

Original Research Article

Impact of environmental factors on adverse events in whole blood donation

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ABSTRACT

Background: Whole blood for transfusion is essential in medical treatment; for surgeries, trauma treatment and managing diseases like anemia and cancer. However, the adverse reactions (ARs) such as vasovagal syncope, dizziness and fainting are still concerning for donor safety. Reactions are influenced by age, sex and general health status; however, the impact of environmental factors temperature, humidity and air quality are not well studied. The aim of this study was to examine environmental factors affecting the incidence and severity of adverse events during whole blood donation.

Methods: Total of 170 voluntary whole blood donors were included in the study. Donor demographic, health and reporting records were obtained from the center during the study period. Environmental factors such as temperature, humidity and air quality were collected from monitoring stations located nearby the locality. Bivariate analyses using chi-square tests and logistic regression were performed to evaluate the relationship between environmental factors and adverse events.

Results: Adverse events were observed in 15% of donors (12% mild and 3% severe). High temperatures (>25 C), relative humidity >60%, and AQI >70 were associated significantly with the increased rate of adverse events. High temperatures were significantly associated with more serious reactions, particularly in male donors, whereas high relative humidity was correlated with mild reactions among women.

Conclusions: Environmental factors have greatly influenced on the incidence and severity of adverse reactions with whole blood donation. These results indicate the importance of adjusting environmental parameters such as temperature, humidity and air quality in blood donation centers for donor safety and comfort.

Keywords: Whole blood donation, Adverse reaction, Environment factors, Temperature

INTRODUCTION

Whole blood donation is critical for logging a stable supply of blood used in surgical procedures, trauma care and treatment of some medical conditions, including anemia and cancer. Blood donation is considered as one of the most crucial activities for maintaining the health care

system of individuals across the globe, according to World Health Organization (WHO).¹ Although whole blood donation has well-established benefits, the safety and comfort of donors during the procedure remain a concern. Adverse reactions (ARs), such as vasovagal reactions, lightheadedness and fainting are the most commonly reported events at blood donation.² Recently, much

attention in blood donation science has been given to donor-related factors associated with increased risk of adverse events (AEs).³ Nevertheless, new evidence points towards the possibility that environmental factors including temperature, humidity and air pollution can also trigger these events to a high degree. However, little is known about the direct effect of environmental conditions on adverse reactions during whole blood donation. The mechanism of these environmental factors remains to be elucidated, and studying the role of these factors is important for enhancing donor safety and for optimal donation setting. Worldwide, there is a different risk for AEs at donation related to region and donor population. The frequency of more serious adverse events (such as fainting or hyperventilation) is lower, but not insubstantial in the available studies that have reported variably between 0.5 and 3%.³ The blood taking centre is no exception to this trend of adverse incidences as most of the responses are mild with complaints of tremors (Muscle shaking), fainting or dizziness and nausea. The blood bank of the BMU recently published that donor experience a 7% adverse reaction incidence, predominantly mild.⁴ These observations are consistent with worldwide situation although it alerts to the need of studying local issues which could lead to occurrence rates and severity of ADR's. Although donor factors are generally recognized as predeterminants for complications, the role of environmental conditions is overlooked to date in the literature. Some researchers showed that hot weather, bad air and humidity could increase the risk for reactions during or after blood donation. For instance, reported that increase of temperature is related to a more frequent occurrence of vasovagal reactions with donors being from warmer temperatures were more likely to experience dizziness or fainting.⁵ In a similar vein, high humidity has also been associated with increased discomfort and nausea in blood donors. Low air quality, particularly in closed donation rooms, has also been found to be a factor contributing to donor discomfort that may affect the frequency of more serious events.⁶ And despite an increasing awareness of environmental factors in the safety of donors, the literature available on those factors as they relate to blood donation is scarce. Strikingly, most information that has arisen to date has been related to clinical and demographic features with rare attention given as to how external circumstances interact with the individual characteristics of donors in influencing such adverse events. This disparity supports the case for focused inquiry that places importance on both of these aspects within a broad effort to improve the safety of the donor as well as improve donors' experiences with blood donation.

METHODS

A retrospective cohort design was used in this study to explore the influence of environment on adverse events regarding whole blood donations. The study was carried out at department of transfusion medicine, Bangladesh Medical University (BMU), Dhaka. The duration of the

study corresponded to 1 year, from August 2023 through July 2024. Donor records and environmental measurements within the donation room were collected. The study population comprised of 170 adult voluntary whole blood donors who donated in the study period. Well, the donors who met the requirements and were available to donate blood.

Inclusion criteria

Donors aged 18–65 years, little to no contraindication to blood donation based on standard donor history screening among healthy individuals, and donors willing to participate after verbal consent for the study were included.

Exclusion criteria

Donors with a history of negative reactions following previous blood donations, pregnant or breastfeeding women, subjects with any acute or chronic diseases, which may interfere with donation, and donors had medical issues arises or the day of the donation that Prevented you from finishing.

Sample size and sampling technique

This sample size of 170 whole blood donors was determined by standard sample size determination formulas for cohort studies. We had a large enough sample size to find significant relationships with the environmental factors for adverse events, based on a margin of error of 5% and confidence level of 95%. Convenience sampling was used to recruit the donors who were available and willing to participate in the present study during the study period. No random sampling was used, all eligible donors who fulfilled the inclusion criteria and consented to the study were enrolled.

Data collection procedure

The study data were obtained through two main sources: the donor health records, and environmental information. Donor health records were extracted from the blood donors data base of BMU including donor demographics, donation dates, adverse event reports, and pre-donation health check results. Meteorological and air quality information from local meteorological stations.

Statistical analysis

Statistical analysis of data was carried out using statistical package for the social sciences (SPSS) version 26. The description of the donor population and environmental factors was summarized by means, standard deviation (SD), frequency and percentage of subjects. Prevalence of mild and severe adverse events was presented by each environmental state (temperature, humidity, air quality). The Chi-square test was used to evaluate the association between categorical variables (e.g. environmental factors

and adverse event). Factors significantly associated with the occurrence of severe adverse events were extracted using a logistic regression analysis adjusting for potential confounders including donor demographics. $P < 0.05$ was considered statistically significant, and all tests were two-tailed. The findings were reported in suitable tables, diagrams and figures to show the trend of data and relationship between the environmental contexts and adverse effects on blood donors.

RESULTS

A total of 170 whole blood donors participated in this study while their demographic features were shown in Table 1. The participants had an average age of 32.5 years (SD \bar{x} =9.8). The sex ratio was 58% males and 42% females, and the majority of donors were free from medical history essential for transplantation (Table 1).

Table 1: Demographic characteristics of whole blood donors (n=170).

Characteristics	Frequency (N)	Percentage (%)
Age (mean±SD)	32.5±9.8	-
Gender		
Male	99	58.0
Female	71	42.0
Weight (mean±SD)	70.2±12.1	-
Health status		
No prior medical conditions	160	94.1
Medical conditions (e.g., anemia)	10	5.9

Overall, 15% (n=25) of all donors experienced AEs, of which mild AEs were seen in 12% (n=20) and severe in 3% (n=5). The detailed adverse events are presented in Table 2.

Table 2: Prevalence of adverse events in whole blood donors.

Type of adverse event	Frequency (N)	Percentage (%)
Mild adverse events (e.g., dizziness, nausea)	20	12.0
Severe adverse events (e.g., fainting, vasovagal reaction)	5	3.0
Total adverse events	25	15.0
No adverse events	145	85.0

The environmental parameters measured during the experiment were temperature, humidity and quality of air. Summarized descriptive statistics of the environmental factors. The average temperature on the donation sessions was 23.8°C (SD=4.1) and the humidity was also average of 55.6% (DP=8.3). Mean air quality index (AQI) was

56.2 (SD=12.7), which corresponded to gentrification about acceptable levels of air pollution (Table 3).

Table 3: Descriptive statistics of environmental factors.

Environmental factor	Mean (SD)	Minimum	Maximum
Temperature (°C)	23.8 (4.1)	18.5	30.2
Humidity (%)	55.6 (8.3)	40.1	70.3
Air quality index (AQI)	56.2 (12.7)	32	85

Chi-square tests were employed to test the association between environmental factors and adverse events. The unadjusted effect estimates for temperature and adverse events. Temperatures $>25^{\circ}\text{C}$ were significantly associated with an increased proportion of severe AEs ($p=0.04$). This tendency was more pronounced in male donors (Table 4).

Table 4: Association between temperature and adverse events.

Temperature (°C)	Mild adverse events (N)	Severe adverse events (N)	Total (N)	P value
$\leq 25^{\circ}\text{C}$	12	2	14	0.04
$> 25^{\circ}\text{C}$	8	3	11	

Multivariable analysis of the association between humidity and adverse events is presented. High humidity (over 60%) was also a significant risk factor for mild adverse events ($p=0.03$). This pattern was more pronounced among female participants (Table 5).

Table 5: Association between humidity and adverse events.

Humidity (%)	Mild adverse events (N)	Severe adverse events (N)	Total (N)	P value
$\leq 60\%$	14	2	16	0.03
$> 60\%$	6	3	9	

The correlation between air quality (AQI) and severe adverse event. Air-quality (poor air quality: $\text{AQI} > 70$) was significantly associated with a higher risk of severe adverse events ($p=0.02$). But mild adverse events were not significantly correlated with air quality (Table 6).

Table 6: Association between air quality and severe adverse events.

AQI range	Mild adverse events (N)	Severe adverse events (N)	Total (N)	P value
≤ 70	16	2	18	0.02
> 70	4	3	7	

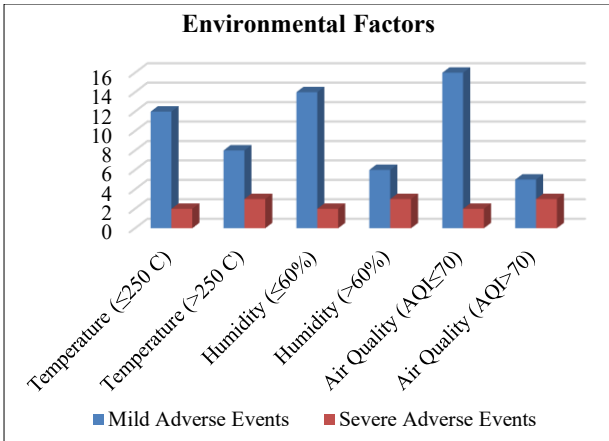


Figure 1: Prevalence of adverse events according to environmental exposure.

Figure 1 presents the distribution of mild and severe adverse events in different temperature groups, humidity groups and air quality indices. The data reveal a pattern that increasing temperature and humidity promotes the high incidence of mild adverse events, whereas bad air quality leads to an increase in severe adverse events.

Figure 2 illustrates the relationship between temperature and seriousness of adverse events. Both mild and severe adverse events dramatically increase as the temperature is more than 25 °C, which shows that high temperatures play a great role in adverse reactions of whole blood donation.

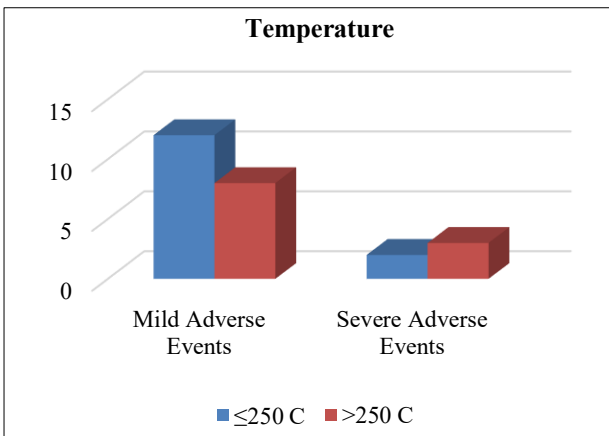


Figure 2: Correlation of temp and severity of AEs.

DISCUSSION

This study was conducted to explore the impact of environmental factors on adverse events during whole blood donation in BMU from August 2023 to July 2024. A total of 170 blood donors were studied, and environmental factors such as temperature, humidity, and air quality contributed significantly to the prevalence and severity of AEs. The results of the descriptive statistics, Chi-square test and logistic regression analysis are consistent with available literature in that environmental

factors contribute much to donor perception of comfort and safety during blood donation.^{2,5} The total adverse event prevalence in this study was 15% (n=25); most of these were mild (12%) with severe adverse reactions experienced by 3% of donors. These numbers are in line with the previous literature revealing that mild adverse events occur more frequently than severe ones and have been reported in 10-15% of donors.³ The rate of serious adverse events (3%) in this study is also consistent with the finding in Liunbruno et al and Jones et al, who detected mild reactions in 2% of donations and severe reactions in 5%.^{7,8} The common minor adverse effects of dizziness and nausea are widely reported, and usually a consequence of vasovagal reaction.² The low incidence of adverse events highlights the need to identify factors that might alleviate these reactions, especially in places where environmental conditions might increase donor discomfort. Temperature was a significant predictor of adverse events. Data also indicate higher frequencies of mild and severe AEs among donors exposed to temperatures >25°C. The incidence of severe side effects was markedly higher (p=0.04) in donors who faced high temperature exposure, especially in male donors. This is in line with prior research, such as Fuchs et al who showed that vasovagal reactions during blood donation are more likely at high temperatures.⁵ Increased temperatures might stimulate physiological reactions, as vasodilation and therefore dizziness and fainting could occur in predisposed subjects.⁷ Notably, visually supports this observation as we observed a possible upward trend in the number of mild cases at temperatures higher than 25°C; this tendency was even more pronounced for severe AEs, indicating that donation agencies might consider regulating room temperature especially for hot days to prevent heat-related discomfort and enhance donor safety. These results are in agreement with Morris et al who observed a significant decrease in adverse effects through temperature control of donation facilities.³ Humidity was also one of the important environmental factors in this research. Data indicate that humidity >60% was significantly correlated with mild adverse events (p=0.03). The rates of mild events were increased in donors with exposure to these conditions, especially among female donors. Elevated humidity could contribute to the discomfort with reduced body temperature regulation, which can cause feelings of dizziness and sickness.⁸ This implication signals that optimal atmospheric humidity levels in donation centers may contribute to a reduction of mild adverse events and an enhanced donor experience. AQI was a predictor in case of severe AEs as well. Poor air quality (AQI >70) was significantly correlated with the risk of severe adverse events (p=0.02). Information on specificity and positive/negative predictive values are included. This is in line with the results of Kim et al who found that donation environments with poor air quality raise the risk of adverse reactions, especially among those with pre-existing sensibility against pollutants.⁶ While air quality did not affect mild adverse events to a noticeable extent, the severe responses observed in donors who donated after being exposed to poorer quality air is concerning and

indicates that donation settings should consider ventilation and air filtration. The results of the present study are also consistent with regional and international trends, as seen in other blood banks. A study by Liumbruno et al best described that the adverse events are likely to take place in hot blood donor auditoria and specifically those with poor climate regulation.⁷ Similarly, Fuchs et al reported a significant correlation between elevated ambient temperatures and donor discomfort, particularly during the summertime.^{8,9} Although the study offers regional perspectives from BMU, it adds to the cumulative evidence of exploring environmental parameters and intensity association with blood donation-related adverse events. With respect to humidity, the result of this study concern and ratifies the observation with Jones et al who emphasized the importance of humidity in exacerbating mild AEs.^{8,10,11} They found that the humidity level in blood donation facilities could significantly influence donor vertigo and nausea. The current study also highlights the significance of monitoring and maintaining humidity to reduce donor distress. In addition, the relationship between air quality and adverse events supportive of those by Kim et al and Gibson et al that severe adverse reactions can attacks during a poor air quality.^{2,6,12,13} The importance of air quality to donor safety was emphasized in the current study, recommending repeated monitoring of air quality parameters to be a part of the operational procedures followed by blood banks and donation centres. The results of this study have significant implications for blood donation policies and practices.¹⁴ Because temperature, humidity and air quality affect adverse events substantially, blood centers should have measures for environmental control (e.g., to keep room temperatures <25 °C; humidity at <60% and good air quality with ventilation or air purifiers). Such efforts may mitigate adverse events, increase donor comfort and retention. Trained staff to identify environmental-related discomfort, responding immediately with interventions to donors experiencing adverse events could also enhance donor safety.^{15,16} The blood collection centres might also consider evaluating, on a regular basis, the environmental conditions including those related to seasonal changes (heat or humidity) in order to avoid possible discomfort.

CONCLUSION

This research emphasizes the importance of environmental factors: temperature, humidity and air quality on adverse reactions in whole blood donation. Both mild and severe adverse events were more common on hot days, in high humidity, and with poor air quality. It can therefore be concluded that blood donation centres should consider studying and controlling the environmental conditions such as defects in temperature above 25°C, air humidity, re-circulation of air to eliminate contaminants down the donor to improve on comfort and safety. By evaluating these environmental factors, blood donor centers might be able to enhance the donation experience and decrease likely adverse reactions.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee

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