

# Impact of long duration wearing of N95 masks on cardiorespiratory system and subjective sensations of health-care workers during COVID-19 era

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## Abstract

**Background and Aims:** N95 mask being an essential element of personal protective equipment to be worn by health-care workers (HCWs) may lead to adverse effects and physiological stress as HCWs have to wear it for prolonged hours. Therefore, we planned to conduct a study in our intensive care unit staff to look for the effects of N95 masks on their health as well as to plan recommendations to ease them.

**Material and Methods:** We conducted this study on our intensive care unit nursing staff and HCWs. We noted their oxygen saturation and heart rate at baseline as well as after 1 h, 2 h, 3 h, and 6 h of duty along with their subjective sensations. Institutional ethical clearance for the same was taken. Collected data were entered in MS Excel database and analyzed using SPSS version 20.0. Fisher's Z test was applied for comparing proportion and analysis of variance for comparing two means.

**Results:** One hundred and nine HCWs participated in this, out of which 93 (85.3%) were females and 16 (14.7%) were males. Eighty-four (77.1%) participants were below 40 years. Twenty-three participants (21.1%) were overweight and 37 (33.9%) were obese. There was no significant drop in saturation and rise in heart rate during these hours.

**Conclusions:** On comparing subjective sensations of HCWs, our study found that feeling of uneasiness was found more in less than 40 years age group as compared to more than 40 years. N95 masks were found to have no impact on cardiovascular system and do not lead to hypoxia while working routinely even for prolonged hours.

**Keywords:** Health-care workers (HCWs), hypoxia, N95 masks, palpitations

## Introduction

A significant number of cases infected with coronavirus are related to occupational exposure. Health-care workers (HCWs) are the highest level of risk group to acquire this infection. Therefore, it is desired to adopt the practice of consistent use of face masks by HCWs so as to prevent the spread of

infection between health-care professionals and patients and vice versa.<sup>[1]</sup> Nowadays N95 face masks or high-level respirators are important and essential component of personal protective equipment for HCWs in hospitals. N95 respirators block 95% airborne particles. These are tight-fitting masks and seal the nose and mouth and prevent the wearer for inhalation of smaller infectious particles.<sup>[2,3]</sup> Despite the protective function

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of N95 masks, other discomforts like effects on respiratory microclimate, oxygen saturation, heart rate, and individual sensational hazards, namely, breathlessness, headache, and suffocation, also need to be examined.<sup>[4-6]</sup> N95 masks are likely to induce different temperatures and humidification on outer and inner mask surface; it is likely to be because of lower air permeability and water vapor permeability in N95 respirator.<sup>[7,8]</sup>

During these ongoing days of COVID-19 pandemic, medical staff, intensive care unit (ICU) workers, and other paramedics are wearing N95 masks for extended hours. The physiological and psychological stress on the wearer is making the regular tasks more challenging. HCWs perceived that there is CO<sub>2</sub> retention due to prolonged wearing of N95 mask, though it is reported that there is no risk of hypercapnia (CO<sub>2</sub> retention)<sup>[9]</sup> Recently, print and electronic media also raised the concerns regarding prolonged use of N95 masks leading to hypoxia and carbon dioxide retention. Therefore, in spite of protective function of N95 mask, the genesis of perception about respiratory and individual subjective sensations needs attention. Headaches and cervical neck pain are reported by HCWs due to prolonged use of mask. This is attributed to mechanical factors like tight straps and pressure on cervical nerves, hypoxemia, and hypercapnia. Another factor leading to headache reported is irregular mealtimes during prolonged mask usage as well as emotional stress.<sup>[6,10,11]</sup> Frequent changing and tight fitting of masks lead to skin allergies, rash, and shearing of skin at the bridge of nose and cheeks.<sup>[12]</sup> Keeping the above points into consideration, we conducted the present study among HCWs posted in ICUs who are daily wearing N95 masks for extended hours of their duty.

The aim and primary objective of this study was to assess the impact of prolonged wearing of N95 masks on HCWs on their respiratory and cardiovascular system, by monitoring their oxygen saturation and pulse rate. Secondary objective was to record their subjective feelings like breathlessness, uneasiness, headache, skin irritation, and effortful breathing so as to form recommendations to relieve their burden on HCWs.

## Material and Methods

The study protocol was approved by the Institutional Ethics Committee (Ref No. DMCH/R&D/2020/158 dated 9/11/2020). A written informed consent of all the participants was obtained and the confidentiality of the data was assured. This was a cross-sectional study, based on a self-constructed questionnaire prepared by the investigators. This questionnaire was based on the problems faced by HCWs while wearing N95 masks for prolonged hours. Study was conducted in nursing staff and other HCWs working in the ICU, such as

medical ICU, stroke ICU, surgery ICU, trauma ICU, and neurosurgery ICU of our tertiary care level teaching hospital of Ludhiana, Punjab.

Only HCWs who were posted in ICU and doing at least 6 h of continuous duty, wearing N95 masks during the ongoing COVID-19 pandemic, were enrolled for the study. This survey was conducted between November 1, 2020 and December 1, 2020. At the outset, we asked open-ended questions to 25 HCWs about the problems faced by them and their concerns wearing N95 masks. We compiled their common concerns and problems and constructed a questionnaire. Questionnaire consisted of baseline parameters including age, gender, and height in centimeters, weight in kilograms, any comorbid conditions like diabetes mellitus, hypertension, coronary artery disease, and thyroid disorders. Other part of the questionnaire consisted of objective parameters like oxygen saturation and pulse rate at baseline as well as 1 h, 2 h, 3 h, and 6 h. Third part of questionnaire was consisting questions regarding subjective sensations like uneasiness, palpitations, breathlessness, feeling of suffocation, headache, skin rash, and allergies, and feeling of breathlessness on sitting, standing, and walking.

We planned to apply this questionnaire on all the nursing staff and other health workers working in ICUs. We screened 114 HCWs; 4 HCWs refused to take part in the study as they were not able to wear masks for continuous 6 h. Thus, we planned to enroll 110 HCWs; 1 HCW was pregnant and she was excluded from the study [Figure 1]. Therefore, the study sample comprised 109 HCWs. One of the investigators applied this questionnaire to all the HCWs visiting the ICUs. After checking baseline data, values of heart rate, oxygen saturation, and questions regarding subjective sensations, followed by one hourly evaluation of all the HCWs, were done. Age, gender, height in centimeters, and weight in kilograms of all the participants were recorded. BMI was calculated by using the standard formula. WHO Classification for Asians was used to categorize the obesity level. Information about any existing comorbidity, namely, diabetes mellitus, hypertension, coronary artery disease, and hypothyroidism, was also noted. Oxygen saturation level and heart rate of all participants using pulse oximeter were recorded at baseline (before the start of work) and thereafter 1 h, 2 h, 3 h, and then at 6 h of continuous work and wearing of N95 mask. The responses of participants on wearing N95 mask regarding their subjective discomfort and feeling about breathlessness, palpitations, uneasiness, suffocation, headache, redness, allergy over face, itching, need of increased moisturizer over face, effortful breathing while sitting, standing and walking, tiredness, sight discomfort, scalene fatigue, nasal droplets, and conversation problem while talking with colleagues and patients were also noted.

## Statistical analysis

The data collected for the study were entered in MS Excel database and analyzed using SPSS version 20.0. Data were expressed as number and percentages. Mean and standard deviation of the quantitative variables were computed. Fisher's Z test was applied for comparing proportion and analysis of variance for comparing two means. A *P* value <0.05 was considered as level of significance.

## Results

A sample of 109 HCWs working in ICUs was evaluated to assess the impact of wearing N95 masks on their cardiorespiratory system as well as their subjective sensations.

There were 93 (85.3%) females and 16 (14.7%) males. Majority of workers (77.1%) were below the age of 40 years, 23 (21.1%) were overweight, and 37 (33.9%) were obese. Hypertension, diabetes, thyroid disease, and coronary artery disease were disclosed by 9 (8.3%), 5 (4.6%), 12 (11.0%), and 3 (2.8%) HCWs, respectively [Table 1].

The comparison of saturation and heart rate at baseline and after an interval of 1 h, 2 h, 3 h, and 6 h is presented in Table 2. Mean baseline oxygen saturation in the HCWs was  $97.75 \pm 1.38$  and mean heart rate was  $94.67 \pm 12.09$ . At 1 h, SpO<sub>2</sub> was  $97.98 \pm 1.36$  and heart rate was  $92.96 \pm 11.21$ . At 2 h, SpO<sub>2</sub> was  $97.95 \pm 1.30$  and heart rate was  $91.50 \pm 10.48$ . At 3 h, SpO<sub>2</sub> was  $98.06 \pm 1.31$  and heart rate was  $89.33 \pm 10.01$ . After 6 h, SpO<sub>2</sub> was  $97.95 \pm 1.72$  and heart rate was  $86.46 \pm 10.57$ . It is seen that there was no drop in saturation after different intervals of time. Also, there was no rise in heart rate, that is, tachycardia at any time on wearing N95 face masks continuously.

The subjective physiological symptoms felt by HCWs were assessed and compared with respect to age, gender, and obesity level as presented in Table 3. Among the subjects aged below 40 years, feeling of uneasiness was found in 31 (36.9%), palpitations in 35 (41.7%), breathlessness in 34 (40.5%), and headache in 32 (38.1%), though it was not statistically significant as compared to HCWs aged above 40 years.

When we inquired about skin changes like redness, itching, dryness of skin, use of moisturizer, and rashes, it was found to be more common less than 40 years age group. Redness (*P* = 0.014), rashes (*P* = 0.030), and use of moisturizer (*P* = 0.039) was found to be significantly much more common in below 40 years age group as compared to HCWs aged above 40 years.

Gender-wise comparison of all these parameters revealed that higher numbers of female workers complained of feeling of

**Table 1: Sample characteristics (n=109)**

Variable	n (%)
Age (years)	
<40	84 (77.1)
≥40	25 (22.9)
Gender	
Male	16 (14.7)
Female	93 (85.3)
BMI	
<18.5 (underweight)	06 (05.5)
18.5-22.9 (normal)	43 (39.4)
23.0-27.5 (overweight)	23 (21.1)
>27.5 (obese)	37 (33.9)
Hypertension	
Yes	09 (08.3)
No	100 (91.7)
Diabetes	
Yes	05 (4.6)
No	104 (95.4)
Thyroid disease	
Yes	12 (11.0)
No	97 (89.0)
CAD	
Yes	03 (2.8)
No	106 (97.2)

BMI: Body mass index; CAD: Coronary artery disease

uneasiness (36.6%) versus male (18.8%) and palpitations were complained by 40.9% females versus 25.0% males but the difference was found to be nonsignificant. Breathlessness was reported by 40 (43.0%) females as compared to 2 (12.5%) males and suffocation by 42 (45.2) females as compared to 3 (18.8%) males. The analysis of feeling of effortful breathing while sitting, standing, or walking on wearing N95 mask revealed that more females complained of respiratory difficulty on sitting, standing, and walking as compared to males. Similarly, redness was reported by significantly (*P* = 0.030) higher number of female HCWs.

HCWs who were obese and overweight complained of feeling of uneasiness more, that is, 28 (43.3%) as compared to with normal BMI 11 (22.4%), and the difference was found to be statistically significant (*P* = 0.022). Overweight and obese HCWs had felt more of palpitations, that is, 24 (40.0%) as compared to 18 (36.7%) with normal BMI, breathlessness in 26 (43.3%) obese HCWs versus 16 (32.7%) with normal BMI and suffocation in 25 (41.7%) obese HCWs versus workers having normal BMI. Respiratory difficulty too was complained more by overweight/obese HCWs.

## Discussion

The present study was aimed to investigate the impact of N95 mask on HCWs on their cardiorespiratory system and subjective sensations. In view of ongoing pandemic, we planned to conduct this study to look for any adverse effects

**Table 2: Comparison of SPO<sub>2</sub> and heart rate at different interval (n=109)**

Parameter	Baseline	1 h	2 h	3 h	6 h
SPO <sub>2</sub>	97.75±1.38	97.98±1.36	97.95±1.30	98.06±1.31	97.95±1.72
HR	94.67±12.09	92.96±11.21	91.50±10.48	89.33±10.01	86.46±10.57
Comparison			P SPO <sub>2</sub>		P HR
Baseline vs. 1 h			0.091		0.001*
Baseline vs. 2 h			0.067		0.001*
Baseline vs. 3 h			0.201		0.001*
Baseline vs. 6 h			0.249		0.001*

\*Significant at 5% level. SPO<sub>2</sub>: Oxygen saturation; HR: Heart rate

**Table 3: Age, gender, and obesity level-wise physiological problems felt by health-care workers**

Physiological problems	Age (years)		P	Gender		P	Obesity level		P
	<40	≥40		Male	Female		Normal	Obese and overweight	
	(n=84)	(n=25)		(n=16)	(n=83)		(n=49)	(n=69)	
Uneasiness	31 (36.9)	06 (24.0)	0.232	03 (18.8)	34 (36.6)	0.165	11 (22.4)	28 (43.3)	0.022*
Palpitations	35 (41.7)	07 (28.0)	0.218	04 (25.0)	38 (40.9)	0.229	18 (36.7)	24 (40.0)	0.727
Breathlessness	34 (40.5)	08 (32.0)	0.445	02 (12.5)	40 (43.0)	0.021*	16 (32.7)	26 (43.3)	0.254
Suffocation	35 (41.7)	10 (40.0)	0.882	03 (18.8)	42 (45.2)	0.047*	20 (40.8)	25 (41.7)	0.929
Headache	32 (38.1)	05 (20.0)	0.093	06 (37.5)	27 (29.0)	0.496	16 (32.7)	17 (28.3)	0.625
Fitness to face	10 (11.9)	02 (08.0)	0.014*	03 (18.8)	09 (9.7)	0.284	05 (10.2)	07 (11.7)	0.808
Redness	36 (40.5)	04 (16.0)	0.014*	02 (12.5)	38 (40.9)	0.030*	17 (34.7)	23 (38.3)	0.695
Itching	32 (38.1)	03 (12.0)	0.218	04 (25.0)	31 (33.3)	0.510	15 (30.6)	20 (33.3)	0.762
Dryness	27 (32.1)	04 (16.0)	0.116	04 (25.0)	27 (29.0)	0.741	14 (28.6)	17 (28.3)	0.978
Use of moisture	32 (38.1)	04 (16.0)	0.039*	03 (18.8)	33 (35.5)	0.189	19 (38.8)	17 (28.3)	0.249
EBμ sitting	09 (10.7)	02 (08.0)	0.986	01 (6.2)	10 (10.8)	0.581	04 (8.2)	07 (11.7)	0.546
EBμ standing	14 (16.7)	03 (12.0)	0.572	01 (6.2)	16 (17.2)	0.265	07 (14.3)	10 (16.7)	0.733
EBμ walking	38 (45.2)	08 (32.0)	0.239	04 (25.0)	42 (45.2)	0.131	24 (49.0)	22 (36.7)	0.195
Skin rashes	29 (34.5)	03 (12.0)	0.030*	02 (12.5)	30 (32.3)	0.109	15 (30.6)	17 (28.3)	0.795
Tiredness	33 (39.3)	04 (16.0)	0.031	03 (18.8)	34 (36.6)	0.165	12 (24.5)	25 (41.5)	0.060
Sight discomfort	29 (34.5)	07 (28.0)	0.543	05 (31.2)	31 (33.3)	0.870	16 (32.7)	20 (33.3)	0.940
Scalene fatigue	27 (32.1)	04 (16.0)	0.116	03 (18.8)	28 (30.1)	0.352	14 (28.6)	17 (28.3)	0.978
Nasal droplet	26 (31.0)	03 (12.0)	0.060	04 (25.0)	25 (26.9)	0.875	13 (26.5)	16 (26.7)	0.987
Immune system	31 (36.9)	03 (12.0)	0.018*	06 (37.5)	28 (30.1)	0.555	15 (30.6)	19 (31.7)	0.906
Conversation problem	36 (42.9)	13 (52.0)	0.420	05 (31.2)	44 (47.3)	0.233	24 (49.0)	25 (41.7)	0.445

Figures in parentheses indicate percentages. \*Significant at 5% level. \*EB: Effortful breathing

on HCWs so as to make some recommendations to prevent these problems as they have to wear N95 masks for prolonged hours. Large number of HCWs complained of breathlessness, palpitations, headache, skin allergies, rashes, and effortful breathing.

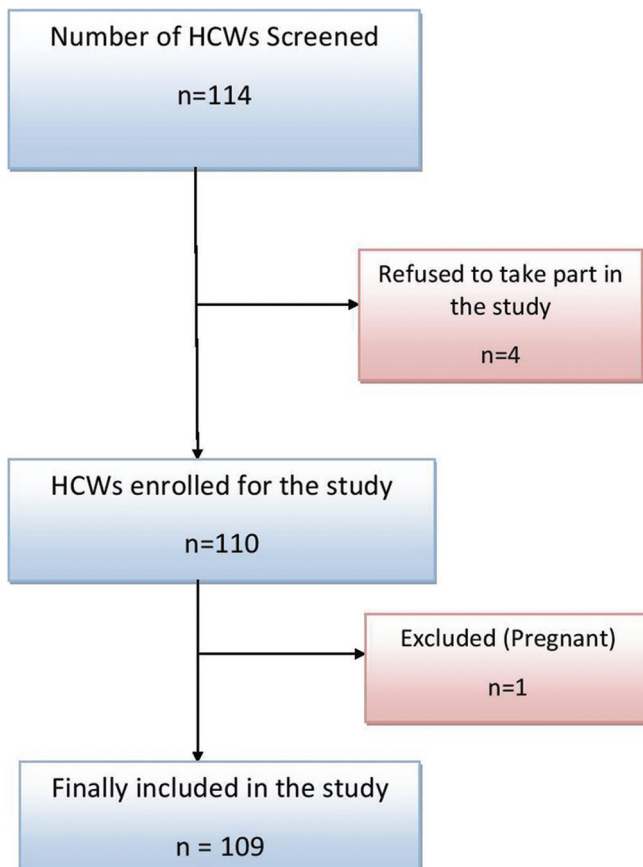
In our study, subjective parameters like feeling of uneasiness, palpitations, and breathlessness were found to be more common in below 40 years age group. Headache was marginally significant in below 40 years age group though it was not statistically significant. On analyzing further, it was found that majority of people who complained of headache were the ones who had previous history of migraine.

The study group comprised more females than males. More number of female health workers complained of feeling of uneasiness 34 (36.6%) as compared to male staff 3 (18.8%) and palpitations 38 (40.9%) in females as compared to 4 (25.0%) males. Feeling of suffocation and breathlessness was seen more commonly in females. Headache and scalene

fatigue were complained more by females, that's also because of the reason that migraine is more common in females. Skin rashes, redness, and frequent use of moisturizer were also complained by more of the female workers. It may be because females have more sensitive skin and thereby feel more skin problems because of continuous wearing of masks. Skin problems, such as contact dermatitis and urticaria, because of adhesives and rubber in straps, have earlier been also reported in the previous studies as well among HCWs due to prolonged use of face masks. Even free formaldehyde is supposed to be released from the nonwoven polypropylene and from metal in clips.<sup>[13]</sup> Foo *et al.* also reported itching in 51.4% HCWs by face masks during the SARS pandemic at Singapore<sup>[14]</sup> and Yan *et al.* released consensus statement of protection of skin of HCWs fighting against coronavirus disease 2019.<sup>[15]</sup> In another study, 56.0% of the participants were found to develop acne and 39.0% of the participants developed redness of face.<sup>[16]</sup>

On analyzing according to BMI, we observed that feeling of uneasiness was more common in obese and overweight





**Figure 1:** Flow Chart showing recruitment of eligible HCWs

28 (43.3%) participants as compared to those having normal BMI, that is, in 11 (22.4%). Overweight HCWs complained more of palpitations 24 (40.0%), breathlessness 26 (43.3%), and suffocation 25 (41.7) as compared to normal BMI participants. Respiratory difficulty was also complained commonly by overweight people; it may be because of the reason that overweight people have poor respiratory reserve.

## Recommendations

We framed some recommendations for HCWs after conducting this study. Recommendations have been given in the literature previously also. First recommendation is getting small breaks in between shifts to avoid palpitations and breathing difficulty. Second recommendation is taking frequent meals to avoid hypoglycemia and headaches. Adequate hydration is also advised. Third recommendation is to use well-fitted masks and avoid tight straps to prevent headache and neck pain. Fourth recommendation is lifestyle modification in the form of exercise, diet control, and weight control to get rid of overweight- and obesity-related problems. Fifth recommendation is to apply frequent moisturizer to avoid skin-related problems. To avoid skin breakdown, use of tegaderm, tape, fresh wipes, and dressing over bridge of nose is advisable.<sup>[17]</sup>

The strength of our study was its large sample size and long monitoring period, that is, for whole 6 h till they were on duty. Another strong point of our study was that we did monitoring for their routine ICU work when they used to complain of breathlessness and palpitations, not during intense exercises as wearing of N95 masks during intense exercise in gyms or while doing running is not recommended. The limitation of our study was that we could not monitor carbon dioxide levels as it was not possible to perform invasive tests for all the HCWs twice.

## Conclusion

N95 masks have no impact on cardiovascular system and do not lead to any hypoxia while doing routine work for prolonged hours. There is just reporting of subjective symptoms like feeling of breathlessness, palpitations, effortful breathing, headache, and skin problems. These are found more commonly in below 40 age group and overweight participants. Feeling of uneasiness, breathlessness, headache, and respiratory difficulty were more reported by female HCWs as compared to males. N95 masks may lead to skin rashes and irritation that may be because of humidity and sweating. Hence, N95 masks were found to be safe for the health of medical as well as other health-care personnel for the prolonged use on their routine work without any major side effects and complications.

## Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Nil.

## Conflicts of interest

There are no conflicts of interest.

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