



TOSHKENT TIBBIYOT AKADEMIYASI URGANCH FILIALI
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Soliyeva Madina Iqboljon qizi
Master's student in Endocrinology
Department of Hospital Therapy and Endocrinology
Andijan State Medical Institute
ORCID: <https://orcid.org/0009-0006-9395-5683>
madinaakbar0404@gmail.com

BURDEN OF PREDIABETES AND TYPE 2 DIABETES MELLITUS IN THE ANDIJAN REGION: EPIDEMIOLOGICAL FINDINGS FROM URBAN AND RURAL COMMUNITIES

Annotation. Prediabetes and type 2 diabetes mellitus (T2DM) are among the most significant public health problems due to their increasing prevalence and high risk of cardiovascular and metabolic complications. Early identification of carbohydrate metabolism disorders plays an important role in preventing disease progression. **The aim of the study** was to assess the prevalence and epidemiological characteristics of prediabetes and type 2 diabetes mellitus among urban and rural populations of the Andijan region. A population-based cross-sectional epidemiological study was conducted among residents of Andijan city and the Markhamat district, including individuals over 40 years of age. Carbohydrate metabolism disorders were assessed based on fasting blood glucose, glycated hemoglobin (HbA1c), and diagnostic criteria recommended by WHO, ADA, and EASD. The study revealed a high prevalence of carbohydrate metabolism disorders, with combined impaired fasting glucose and impaired glucose tolerance (IFG+IGT) being the most frequent form. A significant number of newly diagnosed cases of type 2 diabetes mellitus were identified. Higher rates of metabolic disorders were observed among women and individuals of middle and older age groups. The obtained results demonstrate a significant burden of prediabetes and type 2 diabetes mellitus in the Andijan region and emphasize the necessity of implementing population-based screening programs and preventive strategies aimed at early detection and reduction of diabetes-related complications.

Keywords: prediabetes, type 2 diabetes mellitus, carbohydrate metabolism disorders, impaired fasting glucose, impaired glucose tolerance, epidemiological study, screening, Andijan region.

Soliyeva Madina Iqboljon qizi
Gospital terapiya va endokrinologiya
Endokrinologiya yo'nalishi magistranti
Andijon Davlat Tibbiyot Instituti

ANDIJON VILOYATIDA PREDIABET VA QANDLI DIABET 2-TURIDA YUKLAMASI:
SHAHAR VA QISHLOQ AHOLISI ORASIDA OLIB BORILGAN EPIDEMIOLOGIK
TADQIQOT NATIJALARI



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Annotatsiya. Prediabet va 2-tip qandli diabet (2TQD) tarqalishining tobora ortib borishi hamda yurak-qon tomir va metabolik asoratlarning rivojlanish xavfining yuqoriligi sababli zamonaviy tibbiyotning dolzarb muammolaridan biri hisoblanadi. Uglevod almashinuvi buzilishlarini erta aniqlash kasallikning rivojlanishini oldini olish va samarali profilaktik choralarini ishlab chiqishda muhim ahamiyatga ega. **Tadqiqot maqsadi** Andijon viloyati shahar va qishloq aholisi orasida prediabet va 2-turida qandli diabetning tarqalishi hamda epidemiologik xususiyatlarini baholashdan iborat bo'ldi. Andijon shahri va Marhamat tumanida 40 yoshdan katta aholi orasida populyatsion bir bosqichli epidemiologik tadqiqot o'tkazildi. Uglevod almashinuvi holati och qoringa qon glyukoza darajasi, glikozillangan gemoglobin (HbA1c) ko'rsatkichlari hamda JSST, ADA va EASD tavsiyalariga asoslangan diagnostik mezonlar yordamida baholandi. Tadqiqot natijalariga ko'ra, tekshirilgan aholi orasida uglevod almashinuvi buzilishlarining yuqori tarqalishi aniqlandi. Eng ko'p uchragan holat nahorgi glikemiya buzilishi va glyukozaga tolerantlik buzilishining kombinatsiyasi bo'ldi. Shuningdek, birinchi marta aniqlangan qandli diabet 2-turida holatlarining sezilarli ulushi qayd etildi. Metabolik buzilishlar ayollar hamda o'rta va katta yosh guruhlarida ko'proq uchrashini aniqlandi. Olingan natijalar Andijon viloyati aholisi orasida prediabet va qandli diabet 2-turining sezilarli yuklamasi mavjudligini ko'rsatadi hamda kasalliklarni erta aniqlash va diabet bilan bog'liq asoratlarni kamaytirishga qaratilgan skrining dasturlari va profilaktik strategiyalarni joriy etish zarurligini ta'kidlaydi.

Kalit so'zlar: prediabet, qandli diabet 2-turida, uglevod almashinuvi buzilishlari, och qoringa glyukoza buzilishi, glyukozaga tolerantlik buzilishi, epidemiologik tadqiqot, skrining, Andijon viloyati.

Солиева Мадина Икболжон кизи
Магистрант направления Эндокринология
Кафедры госпитальной терапии и эндокринологии
Андижанского государственного медицинского института

РАСПРОСТРАНЁННОСТЬ И ЭПИДЕМИОЛОГИЧЕСКИЕ ОСОБЕННОСТИ ПРЕДИАБЕТА И САХАРНОГО ДИАБЕТА 2 ТИПА В АНДИЖАНСКОЙ ОБЛАСТИ: РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЯ ГОРОДСКОГО И СЕЛЬСКОГО НАСЕЛЕНИЯ

Аннотация. Предиабет и сахарный диабет 2 типа (СД2) являются одной из наиболее актуальных медико-социальных проблем современности в связи с постоянным ростом их распространённости и высоким риском развития сердечно-сосудистых и метаболических осложнений. Раннее выявление нарушений углеводного обмена имеет важное значение для предупреждения прогрессирования заболевания и разработки эффективных профилактических мероприятий. **Цель исследования** — оценить распространённость и эпидемиологические особенности предиабета и сахарного диабета 2 типа среди городского и сельского населения Андижанской области. Проведено популяционное одномоментное эпидемиологическое исследование среди жителей города Андижана и Мархаматского района с включением лиц старше 40 лет. Состояние углеводного обмена оценивали на основании определения уровня глюкозы крови натощак, гликированного гемоглобина (HbA1c) и диагностических критериев, рекомендованных ВОЗ, ADA и EASD. В результате исследования выявлена высокая распространённость нарушений углеводного обмена среди обследованного населения. Наиболее часто встречалась сочетанная форма нарушений — нарушение гликемии натощак и нарушение толерантности к глюкозе (НГН+НТГ). Также выявлена значительная доля пациентов с впервые диагностированным сахарным диабетом 2 типа. Более высокая частота метаболических нарушений отмечалась среди женщин и лиц среднего и пожилого возраста. Полученные результаты свидетельствуют о значительном бремени предиабета и



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сахарного диабета 2 типа среди населения Андижанской области и подчёркивают необходимость внедрения популяционных программ скрининга и профилактических стратегий, направленных на раннее выявление заболевания и снижение риска развития диабет-ассоциированных осложнений.

Ключевые слова: предиабет, сахарный диабет 2 типа, нарушения углеводного обмена, нарушенная гликемия натощак, нарушение толерантности к глюкозе, эпидемиологическое исследование, скрининг, Андижанская область.

Abstract. In 2021, the International Diabetes Federation (IDF) published new data showing that **537 million adults worldwide are living with diabetes mellitus (DM)**, representing a 16% increase (74 million people) compared with the previous IDF estimates from 2019. Published ahead of World Diabetes Day on November 14, these updated figures highlight the alarming global rise in diabetes prevalence. Direct healthcare expenditures associated with diabetes are already approaching **one trillion US dollars** and are expected to exceed this amount by 2030.

According to the **National Diabetes Statistics Report of the Centers for Disease Control and Prevention (CDC)**, 37% of adults aged over 20 years and 51% of individuals aged over 65 years in the United States had prediabetes during 2009–2012, defined by fasting plasma glucose (FPG) levels or glycated hemoglobin (HbA1c) levels. Applied to the entire US population, these estimates indicated that approximately **86 million adults had prediabetes in 2012** [1; pp.1–7]. By 2018, this proportion had increased to more than **38% of the adult population** [2; pp.1135–1150].

In China, the prevalence of prediabetes reaches approximately **50% among adults**, demonstrating the magnitude of this problem even in economically developed countries [3; p.13749].

The prevalence of prediabetes is also rapidly increasing in developing regions. For example, a meta-analysis conducted in Nepal, a low-income country, demonstrated a prediabetes prevalence of **9.2%** [4; pp.1935–1946]. Particularly high rates are observed in urbanized populations: in South Asian countries, urban residents have a significantly higher prevalence of prediabetes, which is associated with urbanization-related lifestyle changes, including increased consumption of high-calorie foods and reduced physical activity [5; pp.020301,145; p.4565].

Currently, prediabetes is increasingly recognized as an important metabolic disorder that serves as a predictor of a high probability of progression to overt diabetes mellitus, with an annual conversion rate of **5–10%** [6; pp.124–132; 47; pp.160–166; 75; pp.3329–3345; 169; pp.2279–2290]. These findings reflect a global trend in which urbanization and associated lifestyle changes significantly contribute to the diabetes epidemic.

Central Asian countries are also experiencing an increase in the incidence of type 2 diabetes mellitus (T2DM) and prediabetes, associated with rapid socio-economic transformations. According to IDF estimates, the prevalence of diabetes among adults in Uzbekistan is approximately **6–7%**, corresponding to around **1.3–1.4 million cases**. An epidemiological screening study using an oral glucose tolerance test (OGTT), conducted in different regions of Uzbekistan, revealed **7.9% prevalence of T2DM among adults over 35 years of age**, as well as **4.4% impaired glucose tolerance (IGT)** and **1.4% impaired fasting glucose (IFG)**, indicating an overall prediabetes prevalence of approximately 6%. Importantly, in **74% of cases, diabetes was diagnosed for the first time during active screening rather than being previously known**. In other words, the majority of individuals with diabetes in the community had not previously undergone examination or been registered in healthcare systems, indicating significant gaps in early detection strategies. A clear association was observed between the prevalence of disorders of carbohydrate metabolism and age, with significantly higher rates among older age groups.

The socio-medical consequences of delayed detection of prediabetes and T2DM are extremely serious. Without early diagnosis, the disease progresses silently, and patients often seek medical care only after the development of complications such as coronary heart disease, stroke, renal failure, diabetic retinopathy, and neuropathy. This leads to increased disability and mortality, reduced quality



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of life and life expectancy among the working-age population, and creates an additional burden on healthcare systems and the economy. Considering the continued growth in the prevalence of prediabetes and diabetes worldwide and in our region, studying these conditions at the local level has become particularly relevant [7; p.2297; 91; pp.7839101–9; 108; pp.191–201; 169; pp.2279–2290].

Aim of the study: To assess the prevalence of prediabetes and type 2 diabetes mellitus among urban and rural populations of Andijan.

Materials and methods: To achieve the aim and objectives of the dissertation research, a cross-sectional epidemiological study was conducted involving men and women aged 35–75 years living in rural and urban areas. The survey included **1,800 individuals over 40 years of age from the Markhamat district of Andijan region** and **1,600 individuals over 40 years of age from the city of Andijan**.

The study was carried out in **three stages**. The stepwise approach to monitoring involved the collection of data on major risk factors through questionnaires at the first stage. At the second stage, basic physical examinations were performed. Only after these stages, blood samples were collected for biochemical investigations at the third stage.

The diagnosis of prediabetes was established according to the criteria proposed by the **World Health Organization (WHO)** and recommendations developed by experts of the **Russian Association of Endocrinologists (2017)**, the **European Association for the Study of Diabetes (EASD)**, and the **American Diabetes Association (ADA) (2015, 2018)**. Prediabetes was defined as **impaired fasting glucose (IFG) or impaired glucose tolerance (IGT)**. Hyperglycemia included the diagnosis of diabetes mellitus or prediabetes.

Carbohydrate metabolism parameters were assessed based on capillary blood glucose levels measured using glucometers. The level of **HbA1c** was determined using reagent kits from **HUMAN** with automated measurement of blood hemoglobin levels and calculation of the percentage ratio of HbA1c to total hemoglobin.

Statistical analysis of the obtained results was performed using the **Statistica 6.0** software package. The **Spearman rank correlation method** was used to calculate correlation coefficients. The significance of differences between proportions was assessed using the **Pearson chi-square (χ^2) test**. Differences were considered statistically significant at **$p < 0.05$** .

Results and Discussion

Table 1 presents the age distribution of examined individuals from the Markhamat district and the city of Andijan.

The analysis of Table 1 shows that the largest number of patients belonged to the 45–59-year age group in both study regions, accounting for 25 and 32 patients, respectively. An increased relative risk of developing early disorders of carbohydrate metabolism was observed among both urban and rural populations, particularly in individuals of middle and older age groups. The risk of developing type 2 diabetes mellitus (T2DM) was higher among individuals of middle age compared with other age categories.

These findings emphasize the necessity of intensive monitoring and early detection of carbohydrate metabolism disorders in individuals over 40 years of age.

The epidemiological data obtained in our study demonstrate that prediabetes significantly increases the risk of developing not only type 2 diabetes mellitus but also the entire spectrum of metabolic disorders associated with its progression, regardless of age.



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Table 1. Distribution of selected patients by age among 184 residents of the Markhamat district and 180 residents of Andijan city

Group	Age category	Markhamat district (n=184), abs. (%)	Andijan city (n=180), abs. (%)
Impaired fasting glucose (IFG), n=19/20	18–44 years (young age)	5 (2.7%)	2 (1.08%)
	45–59 years (middle age)	3 (1.6%)	7 (3.88%)
	60–74 years (elderly age)	11 (5.9%)	11 (6.11%)
Impaired glucose tolerance (IGT), n=30/30	18–44 years (young age)	9 (4.9%)	4 (2.22%)
	45–59 years (middle age)	7 (3.8%)	17 (9.44%)
	60–74 years (elderly age)	14 (7.6%)	9 (5.00%)
IFG + IGT, n=53/50	18–44 years (young age)	5 (2.7%)	6 (3.33%)
	45–59 years (middle age)	18 (9.7%)	16 (8.89%)
	60–74 years (elderly age)	30 (16.3%)	28 (15.56%)
Type 2 diabetes mellitus (T2DM), n=52/50	18–44 years (young age)	11 (6.0%)	5 (2.77%)
	45–59 years (middle age)	25* (13.6%)	32* (17.7%)
	60–74 years (elderly age)	16 (8.7%)	13 (7.22%)
Without carbohydrate metabolism disorders, n=30/30	18–44 years (young age)	15 (8.2%)	8 (4.44%)
	45–59 years (middle age)	13 (7.06%)	17 (9.44%)
	60–74 years (elderly age)	2 (1.08%)	5 (2.77%)

Note: $p < 0.05$ compared with other age groups.

Abbreviations:

IFG — impaired fasting glucose;
 IGT — impaired glucose tolerance;
 T2DM — type 2 diabetes mellitus.

Results and Discussion. The analysis of Table 1.1 demonstrates that the highest number of patients in the pilot regions belonged to the **45–59-year age group**, accounting for **25 and 32 patients**, respectively. An increased relative risk of developing early disorders of carbohydrate metabolism was observed among both urban and rural populations, particularly in individuals of middle and older age groups. The risk of developing **type 2 diabetes mellitus (T2DM)** was higher among middle-aged individuals compared with other age categories. These findings emphasize the necessity of intensive monitoring and early detection of carbohydrate metabolism disorders in individuals over 40 years of age.

The epidemiological data obtained in our study provide evidence that **prediabetes significantly increases the risk of progression not only to type 2 diabetes mellitus but also to the entire spectrum of metabolic disorders associated with its development, regardless of age.**

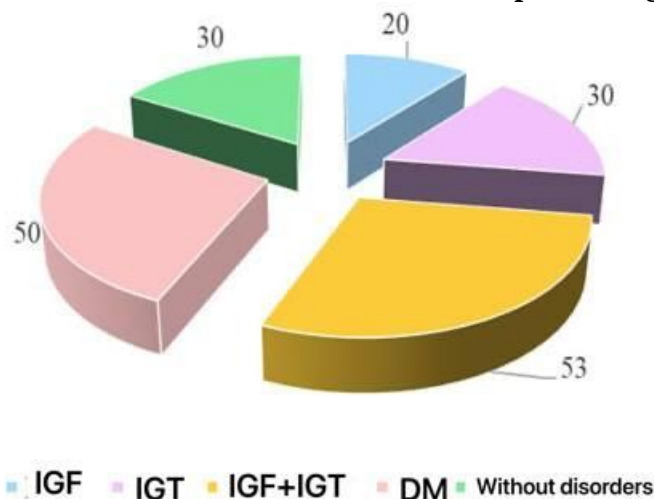


Figure 1. Frequency of carbohydrate metabolism disorders among the studied groups in Andijan city

Figure 1 presents the distribution of different forms of carbohydrate metabolism disorders among examined individuals in Andijan city.

According to the presented data, the largest proportion consisted of patients with combined impairment of fasting glucose and glucose tolerance (**IFG + IGT**) — **53 cases**. The second most frequent condition was newly diagnosed **type 2 diabetes mellitus**, identified in **50 examined individuals**. Impaired glucose tolerance (**IGT**) was detected in **30 patients**, while impaired fasting glucose (**IFG**) was found in **20 individuals**. In **30 participants**, carbohydrate metabolism parameters were within normal limits (the “without disorders” group).

Thus, the total number of examined individuals with carbohydrate metabolism disorders was **153 people**, indicating a high prevalence of prediabetic states and newly diagnosed diabetes mellitus among the population of Andijan city. Particular concern is associated with the high proportion of individuals with combined forms of disorders (**IFG + IGT**), as this category is considered to have the highest prognostic significance regarding the risk of developing type 2 diabetes mellitus [14; pp.529–537, 15; pp.1047–1053].

Therefore, the results obtained in Andijan city (Figure 1) demonstrate a high prevalence of carbohydrate metabolism disorders, especially combined forms (**IFG + IGT**) and type 2 diabetes mellitus.

A similar analysis was conducted among the rural population — residents of the **Markhamat district**, presented in Figure 2. The distribution of various forms of carbohydrate metabolism disorders in this group demonstrated a similar overall trend with certain differences.

The largest number of examined individuals consisted of patients with combined impairment of fasting glucose and glucose tolerance (**IFG + IGT**) — **53 cases**. A slightly lower number — **52 cases** — was recorded among individuals with newly diagnosed type 2 diabetes mellitus. Impaired glucose tolerance (**IGT**) was observed in **30 cases**, while impaired fasting glucose (**IFG**) was detected in **19 examined individuals**. The group without carbohydrate metabolism disorders consisted of **30 people**.

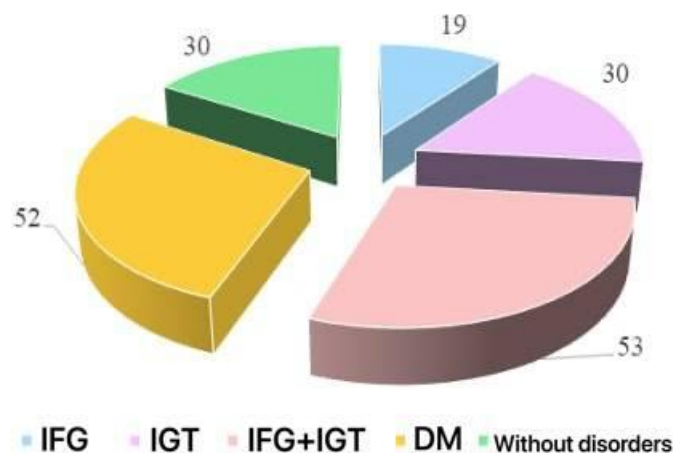


Figure 2. Frequency of carbohydrate metabolism disorders among the studied groups in Markhamat district

Thus, both in rural and urban populations, the largest proportion of patients belonged to the group with combined disorders (**IFG + IGT**), confirming the high probability of progression to overt diabetes mellitus in the presence of these abnormalities.

However, the rural group demonstrated a slightly higher proportion of patients with diabetes mellitus and, conversely, a lower proportion with impaired fasting glucose. These differences may be explained by urbanization-related factors, including higher levels of chronic stress, unbalanced nutrition, reduced physical activity, and age-related characteristics of the examined population.

The obtained results confirm the necessity of **gender- and region-specific approaches** for the prevention and early detection of carbohydrate metabolism disorders [14; pp.529–537, 15; pp.1047–1053].

The next stage of our study involved evaluating the frequency of carbohydrate metabolism disorders according to gender in the Markhamat district and Andijan city (Figures 3 and 4).

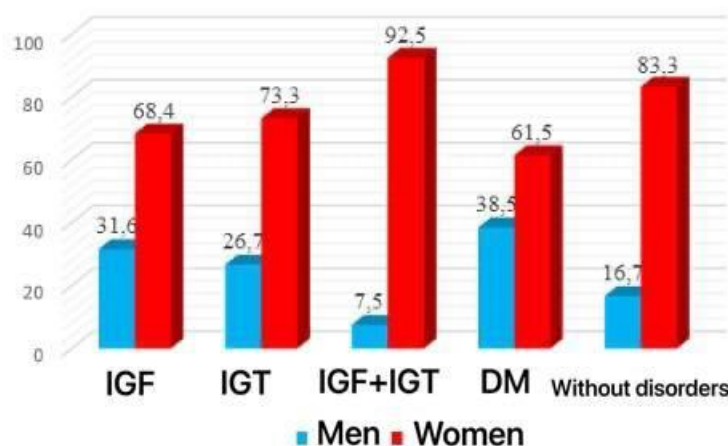


Figure 3. Frequency of carbohydrate metabolism disorders among patients by gender in Markhamat district

The analysis of the prevalence of various forms of carbohydrate metabolism disorders among males and females in the Markhamat district (Figure 3) revealed pronounced gender differences.

According to the presented data, women demonstrated a higher prevalence of carbohydrate metabolism disorders compared with men in all studied groups.



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For impaired fasting glucose (**IFG**), the prevalence among women was **68.4%**, compared with **31.6% among men**. Impaired glucose tolerance (**IGT**) was diagnosed in **73.3% of women** and **26.7% of men**.

The most significant gender difference was observed in the group with combined disorders (**IFG + IGT**): the prevalence among women reached **92.5%**, whereas among men it was only **7.5%**.

Among individuals with newly diagnosed type 2 diabetes mellitus, women accounted for **61.5%**, while men represented **38.5%**.

Even among participants without carbohydrate metabolism disorders, women predominated (**83.3% compared with 16.7% in men**).

The identified characteristics indicate a greater susceptibility of the female population to carbohydrate metabolism disorders in the studied region, which may be associated with both biological and socio-hygienic factors. These findings should be considered when developing and implementing preventive, diagnostic, and therapeutic strategies.

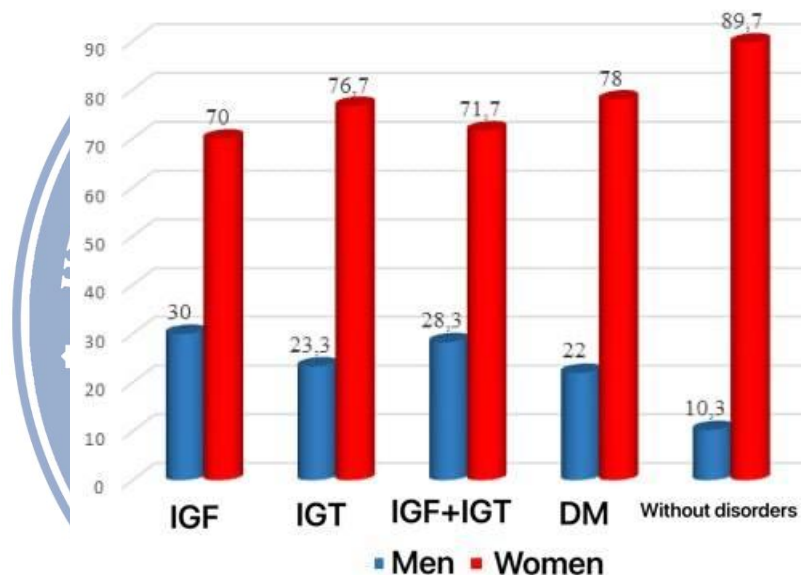


Figure 4. Frequency of carbohydrate metabolism disorders among patients by gender in Andijan city

Figure 4 presents the distribution of the frequency of carbohydrate metabolism disorders among patients living in Andijan city according to gender.

According to the presented data, **female predominance was observed in all studied groups**. Thus, among patients with impaired fasting glucose (**IFG**), the proportion of women was **70%**, whereas men accounted for **30%**. In the group with impaired glucose tolerance (**IGT**), the ratio was **76.7% and 23.3%**, respectively. Among patients with combined carbohydrate metabolism disorders (**IFG + IGT**), women also significantly predominated, accounting for **71.7%**, compared with **28.3% of men**.

A similar tendency was observed among patients with newly diagnosed **type 2 diabetes mellitus (T2DM)**, where the prevalence among women reached **78%**, while among men it was **22%**. Even among individuals without carbohydrate metabolism disorders, women predominated (**89.7% compared with 10.3% among men**).

The obtained results indicate that disorders of carbohydrate metabolism demonstrate significant **geographical variability**. For example, the prevalence of diabetes mellitus varies considerably across different regions of the world: **6.1% in Europe, 14.3% in the United States, 12.8% in China, 22% in South Africa, and 5.4% in the Russian Federation** [15].



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According to the **NATION study**, the prevalence of prediabetes in the Russian population was high and reached **19.3% when assessed by glycated hemoglobin (HbA1c)** [8], which is **2.6 times higher** than the corresponding indicators observed in the Andijan region.

In Asian countries, for example, in India, the prevalence of prediabetes among adults reaches **16.3%** [17]. Studies conducted in Japan demonstrate that approximately **25% of the adult population** has carbohydrate metabolism disorders, with the highest prevalence observed among individuals over **60 years of age**. In some Latin American countries, such as Mexico, the prevalence of prediabetes and type 2 diabetes mellitus is also high, reaching **30% among adults** [17]. These findings emphasize the importance of developing region-specific preventive programs.

Conclusion. **The conducted study demonstrated that the prevalence of prediabetes in the studied population was 12.4%. This value corresponds to the prevalence range reported by the World Health Organization (WHO), which estimates the global prevalence of prediabetes at approximately 9% among the adult population (WHO, 2021).**

Our findings are also comparable with data from other countries. For example, according to the **Centers for Disease Control and Prevention (CDC)**, approximately **38% of adults in the United States** have prediabetes, which is significantly higher than global estimates. This difference may reflect the influence of Western lifestyle patterns, high obesity rates, and insufficient preventive strategies (Centers for Disease Control and Prevention, 2023).

Compared with European countries, where the prevalence of prediabetes is estimated at **6–8%** (International Diabetes Federation, 2021), the rate identified in our study was higher. This may be associated with regional climatic characteristics, insufficient physical activity, and dietary patterns of the studied population.

In low- and middle-income countries with limited opportunities for diabetes prevention, such as India, the prevalence of prediabetes ranges from **10% to 15%** (Vij, 2020) and is strongly influenced by socio-economic factors.

An important finding of this study was the identification of the role of **vitamin D deficiency in the development of prediabetes**. This observation is consistent with previous European and Asian studies demonstrating an association between vitamin D deficiency and an increased risk of impaired glucose tolerance and type 2 diabetes mellitus (Borch-Johnsen et al., 2006). In countries with limited sunlight exposure, such as Scandinavian regions, vitamin D deficiency may contribute to the development of metabolic disorders, including prediabetes (Pittas et al., 2007).

It is important to note that in different regions of the world, including our study area, there is a strong association between **lifestyle changes and progression of prediabetes to type 2 diabetes mellitus**. International studies, including the **DECODE study**, have demonstrated that more than **80% of individuals with prediabetes may develop diabetes within 10 years if lifestyle modifications are not implemented** (Dekker et al., 2009). The results of our study also confirm the importance of lifestyle modification in preventing disease progression.

The prevalence of prediabetes identified in our region corresponds with global trends; however, the observed differences may be explained by specific regional characteristics, including climate, physical activity levels, dietary habits, and accessibility of preventive healthcare measures. These findings highlight the necessity of developing **regional prevention programs based on local epidemiological and socio-economic conditions**.

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