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والثلاثون

استكشاف العوامل المناعية والميكروبية والعوامل الأخرى المساهمة في تدهور الحالة الصحية لدى المرضى المصابين بالسكري غير المسيطر عليه: دراسة مجتمعية لتحديد الأسباب والحلول.

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المستخلص:

يُعد داء السكري غير المسيطر عليه (Uncontrolled Diabetes Mellitus) اضطراباً أيضاً مزمنًا يتميز بارتفاع مستمر في مستويات سكر الدم نتيجة نقص إنتاج الإنسولين، أو ضعف تأثيره، أو كليهما. ويظل داء السكري غير المسيطر عليه مشكلة صحية عامة رئيسية نظرًا لارتباطه بالعديد من المضاعفات الصحية. هدفت هذه الدراسة إلى تقييم العوامل الميكروبية والمناعية وغيرها من العوامل المساهمة المرتبطة بتدهور الحالة الصحية لدى المرضى المصابين بداء السكري غير المسيطر عليه مقارنةً بالأفراد الأصحاء كمجموعة سيطرة. تم استخدام استبيان منظم لجمع البيانات بالاعتماد على إرشادات الجمعية الأمريكية للسكري (American Diabetes Association)، كما تم اختبار الاستبيان من خلال دراسة استطلاعية (Pilot study) والتحقق من ثباته باستخدام معامل كرونباخ - ألفا (Cronbach's alpha). علاوة على ذلك، تم جمع 200 مسحة فموية وفحصها باستخدام الطرق الميكروبيولوجية التقليدية ونظام VITEK 2 Compact لتحديد العوامل الفطرية. بالإضافة إلى ذلك، تم قياس كل من HbA1c و IAA و ANA و ESR. أظهرت النتائج أن معدل انتشار العدوى الفطرية الفموية كان أعلى بشكل ملحوظ لدى مرضى السكري مقارنةً بمجموعة الأصحاء، وكانت *Candida albicans* الأكثر شيوعًا بين العزلات الفطرية. كما أظهرت مستويات المؤشرات الالتهابية ارتفاعًا معنويًا كبيرًا لدى المرضى مقارنةً بالأصحاء. إضافةً إلى ذلك، لوحظ انخفاض في جودة الحياة الجنسية والقدرة على العمل، مع ارتفاع معدل المشاعر



السلبية لدى مرضى السكري. تشير هذه النتائج إلى التأثيرات متعددة الأبعاد لمرض السكري غير المسيطر عليه على الصحة المناعية والميكروبية والنفسية الاجتماعية. كما تبين أن العوامل الديموغرافية والمستوى التعليمي تؤثر في مستوى الوعي بالمرض والرضا عن الرعاية الصحية. إن وجود العدوى الميكروبية وارتفاع مستويات المؤشرات الالتهابية والمعاناة المرتبطة بالمرض يؤكد أهمية تبني خطط علاجية شاملة لإدارة المرضى تتجاوز مجرد التحكم بمستويات سكر الدم. أظهرت هذه الدراسة أن السكري غير المسيطر عليه يرتبط بزيادة القابلية للإصابة بأمراض الفم، وحدوث خلل في الجهاز المناعي، وانخفاض جودة الحياة، إضافةً إلى الاضطرابات النفسية. لذلك، من الضروري إدراج الفحص الفموي الدوري، ومراقبة المؤشرات المناعية، وتقديم الدعم النفسي، وتبني رعاية صحية متعددة التخصصات ضمن برامج إدارة مرض السكري، بهدف تحسين النتائج السريرية ومستوى المعيشة لدى هذه الفئة من المرضى.

الكلمات المفتاحية: السكري غير المسيطر عليه؛ العدوى الفطرية الفموية؛ أنواع *Candida*؛ جودة الحياة؛ الضعف الجنسي؛ إدارة الأمراض المزمنة؛ الحالة المناعية.

Exploring Immunological, Microbial, and Other Contributing Factors in the Deterioration of Health among Patients with Uncontrolled Diabetes: A Community-based Study to Identify Causes and Solutions

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Abstract:

Uncontrolled diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistently elevated blood glucose levels due to insufficient insulin production, impaired insulin action, or both. The Uncontrolled-DM remains a major public health problem due to its association with multiple health complications. This study aimed to evaluate microbial, immunological, and other contributing factors associated with health deterioration among patients compared with healthy controls. The structured questionnaire was used to collect the data on the basis of the guidelines of the American Diabetes Association and was tested on the pilot



study, and on the basis of Cronbach's alpha. Moreover, two hindered oral swab samples were gathered and examined on the basis of traditional microbiological procedures and the VITEK 2 Compact system to determine fungal agents. Additionally, HbA1c, IAA, ANA, and ESR were measured. The outcomes indicated that the prevalence of oral fungal infections was much higher in diabetic patients, and *Candida albicans* was the most common one. The level of inflammatory markers were high significant increasing in the patients compared to control, poor sexual life and work capacity, along with a high rate of negative emotional feelings, were also observed in diabetic patients, implying a high psychological burden. The findings indicate the multi-dimensional effects of uncontrolled diabetes on immunological, microbial, and psychosocial health. In addition to this, demographics and education were discovered to be factors that affected disease awareness and healthcare satisfaction. The presence of microbial infections, an increase in the level of inflammatory markers, and suffering highlight the importance of multidimensional patient management plans beyond glycemic control. In conclusion: this study has shown that uncontrolled diabetes is also linked to higher vulnerability to oral diseases, dysfunction in the immune system, lower quality of life, and psychological impairment. It is important to include oral screening, immunological markers, psychological assistance, and multidisciplinary care in the program of diabetes management to achieve a better clinical outcome and overall living standards in this demographic.

Keywords: Uncontrolled diabetes; Oral fungal infection; *Candida* species; Quality of life; Sexual dysfunction; Chronic disease management; Immunological status.

1. Introduction

1.1. Epidemiological and societal axis

1.1.1. Demographic factors of individuals with uncontrolled diabetes (age, gender, residence, educational level)

Uncontrolled diabetes is a growing international population health issue, but it is not a biological issue; rather, it is a demographic, behavioural, and health systems issue. The adult population is the most affected by



diabetes, with middle-aged and older adults being affected the most (after approximately the fifth decade of life, the prevalence of diabetes and its complications increases exponentially) (Chowdhury *et al.*, 2015; Neupane *et al.*, 2024). The male and female patients have approximately equal prevalence of the disease, although the awareness, treatment, and risk behavioural patterns differ by sex: in certain areas, men smoke and drink more frequently, and women present more often with obesity and poor lipid profiles (Carter *et al.*, 2023; Vich-Perez *et al.*, 2025). The education level and the geographic location are also applicable. In the majority of low and middle-income states, urban status and better socioeconomic status are associated with an increased rate of diabetes, and rural status, low income, and lack of, or insufficient, schooling are associated with lower rates of adherence following a diabetes diagnosis (Chowdhury *et al.*, 2015; Wu *et al.*, 2025). The less educated and less affluent individuals in LMICs are much less likely to receive all the suggested pharmacologic and lifestyle interventions, which accentuates social gradients in the incidence of uncontrolled disease (Flood *et al.*, 2021).

1.1.2. Lifestyle and behavioral factors

Unhealthy lifestyle behaviours, such as energy-dense foods, lack of physical activity, smoking, excess body weight, and dangerous drinking, rank among the most detrimental factors that put an individual at great risk of developing type 2 diabetes and its adverse effects (Geng *et al.*, 2023; Zhang *et al.*, 2019). Large cohort and meta-analytic data show that adherence to multiple low-risk behaviors (healthy diet, regular activity, non-smoking, healthy body weight, moderate alcohol) can reduce incident diabetes by 75–85% and lower microvascular complication risk by about half among those with established diabetes (Geng *et al.*, 2023; Khan *et al.*, 2023). Nevertheless, many patients report low physical activity, suboptimal diet, and substantial rates of smoking and alcohol use, especially among men (Măriuş *et al.*, 2025; Carter *et al.*, 2023).

1.1.3. Community awareness and health literacy

Community knowledge and awareness of diabetes and its complications are oftentimes limited. Studies from Ethiopia and Jordan



report that only about half of community members or the general public have good knowledge scores, and large proportions are ignorant of pivotal danger factors (fattiness, inactivity) or complications (cardiovascular ailment, blindness) (Kassahun and Mekonen, 2017; Alsous *et al.*, 2019). They often have a low perception of personal risk and have never tested their blood glucose (Kassahun and Mekonen, 2017). Such gaps in health literacy contribute to late diagnosis, poor self-management, and uncontrolled disease at the population level.

1.1.4. Treatment adherence and medical follow-up

Indeed, after opinion, adherence to the drug and follow-up is constantly sour. In community and sanitarium studies, non-adherence to antidiabetic medicines ranges from roughly one quarter to over 60 of cases, with lower adherence constantly linked to youngish age, pastoral hearthstone, low education, comorbidities, and shorter duration since opinion (Măriuț *et al.*, 2025). Increased adherence is linked to frequent visits to clinics, the availability of glucose monitoring devices, increased knowledge, and more favorable attitudes toward diabetes (Mariut *et al.*, 2025; Chefik *et al.*, 2022). In 55 low and middle-income countries, small proportions of adults with diabetes are hospitalized with comprehensive, guideline-suggested pharmacologic and life care, and the highest content and lowest proportions in poorer and less educated populations (Flood *et al.*, 2021). These epidemiological and community trends drive home the point that unchecked diabetes is firmly rooted in social surroundings, daily behaviors, as well as health system delivery, just like it is rooted in individual biology.

1.2. Immunological Factors

1.2.1. The Effect of Uncontrolled Diabetes on Immune Efficiency

Unbridled diabetes is being respected less and less as a condition of habitual vulnerable dysfunction where patient hyperglycemia and metabolic stress restructure the innate and adaptive immunity. Individuals having poorly managed type 1 or type 2 diabetes flaunt a low grade, systemic seditious state - which is often referred to as, meta-flammation or inflammaging - that embodies in advanced rates of infection, bloody reactions to vaccines, slow healing of cracks, quick maturation of micro and



macro vascular problems (Alexander *et al.*, 2024; Rohm *et al.*, 2022). Simultaneously, some of the main antimicrobial and regulatory pathways are blunted, and thus, diabetic immunity is both paradoxically activated and unable to work (Alexander *et al.*, 2024).

1.2.2. Indicators of chronic inflammation in diabetic patients

Diabetes-related chronic inflammation is documented by several circulating labels. From normoglycemia through prediabetes to overt type 2 diabetes, large population-based and clinical studies demonstrate progressive increases in white blood cell counts, granulocytes, monocytes, C-reactive protein (CRP), fibrinogen, IL-1 receptor antagonist, IL-18, and neopterin (Rohm *et al.*, 2022; Grossmann *et al.*, 2015). According to Rohm *et al.* (2022), R. *et al.* (2014), Mousa *et al.* (2018), and Koufakis *et al.* (2025), diabetic cases also exhibit elevated IL-6, TNF α , IL-8, and altered microRNAs similar to decreased anti-septic miR 146a, which reflects patient septic activation and vascular form signalling. Hematologic indicators like neutrophil to lymphocyte and monocyte to lymphocyte ratios rise with worsening glycemic indicators, supporting their use as simple septic surrogates in persons with perturbed glucose metabolism (Dera *et al.*, 2025; Grossmann *et al.*, 2015). Together, these biomarkers characterize diabetes as a habitual low-grade septic condition.

1.2.3. Impaired immune response and its role in health deterioration

Besides these inflammatory signals, diabetes directly affects cellular immune function. Advanced glycation end products, oxidative stress, and hyperglycemia alter bone marrow composition, distort myeloid/lymphoid differentiation, and promote immune cell senescence (Alexander *et al.*, 2024; Ren *et al.*, 2025). The innate and adaptive arms that are affected include neutrophil chemotaxis and phagocytosis, macrophage polarization, lymphocyte proliferation, and cytokine production. This leads to worse outcomes with respiratory viruses, tuberculosis, and chronic wounds like diabetic foot ulcers, as well as higher infection rates and lower vaccination responses (Alexander *et al.*, 2024; Omotosho *et al.*, 2025). Innate immune receptor pathways (e.g., TLRs, NLRP3 inflammasome) promote tissue inflammation, fibrosis, and organ dysfunction in target organs such as the kidney, retina, and eye surface, hastening complications like retinopathy and nephropathy (Rohm *et al.*, 2022; Wada and Makino, 2016).



1.2.4. Correlation between blood sugar control and the state of immune dysfunction

The immunological dysregulation is directly proportional to the level of glycemic control. Uncontrolled type 2 diabetes results in a heightened oxidative stress, a reduction in the activities of the NLRP3 inflammasomes, and low production of IL-12 and IL-1 β . This implies that there is a change in pathogen sensing and cytokine reactions as HbA1c increases (Iannantuoni *et al.*, 2019). The condition of poor glycemic control (HbA1c ≥ 7) in type 1 diabetes is associated with significantly high levels of IL-6 regardless of age or BMI, which is indicative that hyperglycemia augments systemic inflammation even in autoimmune diabetes (Koufakis *et al.*, 2025). In adults with type 2 diabetes, it has been demonstrated clinically that enhanced mean HbA1c within one year of vaccination relates to positive neutralizing antibody and CD4+ T cell cytokine reactions, and reduced instances of SARS-CoV-2 breakthrough infections, which connects glycemic management with actual immune defense (Marfella *et al.*, 2022). Obesity and hyperglycemia influence cytokine release, T cell phenotype, and inflammation, with poorer glucose management leading to weaker IL 2 and IFN- γ responses (Tibães *et al.*, 2025). Collectively, our findings show that increasing glycemic management can reduce—but not completely reverse—diabetes-associated immunological impairment and should be a key component of measures to preserve immune competence in this population.

1.3. Microbial Factors

1.3.1. Common types of infections in patients with uncontrolled diabetes

Uncontrolled diabetes creates a biologic environment in which microbial infections are more frequent, more severe, and harder to eradicate. Chronic hyperglycemia impairs innate and adaptive immune defenses, alters tissue perfusion, and changes the composition of skin, mucosal, and gut microbiota, collectively predisposing patients to a broad spectrum of bacterial and fungal infections (Erener, 2020; Holt *et al.*, 2024). Clinically, people with diabetes show increased rates of urinary tract infections (including complicated pyelonephritis), diabetic foot and other skin/soft



tissue infections, osteomyelitis, pneumonia and influenza, tuberculosis, gastrointestinal and hepatobiliary infections, and several life threatening syndromes (emphysematous cholecystitis, rhino orbital mucormycosis) that are rare outside diabetes (Erener, 2020; Kim and Choi, 2025). Additionally, common fungal infections, including mixed bacterial-fungal infections in diabetic foot ulcers and candidiasis of the oral cavity, genital tract, and, in extreme situations, systemic candidemia (Rodrigues *et al.*, 2019; Kim and Choi, 2025). In this population, these infections significantly increase the risk of hospitalization, amputation, and infection-related mortality (Erener, 2020; Holt *et al.*, 2024).

1.3.2. Hyperglycemia and susceptibility to bacterial and fungal infections

Diabetic patients are highly susceptible to infections caused by bacteria and fungi, where hyperglycemia is essential in causing the infections. High levels of blood glucose create a good environment to facilitate the growth of microorganisms, increase pathogen adhesion to epithelial surfaces, and foster the growth of biofilms, which shield microorganisms against host defenses and antimicrobial agents (Holt *et al.*, 2024; Kim and Choi, 2025). Hyperglycemia disrupts the integrity of the epithelial barrier in the urinary tract and decreases the generation of antimicrobial peptides, including psoriasin, which enhances the colonization of *Escherichia coli* and the frequency of urinary tract infection in diabetic individuals (Mohanty *et al.*, 2022). Moreover, impaired glycemic control makes a person highly vulnerable to fungal infection, especially *Candida* species, and the rate of the infection grows in proportion to poorer metabolic control (Rodrigues *et al.*, 2019). Taken together, all these processes underscore the fact that sustained hyperglycemia interferes with host defense systems and predetermines the persistent and recurrent infections in diabetic patients.

1.3.3. Antibiotic resistance in diabetic patients

Recurrent and often prolonged antimicrobial exposure in diabetic patients, together with chronic wounds rich in nutrients and biofilms, fosters selection of antibiotic-resistant organisms. Large reviews and meta-analyses show that people with type 2 diabetes have roughly a twofold higher odds of



antibiotic-resistant urinary tract and respiratory infections compared with non-diabetic individuals (Carrillo-Larco *et al.*, 2021). Polymicrobial infections dominated by Gram-negative bacteria (e.g., *Klebsiella pneumoniae*, *Proteus spp.*, *E. coli*, *Pseudomonas aeruginosa*) and *S. aureus* are common in diabetic foot ulcers. These infections have high rates of multidrug resistance, with *E. coli* resistance surpassing 80% in some series and significant resistance to first-line agents among other pathogens. (Baral *et al.*, 2024; Shankar *et al.*, 2005). Multidrug-resistant *S. aureus* is also more commonly carried in the nares of diabetic patients; over 40% of *S. aureus* isolates from diabetics have multidrug resistance, whereas non-diabetic controls do not. (Anafo *et al.*, 2021). At a population level, higher infection incidence leads to greater antibiotic prescribing and, in turn, rising rates of multidrug-resistant infections in this group (Kim and Choi, 2025).

1.3.4. Recurrent infections and decline in overall health

The cumulative impact of recurrent infections in uncontrolled diabetes extends beyond individual episodes. Infection-related hospitalizations and deaths are consistently higher among people with diabetes; serious infections such as bone and joint infections, tuberculosis, and sepsis account for a sizable fraction of excess mortality, particularly when glycemic control is poor (Erener, 2020; Kim and Choi, 2025). Chronic diabetic foot infections result in prolonged hospital stays, frequent surgical debridements, major amputations, and considerable loss of mobility and independence (Kalan *et al.*, 2019; Baral *et al.*, 2024). Moreover, frequent UTI and respiratory infections have the potential to lower the quality of life dramatically and increase the rates of diabetic nephropathy and cardiovascular disease development (Erener, 2020; Holt *et al.*, 2024). Major epidemiological research shows that infectious diseases significantly lower the life expectancy of people with diabetes, and the risk ratios of mortality due to any infection are more than twice higher than among the non-diabetic population (Erener, 2020). Hence, microbial factors not only present as complications but are also major contributors to the loss of functionalities, disability, and even early death in uncontrolled diabetes cases.



1.4. Clinical axis and problems with health

1.4.1. Acute and chronic effects of uncontrolled diabetes

Diabetes mellitus is a long-lasting metabolic disorder, which is marked by incessant hyperglycemia because of reduced insulin production, reduced insulin action, or both. Long-term high blood glucose damages several organs, specifically the eyes, kidneys, nerves, heart, and blood vessels, leading to retinopathy, nephropathy, neuropathy, and a much more negative impact on atherosclerotic cardiovascular and cerebrovascular disease (Basevi, 2011; Spinetti *et al.*, 2023). Clinically, severe hyperglycemia is associated with polyuria, polydipsia, weight loss, and, at times, blurred vision; acute life-threatening decompensations are diabetic ketoacidosis and hyperosmolar hyperglycemic state (Basevi, 2011). Uncontrolled diabetes mellitus can lead to anemia, attributed to compromised immune response and heightened vulnerability to fungal infections resulting from persistent hyperglycemia (Shakir *et al.*, 2025). Chronic complications along with acute metabolic crises characterize the clinical image of uncontrolled diabetes and most of its morbidity and mortality.

1.4.2. Infections, immune dysfunction, and progression of complications

Uncontrolled hyperglycemia causes significant alteration of both innate and adaptive immunity. High glucose levels stimulate the progression of advanced glycation end products, oxidative stress, and chronic low-grade inflammation that redefine cytokine, worsen leukocyte functioning, and accelerate immune senescence (Ferlita *et al.*, 2019; Alexander *et al.*, 2024). According to epidemiological studies, people with diabetes have a 1.5–4 times higher risk of getting infections, and as HbA1c levels rise, hospitalizations and mortality from infections sharply increase (Kim and Choi, 2025). Urinary tract infections, pneumonia, diabetic foot infections, sepsis, and opportunistic fungal diseases like candidiasis and mucormycosis are particularly associated with uncontrolled diabetes and are often associated with longer hospital stays, higher rates of relapse, and worse outcomes compared to patients without diabetes (Alexander *et al.*, 2024; Kim and Choi, 2025). Consequently, these infections add immunological



dysfunction and infection to the natural history of diabetic organ damage, aggravating metabolic instability and causing or accelerating microvascular and macrovascular complications (Ferlita *et al.*, 2019; Tesch, 2017).

1.4.3. Hospitalization burden and its causes

Hospitalization patterns demonstrate the systemic consequences of poorly managed diabetes. With incidence rate ratios of approximately 1.8 for overall hospitalizations and >2 for infectious, dermatologic, genitourinary, neurological, and respiratory diseases, large population-based cohorts demonstrate that individuals with diabetes have noticeably higher rates of both cause-specific and all-cause admissions than people without diabetes. (Pearson-Stuttard *et al.*, 2021; Johansson *et al.*, 2024). Over the past few decades, hospitalizations for infections, non-diabetes cancers, and non-cancer respiratory conditions have increased proportionately to the excess burden of diabetes, while hospitalizations for acute metabolic crises, classic vascular events, and end-stage microvascular disease have decreased (Pearson-Stuttard *et al.*, 2021). However, the most common causes of admission, prolonged hospital stays, and hospital mortality in resource-constrained settings remain infections (especially bacterial and COVID-19 infections), cardiovascular disease, and hyperglycemic emergencies such as diabetic ketoacidosis (Birhanu *et al.*, 2025). According to these data, uncontrolled diabetes is a major cause of both traditional hospitalizations related to complications and a wider range of acute illnesses, many of which are infection-mediated and may be avoided with improved outpatient care (Pearson-Stuttard *et al.*, 2021; Johansson *et al.*, 2024).

1.4.4. Impact on the patient's quality of life

Along with biomedical outcomes, unchecked diabetes and its consequences dramatically reduce health-related quality of life (HRQoL). Cross-sectional investigations of adults with type 2 diabetes have consistently revealed that decreased utility scores and worse self-reported health on basic instruments such as the EQ-5D and visual analogue scales were associated with poor glycemic control, longer disease duration, insulin use, obesity, comorbidities, and the existence of micro- and macrovascular problems (Gebremariam *et al.*, 2022; Asrie *et al.*, 2025). Pain/discomfort,



mobility limitations, difficulty with everyday chores, and anxiety/depression are among the usual problem areas; these grow more frequent as complications rise. Most of the observed lowering in HRQoL in patients with diabetes comes from poor glycemic control and complication burden, even when average utility scores seem rather high (Gebremariam *et al.*, 2022). Among people with type 2 diabetes elsewhere, comparable patterns have been seen; obesity and depressive symptoms are potent predictors of worse overall health and diabetes-specific quality of life independent of HbA1c alone (Sundaram *et al.*, 2007). Uncontrolled diabetes, hence, causes biochemical disturbance and organ damage as well as chronic pain, functional impairment, emotional stress, and social limitations, all of which combine to compromise daily well-being—independent of age or type (Gebremariam *et al.*, 2022; Asrie *et al.*, 2025).

1.5. Health and services axis

1.5.1. Health services are provided for diabetic patients in the community.

Early detection, diabetes prevention, and minimization of its long-term effects all depend on the provision of effective community-based health care. Primary care, pharmacies, and other community settings are increasingly important screening, education, and chronic disease management sites, especially for those at high risk or with limited access to specialized care (Messina *et al.*, 2017; Zehra *et al.*, 2025). The outcomes for individuals at risk of or living with diabetes are generated from the educational and preventative function of medical experts, early detection and coordinated follow-up, and systemic problems.

1.5.2. Early detection and follow-up programs

Community- and primary care-based screening programs, including risk assessment, point-of-care glucose or HbA1c testing, and systemic referral routes, can help to find formerly undiagnosed prediabetes and type 2 diabetes and reduce the number of missed or delayed diagnoses, especially in preferred or disadvantaged communities (Zehra *et al.*, 2025; Hoffmann *et al.*, 2025). Well-supported, locally accessible, and connected to primary care for verification and ongoing monitoring, community screening projects in pharmacies, mobile vans, and



other nonconventional settings are viable and effective (Zehra *et al.*, 2025; Ali *et al.*, 2025). Many interventions, however, struggle with poor referral paths, attrition, and long-term follow-up; hence, integrated, long-term follow-up systems rather than one-time screening events are required (Messina *et al.*, 2017; Zehra *et al.*, 2025).

1.5.3. Role of healthcare professionals in education and prevention

Healthcare professionals—especially primary care physicians, nurses, diabetes educators, pharmacists, and community health workers—are pivotal in lifestyle counseling, self-management support, and complication prevention. Clinicians in primary care consider screening, diagnosing, and following up at-risk patients to be a crucial aspect of diabetes services, and training, along with practice support, may help them become more proficient and confident in prevention efforts (Messina *et al.*, 2017; Aldahmashi *et al.*, 2024). Team-based and nurse-led or community-health worker-led models emphasize the value of multidisciplinary, community-anchored care teams by enhancing risk factor management, patient experiences of chronic care, and in some cases self-management behaviors and quality of life (Levengood *et al.*, 2019; Saulsberry *et al.*, 2023). Education given through these teams can address both medical and social determinants of health, connecting patients to community resources and individualized support (Saulsberry *et al.*, 2023).

1.5.4. System challenges in controlling diabetes

Notwithstanding robust evidence supporting effective interventions, the translation of such findings into standard community practice is far from complete. Primary care teams indicate that they are encumbered by excessive workloads, time limitations, insufficient resources, and competing clinical obligations, which often detract from prevention efforts and thorough follow-up (Messina *et al.*, 2017; Green *et al.*, 2024). Systemic barriers, including limited access to healthcare services, insufficiently trained professionals, and fragmented services, in addition to socioeconomic and



environmental factors, undermine long-term diabetes management and increase disparities in many areas (Blasco-Blasco *et al.*, 2020; Zehra *et al.*, 2025). Besides, the lack of consistency in the application of guidelines, discrepancies in the screening and treatment processes, and the inability to sustain community programs over a long period, additionally hinder the ability of health systems to reduce the growing diabetes crisis (Messina *et al.*, 2017; Green *et al.*, 2024). Addressing such challenges requires the implementation of coordinated policies that will expand access, team-based and community-connected care, and long-term and equity-focused preventive and management efforts.

2. Methodology

2.1. Design of the study

In the study, two patient samples with uncontrolled diabetes mellitus were used that were compared with a group of healthy people. The period of the research was between October 1, 2025, and March 1, 2026. It has been regarded as a holistic and multidisciplinary study since it has included several factors, such as environmental, lifestyle, microbial, and immunological factors, among other factors that were related. The research was conducted in a validated scientific and methodological design, as per the specifications of the appropriate professional body.

2.2. Inclusion and Exclusion Criteria

Inclusion criteria in this study were that the patients must be adults of 18 years and above with a confirmed diagnosis of uncontrolled diabetes mellitus. Male and female subjects were recruited. The duration of the disease of all patients was at least one year, and written informed consent was obtained before participation. Individuals with complete clinical and laboratory records were the only ones considered as being eligible for inclusion. The control group was a group of putatively healthy volunteers having neither a history of diabetes nor other significant systemic illnesses, and whose lab results were normal. The exclusion criteria included acute or



chronic infectious disease, autoimmune disease other than diabetes, chronic kidney disease, liver disease, cardiovascular disease, malignancy, and immunodeficiency. Women who are pregnant and lactating were also not included. Moreover, patients under immunosuppressive or corticosteroid treatment, those who had undergone recent blood replacement in the past three months, as well as patients with incomplete medical histories or laboratory test results, were also excluded from the study.

2.3. Questionnaire Design and Validation

The data were received as the result of the questionnaire that was rigorously designed, developed in strict compliance with the American Diabetes Association (ADA) overall guidelines, which helped to conduct a subtle and comprehensive assessment of the clinical, behavioral, and health-related aspects that are relevant to people fighting with diabetes. A pre-test study was carefully conducted before embarking on the main data collection activity to test the readability, relevance, and functionality of the instrument, and therefore, protect the methodological strength of the study to be conducted. The internal consistency and the overall reliability of the instrument were quantitatively verified using the alpha coefficient of Cronbach, which gave a decent value of $\alpha = 0.82$, hence supporting the validity and suitability of the questionnaire to be used in the current research scenario.

2.4. Swabs Collection and Microbial Identification

Strictly speaking, on the aseptic measures, oral swab specimens were collected using sterile, cotton-tipped swabs on patients who were using them. All the swabs were wiped once on the mouth mucosa, tongue, and the periodontal regions to ensure they had a representative sample. The swabs were then plunged in sterile Amies transport medium and sent to the microbiology lab within one hour to maintain the viability of the microbes. After the reception, the samples were inoculated in some of the culture media, including Blood agar, McConkey agar, and Sabouraud dextrose agar, thus making the isolation of bacterial and fungal pathogens easier. The plates were incubated under aerobic conditions at $37\text{ }^{\circ}\text{C}$ between 24-48 hours to allow bacterial growth and at $25\text{-}30\text{ }^{\circ}\text{C}$ up to five days to allow fungal



growth. Colony morphology was then examined after incubation, concerning size, color, shape, and hemolytic activity. To discriminate between bacterial and fungal isolates, a preliminary Gram stain and lactophenol cotton blue stain were used, respectively. Traditional biochemical tests, i.e., catalase, oxidase, coagulase, and carbohydrate fermentation, were conducted in order to obtain initial characterization of the organisms. To be completely identified, purified isolates were analyzed using the VITEK 2 Compact system (bioMérieux, France), and their protocols were performed. Correct identification of bacteria and yeasts was done, and conclusions were drawn when compared with the built-in database of the instrument. This combined method involving the use of the traditional microbiological methods and automated identification methodology was essential in ensuring that the microbial species of the patients with diabetes were accurately and reliably identified.

2.5. Collection of serum and estimation of the biochemical and immunological parameters in the participants.

All the participants were requested to fast overnight (812 hours) and provide their blood samples. The level of fasting blood glucose was assessed with the help of an automated biochemical analyzer based on the glucose oxidase-peroxidase reaction. HbA1c levels were determined using high-performance liquid chromatography (HPLC) on a standardized automated column. Enzyme-linked immunosorbent assay (ELISA) kits were used to measure serum insulin autoantibodies (IAA) and antinuclear antibodies (ANA) using the procedures of the manufacturers. The standard calibration curves were used to convert the readings of absorbance at the specified wavelength to the concentrations used. ESR rate was determined through the Westergren method using standardized tubes as well as anticoagulated blood. All the parameters were measured twice to ensure accuracy and reproducibility, and to avoid internal and external quality-control procedures, stringent internal and external quality control measures were kept during the study.

2.6. Ethical Approval



The current study was done within the framework of the ethical principles described in the Declaration of Helsinki. The Ministry of Health, Directorate of Wasit Health, Republic of Iraq (Approval No.796) gave ethical approval on 1 October 2025. All study procedures were reviewed and approved by the relevant scientific and ethical committee before the commencement of the study. Written informed consent was obtained from all participants before sample collection. Confidentiality and privacy of participants' data were strictly maintained throughout the study.

2.7. Statistical Analysis

Statistical Package of the Social Sciences (SPSS) software (version 25) was used to analyze the data in combination with the Graphpad Prism software (version 8.0). The continuous variables were provided as mean and standard deviation (SD). The Shapiro-Wilk test was used to determine the normality of the distribution, and then the inferential statistics were applied. The comparison between two independent groups (patients and controls) was also conducted using an independent samples Student's t -test. In cases where there were two or more groups, one-way analysis of variance (ANOVA) was conducted, and a Tukey post hoc test was followed. The correlation coefficient was used to measure linear relationships among continuous variables to evaluate Pearson's.

Graphical displays included bar charts, box-and-whisker plots, scatter plots, and line graphs, which were aimed at presenting group differences and relationship of variables as visual images. Regression lines were drawn on scatter plots to assess the linear trends, as well as to explain the associations between the biochemical and immunological parameters. The reliability of laboratory measurements was evaluated using intra-assay and inter-assay coefficients of variation (CV). All assays were performed in duplicate, and quality control samples were included in each analytical run. The validity of the obtained data was ensured through calibration of instruments, use of standardized commercial kits, and adherence to manufacturer protocols. Internal and external quality control procedures were implemented throughout the study. A p-value of less than 0.05 was considered statistically significant for all analyses.



3. Results and discussion

3.1. Classification of patients according to age, Education and health services

As shown in Figure 1, the age distribution analysis showed that the majority of participants were within the age groups of 31–40 years (46%) and 41–50 years (41%), indicating that most patients were in the middle-age category. A smaller proportion was observed in the age group below 30 years (2%), while 11% were aged above 51 years. Regarding educational level, most participants had a secondary school education (42%), followed by primary school (25%) and college education (18%). The statistics indicated that there was lower representation in cases where the participants did not have formal literacy (11%) and where the participants had postgraduate qualifications (4%). In the evaluation of patient satisfaction with regard to accessibility of health services, the highest proportion of respondents indicated moderate satisfaction (43%), compared to those who indicated complete satisfaction (22%). Fewer respondents reported dissatisfaction (13%) and extreme dissatisfaction (4%), and (8%) claimed to be extremely satisfied. All such findings are indicative of a general moderate degree of satisfaction with the healthcare services of people with diabetes.

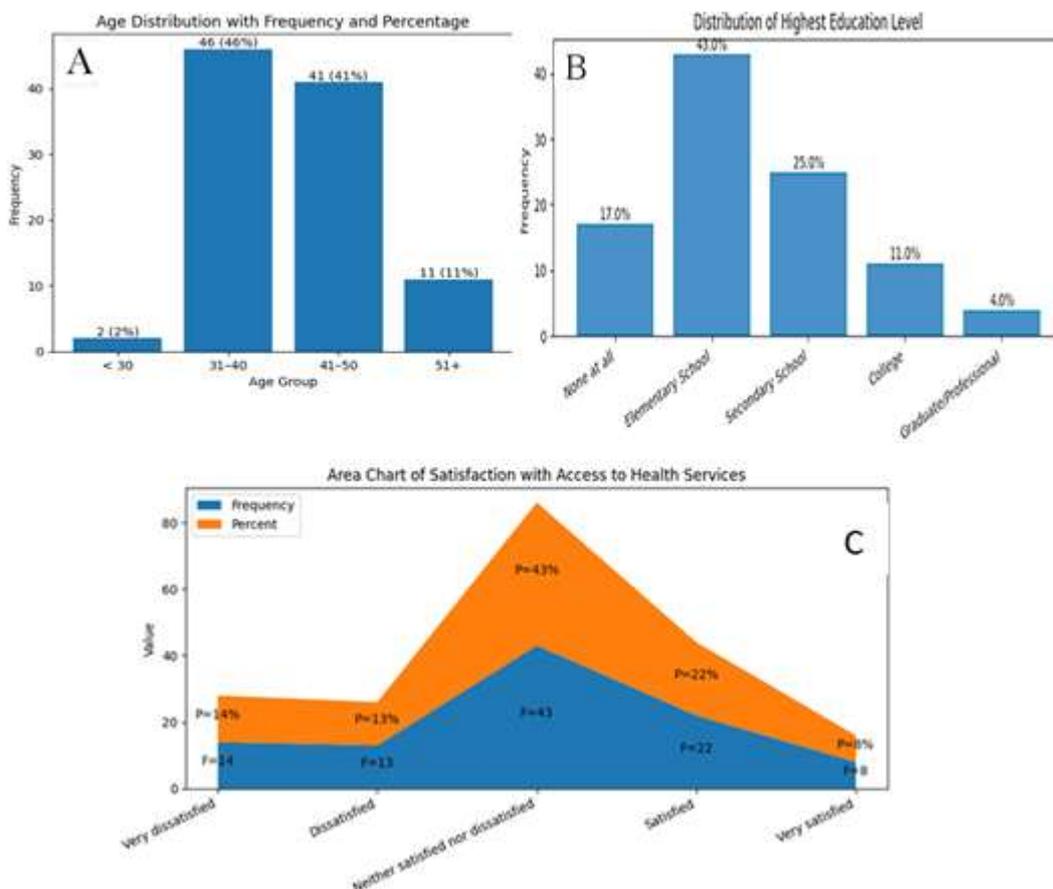


Figure 1. Demographic Characteristics and Diabetic Patient Satisfaction with Healthcare Services. The figure that comes along presents the distribution of study participants in terms of age cohort and the highest level of education achieved, with the self-reported satisfaction with the availability of healthcare services. In Panel (A), the frequency and proportion of patients in separate categories of ages are listed, therefore, depicting the patterns of distribution with age. Panel (B) shows the frequency distribution of the participants according to the highest level of education, stratified. The frequency and proportion of answers concerning patient satisfaction with the healthcare services are provided in Panel (C) and were categorized under very dissatisfied, dissatisfied, moderately satisfied, satisfied, and very satisfied. All these results will provide a complete demographic profile of the participants in the study and clarify their perception of health care accessibility.

The current study has shown that most of the diabetic individuals were middle-aged, with most of them falling in the group of 31-50 years. This finding correlates with the world epidemiological records released by the World Health Organization that assume that the prevalence of type 2



diabetes increases significantly in the middle stage of adulthood due to lifestyle change, insulin resistance, and metabolic imbalances. Similar age patterns are reported in preceding local and global studies. The fact that the majority of the participants held secondary and primary education levels indicates the possible influence of educational attainment on the cognizance of the disease, self-management, and therapeutic compliance. Educational level, according to the articulation by the American Diabetes Association, is a critical factor that determines self-care practices of diabetes, which include glucose monitoring, nutritional regulation, and pharmacological adherence. The lower level of education can limit access to information about health and, hence, dampen the disease management efforts. On the issue of healthcare satisfaction, most of the respondents expressed moderate satisfaction with the availability of health services. This feeling can be explained by the unavailability of medical facilities, limited time spent on consultation, and the inconsistency in the quality of the services. Previous studies have emphasized that patient satisfaction is closely connected to continuity of care, access to specialized services, and effective communication between patients and their providers. The medium levels of satisfaction observed herein can have a negative effect on the long-term compliance with the treatment rules and follow-ups. Altogether, the results suggest that the demographic and socioeconomic factors, in particular, age and education level, have a significant impact on the management of disease and healthcare services perception among diabetic patients. Therefore, improvement of health education programs, fortification of primary healthcare delivery, and patient-centered care promotion are the urgent measures that should optimize clinical outcomes and quality of life among this population grouping.

3.2.Life Quality Indexes with Diabetic Patients



The satisfaction of the patients with their sexual life was analyzed, and the greatest percentage of the respondents were not satisfied (40%), then there were the satisfied ones (32%). About 17 per cent were neither dissatisfied nor satisfied, and ten per cent said that they were very satisfied. A minor percentage (10%) were found to be very dissatisfied, as expressed in Figure 2. moderately satisfied patients. Very dissatisfied and dissatisfied participants were found to have lower frequencies. Evaluation of negative emotional mood revealed that the negative emotions were quite frequent (36) or very frequent (42) among the majority of the patients. On the contrary, a smaller percentage expressed such as feeling rarely (16%), infrequently (2%), or not at all (2%). These results indicate a high level of psychological burden in patients with uncontrolled diabetes.

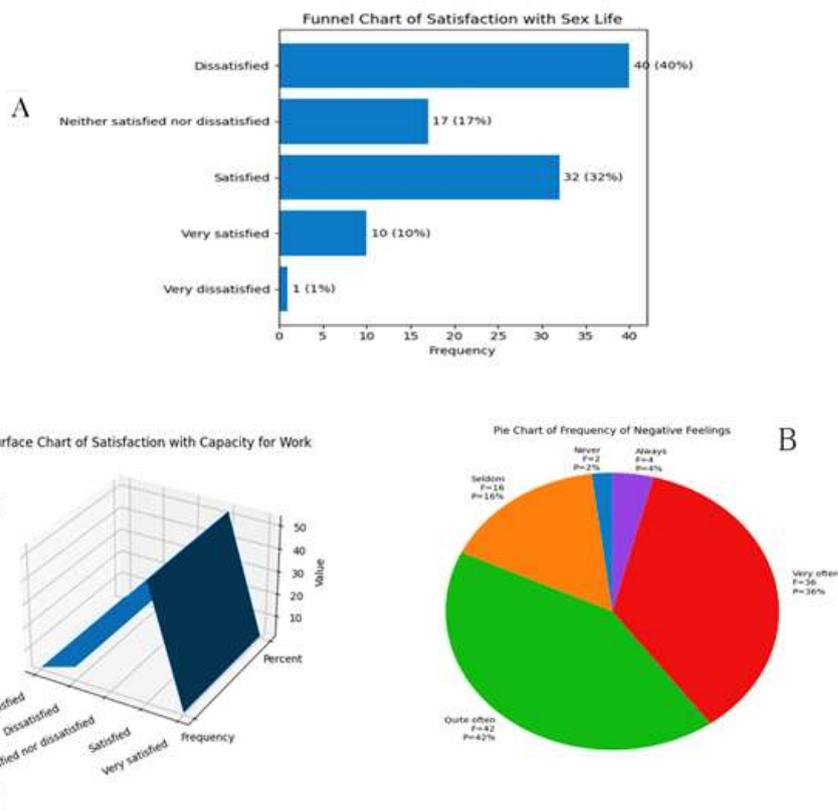




Figure 2. Psychosocial and Functional Impact of Uncontrolled Diabetes on Quality of Life: Sexual Satisfaction (A), Work Capacity (B), and Negative Emotional Feelings (C). The patients are satisfied with their sexual life (Panel A), their satisfaction with the capacity to work (Panel B), and the number of negative emotional feelings (Panel C). Panel A shows the spread of the participants in the different degrees of sexual life satisfaction, thus providing an idea about the subjective sexual well-being of the individuals who are struggling with diabetes. The surface presentation of satisfaction with work capacity in panel B allows for a fine evaluation of the functional requirements of the disease in occupational performance. Panel C shows the prevalence of the negatively emotional experiences, with the specific categories of never, rarely, seldom, quite often, very often, and always as a total of the emotional price paid by uncontrolled diabetes. All these indicators are a manifestation of the psychosocial and functional effects of uncontrolled diabetes on the overall quality of life of patients.

We have found that there is a significant dissatisfaction with sexual activity in the patients who have even poorly controlled diabetes. A known outcome of diabetes that is often associated with vascular compromise, peripheral neuropathy, and endocrine dysregulation is sexual dysfunction (Maiorino *et al.*, 2021). In line with the reports published by the American Diabetes Association, among the widely observed but underreported complications of the diabetic population are the problems with sexual health (American Diabetes Association [ADA], 2024). The somewhat moderate levels of work capacity satisfaction in this group might also indicate the partial functional impairment due to long-lasting hyperglycaemia, constant fatigue levels, and the presence of comorbidities. Previously existing studies indicated that reduced physical fitness, regular visits to the doctor, and ambiguities related to the disease may affect occupational performance and productivity among diabetes patients negatively (Lloyd *et al.*, 2020). Also, the large prevalence of negative emotional ailments, in this instance, anxiety and depression, highlights that uncontrolled diabetes has a high psychological cost. The prevalence of chronic conditions, like diabetes, significantly increases the likelihood of having a mental health condition that, in turn, will lead to impaired compliance with treatment and poor glycaemic regulation (World Health Organisation [WHO]). There is also interference between the psychosocial distress and the proper self-management behaviours, hence worsening the metabolic outcomes. The



concomitant effect of sexual dissatisfaction, diminished working ability, and emotional suffering depicts the multidimensionality of the effects of diabetes on the quality of life of patients. All these aspects are interrelated, and it goes to show that diabetes is not only a physical condition but also a psychological and social one too. Therefore, the vision of holistic patient care should not be limited to glycaemic control but instead include the provision of psychosocial support and lifestyle modification. The results highlight the importance of sexual health examination, psychological counselling, and occupational support that should be implemented as a part of normal diabetes management. There is a need to consider an interdisciplinary model of management that involves physicians, psychologists, and rehabilitation to cover the entire gamut of medical and psychosocial needs of patients. These combined measures have the potential to enhance compliance with therapy, overall life quality, and eventually provide high-quality clinical care for patients with uncontrolled diabetes.

1.1.Perfection and Distribution of Oral Fungal Infection in Diabetic Patients and Healthy Controls

Figure 3 (A, B) indicates that in the analysis of oral fungal infection, there was a significant difference between diabetic patients and healthy controls.

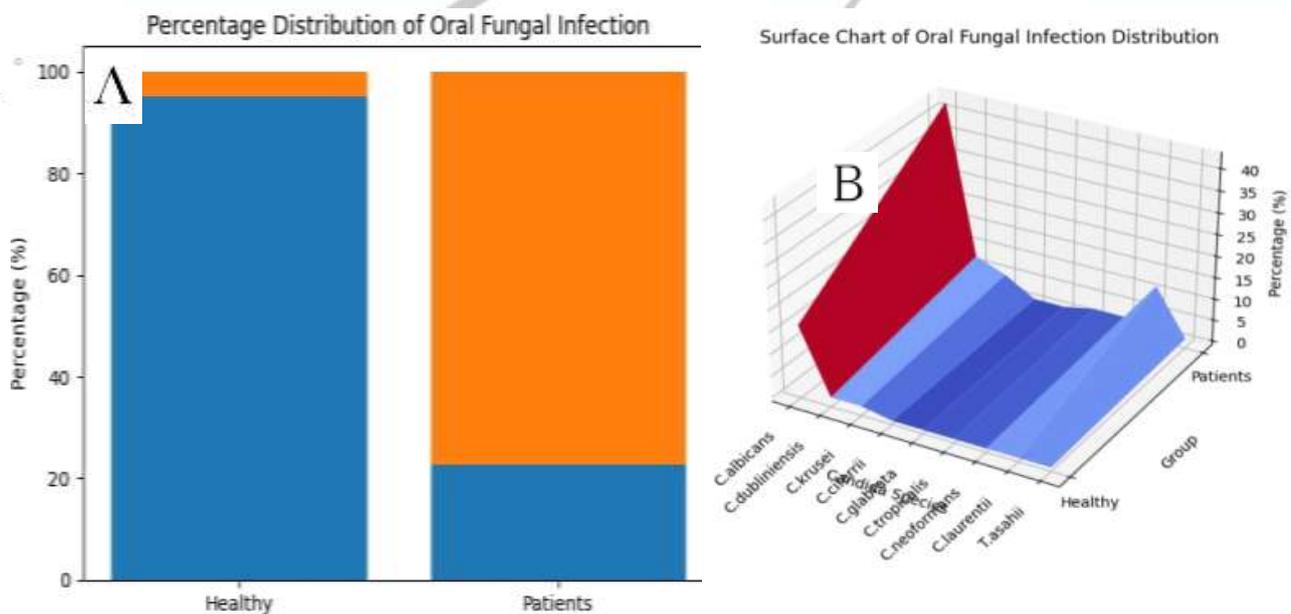




Figure 3. Occurrence of Oral Fungal Infection in Diabetic Patients and Healthy Controls. The figure gives a more precise idea of the prevalence of oral fungal infections in a group that included diabetic patients and control persons. In panel A and panel C, the frequencies of positive and negative yield of specimens in the initial isolation of fungi relative to each of the cohorts are presented. Panel B shows the topographical representation of the different fungal taxa that were obtained in the patient and control groups. The aggregate data of the figure are used to highlight a significantly higher prevalence and taxonomic support of fungal colonisation in diabetes mellitus patients when compared to non-diabetic subjects.

The participants of the cohort of people who were healthy were dominated by negative outcomes to fungal infection (around 95 percent), but a smaller percentage (5 percent) showed positive outcomes. In contrast, a previously undetermined high prevalence of oral fungal infection was experienced among diabetic patients, with an approximate 77:230 of the tested individuals reporting positive and negative results, respectively. At the species level, it was found that most species were found in the diabetic cohort in the form of the single species of *Candida albicans*, which was then followed by *Candida dubliniensis* (2), *Candida krusei* (2), and *Candida tropicalis* (2). We also found other species, such as *C. glabrata*, *C. parapsilosis*, and non-*Candida* species, at lower frequencies. Fungal isolates were rare in healthy subjects and were mostly restricted to low concentrations of the species of *Candida*. The surface chart also outlined that there was even more diversity and prevalence of fungal species in patients compared to controls which highlights that people can easily be colonised by opportunistic fungi in cases where the condition of diabetes has not been controlled.

The current study to be discussed showed much more prevalence of oral fungus in diabetic subjects than in health-concordant controls. This finding supports antecedent evidence, which hypothesises that complications of the chronic hyperglycaemia precondition the formation of a favourable environment to favour fungi colonisation, by increasing salivary glucose levels, disrupting neutrophilisation, and reducing cellular immunisation. Consistently inadequate glycaemic administration has been shown to be the cause of increased susceptibility to opportunistic diseases, such as oral



candidiasis (American Diabetes Association [ADA], 2024). In the present study, the most common fungal species observed in diabetic individuals were the genus of the family Candida and genus-to-genus taxa of non-albicans, which occurred with the ascending importance of the genus Candida. Such preponderance agrees with the other literature existing, which describes that, due to its strong adhesion ability, the formation of biofilms, and enzymatic hydrolytic behaviour, *C. albicans* is the primary etiologic agent of oral candidiasis (Williams and Lewis, 2011). These virulence factors contribute to its pathogenicity, especially in persons with weak immunity. Similar results were presented by Akpan and Morgan (2002), who emphasised the predominance of the oral infections of diabetic patients by *C. albicans*. The increased identification of non-albicans species of Candida in the group of patients might indicate metabolic disregard and stability, and cumulative mucosal immunodeficiency. It is emerging that these species become more and more common in diabetic populations and can be characterized by enhanced resistance to traditional antifungal drugs, which is an augmenting clinical problem (Patil *et al.*, 2015). Furthermore, the significant decrease in the cases of fungal infection in healthy controls highlights the immune-protective action and normal metabolic homeostasis. Such chronic conditions as diabetes are reported to undermine the host defence systems, which increase the vulnerability to infectious processes (World Health Organisation [WHO], 2022). Poor salivary flow, xerostomia, and changed oral microbiota, these changes being prevalent in patients with diabetes, could contribute to fungal growth further. These research results thus underline the severe importance of routine oral examination as well as early screening microbiologically among diabetic patients, especially those with inadequate glycaemic control. Embarking on oral healthcare as part of comprehensive diabetes management initiatives would predict the onset of recurring infections and prevent the occurrence of disease-associated complications. Also, it is unquestionable to enrich patient education on oral care, the regularity of visiting a dental clinic, and a balanced metabolism to improve the overall health levels (ADA, 2024). Finally, the high rate of oral fungal infections, as well as the diversity of the fungus, recorded in this



study, gives the indication of the multifactorial effect of diabetes on oral health. As a result, the multidisciplinary treatment of oral fungal infections of this at-risk population will require the engagement of physicians, dentists, and microbiologists to prevent, diagnose, and treat oral fungal infections effectively.

1.2. Factors estimating the fluctuation of immunological and biochemical in the patients as compared to the controls

As shown in **Table 1**, they statistically show significant differences between any two groups of people with uncontrolled diabetes mellitus and healthy controls in all parameters that are investigated. The level of fasting blood sugar (FBS) is significantly different in groups ($p = 0.001$). Patients have changed levels of fasting glucose in comparison to controls, and this is clear evidence of metabolic imbalance. The levels of glycated hemoglobin (HbA1c) are significantly higher in patients (13.4 ± 5.9) than in controls (4.2 ± 0.1) and statistically significant ($p = 0.001$), and clearly demonstrate the importance of inappropriate long-term glycemic regulation. In terms of immunological markers, insulin autoantibodies (IAA) are much longer than in the controls (85.9 ± 4.0 pg/mL) (9.1 ± 1.0 pg/mL) ($p = 0.001$). Similarly, the antinuclear antibodies (ANA) show a significant rise in the patient group (40.9 ± 1.1 pg/ml) when compared to healthy people (5.2 ± 0.9 pg/ml) ($p = 0.003$). Further colloquial indications that offer evidence on inflammatory status are that the erythrocyte sedimentation rate (ESR) in the patients (30.9 ± 1.4 mm/h) is notably higher in comparison to that of controls ($24. \pm 0.9$ mm/h) ($p = 0.001$).

Table 1 : Comparison of Biochemical, Immunological, and Inflammatory Parameters Between Patients and Controls.

Parameter	Patients (Mean \pm SD)	Controls (Mean \pm SD)	P-value
FBS (ng/mL)	3.9 ± 0.9	7.4 ± 1.1	0.001
HbA1c (%)	13.4 ± 5.9	4.2 ± 0.1	0.001
IAA (pg/mL)	85.9 ± 4.0	9.1 ± 1.0	0.001
ANA (pg/mL)	40.9 ± 1.1	5.2 ± 0.9	0.003
ESR (mm/h)	30.9 ± 1.4	24.0 ± 0.9	0.001

Abbreviation : FBS : Fasting blood sugar , HbA1c: Hemoglobin A1c , IAA: insulin



Autoantibodies , ANA: Antinuclear antibodies , and ESR: Erythrocyte sedimentation rate .

The current observations indicate significant upheavals in the metabolism, immunology, and inflammation in the cases of diabetes mellitus that are not well controlled. The significantly high HbA1c levels are an unquestionable indication of chronic hyperglycemia and inefficient glycemic control, which is consistent with the American Diabetes Association (2023) definition, which considers HbA1c as the gold-standard measure of the long-term glycemic control. The increased levels of insulin autoantibodies (IAA) that are found in this group of people highlight an autoimmune factor in the pathogenesis of the disease. The autoantibodies against pancreatic beta-cell production have also been widely reported in diabetic patients, and it is associated with immune-mediated dysfunction of beta-cells (Atkinson *et al.*, 2014). Similarly, the simultaneous increase in the levels of antinuclear antibody (ANA) points once again to systemic immune involvement, which implies a wider autoimmune reactivity in uncontrolled diabetes (Conrad *et al.*, 2018). Besides, the greatly elevated erythrocyte sedimentation rate (ESR) highlights a continuous low-grade inflammatory scenario. Inflammation is now being recognized as a determining factor in insulin resistance and diabetic complications (Donath and Shoelson, 2011). The long-term effects of inflammation can worsen vascular damage and increase the threat of cardiovascular disease. A combination of the coinciding increase of HbA1c, IAA, ANA, and ESR suggests that uncontrolled diabetes does not simply represent one of the metabolic conditions, but significant immune and inflammatory dysfunction. These data reaffirm the significance of the multidisciplinary management to combine glycemic management, strict immune control, and specific anti-inflammatory therapy.

4. Conclusion

The current research proved that uncontrolled diabetes mellitus is linked with a high degree of metabolic, immunological, and inflammatory disruptions. Poorly controlled glycemic levels with immune activation and chronic inflammation were evident in the patients with significantly high levels of HbA1c, insulin autoantibodies, antinuclear antibodies, and



erythrocyte sedimentation rate. These results indicate that uncontrolled diabetes does not consist of metabolism dysregulation only, but also includes significant immunological and inflammatory aspects. Demographic analysis indicated that most of the patients were middle-aged adults, with some of them falling within the 31 to 50 age range, thus showing that this group is a high-risk population. Moreover, the majority of the respondents possessed low/moderate educational levels, which can be the cause of low levels of health literacy, inappropriate behavior of self-management, and insufficient compliance with treatment procedures. Moreover, the level of satisfaction with healthcare access indicated that the majority of the participants expressed neutral to moderate levels of satisfaction, with low percentages of high rates of satisfaction, which can be seen as possible gaps between the quality and accessibility of healthcare services. Taken together, the mentioned results suggest that the problem of uncontrolled diabetes among the considered population is a complex combination of biological, social, and healthcare-related factors. Poor glycemic control, immune dysregulation, low educational levels, and low healthcare satisfaction provide additional reasons to state that multidisciplinary treatment approaches must be applied.

5.Recommendations

Following the results of the current study, it is possible to recommend the following recommendations:

1. Enhancing the Glycemic Monitoring: HbA1c and fasting blood glucose monitoring should be highlighted regularly to identify the occurrence of poor glycemic control early enough and provide therapeutic intervention.
2. Immunological Assessment should be incorporated: Daily monitoring of immunological and inflammatory proteins, including IAA, ANA, and ESR, is suggested to high-risk patients to detect the early signs of complications associated with immunity.
3. Health Education Programs that are specific: Culturally sensitive and simplified education interventions that are especially useful in patients with low educational levels should be created to enhance disease awareness, self-care, and medication adherence.



4. There is an enhancement in Healthcare Access: To increase patient satisfaction and continuity of care, healthcare facilities should increase the availability of services, decrease waiting time, and increase access to specialized diabetes care.
5. Age-specific prevention measure: The middle-aged adults should be targeted by preventive and screening programs, as they are the most vulnerable group in the current research.
6. Multidisciplinary Management style: The provision of diabetes care should be through physicians, nurses, nutritionists, psychologists, and health educators to cover metabolic, psychological, and social concerns of the disease.
7. Policy and Community-based Interventions: Community-based screening and education should be enacted by the health authorities to lower socioeconomic obstacles and enhance early diagnosis and treatment.
8. Future Research Directions: It is suggested that further longitudinal and multicenter research studies be conducted to establish causal associations among immunological, socioeconomic, and healthcare-related factors and the outcomes of diabetes.

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