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Use of face mask by blood donors during the COVID-19 pandemic: Impact on donor hemoglobin concentration: A bane or a boon

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ABSTRACT

Background: COVID-19 virus has caused the world's deadliest pandemic. Early April 2020, the Delhi Government made it compulsory for people to wear face masks while going outdoors to curb disease spread. Prolonged use of surgical masks during the pandemic has been reported to cause many adverse effects. Intermittent hypoxia has been shown to activate erythropoietin (EPO leading to increased hemoglobin mass.
Aim: To analyze whether face mask induced intermittent hypoxia has any effect on the hemoglobin levels of healthy blood donors.
Materials and methods: We retrospectively analyzed donor data from 1st July 2019-31st December 2020 for hemoglobin distribution across hemoglobin ranges and donor deferral on basis of hemoglobin. Study population was divided into two cohorts Group 1- (1st July 2019-31 st March 2020): before implementation of mandatory face masks Group 2- (1st April 2020-31 st December 2020): after implementation of mandatory face masks
Results: Mean Hb of blood donors in Group 2 (15.01 ± 1.1 g/dl) was higher than Group1 (14.49 ± 1.15 g/dl), ($p < 0.0001$). 47.1 % group2 donors had Hb of 16.1−18 g/dl compared to group1 (38.4 %). 52.9 % group 2 donors had Hb between 12.5−15 g/dl compared to 61.6 % Group 1 ($p < 0.05$). Deferral due to anemia was lesser in group 2 compared to group 1 ($p < 0.00001$). Group 2 had significantly higher deferral due to high Hb (>18 gm/dl) was than Group 1 ($p = 0.0039$).
Conclusion: This study including 19504 blood donors spanning over one and a half year shows that prolonged use of face mask by blood donors may lead to intermittent hypoxia and consequent increase in hemoglobin mass.

1. Introduction

COVID-19 virus that has led to one of the world's deadliest pandemic is thought to spread from person to person, mainly through respiratory droplets produced when an infected person coughs or sneezes [1]. Along with the well-accepted measures of physical distancing and frequent hand washing, the use of face masks or face covering, emerged as a third pillar in community action as a doable and low-cost measure to contain the spread of the disease. In early April 2020, the Delhi Government like many other states across India made it compulsory for people to wear face masks while going outdoors to curb the disease spread [2]. Various studies have emerged ever since analysing the benefits and risks of face masks during the COVID-19 crisis [3].

With the continuous use of face mask as personal protective equipment, infectious disease studies have reported a historic drop in cases of influenza with sustainably low inter-seasonal levels across the world during the COVID-19 crisis [4,5]. Face mask, are now well established personal protective equipment against respiratory droplets, however prolonged use of surgical masks and N95 by healthcare professionals during COVID-19 pandemic have been reported to cause many adverse effects such as headaches, rash, acne, skin breakdown, breathing difficulty and impaired cognition in the majority of those surveyed [6,7]. Beder A et al. [8] in their study have reported decrease in the oxygen saturation of arterial pulsations (SpO2) and a slight increase in pulse rates compared to preoperative values in all surgeon groups after performing operations, possibly correlated to use of facial mask and also operational stress. Surgical mask usage has also been reported to result in hypo-oxygenemia and hypercapnia which reduce working efficiency

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[9]. As recent history has not experienced a time that has mandated the use of face coverings and use of face masks in public spaces, the majority of research exploring the impact of masks on human physiology has been conducted on surgical masks [8] and N95 respirators [9] but none of them consider the simple cloth mask.

Under normal conditions, erythropoietin (EPO) production is mediated by decreased oxygen saturation of hemoglobin (Hb), that is, hypoxemia. The ambient hypoxia triggers a number of physiologic responses including hyperventilation, increased resting heart rate and stimulation of erythrocyte production with the goal of maintaining the oxygen content of arterial blood at or above sea level values [10–12].

Wearing Face masks over a period of 8–10 h per day continuously may create a condition of intermittent hypoxia that may lead to change in Hb levels in otherwise healthy blood donors.

2. Aims and objectives

The aim of this study is to analyse if face mask induced intermittent hypoxia has any effect on the hemoglobin levels of healthy blood donors. Analysing the hemoglobin distribution across hemoglobin ranges and donor deferral on basis of hemoglobin in the period before and after regulatory requirement mandating use of face, to quantify this expected variation. There are no studies in literature so far which have studied effect of face mask in blood donors during this COVID-19 crisis.

3. Materials and methods

This is a retrospective single centre-based cross-sectional study analysing a changing trend in average hemoglobin range and pre-donation deferral record of blood and platelet apheresis donors on basis of hemoglobin level at our blood bank attached to a large super speciality hospital in New Delhi, India. Data was retrieved from the blood bank information system and manual records for a period of one and half years, from 1st July 2019 to 31st December 2020. Analysis of donor deferral reasons was performed in relation the donor questionnaire and hemoglobin (Hb) estimation. Blood donors acceptance or deferral was based on for donor selection as per Drugs and Cosmetics Drugs and Cosmetics Act (the rules thereunder) [13] and supplemented by the National Blood Transfusion Council (NBTC) and National AIDS Control Organisation (NACO) guidelines, including their amendments [14]. Hb cut-off of 12.5–18 g/dl detected by quantitative method of hemoglobin estimation on a portable hemoglobin analyser (Hemocue Hb 301) was followed for donations for donors were fulfilling all other selection criteria.

3.1. Study design and setting

Study population was divided into two cohorts based on compulsory enforcement for people to wear face masks while going outdoors to curb the disease spread by the Delhi Government.

Group 1- (1st July 2019-31st March 2020): before implementation of mandatory face masks

Group 2- (1st April 2020-31st December 2020): after implementation of mandatory face masks

3.2. Ethical approval

The institutional ethical clearance was obtained from the Institutional ethics committee. As a blood donation screening and registration protocol of the blood bank all blood donors give an informed consent prior to blood donation for any additional testing on the blood collected and its subsequent use for study/research purposes and the same are in place. In view of retrospective study design and no risk of disclosure of donor identity involved in this study, the requirement to obtain the blood donors' consent to review the donor records was waived off by the institutional ethical committee. Confidentiality of the data was maintained, and the study procedures were performed in compliance with the 1964 Helsinki declaration and its later amendment.

3.3. Inclusion and exclusion criteria

Voluntary, non-remunerated, whole blood donors and platelet apheresis donors recruited during this time period and deferred either due to low Hb (<12.5 gm/dl) or high Hb (>18 gm/dl) were included however, donors deferred because of high hemoglobin due to primary polycythaemia & established causes of secondary polycythaemia e.g.: giving history of chronic smoking) or with permanent address of high altitude areas or donors with history of renal disease or other known cases of polycythaemia were excluded from the study.

3.4. Statistical analysis

Descriptive statistical analysis, like percentage was used. Chi-square $\chi 2$ test with Yate's correction was used to assess the categorical variables. P-value <0.05 was considered as statistically significant.

4. Results

A total of 19,504 voluntary, non-remunerated, whole blood donors and platelet apheresis donors including 20.5 % (n = 3998) of family/friend donors were included in the study. The mean age was 34.5 ± 7.63 years (18–65). The ratio of male to female donors screened was 17:1 (Table 1).

4.1. Hemoglobin based distribution of selected donors according to hemoglobin range (Table 2)

4.1.1. Group 1 (1st July 2019 to 31st March 2020)

10873 donors were screened during this period, of which 94.4 % (n = 10259) were males and 5.6 % (n = 614) were female donors. Following the pre-donation screening process, 9296 blood donors were selected and 1577 donors were deferred, resulting in a mean deferral rate of 14.5 %. 80.2 %(n = 7420) of the 9296 selected donors were voluntary donors, 19.8 % (n = 1836) were family/friend donors and 64.3 % (n = 5977) of the accepted donors were repeat blood donors. The accepted blood donors had a mean Hb of 14.49 ± 1.15 g/dl. 30 % of the

Table 1
Donor profile with percentage of selected and deferred blood and platelet donors.

	Group 1		Group 2	
	N	%	N	%
Total Screened	10873		8631	
Gender				
Male	10259	94.4	8069	93.5
Female	614	5.6	562	6.5
Occupation				
Professional	3175	29.2	2931	34.0
Government service	1935	17.8	2512	29.1
Semi-professional /self employed	3382	31.1	1695	19.6
Student	1294	11.9	766	8.9
Others	1087	10.0	727	8.4
Total Donated	9296		7621	
Donor Type				
Voluntary	7460	80.2	5989	78.6
Voluntary Family/Friend donors	1836	19.8	1632	21.4
First Time Donors	3319	35.7	2890	37.9
Repeat Donors	5977	64.3	4731	62.1
Gender				
Male	9060	97.5	7430	97.5
Female	236	2.5	191	2.5
Total Deferral	1577	14.5	1010	11.7
Male	1199	11.03	839	9.72
Female	378	3.48	171	1.98

selected blood donors fell in 14.1−15 gm/dl range, followed by 25.7 % in 15.1−16 g/dl range and 21.7 % were in the 13.1−14 g/dl bracket. 9% had an Hb between 12.−13 g/dl. The higher Hb ranges of 16.1−17 g/dl and 17.1−18 g/dl had 12.5 % and 0.2 % respectively, in the Group 1.

4.1.2. Group 2 (1st April 2020 to 31st December 2020)

A total of 8631 donors were screened during this period, of which 93.5 % (n = 8069) were male, and 6.5 % (n = 562) were female donors. 7621 blood donors were accepted after the pre-donation screening process. 78.2 %(n = 5989) of the 7621 selected donors were voluntary donors, 21.4 % (n = 1632) were family/friend donors and 62.1 % (n = 4731) of the accepted donors were repeat blood donors. The accepted blood donors had a mean Hb of 15.01 ± 1.1 g/dl. 29.3 % of the blood donors fell in 15.1−16 gm/dl range, followed by 27.3 % in 14.1−15 g/dl range and 18 % in the 13.1−14 g/dl bracket. 7.6 % of the total donors had an Hb between 12.−13 g/dl. The higher Hb ranges of 16.1−17 g/dl and 17.1−18 g/dl had 17.5 % and 0.6 % respectively.

4.2. The characteristics of deferred donors on basis of hemoglobin (Table 3 & Fig. 1)

4.2.1. Group 1 (1st July 2019 to 31st March 2020)

Of the total deferrals 27.2 % (n = 429) deferrals were due to low Hb and 3.93 % (n = 62) due to high hemoglobin (due to unknown cause) against Hb cut-off of 12.5–18 g/dl. The proportion of low Hb deferral was high in female donors 62.24 % (267/429) as compared to male donors 37.76 % (162/429), while 100 % (n = 62) of high Hb deferrals were male donors. High Hb levels ranged between 18.1 and 20.0 g/dl.

4.2.2. Group 2 (1st April 2020 to 31st December 2020)

Amongst the total deferral of 1010 donors, 22.38 % (n = 226) deferrals were due to low Hb and 0.92 % (n = 80) were deferred due high hemoglobin (due to unknown cause). High Hb levels ranged between 18.1 and 21.1 g/dl. Female deferral due to low Hb was higher than male deferrals.

The percentage of donor deferrals in our study due to low Hb was lesser in group 2 (22.38 %) as compared to group 1 (27.20 %) and this difference was statistically significant (p < 0.00001). This drop in female donors with anemia in group 2 (53.98 %) as compared to group 1 (62.24 %) was also statistically significant (p < 0.00001).

A significant rise in donor deferral due to high Hb is seen in group 2 as compared to group 1 (p = 0.093).

5. Discussion

The use of masks has become the new normal for humankind after the COVID-19 outbreak. It will not be incorrect to say that -face masks have become a new iconic symbol of 2020. When history looks back on the pandemic of 2020, those white or baby blue rectangles that hide the mouth and nose, turning everyone into a muzzled pelican, will be what they will see [15].

Table 2
Hemoglobin based distribution of selected donors according to hemoglobin range.

Hb range	Group1		Group 2		P- value
(g/dl)	N	%*	N	% *	
Mean (±SD) Hb	14.49 (1.15)		15.01(1.1)		P < 0.0001
12.5–13	917	9.9	576	7.6	0.03
13.1–14	2012	21.7	1372	18.0	0.0199
14.1–15	2793	30	2080	27.3	0.006
15.1–16	2392	25.7	2234	29.3	0.0003
16.1–17	1161	12.5	1310	17.2	0.0016
17.1–18	21	0.2	49	0.6	0.0032
Total	9296	100	7621	100	

* Percentage of the total in the respective Hb category.

Table 3
Characteristics of deferred donors on basis of hemoglobin.

	Group 1		Group 2		P value
	N	%	N	%	
Total Deferred	1577		1010		
Low Hb (<12.5 g/dl)	429	27.20	226	22.38	<0.00001
Male	162	37.76	104	46.02	0.093
Female	267	62.24	122	53.98	< 0.00001
High Hb (>18 g/dl)-(Included in the study)	62	3.93	80	7.92	0.0039
Male	62	100	80	100	
Female	0	0	0	0	

In this single centre, retrospective, cohort study, hemoglobin concentrations showed a significant variation in the group of donors after wearing face masks was mandated by authorities as compared to donors in the period without mandatory use of face masks. To our best knowledge, this is the first study, studying the effect of hemoglobin profile of healthy blood donors, after prolonged use of face masks by blood donors.

In our study, mean Hb of accepted blood donors in Group2 (15.01 ± 1.1 g/dl) was also higher than Group 1 (14.49 ± 1.15 g/dl) and the difference was statistically significant (p < 0.0001). Group 2 showed an overall trend of donors having higher hemoglobin compared to group 1. 47.1 % of group 2 donors had Hb of 16.1−18 g/dl compared to 38.4 % in group 1. Similarly there was overall decrease in percentage of donors in lower Hb ranges in group 2. Lesser number of group 2 donors (52.9 %) had an Hb between 12.5−15 g/dl compared to 61.6 % of Group 1 donors. This trend of an overall increased percentage of donors in higher hemoglobin ranges and a decrease in donors in lower Hb ranges was statistically significant (across all Hb ranges). Two groups were comparable in terms of donor demographics. The percentages of voluntary blood donors in both the groups are similar. Same is the case with percentage of first time and repeat blood donors and therefore these would not have impacted the hemoglobin distribution in the two groups. The occupation profile of donors engaged in outdoor activities is similar in both the groups studied. 91.6 % of the donors of group 2 were involved professions that would need outdoor movement, requiring mandatory use of face masks while performing professional activities. These observations are further substantiated by a statistically significant decrease in donor deferral in group 2 as compared to group 1 due to low Hb especially in female donors. In addition deferral in group2 donors due to high Hb (>18 gm/dl) was significantly higher in group 2 than Group 1, again indicating a shift to higher Hb concentration in the blood donors.

5.1. Possible mechanisms

The potential mechanism of increase in hemoglobin concentrations in blood donors in Group2 can possibly be attributed to the prolonged use of face masks, that can be N95 mask, surgical mask or simply a cloth mask by these blood donors leading to intermittent hypoxia that may have led to EPO production in order to restore oxygen supply to the tissues, resulting in increase in hemoglobin mass in otherwise healthy blood donors. Respiratory rate, oxygen saturation and CO2 levels have been shown to change significantly while wearing N95/FFP2 masks [16,17]. Various studies and trials have being conducted to evaluate the physiological impact of masks in medical staff. An observational study of 52 surgeons wearing surgical masks revealed a decrease in arterial O2 saturation from approximately 98 % before surgery to 96 % after surgery, which ranged from 1 to 4 h in length [8]. Studies have also shown that a few minutes of exposure to hypoxia stabilizes hypoxia inducible factor-1α, which activates erythropoietin (EPO) gene transcription and EPO production, in order to restore oxygen supply to the tissues [16,18]. Burtscher et al. [19], in their study, have reported that fifteen sessions of

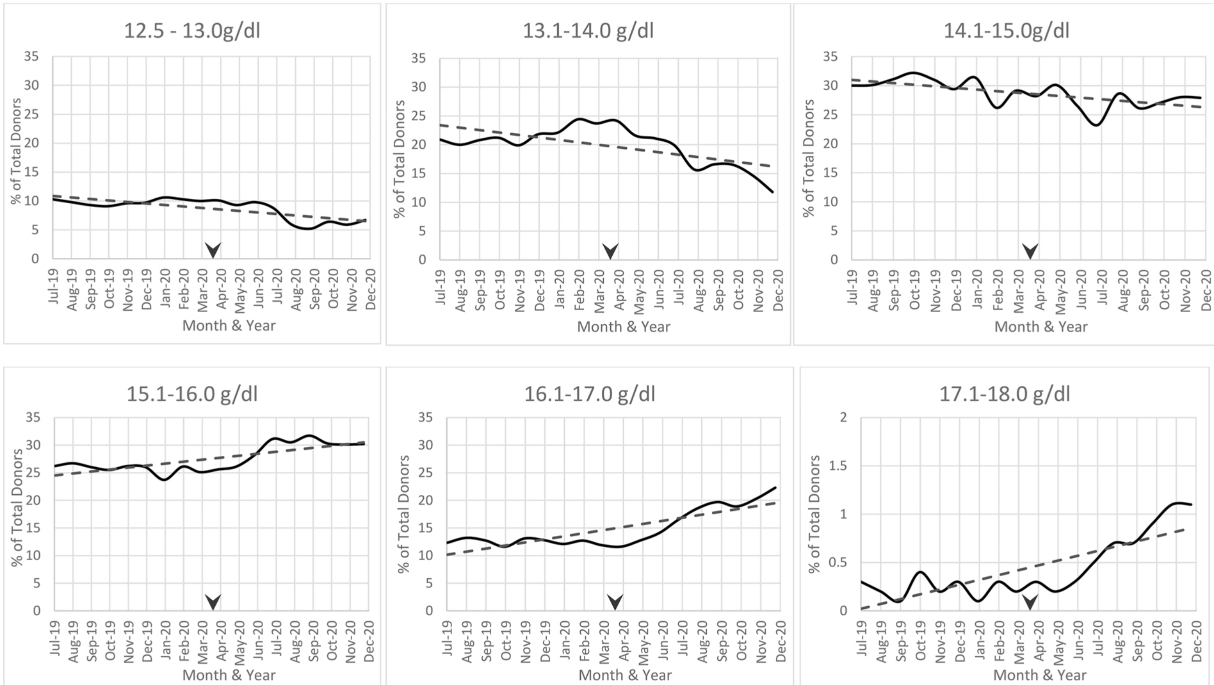

Fig. 1. Hemoglobin based distribution of selected donors according to hemoglobin range.

intermittent hypoxia, by breathing hypoxic air for 3–5 min interspersed with 3 min of breathing normoxic air over a period of 3 weeks led to increased hemoglobin mass and exercise tolerance in a group of healthy active individuals at risk for chronic obstructive pulmonary disease (COPD) and patients with mild COPD. During the period of lockdown and immediately after the lockdown when restricted movements were observed, the Air Quality of Delhi improved significantly and has the potential to affect the haematological parameters. However, an epidemiological study on “Effect of Air Pollution on Human Health (Adults)” in Delhi by Central Pollution Control Board Ministry Of Environment & Forests shows a small, but consistent rise in hemoglobin and RBC level among the residents of Delhi attributed to chronic air pollution induced oxidative stress negating the possibility of good air quality in increasing haemoglobin level [20].

In this study, we also found that an overall shift to higher Hb in the Group 2 donors with a significant number of donors reporting with higher Hb and a drop in donor deferral due to low Hb as compared to group 1, following prolonged usage of facemask.

5.2. Study limitations

Being retrospective and observational in nature, a potential limitation of the present study is that a complete blood count, arterial oxygen saturation and serum EPO level were not performed, which would help elicit a rise in EPO levels or erythrocytosis in these donors. Correlation with pre-COVID-19 Hb of donors with current Hb following exposure to intermittent hypoxia and duration for which the donors wore face masks could also not be elicited. However majority of the donors were from the working category which would involve moving outdoors and therefore use of face masks for longer periods.

Nonetheless, the present findings represent an important first step to future studies to investigate the effect of prolonged use of face masks causing intermittent hypoxia in blood donors and its possible consequences on the Hb mass of blood donors.

6. Conclusion

In conclusion, this study with 19,504 blood donors spanning over one and a half year, is adequate enough for the technical hypothesis, that prolonged use of face mask by blood donors may lead to intermittent hypoxia and consequent increase in Hb mass but insufficient for evaluation of multifactorial effects.

CRediT authorship contribution statement

Conceptualization: **RS**, **MD**, **RY**. Methodology: **RS**, **MD**. Statistical analyses and interpretation: **GPT**, **RS**, **MD**. Resources: **RY**, **GPT**, **AER**. Writing- Original Draft: **RS**, **MD**. Writing- Review & Editing: **RS**, **AH**.

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Declaration of Competing Interest

All authors declare that they do not have any conflict of interest that could inappropriately influence the present study.

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