO_2 levels that might predispose to vasodilatation and headache.[26] However, other data on the masks with exhalation valves indicated that the presence of the valve does not significantly decrease the elevated PCO_2 level.[11] Although putting on N95-mask is vital as a part of the personal protective kit for protecting the healthcare workers against the increased risks of COVID-19 infection, the associated adverse events cannot be excluded. In this regard, institutional regulations should be adopted to ensure scheduled frequent breaks during long shifts, in addition to reporting symptoms related to the use of protective equipment. However, the present study is not without limitations. The hard work environment without adequate ventilation and air conditioning and may augment the feeling of discomfort. Performing a study in a more controlled environment with appropriate temperature and humidity controls should be considered. In all circumstances, healthcare workers should be advised to take breaks and a supportive environment to report adverse impacts like dizziness and other symptoms which may compromise patient safety.

Limitations and recommendation

Our study results highlighted the problems associated with long-term use of N95 face masks, as a part of the personal protective equipment, during the work shifts at the COVID-19 care units. Clinicians, pharmacists and other healthcare workers may use the results of the present study to be aware about the disturbing adverse events associated with the use of these masks, and to adopt local regulations that help avoiding the raised complains. The limitations of the current study include single-region experience at the Sulaimani city, so the findings of the study may not be generalizable to other country regions. Another limitation is the expected failure to perform follow up analysis of the work shift on weekly or monthly bases.

Conclusion

Healthcare workers complain of significant adverse events such as headaches and breathing difficulties while using the N95 face mask over long work shifts during treatment of COVID-19 patients. The hemodynamic changes and the stress of wearing personal protective equipment for a long time may decrease work efficiency.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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