Magnitude of impaired fasting glucose and undiagnosed diabetic mellitus and associated risk factors among adults living in Woreta town, northwest Ethiopia: a community-based cross-sectional study, 2021

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Abstract

Background Impaired fasting glucose (IFG) is an early warning system that provides prior information to prevent the future development of DM and diabetes-related problems, but early detection of DM is not practically applicable in Ethiopia. This study was aimed to assess the magnitude of impaired fasting glucose and undiagnosed diabetes mellitus (DM) and associated factors.

Methods A community-based, cross-sectional study was conducted from May to June 30, 2021. A structured interviewer-administered questionnaire was used to collect data. Anthropometric measurements were also recorded. A fasting blood sugar (FBS) test was assessed by samples taken early in the morning. Epi-Info 7.2.5.0 was used to enter data, which was then exported to SPSS 25 for analysis. To identify factors associated with IFG, logistics regression was used. The level of statistical significance was declared at p 0.05.

Result Three hundred and twenty-four (324) participants with a mean age of 43.76 ± 17.29 years were enrolled. The overall magnitude of impaired fasting glucose (IFG) and undiagnosed diabetes mellitus (DM) were 43.2% and 10.0%, respectively. Waist circumference (AOR: 1.72, 95% CI 1.23–3.14), hypertension (AOR: 3.48, 95% CI 1.35–8.89), family history of Diabetic mellitus (AOR: 2.34, 95% CI 1.37–5.79) and hypertriglyceridemia (AOR: 2.35, 95% CI 1.41–5.43) were found to be independently associated with impaired fasting glucose.

Conclusion Individuals who are overweight, hypertriglyceridemia, and are hypertensive should have regular checkups and community-based screening.
Keywords  Impaired fasting glucose, Undiagnosed diabetic mellitus, Risk factors, Ethiopia

Background
Diabetes mellitus (DM) is a public health problem characterized by a high blood sugar level in the body. It can be caused by a lack of either insulin secretion or insulin resistance. Its magnitude has been increasing in recent decades. The magnitude in people above the age of 18 increased from 4.7% to 1980 to 8.8% in 2017 [1–3]. It affects more than 425 million people worldwide, with the number expected to rise to 529 million by 2030 [1].

Diabetes mellitus is a big public health problem with serious consequences. Undiagnosed diabetes mellitus (UDM) affects 50% of people aged 20 to 79 years in the world, 69% in Africa, which is nearly double that of high-income nations (37%). This provides new information on Africa’s high rate of sickness and mortality, which could occur at a younger age [2, 3].

Impaired fasting glucose (IFG) is characterized by glycemic levels that are greater than normal but below diabetes thresholds (fasting glucose >60.0 mmol/L and >70.0 mmol/L). It is a major risk factor for diabetes and its consequences, including nephropathy, diabetic retinopathy, and an elevated risk of macrovascular disease [4–6]. As a result, understanding IFG is critical for avoiding diabetes forecasts in the future.

According to studies in Behar Dar city and rural areas of Dire Dawa, UDM was 10.2% and 6.2%, respectively [7, 8]. A worldwide study by 2030 reported that 470 million people will be affected by IFG [9, 10]. In addition, studies have shown that people diagnosed with IFG are more likely to develop diabetes. Diabetes is a 5–10% annual risk for patients with IFG, according to Tabak et al. [11]. Larson et al. found that 25% of postmenopausal women with impaired fasting glucose (IFG) or impaired glucose tolerance (IGT) tests progressed to type 2 diabetes (T2DM) in 5 years [12]. However, there is evidence that controlling IFG with lifestyle changes, including physical activity and healthy diets, [13–15], can prevent or postpone the advancement of DM, and another study found that behavioral changes alone lowered the risk of DM by 40–70% [11]. In general, it is critical to identify people who have an IFG condition so that early preventive actions can be implemented.

In 2015, the International Diabetes Federation (IDF) reported that the magnitude of DM in Ethiopia was 2.2%[16]. Despite the fact that IFG is an early warning system that provides a warning to prevent the future development of DM and diabetes-related problems, data on the prevalence of prediabetes (IFG), undiagnosed DM, and associated risk factors in Ethiopia is inadequate. As a result, this research will give baseline data on the magnitude of IFG, UDM, and associated factors in Ethiopia.

Methods
Study area
The research was carried out in Wereta, Fogera district. Woreta town is located in the Amhara National Regional State, 561 km from Addis Ababa, the capital city of Ethiopia. The town has 18,400 inhabitants, living in five kebeles (the smallest administrative units). There is one government health center and one private hospital in town.

Study design and period
A community-based cross-sectional study design was conducted from June to July 2021.

Source population
All adults (age over 18 years old) who live in Woreta town.

Study population
Adults who live in Woreta town (selected kebeles) and fulfill the inclusion criteria.

Sample size
The sample size was generated using the single population proportion approach, which factored in a 12% prevalence of IFG discovered in a prior study in Koladiba town, northwest Ethiopia [17], a 5% level of significance, and a 5% margin of error. The minimum sample size was 324 as a result of multiplying the estimated result (162) by the design effect of 2.

Sampling procedure
A multistage sampling procedure was used to choose the participants, and three kebeles (the smallest administrative units with similar demographics) were picked at random from five kebeles. Participants were proportionally assigned to each of the selected kebeles based on the number of households. Thus, 120, 98, and 106 participants were selected from Kebele one, three, and five, respectively, using the systematic random sampling technique. When there were multiple eligible subjects in a family, the lottery method was employed to choose one at random.

Data collection procedures
Before the actual data collection, the data collectors received a 3-day training on interviewing techniques, questionnaire administration, and physical measuring procedures. Data was collected by two health officers and two laboratory technicians.

The timing of a participant’s last meal was checked to ensure that they had fasted for at least eight hours the
night before. A pre-test was conducted from non-study areas to confirm that the data collectors and responders understood the questions. As a result of the pre-test comments, necessary improvements were made prior to actual data collection.

The WHO NCD STEPS tool, which consists of three steps for measuring the risk of NCD risk variables, was used in this study [18]. First, the study population’s core and expanded socio-demographic and behavioral characteristics are gathered. The second step involves taking core and expanded physical measurements, while the third step involves biochemical analysis [18]. The data collection application was originally written in English and then translated into Amharic, the commonly spoken language in the study area, by language experts. To guarantee uniformity, a back translation into English was undertaken prior to data collection.

Variable measurements
The International Diabetes Association’s (IDA) definition was used to define DM: “fasting blood glucose (FBG) ≥126mg/dL.” Previously undiagnosed DM was defined as participants who had not had their blood sugar tested before and were not taking DM medications during the survey and had an FBG ≥126mg/dL”[16].

Anthropometric measures were taken using standardized methodologies and calibrated equipment. Each study subject was weighed to the nearest 0.1kg. Height and weight were measured to calculate their BMI (kg/m2). Height was measured using a portable stadiometer. “Underweight was defined as <18.5 kg/m², normal was defined as 18.5–24.9 kg/m², overweight was defined as 25–29.9 kg/m², and obesity was defined as ≥30 kg/m².” The midpoint between the lower margin of the last palpable rib and the top of the iliac crest was marked to measure the waist circumference (WC). According to the World Health Organization, WC values of more than 102cm for boys and more than 88cm for females were considered high-risk [18].

Blood pressure (BP) was measured twice with a mercury sphygmomanometer, first in a sitting position and once after 15min of rest. The second BP measurement was done 5min after the first. The average value was calculated and the BP result was taken. SBP of 140 mmHg or DBP of 90 mmHg, as well as the usage of antihypertensive medicines on a regular basis, were used to identify hypertension [17].

A smoking habit was defined as smoking tobacco products on a daily basis during the data collection period. Participants who consumed alcohol and chewed khat within the previous 30 days of the data collection period were classified as current alcohol users and khat chewers, respectively.

Data quality management
A pretest was conducted to check that the questions were appropriate for the study. An Amharic-translated version of the questionnaire was employed. Physical measurements were taken twice, and in some cases, three times, to reduce observer error in measurements and records, and data collectors were rotated to compare values. Before and after each day’s data collection, the sphygmomanometer used in the field was compared to the one used in the nearby hospital, Debre Tabor comprehensive hospital. For uniformity in reference and test readings, the glucometer gadget and strips were examined on a regular basis. Every day, the data is cleaned, coded, and recorded.

Data analysis
The collected data was double-checked for accuracy. Completed questionnaires were entered into Epi–Info version 7.2.5.0 immediately after data collection and then exported to SPSS version 25 for analysis. Means, percentages, standard deviations, and ranges were calculated using descriptive statistics. A logistics regression was done to identify factors associated with IFG and UDM. The statistical level of significance was declared at p 0.05.

Results
Sociodemographic characteristics of study participants
A total of 324 participants were incorporated for the final analysis, with a response rate of 100%. The mean age of the participants was 43.76±17.29 years (range 20–80 years). The bulk of the participants, 190 (58.6%) were men; 248 (76.5%) were married; 256 (79.0%) were Orthodox Christians; and 80 (24.7%) had no formal education (Table1).

Magnitude of impaired fasting glucose and undiagnosed DM
The magnitude of IFG and UDM among the study subjects were 12% (95% CI 9–16) and 2.3% (95% CI 1.1–4), respectively, according to the American Diabetes Association (ADA) fasting criteria. IFG was found to be prevalent in 19.7% of males and 23.5% of females in our study area (Table2).

Clinical presentations of study subjects with IFG and UDM
Thirty-six (11.11%) of the subjects had an overweight BMI, whereas 88.9% of the overweight subjects had IFG. About 7.4% of the participants had examined their blood glucose level previously, and 1.2% had screened for DM within the last month. The most commonly elicited symptoms of diabetes were polyuria, polydipsia, polyphagia, and weariness, which were known by eight (2.5%) of the individuals. The prevalence of UDM was reported to be 9.9%, with a 95% confidence interval of 7.5 to 11.7.
Furthermore, the magnitude of IFG was 44.14%, with a 95% confidence interval of 19.45 to 64.54 (Table 3).

### Factors associated with IFG and UDM

Age, family history of diabetes mellitus, body mass index, waist circumference, hypertriglyceridemia, and hypertension were found to be substantially associated with the prevalence of impaired fasting glucose in the bivariate analysis (Table 4).

The results of the multivariate logistic regression analysis revealed that IFG was independently associated with WC, HPN, FHDM and hypertriglyceridemia. The magnitude of IFG was 1.72 times greater in participants with high risk of WC compared to low-risk WC subjects (AOR = 1.72, 95% CI 1.23–3.14). Prediabetes was 2.35 times more common in people with hypertriglyceridemia than in people with normal TG (AOR = 2.35, 95% CI 1.41–5.43). IFG was 3.48 times more common in people with hypertension compared to people without hypertension (AOR = 3.48, 95% CI 1.35–8.89) (Table 4).

### Discussion

This study revealed that the prevalence of IFG was 43%, indicating that if appropriate interventions were not made, the individuals might develop diabetes. This report was higher than a population-based study in Qatar (12.5%)[19]. In Denmark (27.1%)[20] and Bukittinggi, Indonesia (32%)[21], Uganda (3.9%)[22], and Kenya (3.1%)[1]. The probable reason could be the differences in relation to sociodemographic and living standards.
In this study, the magnitude of UDM was 9.87%. It was associated with obesity, hypertriglyceridemia, a family history of DM, and hypertension. This report was in line with reports from studies in the East Gojam zone, northwest Ethiopia (11.5%) [23] Bahir Dar city, northwest Ethiopia (10.2%) [7], Germany (8.2%) [24] USA (11.5%) [25] Italia (10%) [26] and African urban population (8.68%) [27]. However, the magnitude of UDM in this study was higher than that of a study in Uganda (2.3%) [22] and Kenya (2.4%) [1]. The possible difference between Kenya’s study and the current study is that the current study was from a single center while Kenya’s sample was a nationally representative sample. The study in Uganda was among municipal communities with better educational status, expected to have better awareness of diabetic mellitus.

Nevertheless, this report was higher than that of a study at Koladiba (2.3%) [17], Bishoftu town (5%) [7], and Addis Ababa, Ethiopia (6.6%) [28], Teheran, Iran (5%) [29] and Qatar (5.9%) [19]. Moreover, our report was lower than those of patients with UDM and hypertension in India (15%) [30]. The probable reasons for these differences could be different study settings, lifestyles, health-seeking behavior, and practice in routine screening of diabetes and other health problems. In particular, this report was significantly higher than that of the previous study in Koladiba, a rural district in northwest Ethiopia [17]. The disparity could be due to differences in sample size.

For participants with high risk of WC, the odds of IFG was twice higher than those who have low risk of WC. This finding was in line with those of studies conducted in koladiba [17]. The probable reason could be in relation to the relationship between central obesity and insulin resistance. Similarly, among those who had hypertension, the odds of getting IFG were three times higher as compared to no hypertension.

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Any causal association is not estimated by the cross-sectional design of this study. Self-reported dietary

### Table 3

Clinical presentation and laboratory measurements of study subjects in Woreta town, Ethiopia, 2021

| Characteristics                  | Normal (<100 mg/dl) | IFG (100–125 mg/dl) | UDM (≥126 mg/dl) | Chi-Square | p-value |
|----------------------------------|---------------------|---------------------|------------------|------------|---------|
| Ever checked your blood sugar level | Yes                 | 4(16.7)             | 16(66.6)         | 23.48      | 0.000   |
|                                  | No                  | 148(49.3)           | 136(45.3)        | 16(5.4)    |         |
| The checked blood sugar level in the last month | Yes                 | 0                  | 4(100.00)        | 1.331      | 0.514   |
|                                  | No                  | 152(47.5)           | 136(42.5)        | 32(10.0)   |         |
| Family history of DM             | Yes                 | 8(25.0)             | 24(75.0)         | 0.989      | 0.61    |
|                                  | No                  | 144(45.4)           | 116(44.6)        | 27(10.9)   |         |
| Diagnosis of hypertension        | Yes                 | 12(12.2)            | 62(63.3)         | 24(24.5)   | 23.158  | 0.000   |
|                                  | No                  | 140(61.9)           | 78(34.5)         | 8(3.5)     |         |
| Know symptoms of DM              | Yes                 | 26(55.3)            | 13(27.7)         | 8(27.0)    | 60.256  | 0.000   |
|                                  | No                  | 126(45.5)           | 127(45.8)        | 24(8.7)    |         |
| Body mass index (BMI), kg/m²     | Under Weight 4(100.0) | 0                  | 23.387           | 0.001      |         |
|                                  | normal              | 144(55.4)           | 96(36.9)         | 20(7.7)    |         |
|                                  | Over Weight 4(11.1) | 32(88.9)            | 0                | 4.761      | 0.092   |
|                                  | Obese               | 0                  | 12(50.0)         | 12(50.0)   |         |
| Perform physical exercise        | Yes                 | 16(100.0)           | 0                | 4.761      | 0.092   |
|                                  | No                  | 136(44.2)           | 140(45.4)        | 32(10.4)   |         |
| Moderate alcohol intake          | Yes                 | 44(40.7)            | 40(18.5)         | 3.449      | 0.178   |
|                                  | No                  | 108(50.0)           | 96(44.4)         | 12(5.6)    |         |

### Table 4

Bivariate and multivariate analysis of factors associated with IFG in Woreta town, Ethiopia, 2021

| Variable                  | Category | IFG  | COR(95%CI) | AOR(95%CI) |
|---------------------------|----------|------|------------|------------|
| Age                       |          |      |            |            |
|                           | 20–30    | 12   | 48         | 1          |
|                           | 31–40    | 12   | 28         | 1.47(0.45– |
|                           |          |      |            | 4.462)     |
|                           | 41–50    | 32   | 40         | 3.98(1.36– |
|                           |          |      |            | 11.02) *   |
|                           | 51–60    | 24   | 36         | 3.32(1.09– |
|                           |          |      |            | 10.27)*    |
|                           | ≥ 61     | 20   | 40         | 2.46(0.77– |
|                           |          |      |            | 7.18)      |
|                           | ≤ 24.9   | 109  | 135        | 1          |
|                           | ≥ 25     | 31   | 17         | 2.26(1.19– |
|                           |          |      |            | 4.30)      |
|                           | ≥ 25     | 31   | 17         | 1.29(1.19– |
|                           |          |      |            | 3.79)      |
|                           | WC       |      |            |            |
|                           | Low risk |     | 89         | 125        |
|                           |          |      |            | 2.65(1.55– |
|                           | High risk|     | 51         | 27         |
|                           |          |      |            | 1.72(1.23–3.14) |
|                           | TG       |      |            |            |
|                           | Normal   |     | 117        | 139        |
|                           |          |      |            | 2.10(1.02– |
|                           | High     |      | 23         | 13         |
|                           |          |      |            | 2.35(1.41–5.43) |
|                           | FHDM     |      | 24         | 8          |
|                           |          |      |            | 3.72(1.61– |
|                           |          |      |            | 8.6)       |
|                           | HPN      |      | 62         | 12         |
|                           |          |      |            | 9.23(4.71– |
|                           |          |      |            | 18.26) ** |

AOR adjusted odds ratio, BMI body mass index, CI confidence interval, COR crude odds ratio, FHDM family history of diabetic mellitus, DM diabetes mellitus, FHDM family history of diabetes mellitus, IFG impaired fasting glucose, TG triglycerides, WC waist circumference, HPN hypertension

** P < 0.05 ** P < 0.01
information, social habits, and physical activity data may yield inaccurate estimations. The study participant’s unpredictability in obtaining a fasting state is another possible limitation in a population-based study like this study, which might easily result in an overestimation of the prevalence of impaired fasting glucose and undiagnosed diabetic mellitus.

**Conclusion**

In conclusion, the magnitude of IFG and UDM was significantly high. Family history of diabetes, hypertension, WC, and TG were all associated with IFG. Regular physical activities are recommended measures for the prevention and control of diabetes mellitus among the population of Ethiopia.

**Abbreviations**

- BMI: Body Mass Index
- DM: Diabetes Mellitus
- FBG: Fasting Blood Glucose
- IDA: International Diabetes Association’s
- IFG: Impaired Fasting Glucose
- NCDs: Non-Communicable Diseases
- UDM: Undiagnosed Diabetes Mellitus
- WHO: World Health Organization

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**Authors’ contributions**

Shegaw Zeleke Balh, Amare Kassaw Wolie, Misanagaw Asmamaw Mengstie, Zelalem Tilahun Muche, and Shambel Nigusse Amare involved in the conception of the research idea, study design and questionnaire development. Mohammed Abdu Seid, Dr. Yalew Melkamu Molla, and Nega Dagnaw Baye Walle Ayehu prepared tables. Getachew Yideg Yitbark and Assefa Agegnehu Teshome analyzed the data, interpreted the results and drafted the manuscript. All authors revised and approved the final manuscript.

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**Data Availability**

The datasets generated and/or analysed during the current study are not publicly available due to relevant data protection but are available from the corresponding author on reasonable request.

**Declarations**

**Ethics approval and consent to participate**

Ethical clearance and permission were obtained from the research ethics review committee of the college of health science at Debre Tabor University. All methods were performed in accordance with the relevant guidelines and regulations. The study was conducted with informed written consent obtained from each participant, and data collection was conducted confidentially. The study participants were informed about the various procedures in the data collection process, as well as the fact that they might withdraw from the study at any moment if they so desired. During biochemical testing, appropriate precautions were considered to reduce the risk of damage to the lab worker and study participants.

**Consent for publication**

Not applicable.

**Competing interests**

The authors declared no competing interests.

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