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Original Research Article

Clinical and lifestyle risk determinants of undiagnosed diabetes and pre-diabetes in a blood donor population

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ABSTRACT

Background: Diabetes and its related complications constitute a major public health challenge due to their high prevalence, healthcare costs, and associated morbidity and mortality. Therefore, this study aimed to identify clinical and lifestyle factors associated with undiagnosed diabetes and pre-diabetes among blood donors in Bangladesh.
Methods: This cross-sectional study at the department of transfusion medicine, Bangladesh Medical University (BMU), Dhaka, enrolled 135 healthy blood donors aged 18-60 years. Participants were assessed for BMI, physical activity, family history of diabetes, FINDRISC score, and HbA1c, with blood analyzed using an automated analyzer (Capillary 3 Octa/Variant II). Data were analyzed in SPSS 24.0 using Chi-square tests ($p<0.05$).
Results: Among 135 blood donors, 83% were 25-44 years and 91.1% male. BMI showed 51.8% overweight and 17.8% obese. FINDRISC scores were mainly 7-11 (52.6%) and 12-14 (25.9%). Glycemia: 49.6% normal, 41.5% prediabetic, 8.9% diabetic. Dysglycemia was higher with obesity (41.7%), overweight prediabetes (57.1%), inactivity ($p=0.029$), and positive family history (73.2-75%; $p<0.001$). FINDRISC scores correlated with risk, with 58.3% diabetes in the 15-20 group ($p<0.001$).
Conclusions: Higher BMI, low physical activity, positive family history, and elevated FINDRISC scores are associated with undiagnosed dysglycemia among apparently healthy blood donors.

Keywords: Blood donors, Diabetes, Prediabetes

INTRODUCTION

Diabetes and its related complications constitute a major public health challenge because of their high prevalence, substantial healthcare expenditure, and associated mortality. The World Health Organization (WHO) has reported that approximately 422 million individuals globally are living with diabetes.[1] Data from the 2017 International Diabetes Federation (IDF) indicate that the global prevalence of diabetes among individuals aged 20-79 years is 8.8%.[2] Furthermore, the IDF estimated in 2021 that nearly 537 million adults worldwide- representing 10.5% of the global adult population- were affected by DM. Over recent decades, the incidence of type 2 DM has

increased markedly, particularly in developing nations. Diabetes is widely regarded as a global epidemic and is disproportionately more common among South Asian populations; consequently, Asia is often described as the epicenter of this epidemic.[3] A considerable proportion of affected individuals remain unaware of their condition, with reports suggesting that around 20% of people with diabetes are undiagnosed, and nearly one in every two individuals does not know they have the disease.[4,5] It is estimated that approximately 240 million people, or 44.7% of those affected, are unaware of their diagnosis. In addition, the prevalence of pre-DM- including impaired fasting glucose and impaired glucose tolerance and/or HbA1C 5.7-6.4% (39-47 mmol/mol)- is rising globally.[6]

Evidence indicates that individuals may remain in the asymptomatic phase of pre-DM and T2DM for approximately 5-6 years before receiving a diagnosis, during which time diabetes-related complications may already be developing.[7,8] Therefore, individuals with CVD who are at risk of DM or prediabetes require careful medical monitoring, with greater emphasis on secondary prevention and prompt identification of dysglycemia, as early diagnosis and management of diabetes can substantially improve prognosis.[9] Effective early management depends largely on preventive approaches, including adherence to a diet rich in fruits and whole grains, engagement in regular physical activity, maintenance of appropriate body weight, and routine medical evaluations. Improved clinical outcomes for patients with hypertension and diabetes are closely linked to early screening and diagnostic testing, such as fasting blood sugar, oral glucose tolerance, and HbA1c.[10,11] The growing burden of type 2 DM is primarily attributed to the increasing prevalence of modifiable, non-genetic risk factors, particularly obesity and physical inactivity.[12] Additionally, more than 60% of the global diabetic population resides in Asian countries, as Asians are considered genetically and ethnically predisposed to diabetes and may exhibit lower tolerance to environmental risk factors.[13]

Blood donors constitute a distinct segment of the population who are typically regarded as healthy at the time of donation, since they undergo routine clinical assessment and must satisfy established eligibility criteria prior to blood donation. Nevertheless, despite being assumed healthy, they may still have unrecognized metabolic abnormalities such as pre-diabetes and diabetes, thereby making this population particularly valuable for risk stratification and early detection initiatives.

Undiagnosed DM can be identified only through health assessments in which individuals undergo blood glucose testing and are queried regarding any prior diagnosis based on their medical history.[14] Despite the substantial burden of disease, only a limited number of studies have been conducted in the Kurdistan Region of Iraq addressing DM.[15-17] Therefore, this study aimed to identify clinical and lifestyle factors associated with undiagnosed diabetes and pre-diabetes among blood donors in Bangladesh.

Objective

To identify clinical and lifestyle factors associated with undiagnosed diabetes and pre-diabetes among blood donors.

METHODS

This cross-sectional observational study was conducted at the department of transfusion medicine, Bangladesh Medical University (BMU), Dhaka, Bangladesh over a 12-month period following protocol approval. A total of 135 healthy, non-remunerated blood donors were enrolled, selected based on specific inclusion and exclusion criteria to evaluate clinical and lifestyle risk determinants of undiagnosed diabetes and pre-diabetes in this population.

Inclusion criteria

Age 18-60 years; weight ≥45 kg. Body temperature <99.5°F; pulse 60–100 bpm; BP 100-140/60-90 mmHg. Hemoglobin ≥12.5 gm/dl (male) or ≥11.5 gm/dl (female). Good physical and mental health; free from acute respiratory distress, skin disease at phlebotomy site, transfusion-transmissible infections, or signs of professional donation/drug use. Female donors during menstruation meeting hemoglobin criteria. Individuals with stable, uncomplicated hypertension under treatment.

Exclusion criteria

Known diabetes mellitus. Temporary deferral conditions: recent surgery, blood transfusion, infections (malaria, dengue, COVID-19, hepatitis, influenza, measles, herpes), immunization, childbirth/abortion, tooth extraction, local infection. Permanent deferral conditions: cancer, cardiac disease, chronic nephritis, HIV/AIDS, liver disease, tuberculosis, epilepsy, asthma, leprosy, schizophrenia, endocrine disorders, rheumatic fever, insulin-treated diabetes, abnormal bleeding, unexplained weight loss.

The study assessed age, sex, body mass index (BMI), physical activity, history of hypertension, family history of diabetes, Finnish diabetes risk score (FINDRISC), and glycemic status using HbA1c. A total of 135 eligible blood donors were enrolled, interviewed using a structured questionnaire, counselled, and examined according to standard donor criteria. The FINDRISC questionnaire was administered to estimate diabetes risk, and 5 ml of blood was collected in EDTA tubes during routine donation for HbA1c analysis using an automated analyzer (Capillary 3 Octa/Variant II) at the Department of Biochemistry & Molecular Biology, BMU. Data were compiled and analyzed using SPSS version 24.0, with categorical variables presented as frequencies and percentages, and associations tested using the Chi-square (χ^2) test ($p<0.05$ considered significant). Ethical approval was obtained

from the BMU institutional review board, and informed written consent was obtained from all participants. Data collection and laboratory procedures were conducted under direct supervision to ensure accuracy and adherence to protocol.

RESULTS

Table 1 presents the age distribution of the blood donors included in the study. The majority of participants were aged 2534 years (43.7%), followed by the 35-44 years age group (39.3%). Smaller proportions were observed in the 45-54 years (8.9%) and 18-24 years (7.4%) categories, with only one participant (0.7%) aged ≥55 years. The mean age of the study population was 36.16±6.39 years.

Table 1: Age distribution of the study participants (n=135).

Age groups (years)	Frequency	Percentage
18–24	10	7.4
25–34	59	43.7
35–44	53	39.3
45–54	12	8.9
≥55	1	0.7
Total	135	100.0
Mean±SD	36.16±6.39	

Table 2: Sex distribution of the study participants (n=135).

Sex	Frequency	Percentage
Male	123	91.1
Female	12	8.9
Total	135	100.0

Table 2 shows the sex distribution of the study participants. The study population was predominantly male, accounting for 91.1% of participants, whereas females represented 8.9% of the total donors.

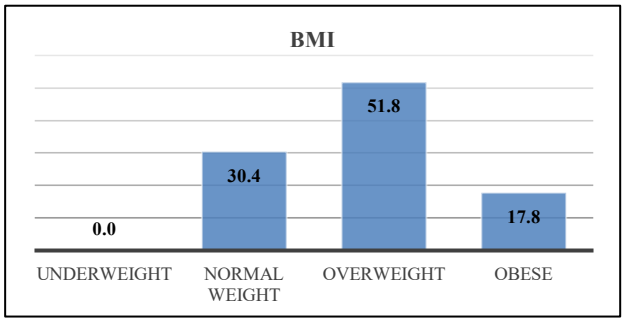

Figure 1: Body mass index (BMI) distribution of the study participants (n=135).

Figure 1 illustrates the BMI distribution among the blood donors. Over half of the participants were overweight (70 participants, 51.8%), while 24 participants (17.8%) were classified as obese. Normal weight was observed in 41 participants (30.4%), and no participants were underweighted.

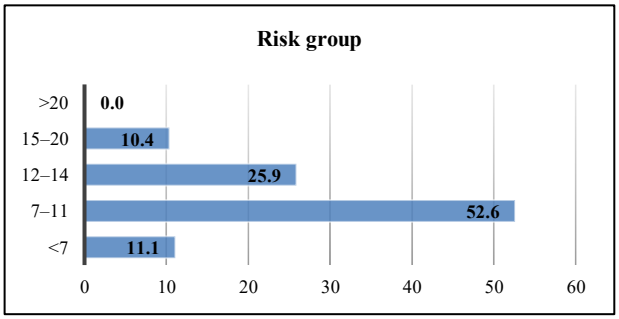

Figure 2: Distribution of participants according to FINDRISC risk categories (n=135).

Figure 2 illustrates the distribution of study participants across different Finnish diabetes risk score (FINDRISC) categories. The majority of participants (52.6%, n=71) were in the 7-11 risk group, followed by 12-14 (25.9%, n=35). A smaller proportion fell into the <7 low-risk category (11.1%, n=15) and 15–20 higher-risk category (10.4%, n=14), while no participants were classified in the >20 very high-risk group.

Table 3: Glycemic status based on HbA1c levels among blood donors (n=135).

Category	Frequency	Percentage
Normal HbA1c <5.7	67	49.6
Prediabetes HbA1c 5.7-6.4	56	41.5
Diabetes HbA1c ≥6.5	12	8.9
Total	135	100.0

Table 3 shows the distribution of glycemic status among the study participants. Normal glycemic levels (HbA1c <5.7%) were present in 67 participants (49.6%), prediabetes (HbA1c 5.7-6.4%) in 56 participants (41.5%), and diabetes (HbA1c ≥6.5%) in 12 participants (8.9%).

A statistically significant association was observed between BMI category and glycemic status (p=0.030), with a higher proportion of diabetes among obese participants (41.7%) compared to those with normal BMI (8.3%). Overweight individuals constituted the largest proportion of the prediabetic group (57.1%). Regular physical activity was also significantly associated with glycemic status (p=0.029); only a small proportion of prediabetic participants (1.8%) and none of the diabetic participants reported regular exercise, whereas 13.4% of normoglycemic individuals engaged in regular physical activity. In contrast, history of hypertension did not show a statistically significant association with glycemic status (p=0.318). However, family history of diabetes demonstrated a strong statistically significant association (p<0.001), with a higher proportion of prediabetes (73.2%) and diabetes (75.0%) observed among participants with a positive family history.

Table 4: Association of selected clinical and lifestyle factors with glycemic status among blood donors (n=135).

Variables		Normal (n=67) (%)	Prediabetes (n=56) (%)	Diabetes (n=12) (%)	P value
BMI category	Normal weight	26 (38.8)	15 (26.8)	1 (8.3)	0.03
	Overweight	32 (47.8)	32 (57.1)	6 (50.0)	
	Obese	9 (13.4)	9 (16.1)	5 (41.7)	
Regular exercise	Yes	9 (13.4)	1 (1.8)	0 (0.0)	0.029
	No	58 (86.6)	55 (98.2)	12 (100.0)	
History of hypertension	Yes	10 (14.9)	6 (10.7)	0 (0.0)	0.318
	No	57 (85.1)	50 (89.3)	12 (100.0)	
Family history of diabetes	Family	31 (46.3)	41 (73.2)	9 (75.0)	<0.001
	Relatives	19 (28.4)	15 (26.8)	3 (25.0)	
	None	17 (25.4)	0 (0.0)	0 (0.0)	

Table 5: Association between FINDRISC score and glycemic status among blood donors (n=135).

Risk Group	Normal (%) (n=67)	Prediabetic (%) (n=56)	Diabetic (%) (n=12)	P value
<7	13 (19.4)	2 (3.6)	0 (0.0)	<0.001
7–11	46 (55.2)	23 (41.1)	2 (16.7)	
12–14	7 (10.4)	25 (44.6)	3 (25.0)	
15–20	1 (1.5)	6 (10.7)	7 (58.3)	
Total	67 (100.0)	56 (100.0)	12 (100.0)	

Table 4 demonstrates the association between FINDRISC score categories and glycemic status among blood donors. Participants with lower FINDRISC scores (<7) were predominantly normoglycemic, whereas higher risk categories showed progressively greater proportions of prediabetes and diabetes. Notably, in the 15-20 risk group, the majority of participants (58.3%) were diabetic. The association between FINDRISC score and undiagnosed dysglycemia was statistically significant (p<0.001).

DISCUSSION

This cross-sectional study at Bangladesh Medical University revealed that a notable portion of healthy blood donors harbored undiagnosed prediabetes or diabetes as determined by HbA1c levels. Elevated BMI, lack of regular exercise, and family history of diabetes were significantly linked to dysglycemia, highlighting the importance of proactive screening and lifestyle-based risk assessment in this population.

The majority of blood donors in this study were young and middle-aged adults, with most participants aged 25-34 years (43.7%) and 35-44 years (39.3%), while older age groups were minimally represented. This predominance of younger adults in donor populations is consistent with previous research. Singh et al reported that 58% of donors were aged 18-30 years, with only 22% in the 31-40 years group, indicating a marked underrepresentation of older individuals.[18] Similarly, Parvin et al observed that nearly half of their donor population (48.5%) belonged to the 26-35 years age group, with older age groups accounting for a smaller proportion.[19] Collectively, these findings suggest that younger adults are the primary contributors to voluntary blood donation across diverse settings, reflecting both demographic availability and the preference or eligibility of younger individuals for donation, a pattern mirrored in the current study.

The study population was predominantly male, with 91.1% of participants being male and only 8.9% female, reflecting a pronounced gender disparity in blood donation. This strong male predominance aligns with findings from other blood donor populations. For example, Choudhury et al. reported that 82.9% of donors in a cohort of 508 individuals in India were male, with females representing only 17.1%.[20] Such trends are commonly observed in many regions and are attributed to a combination of sociocultural factors, health eligibility criteria, and donor recruitment practices that favor male participation. The similarity between these findings and the present study underscores the consistent pattern of male dominance in voluntary blood donation across different populations.

The BMI distribution of the study participants revealed that the majority of donors were overweight (51.8%) or obese (17.8%), with only 30.4% having normal BMI and no participants classified as underweight. This high prevalence of elevated BMI among blood donors is consistent with findings from other studies. Marić et al reported that in a cohort of 1,543 healthy blood donors, the median BMI was 26.3 kg/m^2, with 56% of participants classified as overweight or obese, highlighting that elevated BMI is common even in screened donor populations.[21] Similarly, Murphy et al found that among

over one million US blood donors, 41% of male donors and 31% of female donors were overweight, while 29% of males and 26% of females were obese, further demonstrating that excess weight is prevalent in blood donor cohorts.[22] These similarities indicate that a considerable proportion of voluntary blood donors may have overweight or obesity, reflecting broader trends in adult populations and underscoring the importance of considering BMI in donor health assessments.

The distribution of participants according to FINDRISC risk categories in the present study demonstrated that the majority of blood donors belonged to the moderate risk group (7-11), accounting for 52.6%, followed by 25.9% in the 12-14 risk category. A smaller proportion of donors were classified in the low-risk group (<7) and higher-risk group (15-20), while none fell into the very high-risk category (>20). This pattern suggests that although most blood donors appear healthy, a considerable proportion still possess moderate to elevated risk for developing type 2 diabetes, highlighting the importance of risk assessment in this population. Similar observations have been reported by Samad et al, who found that routine diabetes screening among blood donors revealed a number of individuals with previously undiagnosed hyperglycemia or diabetes, despite donors being generally regarded as healthy volunteers.[23] Their findings emphasize the potential value of incorporating diabetes risk assessment tools such as FINDRISC in blood donation settings, as these accessible populations provide an opportunity for early identification of individuals at risk for dysglycemia and timely preventive interventions.

The glycemic assessment revealed that nearly half of the donors (49.6%) had normal HbA1c levels, while a substantial proportion were classified as prediabetic (41.5%) and diabetic (8.9%), indicating a notable prevalence of undiagnosed dysglycemia among apparently healthy blood donors. This pattern aligns with findings from Anghebem-Oliveira et al, who reported that approximately 9.0% of donors had prediabetes-range HbA1c (5.7-6.4%) and 0.5% had levels suggestive of diabetes (≥6.5%) in a large blood bank screening program, highlighting that even screened donor populations may harbor significant numbers of individuals with impaired glycemic control.[24] The higher prevalence observed in the present study may reflect population-specific factors, such as age distribution, lifestyle habits, and regional metabolic risk profiles, but collectively these findings underscore the importance of glycemic screening among blood donors to identify otherwise unrecognized prediabetes and diabetes.

The present study demonstrated significant associations between several clinical and lifestyle factors and glycemic status among blood donors. Participants classified as overweight or obese showed higher proportions of prediabetes and diabetes compared with those of normal BMI, with 41.7% of obese individuals falling within the diabetic group (p=0.03), highlighting the influence of excess body weight on impaired glucose regulation. This finding is consistent with existing evidence that elevated BMI is a major predictor of dysglycemia in otherwise healthy populations. Regular physical activity was also significantly associated with glycemic status (p=0.029); only 1.8% of prediabetic participants and none of the diabetic participants reported engaging in regular exercise, whereas 13.4% of normoglycemic donors performed routine physical activity. These findings are comparable with those reported by Tura et al., who observed that sedentary individuals are more likely to have elevated blood glucose levels and unfavorable metabolic profiles than physically active individuals.[25] In contrast, history of hypertension did not show a statistically significant association with glycemic status in the present study (p=0.318). However, family history of diabetes demonstrated a strong and statistically significant association (p<0.001), with 73.2% of prediabetic and 75.0% of diabetic participants reporting a positive family history of diabetes, while none of the participants without such history were classified as prediabetic or diabetic. This observation is consistent with previous studies identifying family history as a powerful non-modifiable risk factor for prediabetes and diabetes.[26] Collectively, these findings highlight the combined contribution of modifiable factors such as BMI and physical activity and non-modifiable factors such as family history in determining glycemic status, even among apparently healthy blood donor populations.

The present study demonstrated a significant association between FINDRISC score and glycemic status among blood donors (p<0.001). Participants with lower FINDRISC scores (<7) were predominantly normoglycemic, with 19.4% of normal individuals falling into this category and none classified as diabetic. In contrast, higher FINDRISC categories showed progressively greater proportions of prediabetes and diabetes. Notably, among individuals with scores of 121-4, 44.6% were prediabetic and 25.0% were diabetic, while in the 15-20 risk group, the majority (58.3%) were diabetic. These findings indicate that the prevalence of abnormal glycemic status increases markedly with rising FINDRISC scores. Similar observations were reported by Martin et al, who found that elevated FINDRISC scores among 671 blood donors were strongly associated with prediabetes and diabetes confirmed by glucose testing, particularly in individuals with scores of 12 or higher.[27] The consistency between these findings highlights the effectiveness of the FINDRISC questionnaire as a simple and reliable tool for identifying individuals at risk of undiagnosed dysglycemia within apparently healthy blood donor populations.

The study had a few limitations: The study population was selected from a single center, so the results may not reflect the broader national scenario. The small sample size limited the statistical power and generalizability of the findings. Blood donors are generally healthier than the general population, which may introduce selection bias

and limit the applicability of results to the wider community.

CONCLUSION

Undiagnosed prediabetes and diabetes were common among apparently healthy blood donors. Higher BMI, low physical activity, and a positive family history of diabetes were significantly associated with abnormal glycemic status. Elevated FINDRISC scores effectively identified individuals at greater risk, highlighting the importance of routine screening and risk assessment to detect metabolic abnormalities even in presumed healthy populations.

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

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