

RESEARCH ARTICLE

MEDICAL MICROBIOLOGY

## Study of Superficial Fungal Infections among Diabetes Patients at Diabetic Center in Zliten City-Libya

Fariha Ahmed Alhijjaji<sup>1,\*</sup>  , Salah Farag Alseleni<sup>1</sup>  , Jamal Salem Haider<sup>2</sup>  

<sup>1</sup>Department of Life Sciences, Libyan academy, Misrata, Libya

<sup>2</sup>Department of Periodontology and Oral Diseases, Faculty of Medicine and Dentistry, Alasmarya University, Zliten, Libya

### ARTICLE HISTORY

Received 06 January 2026  
Revised 04 February 2026  
Accepted 11 February 2026  
Online 15 February 2026

### KEYWORDS

Diabetes mellitus;  
Superficial fungal infections;  
Dermatophytes;  
Non-dermatophytes.

### ABSTRACT

This cross-sectional study examined superficial fungal infections (SFIs) among 117 diabetic patients at Dermatology Outpatient Department of Zliten Diabetes Center. Samples were collected from skin, nails, hair, Oral mucosa, and interdigital areas. Fungal identification was performed using culture methods, microscopy, Wood's lamp examination, and potassium hydroxide (KOH) preparation. Positive fungal growth was detected in 105 samples (89.7%). Dermatophytes accounted for 53.3% of isolates, with *Trichophyton violaceum* (14.3%) and *Trichophyton soudanense* (11.4%) being the most common. Non-dermatophytes represented 46.7%, with *Candida spp.* (29.5%) as the predominant species, followed by *Aspergillus* (5.7%), *Cladosporium* (4.8%), *Fusarium* (4.8%), and *Geotrichum* (1.9%). The most commonly affected sites were nails (32.4%) and interdigital areas (33.3%). Statistically significant associations were observed between fungal type and age, HbA1c, Weight, diabetes type, site of infection,. No significant associations were observed with gender, diabetes duration. These findings highlight the impact of clinical and demographic factors among diabetic patients in Zliten.

## دراسة العدوى الفطرية السطحية لدى مرضى السكري في مدينة زليتن-ليبيا

فريحة أحمد الحجاجي<sup>1\*</sup>، صلاح فرج السليني<sup>1</sup>، جمال سالم حيدر<sup>2</sup>

### الكلمات المفتاحية

داء السكري  
الالتهابات الفطرية السطحية  
الفطريات الجلدية  
الفطريات غير الجلدية

### المخلص

اجريت هذه الدراسة المقطعية لفحص الالتهابات الفطرية السطحية لدى 117 مريضاً بالسكري حضروا إلى قسم العيادات الخارجية للأمراض الجلدية في مركز زليتن للسكري. تم جمع العينات من الجلد، الأظافر، الشعر، الفم، والمناطق بين الأصابع، وتم تحديد الفطريات باستخدام الزرع المخبري، والفحص المجهرى. شملت منهجية الدراسة التحليل المخبري للعينات والتقييم الإحصائي للعلاقات بين نوع الفطريات والعوامل السريرية. من بين 117 عينة، أظهرت 105 عينة نمواً فطرياً، حيث شكلت الفطريات الجلدية 53.3% والفطريات غير الجلدية 46.7%، وكانت الكانديدا هي الأكثر شيوعاً. لوحظت العدوى بشكل أساسي في الأظافر والمناطق بين الأصابع. أظهرت النتائج وجود علاقات ذات دلالة إحصائية بين نوع الفطريات والعمر، والوزن، ونوع السكري ومستوي السكر التراكمي، وموقع العدوى. ولم تلاحظ علاقات ذات دلالة إحصائية مع الجنس، أو مدة الإصابة بالسكري. تشير هذه النتائج إلى ارتفاع معدل انتشار الالتهابات الفطرية السطحية بين مرضى السكري في زليتن، وتبرز تأثير عدة عوامل سريرية وديموغرافية على خطر الإصابة. تشير هذه النتائج إلى ارتفاع معدل انتشار الالتهابات الفطرية السطحية بين مرضى السكري في زليتن، وتبرز تأثير عدة عوامل سريرية وديموغرافية على خطر الإصابة.

## Introduction

### Background on Diabetes Mellitus

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by inadequate insulin production, insulin resistance, or both. Its prevalence is increasing worldwide, posing a significant public health challenge. Persistent high blood glucose can lead to severe complications, such as eye, nerve, and heart damage, creating a substantial burden on healthcare systems globally [1]. The number of people with diabetes is expected to exceed 642 million by 2040, with the Middle East and North Africa (MENA) region showing one of the fastest rises. Early intervention, healthier lifestyles, and

better healthcare access are crucial to reducing its impact [2]. local researchers have focused on Type 2 diabetes patients and studied effect of medications [3] lipids , blood glucose levels [4,5], minerals [6,7] and other factors in patients , on the other hand, superficial fungal infections in diabetes patients has not received much attention locally.

### Diabetes Mellitus and Fungal Infections (FIs)

DM is a chronic disease with rising global prevalence. High blood sugar weakens immunity and promotes fungal growth, increasing the risk of infections such as *Candida* species causing oral thrush, vaginal infections, and skin fold infections, and dermatophytosis including athlete's foot,

\*Corresponding author

[https://doi.org/10.63318/waujpasv4i1\\_18](https://doi.org/10.63318/waujpasv4i1_18)

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International License (CC BY-NC 4.0).



ringworm, and nail infections [8]. Although not all fungi are pathogenic, some can cause serious diseases and pose a significant public health risk. Within the last three decades, fungi (especially yeasts of the *Candida* genus) are a major cause of nosocomial infections among immunocompromised patients [9].

### Prevalence and Clinical Impact

About 30% of diabetics develop skin lesions, mainly candidiasis and dermatophytosis. High blood sugar weakens immunity, making infections more severe. Symptoms include itching, redness, scaling, vesicles, and pustules, with chronic tinea potentially leading to nail infections. Opportunistic fungi like *Candida albicans* and *Aspergillus* are more common in diabetics [10,11].

### The Role of Skin in Protection

The skin is the body's largest organ and acts as a protective barrier. It shields the body physically, chemically, and through the immune system, while supporting a healthy community of microbes called the skin microbiome. Healthy skin depends on a balance between microbes, skin cells, and immunity, and any disruption—like infection or barrier damage can impair its function [11].

### Cutaneous Mycoses (Dermatomycoses)

Cutaneous mycoses affect superficial layers of the skin, nails, and hair, including tinea pedis (athlete's foot) and tinea corporis (ringworm) [12]. These infections are often transmitted via direct contact with contaminated surfaces or hosts. Treatment includes topical or systemic antifungal agents depending on the infection type [13]. Superficial mycoses are usually confined to the epidermis and its appendages, with rare involvement of deeper tissues or organs. They are classified as: Non-inflammatory infections  
Inflammatory infections [14,15].

### Superficial Fungal Infections (SFIs)

SFIs are very common globally, mainly affecting the skin, hair, and nails. Dermatophytes like *Trichophyton* and *Microsporum* are the main causes, while yeasts (*Candida*) and NDMs fungi are increasingly important, especially in immunocompromised patients [16]. These infections affect all ages and both sexes. Tinea capitis is more common in children, whereas tinea cruris and tinea pedis occur frequently in adult [17].

Globally, affect approximately 20 SFIs –25% of the population, and their prevalence has been increasing over recent years [18].

### Inflammatory Skin Infections (Dermatophytes):

Fungi that feed on keratin in the skin, hair, and nails cause inflammatory infections like dermatophytes (tinea), which are common in hot and humid climates. Several epidemiological studies have highlighted the influence of demographic and clinical factors. Middle-aged adults (40–59 years) are particularly affected by tinea pedis and onychomycosis, whereas elderly patients ( $\geq 60$  years) show a higher frequency of chronic nail infections, largely due to impaired immunity, vascular disease, and diabetic neuropathy [19].

Gender differences have also been reported, with males showing greater susceptibility to dermatophytoses such as tinea pedis, while females are more prone to mucocutaneous candidiasis, especially in intertriginous areas [20]. Clinical determinants such as long-standing diabetes and poor glycemic control are strongly correlated with recurrent FIs, as hyperglycemia enhances fungal adhesion, reduces neutrophil activity, and delays wound healing [21].

Other health problems such as obesity, vascular disease, and neuropathy further increase the risk. Environmental and social factors also play a role, including animal contact,

family transmission through shared items, and humid living conditions [19].

Most infections affect the feet and nails, followed by skin folds such as the groin and axilla, while chronic paronychia is also seen in recurrent cases. Overall, previous studies indicate that SFIs in diabetic patients are influenced by multiple demographic, clinical, and environmental factors, making them frequent and often persistent complications. Gender differences have also been reported, where men are more prone to dermatophyte infections and women more to mucocutaneous candidiasis [21].

Globally, over 425 million adults suffer from diabetes, a condition marked by elevated blood sugar levels that foster the growth of *Candida* species and increase the risk of FIs like oral thrush and athlete's foot [22].

### Research Problem

In Zliten City, no studies have examined SFIs in diabetic patients. Diabetes increases susceptibility due to weak immunity and poor blood sugar control. This study identifies common fungi and distinguishes dermatophytes from NDMs to improve diagnosis, treatment, and prevention. The results will help guide better clinical management and awareness among healthcare providers.

### Research Importance

This study is important as it provides the first local data on superficial fungal infections among diabetic patients in Zliten City. This study provides important insight into the clinical patterns of FIs among diabetic patients attending Zliten Diabetes Center, improving diagnosis, treatment, and prevention strategies.

### Objectives

- 1- To assess the types of fungal pathogens commonly found in diabetic patients.
- 2- To determine the relationship between glycemic control (HbA1c levels) and the incidence of superficial fungal infections.
- 3- To evaluate the impact of demographic factors (age, gender, duration of diabetes) on the risk of developing fungal infections.

### Materials and methods

#### Sample Size

Participants were recruited using simple random sampling, stratified according to glycemic control to ensure representation across different levels of diabetes management.

#### Study of Population

This cross-sectional study included 117 diabetic patients, aged 18 years and above, who attended the Dermatology Clinic of Zliten Diabetes Center between March 2025 and September 2025. The diagnosis of diabetes mellitus was confirmed by glycated hemoglobin (HbA1c) levels  $\geq 6.5\%$ . Eligible patients presented with superficial fungal lesions involving the skin, nails, hair, oral cavity, or other body sites. Individuals who had received systemic antifungal therapy or oral corticosteroid treatment for at least two weeks prior to enrollment were excluded, thereby ensuring a representative study population with minimal confounding from prior systemic interventions.

#### Data Collection and clinical assessment

This study aimed to assess the prevalence and characteristics of SFIs in diabetic patients. Data were collected using a structured questionnaire designed to obtain comprehensive participant information. The questionnaire covered demographic variables (age, gender, clinic attended), and clinical history, such as diabetes duration, family history of SFIs. Additional information recorded included body weight

(Weight measured using a digital scale) , height (Height was measured using a built-in medical scale or scaling scale (Stadiometer), type of diabetes , current treatment, history of animal contact, number and location of lesions, duration of infection, previous antifungal therapy, Approximately seven participants reported being unaware of their HbA1c levels.

#### Wood's Lamp Examination

Skin and hair lesions were examined using a Wood's lamp emitting ultraviolet light at 365 nm in a darkened room, held 10–15 cm from the lesion. Fluorescence in bright green, yellow-green, or blue-green facilitated rapid presumptive diagnosis. While fluorescence (e.g., *Microsporum* species fluoresce bright green), non-fluorescent fungi such as *Trichophyton* species require confirmation through microscopic and culture [23].

#### Specimen Collection and Transport

Specimens were collected between March and September 2025 using standard aseptic techniques. Each anatomical site was sampled and placed in separately labeled sterile containers. Prior to sampling cleaned with 70% ethanol prior to sampling and examined using Wood's lamp and direct KOH mount.

#### Skin scrapings

The active margins was scraped using a sterile scalpel, while avoiding the lesion centers.

#### Interdigital areas

Each interdigital area was first cleaned with 70% ethanol, and a sab was taken to collect fungi.

#### Nail specimens

Infected nail was clipped and finely pulverized; subungual debris was obtained using a curette or sterile scalpel. Patients were instructed to refrain from antifungal therapy for a minimum of two weeks prior to sampling.

#### Hair samples

Infected hairs, including roots and surrounding scales, were plucked; the scalp was gently scraped.

#### Oral cavity

Swabs were collected from the oral mucosa for fungal examination when clinically indicated.

#### Cleaning of samples

sampled areas (skin, nails, hair, interdigital spaces) were carefully cleaned with 70% ethanol prior to sampling to minimize contamination. Specimens were transported at room temperature and examined within a few hours. All handling was performed under clean conditions to avoid contamination. Samples were clearly labeled and securely stored to ensure traceability and monitoring.

#### Microscopic Examination

Collected specimens, including nail fragments, skin scales, hair samples, interdigital, and oral swabs, were obtained using sterile instruments (scalpel or swab). Direct microscopy was performed using 10–20% potassium hydroxide (KOH) mounts. After KOH was added, air bubbles were removed and the slides were gently warmed, Excess KOH solution was carefully removed, and the slides were protected to prevent drying. A sterile gauze was used to gently press the specimens before microscopic examination . The slides were incubated for 5–10 minutes, or up to 30 minutes for nail samples. Microscopic examination (10× and 40×) revealed various fungal elements, including septate hyphae (dermatophytes), budding yeast and pseudo hyphae (*Candida*), “spaghetti and meatballs” forms (*Malassezia*), and arthrospores. KOH mounts were considered positive when characteristic fungal structures were observed, while negative results did not rule out infection.

#### Fungal Culture and Identification

Sabouraud Dextrose Agar media (SDA) used for fungal culture, helps accurately identify and differentiate dermatophytes and non-dermatophytes species, thereby reducing dermatological complications in this vulnerable group. The medium was prepared using: Dextrose (40 g/L) as an energy source for fungi, Peptone (10 g/L) as a nitrogen and amino acid source, Agar (15–20 g/L) to solidify the medium, and distilled water up to 1 liter, The pH was ~5.6 to inhibit bacterial growth and favor fungal growth. Inoculation, sterile adhesive tape was used to seal the plates carefully, preventing contamination. When contamination occurred, subcultures were prepared from clean areas of the plates. The cultures were then incubated at 25–30°C for up to four weeks.

#### Fungal identification included

Macroscopic evaluation: assessing colony growth rate, surface texture (waxy, fluffy, powdery), and pigmentation (surface and reverse). Dermatophytes showed distinct colony features by species, while NDMs molds and yeasts, including *Candida* spp., exhibited variable morphologies.

#### Microscopic evaluation

Fungal colonies were stained with Lacto-phenol Cotton Blue (LPCB) for microscopic examination. A drop of LPCB was placed on a clean glass slide, and a small piece of sterile lobe (~2 cm) was applied to a mature colony grown on SDA. Adhesive tape was gently pressed onto the colony to transfer hyphae and spores, then placed onto the LPCB drop on the slide. Slides were examined under low-power (10×) and high-power (40×) objectives. Fungal structures, including hyphal threads, arthroconidia, conidia, and budding yeast cells, were stained blue and were identified microscopically. Morphological features such as septation, branching patterns, spore shape, and arrangement were recorded to aid species-level identification. Observed spores and fungal structures were recorded in the patient file and questionnaires, and isolates were numbered for traceability.

#### Statistical Analysis

Data were analyzed using SPSS Version 27 to examine the study objectives. Descriptive statistics including frequencies and percentages were used to summarize participants' demographic characteristics. Associations between categorical variables were assessed using Fisher's Exact Test, particularly appropriate for small sample sizes. The statistical significance for all analyses was determined at a *p-value* < 0.05.

#### Results

This study was conducted on 117 diabetic patients who attended the Dermatology Outpatient Department (OPD) at Zliten Diabetes Center between March and September 2025. Among the 117 cultures obtained, 105 demonstrated fungal growth, whereas 12 showed no growth (Table 1).

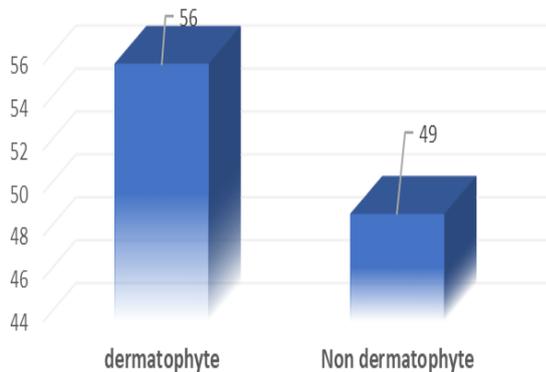
**Table 1:** Distribution of Infected and uninfected samples with fungi

Culture	Isolates	Percent (%)
Infected	105	89.7
Not Infected	12	10.3
Total	117	117

The findings demonstrate a markedly high occurrence of fungal infections (FIs) within the sampled population , as reflected by the very low percentage of non-infected isolates. Collectively, these data underscore a significant clinical concern regarding the prevalence of infections within this specific sample. The infections were classified into two main groups:

**Dermatophytes:** This group includes the following species: (*Trichophyton violaceum*, *Trichophyton soudanense*, *Trichophyton verrucosum*, *Trichophyton rubrum*, *Epidermophyton floccosum*, *Trichophyton mentagrophytes*, and *Microsporum canis*).

**Non-dermatophytes:** This group includes: (*Candida*, *Aspergillus*, *Fusarium* spp., *Geotrichum* spp., and *Cladosporium wernekii*). The following table 2 and figure 1 illustrates this classification.



**Figure 1:** Types of fungi isolated from diabetic patient

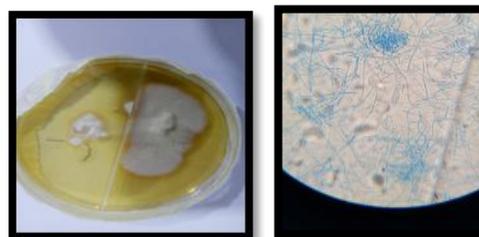
The results indicate the presence of both dermatophytes and non-dermatophyte molds (NDMs) within the analyzed specimens, with dermatophytes exhibiting a marginal predominance. The distribution and diversity of fungal isolates recovered from diabetic patients are detailed in Table 2 and Figure 2.

**Table 2:** Types of fungi isolated from diabetic patients

Type fungi (Non-dermatophytes)	Isolates	Percent
Non dermatophytes	<i>Candida</i> spp.	31 29.5
	<i>Cladosporium</i>	5 4.8
	<i>Aspergillus</i>	6 5.7
	<i>Geotrichum</i> spp.	2 1.9
	<i>Fusarium</i> spp.	5 4.8
	Total	49 46.7%
Type fungi(dermatophytes)	Isolates	Percent
Dermatophytes	<i>Trichophyton violaceum</i>	15 14.3
	<i>Trichophyton soudanense</i>	12 11.4
	<i>Trichophyton verrucosum</i>	9 8.6
	<i>Trichophyton rubrum</i>	5 4.8
	<i>Epidermophyton floccosum</i>	8 7.6
	<i>Trichophyton mentagrophytes</i>	3 2.9
	<i>Microsporum canis</i>	4 3.8
	Total	56 53.3%
Total	105	100.0



M canis



T mentagrophytes



Candida spp.

**Figure 2:** Colonies of isolated fungi

Dermatophytes were the predominant isolates (53.3%), with *T. violaceum* and *T. soudanense* being the most frequently encountered species. NDMs accounted for 46.7%, among which *Candida* spp. constituted the most common (29.5%). Other isolated fungi included *Aspergillus*, *Cladosporium*, *Fusarium*, and *Geotrichum* were recovered in comparatively lower proportions. The data underscore the statistically significant predominance of *Candida* spp. among NDMs, while *T. violaceum* demonstrates a notable prevalence within the dermatophyte.

**Evaluation of demographic factors (risk factors)**

**Gender**

Based on the table 3, the total number of diabetic patients whose samples showed fungal growth was 105. Males constituted the vast majority of the sample, with their number reaching 71 patients, and the total participants number of females was 34 patients.

**Table 3:** distribution of the study sample by gender

Gender	Frequency	Percent
Male	71	%67.6
Female	34	%32.4
<b>Total</b>	<b>105</b>	<b>%100</b>

**Age**

Table 4 shows, the 57–69 age group was the most represented, accounting for 36.2% of participants (38 cases), followed by the 44–56 group at 26.7% (28 cases). The 70–80 group included 19 cases (18.1%), the 31–43 group had 14 cases (13.3%), and the 18–29 group was the least represented with 6 cases (5.7%).

**Table 4:** Distribution of the study culture sample by age

Age	Cases	Percent
18 - 30	6	%5.7
31 - 44	14	%13.3
44 - 57	28	%26.7
57 - 70	38	%36.2
70 - 80	19	%18.1
<b>Total</b>	<b>105</b>	<b>%100</b>

**Height**

Figure 3 indicate that the Most participants in the sample were of medium to tall height. The 170–180 cm group was the largest, with 63 cases (60%), followed by 160–170 cm with 28 cases (26.7%). Both the 180–190 cm group and those under 160 cm included 7 cases each (6.7%).

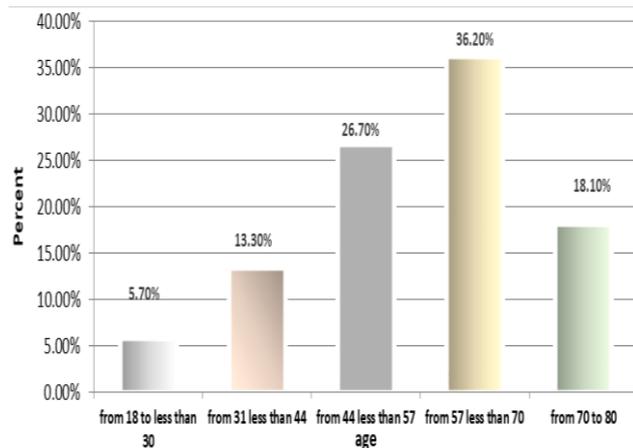


Figure 3: Distribution of the study culture by height

**Weight**

Based on the Table 5, the 75–85 kg and 95–105 kg categories were the most common, each with 27 cases (25.7%). The 85–95 kg group included 23 cases (21.9%), followed by 65–75 kg with 15 cases (14.3%) and 55–65 kg with 9 cases (8.6%). The least represented category was 105 kg and above, with 4 cases (3.8%).

**Type of Diabetes**

Based on the table 6, 31 patients from the total sample have Type 1 diabetes, representing 29.5% of the study sample. In contrast, 74 patients have Type 2 diabetes, representing 70.5% of the study sample. This finding is consistent with global patterns of diabetes prevalence, where Type 2 diabetes is significantly more common than Type 1.

Table 5: Distribution of the study culture by weight.

Weight	Cases	Percent
55-65 kg	9	8.6%
65-75 kg	15	14.3%
75-85 kg	27	25.7%
85-95 kg	23	%21.9
95-105 kg	27	%25.7
105 kg and above	4	%3.8
<b>Total</b>	<b>105</b>	<b>%100</b>

Table 6: Results for the type of diabetes

Type of DM	Frequency	Percent
DM.TYPE1	31	%29.5
DM.TYPE2	74	%70.5
<b>Total</b>	<b>105</b>	<b>%100</b>

**Duration of DM**

Based on the Table 7, most diabetic patients in the study were chronic cases. Among the total participants, 64 patients (61%) had diabetes for more than 5 years, 27 patients (25.7%) for 1–5 years, and 14 patients (13.3%) for less than 1 year.

**Current treatment**

Based on the Figure 4, insulin therapy was the most common treatment, used by 45.7% of participants (48 individuals), indicating that most patients rely on insulin to control their blood sugar. Oral medications were the second most

common, used by 27.6% (29 individuals), reflecting their use in early or moderate stages of the disease.

Table 7: Distribution of the study culture by Duration of DM

Duration of DM	Cases	Percent
less than one years	14	%13.3
from one to five years	27	%25.7
more than five years	64	%60
<b>Total</b>	<b>105</b>	<b>%100</b>

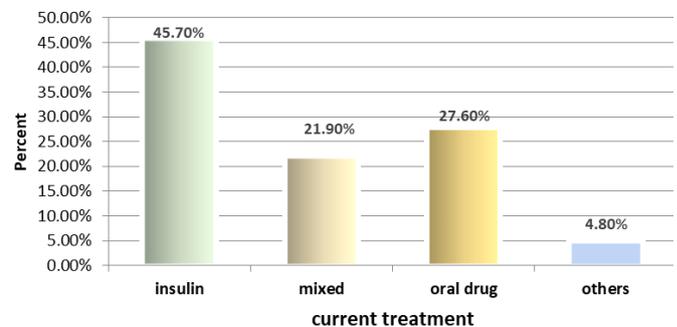


Figure 4: Distribution of the study culture current treatment

**Glycated Hemoglobin (HbA1c) values for the participants in the sample**

Table 8 shows, patients' HbA1c values ranged from 6.5% to 14.7%. Mild cases (6.5–8.9%) were the most common, with 57 patients (54.3%), indicating relatively controlled diabetes. Moderate cases (9–11.4%) included 40 patients (38.1%), showing poor blood sugar control. Severe cases (11.5–14.7%) were the least common, with 8 patients (7.6%), reflecting uncontrolled chronic diabetes. Additionally, most participants were in the higher weight categories (75–105 kg), representing over 70% of the sample, suggesting a strong association between higher weight and elevated HbA1c levels, which may explain the moderate and severe cases.

Table 8: Distribution of Glycated Hemoglobin (HbA1c) values for the participants in the sample

HbA1c	Cases	Percent
Mild ( 6.5-8.9)	57	%54.3
moderate (9-11.4)	40	%38.1
sever (11.5-14.7)	8	%7.6
<b>Total</b>	<b>105</b>	<b>%100</b>

**History of Fungal Infections**

Based on figure 5, FIs sites and sample collection locations among the participants. Interdigital (foot) infections were most common.

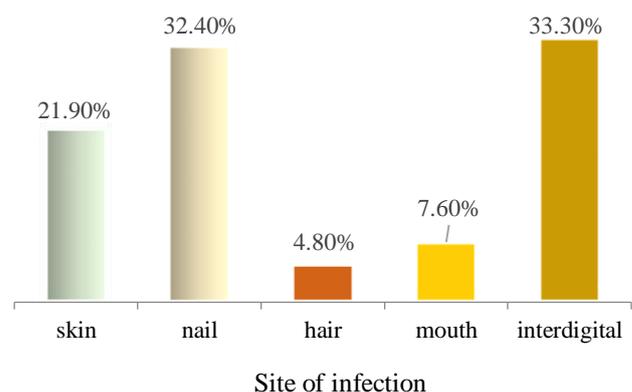


Figure 5: Distribution of the study sample according to the location of the fungal infection

## Discussion

### Fungal Infections in Diabetic Patients

The results show a very high prevalence of FIs among diabetic patients, with 89.7% of samples confirming fungal growth. This high rate reflects how diabetes, as a chronic disease, weakens the immune system and increases the patient's susceptibility to opportunistic infections. Out of 117 cultures, 105 showed fungal growth, while 12 showed no growth. This suggests that FIs are common among diabetic patients, as high blood sugar and weak immunity provide a favorable environment for fungal growth. The negative results may be due to low fungal counts, prior antifungal treatment, or good personal hygiene. Additionally, some fungi are difficult to grow in culture, which may also explain the absence of growth in a few cases.

When classifying the fungi, the results were as follows:

This study demonstrates that dermatophytes were the most common fungi, accounting for 53.3% of infections, making them the primary cause of fungal infections in this population. This finding supports with previous studies, including [24] (79.3%), [18] (52.4%), and [25] (51.2%). However, some studies reported a higher prevalence of NDMs, such as [26] (69.3%) and [27] (47.6%).

These differences may be explained by variations in geographical location, patient characteristics, and study methods, highlighting the importance of local epidemiological data for accurate diagnosis and effective management.

### Dermatophytes and non- dermatophytes

The high prevalence of *Candida* among diabetic patients is expected, as elevated blood glucose levels create a sugar-rich environment favorable for its growth. The dominance of dermatophytes, particularly *Trichophyton* species, reflects both environmental exposure and skin-related factors.

Importantly, the data show a statistically significant presence of both *Candida* spp. among non-dermatophytes and *T. violaceum* among dermatophytes. Overall, dermatophyte infections were more prevalent, yet specific NDMs like *Candida* spp., were also significantly present in this patient population. In this study, *Geotrichum* was also isolated, a rare fungus that is not often seen in clinical cases. Some studies, including those on diabetic patients, have also reported similar findings for *Geotrichum* as [28] and [29].

### Risk factors

#### Gender

In this study, 105 diabetic patients showed fungal growth. Males constituted the majority with 71 patients (67.6%), while females accounted for 34 (32.4%). These results are consistent with previous studies, such as [10] with 45.3% and [27] with 55%, although [25] reported a higher proportion of female patients (63.8%). Although this study observed more FIs in male diabetic patients, this difference was not statistically significant. This means that gender itself is likely not the cause. The higher number in men may instead be linked to other factors that were more common in the male participants in our study, such as higher blood sugar levels, older age, or greater exposure to humid environments at work.

#### Age

The current study shows a clear association between age and the type of FIs. Dermatophytes infections were more common among younger patients, particularly those aged 18–44 years, suggesting higher susceptibility in this age group. In contrast, non-dermatophyte infections (NDMs) increased with age and were more frequent in patients over 44 years.

In the oldest age groups (57–80 years), infections caused by dermatophytes and NDMs were nearly equal, indicating that

both types similarly affect older patients [30]. The statistically significant confirms that age is an important factor influencing the distribution of FIs among diabetic patients.

These results are similar to previous studies [27], which also reported higher rates of FIs among middle-aged and older diabetic patients. This may be explained by age-related changes in immune function and skin integrity, making older individuals more susceptible to NDMs infections, while younger patients are more prone to dermatophytes due to higher exposure and activity levels.

#### Height

The current study shows that most participants were within the 170–180 cm range (60%), followed by those of medium to tall stature in the 160–170 cm group (26.7%). Only a small proportion of participants were shorter than 160 cm or taller than 180 cm (6.7% each).

Similarly, a study in Libya indicated that shorter stature was relatively uncommon among diabetic patients [31].

This can be explained by the fact that, in the current study, most participants were of medium to tall height. This may reflect the characteristics of the population studied, including genetics, nutrition, and lifestyle, which led to fewer shorter individuals compared to previous studies. Shorter people often have less muscle and lower insulin sensitivity, while taller people usually have more muscle and better glucose metabolism. However, this pattern may not be the same for all populations.

#### Weight

The results indicate that most diabetic patients in the study were overweight or moderately obese, which may increase their risk of superficial FIs. Previous studies [32] and [33], reported that overweight and obese diabetic patients are more likely to develop infections such as *Candida* and tinea pedis. However, other studies found different results. [34] and [35] found no clear association between body weight and SFIs, suggesting that factors such as glycemic control, immune system function, and skin hygiene may play a more important role than weight alone.

The higher proportions in the 75–85 kg and 95–105 kg groups can be explained by the fact that both fall within the overweight or moderately obese range. This increases susceptibility to FIs due to several interacting factors:

Skin changes, such as folds and increased moisture, which create a favorable environment for fungi. Partially weakened immunity caused by obesity and diabetes. Metabolic disturbances associated with diabetes and overweight that affect insulin sensitivity and glucose metabolism.

Therefore, higher body weight logically contributes to an increased risk of SFIs through the combined effect of these factors.

**Diabetes duration** Statistical analysis in the current study showed no significant association between diabetes duration and the type of FIs. These findings are consistent with previous studies, such as [36] in Tripoli and [37] in Benghazi, where T2DM patients showed a high prevalence of *Candida* and NDMs infections, despite disease duration not being directly linked to. There may not be a direct link between blood sugar level and the duration of infection. This could be due to other factors such as weak immunity, delayed treatment, poor hygiene, and environmental conditions like heat and moisture, which create a favorable environment for infections to persist, especially in nails, skin, and interdigital spaces.

**Current treatments** The current study found that insulin therapy was the most commonly used treatment among diabetic patients. The results are based on the treatment classification adapted from [38] indicated no significant

association between treatment type and the type of FIs, which aligns with previous studies by [39] and [40], confirming that treatment type does not increase the risk of FIs. Overall, these findings suggest that while treatment type may reflect disease severity and stage, it does not directly influence the risk of specific FIs. Instead, prolonged hyperglycemia, long disease duration, and poor glycemic control appear to be the major contributing factors.

#### HbA1c levels

Analysis revealed a significant association between poor glycemic control and the occurrence of SFIs among diabetic patients in this study. These findings are consistent with previous studies. [8] reported that patients with higher HbA1c levels were more prone to infections by *Candida spp.* and dermatophytes. Similarly, [41] indicated that hyperglycemia with higher HbA1c levels creates a favorable environment for fungal growth, particularly in skin folds and moist areas.

Therefore, the elevated HbA1c levels observed in this study account for the higher prevalence of SFIs, with poor long-term glycemic control serving as a key contributing factor. The sustained hyperglycemia likely impairs immune responses while concurrently creating a favorable microenvironment for fungal colonization and proliferation.

#### History of Fungal Infections

The results indicate that the Interdigital (foot) infections were most common (33.3%), followed by nail infections (32.4%). Skin infections ranked in the third (21.9%), while oral infections were (7.6%), and hair infections were least common (4.8%). These findings are consistent with previous studies. [10] reported that nail infections (34.9%) and athlete's foot (26.3%) were the most common among diabetic patients. Similarly, [21] found that infections of the toes, nails, and skin are the most frequent, with occasional involvement of hair and sensitive skin. This pattern demonstrates a significant relationship between diabetes type and the site of FIs. In type 1 diabetes, fungal colonization may occasionally affect hair and sensitive skin, as these areas become more vulnerable under diabetic conditions. In contrast, type 2 diabetic patients, especially older adults, commonly develop nail and toe space infections due to poor circulation, neuropathy, and inadequate nail care. Additionally, the oral cavity and moist skin folds provide a favorable environment for fungal growth. Overall, diabetes weakens immunity, could be delays wound healing, and causes vascular and nerve damage all of which increase susceptibility to FIs and confirm a strong association between infection site and diabetes. In this study, more than half of the diabetic patients (50.5%) had FIs in only one site. Infections at two sites were observed in 34.3% of patients, while infections at three or four sites were less common (12.4% and 2.9%). This shows that spreading to multiple sites is relatively rare among diabetic patients.

**Author Contributions:** Alhijjaji: Conceptualization and methodology, writing—original draft preparation, review and editing. Alsseleni: Data collection. Alhijjaji and Alsseleni and Haider: results' analysis and discussion. Both authors have read and agreed to the published version of the manuscript.

**Funding:** "This research received no external funding."

**Data Availability Statement:** "No data were used to support this study."

**Acknowledgements:** "Deep thanks go to the Zliten Diabetes and Endocrine Center, especially its Director, Mr. Abdullah Al-Ayyan, and all the staff for their kind cooperation. Also, thanks to thank Beer Al-Esti Milad Hospital and its entire staff."

**Conflicts of Interest:** "The authors declare that they have no

conflict of interest."

## References

- [1] S. Demir, P. Nawroth, S. Herzig, and B. Ekim Üstünel. "Emerging targets in type 2 diabetes and diabetic complications." *Advanced Science*, vol. 8, no. 18, p. 2100275, 2021. <https://doi.org/10.1002/advs.202100275>
- [2] Atlas. "International Diabetes Federation (7th ed.)" (2015). Brussels, Belgium: *International Diabetes Federation*.
- [3] M. Al-Tahir, N. Ibrahim, A. Nouh, M. Al-Darmoun, and A. Alalem. "The Effect of Metformin on Vitamin B12 in Type 2 Diabetes Patients in Wadi Etba Region, Southern Libya." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 3, no. 2, pp. 116-119, 2025. [https://doi.org/10.63318/waujpasv3i2\\_14](https://doi.org/10.63318/waujpasv3i2_14)
- [4] S. Khagkhag, and O. Bousay. "Evaluation of Glycemic and Lipid Profiles Among Patients With Type 2 Diabetes Mellitus in Derna City - Libya." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 3, no. 2, pp. 316-321, 2025. [https://doi.org/10.63318/waujpasv3i2\\_39](https://doi.org/10.63318/waujpasv3i2_39)
- [5] M. Bisher, A. Thamer, and S. Shahata. "Association between Blood Glucose Levels and Biochemical Variables in COVID-19 Patients - A Cross-Sectional Study." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 4, no. 1, pp. 70-75, 2026. [https://doi.org/10.63318/waujpasv4i1\\_07](https://doi.org/10.63318/waujpasv4i1_07)
- [6] A. Almajdoub, M. Alzwayi, and N. Alaasswad. "Estimated Blood Levels of Zinc and Copper Among Type-2 Diabetic Patients and Their Relationship to Insulin Resistance." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 1, no. 1, pp. 5-19, 2023. <https://www.waujpas.com/index.php/journal/article/view/4>
- [7] A. Mosbah, A. Yhmed, A. Elwafa, and M. Alzwayi. "Prevalence of Type 2 Diabetes and Prediction of Renal Failure Phases in Males Attending Brack AlShatti Hospital." *Wadi Alshatti University Journal of Pure and Applied Sciences*, vol. 3, no. 1, pp. 18-23, 2025. <https://www.waujpas.com/index.php/journal/article/view/103>
- [8] C. Rodrigues, M. Rodrigues, and M. Henriques. "Candida sp. infections in patients with diabetes mellitus." *Journal of Clinical Medicine*, vol. 8, no. 1, p. 76, 2019. <https://doi.org/10.3390/jcm8010076>
- [9] D. Cole, N. Govender, A. Chakrabarti, J. Sacarlal, and D. Denning. "Improvement of fungal disease identification and management: combined health systems and public health approaches." *Therapeutic Advances in Infectious Disease*, vol. 17, no. 12, p. e412-e419, 2017. [https://doi.org/10.1016/s1473-3099\(17\)30308-0](https://doi.org/10.1016/s1473-3099(17)30308-0)
- [10] G. Akkus, M. Evran, D. Gungor, M. Karakas, M. Sert, and T. Tetiker. "Tinea pedis and onychomycosis frequency in diabetes mellitus patients and diabetic foot ulcers: A cross-sectional observational study." *Pakistan Journal of Medical Sciences*, vol. 32, no.4, p. 891, 2016. <https://doi.org/10.12669/pjms.324.10027>
- [11] G. Zhao, M. L. Usui, S. I. Lippman, G. A. James, P. S. Stewart, P. Fleckman, & J. E. Olerud. "Biofilms and inflammation in chronic wounds". *Advances in Wound Care*, vol. 2, no. 7, pp. 389-399, 2013. <https://doi.org/10.1089/wound.2012.0381>
- [12] M. Sławińska, M. Sikorska, M. Sokołowska-Wojdyło, R. Nowicki, M. Sobjanek, and M. Hlebowicz. "The role of dermoscopy in the diagnosis of deep mycoses and systemic mycoses with cutaneous involvement." *Journal of Dermatological Diagnosis & Venereology*, vol. 33, no. 1, pp. e35-e36, 2019. <https://doi.org/10.1111/jdv.15155>
- [13] M. Dias, M. Quaresma-Santos, F. Bernardes-Filho, A. Amorim, R. Schechtman, and D. Azulay. "Update on therapy for superficial mycoses: review article part I." *Anais Brasileiros de Dermatologia*, vol. 88, no. 5, pp. 764-774, 2013. <https://doi.org/10.1590/abd1806-4841.20131996>
- [14] S. Verma. "Superficial fungal infection: dermatophytosis, onychomycosis, tinea nigra, piedra." *Future Science & Dermatology Insights Global Medicine*, vol. 2, pp. 1807-

- 1821, 2008. <https://www.scirp.org/reference/referencespapers?referenceid=1407378>
- [15] P. Vishwakarma & N. Kumar. "Unraveling the world of human fungal infections: An introductory exploration." In *Human Fungal Diseases*, pp. 1–8. CRC Press. 2025. <https://doi.org/10.1201/9781032642864-1>
- [16] S. Otašević, S. Momčilović, M. Golubović, A. Ignjatović, N. Rančić, M. Đorđević, and V. Arsić-Arsenijević. "Species distribution and epidemiological characteristics of superficial fungal infections in Southeastern Serbia." *Mycoses*, vol. 62, no. 5, pp. 458–465, 2019. <https://doi.org/10.1111/myc.12900>
- [17] K. Guruprasad, M. W. Javed, C. Roopa, H. Ansari, and A. Takalkar. "Clinico-epidemiological study of dermatophytosis in teaching hospital of North Karnataka." *International Journal of Research in Dermatology*, vol. 5, pp. 106–109, 2019. <https://doi.org/10.18203/issn.2455-4529.intjresdermatol.20190100>
- [18] S. Araya, M. Abuye, and A. Negesso. "Epidemiological characterization of dermatomycosis in Ethiopia." *Clinical, Cosmetic and Investigational Dermatology*, vol. 83, no. 8, 2021. <https://doi.org/10.2147/ccid.s292286>
- [19] L. Trovato, M. Domina, M. Calvo, R. De Pasquale, G. Scalia, and S. Oliveri. "Use of real time multiplex PCR for the diagnosis of dermatophytes onychomycosis in patients with empirical antifungal treatments." *Journal of Infection & Public Health*, vol. 15, no. 5, pp. 539–544, 2022. <https://doi.org/10.1016/j.jiph.2022.03.019>
- [20] J. Aragón-Sánchez, M. López-Valverde, G. Viquez-Molina, A. Milagro-Beamonte, and L. Torres-Sopena. "Onychomycosis and tinea pedis in the feet of patients with diabetes." *International Journal of Low Extremity Wounds*, vol. 22, no. 2, p. 321–327, 2023. <https://doi.org/10.1177/15347346211009409>
- [21] A. Gupta, M. MacLeod, K. Foley, G. Gupta, and S. Friedlander. "Fungal skin infections". *Pediatric Infectious Disease Journal*, vol. 38, no. 1, pp. 8–22, 2017. [https://doi.org/10.1007/978-0-387-40045-7\\_3](https://doi.org/10.1007/978-0-387-40045-7_3)
- [22] A. Man, C. Ciurea, D. Pasaroiu, A. Savin, F. Toma, F. Sular, and A. Mare. "New perspectives on the nutritional factors influencing growth rate of *Candida albicans* in diabetics: an in vitro study." *Journal of Nutrition & Metabolism*, vol. 112, no. 9, pp. 587–592, 2017. <https://doi.org/10.1590/0074-02760170098>
- [23] J. Dyer, and V. Foy. "Revealing the unseen: a review of Wood's lamp in dermatology." *Journal of Investigative Dermatology*, vol. 15, no. 6, p. 25, 2022. <https://jcadonline.com/review-of-woods-lamp-in-dermatology/>
- [24] S. Cheikhrouhou, A. Attoini, D. Aloui, M. Bouchekoua, S. Trabelsi, and S. Khaled. "Epidemiological, clinical and mycological study of dermatomycosis in diabetic patients." *La Tunisie Médicale*, vol. 99, no. 8, pp. 911–918, 2021. <https://pubmed.ncbi.nlm.nih.gov/articles/PMC9003591/>
- [25] A. Husain, N. Abdel Fattah, A. Afify, and N. Mostafa. "Epidemiology and risk factors of superficial fungal infections in Toukh primary health care Centre." *The Egyptian Journal of Hospital Medicine*, vol. 72, no. 7, pp. 4898–4902, 2018. <https://doi.org/10.21608/ejhm.2018.10171>
- [26] A. Atia, A. Ashour, and N. Elyounsi. "Trends in skin fungal infection in Tripoli, Libya, during 2007–2015." *International Journal of Medical and Biomedical Sciences*, vol. 11, no.3, pp. 116–119, 2019. [https://doi.org/10.4103/ijmbs.ijmbs\\_29\\_19](https://doi.org/10.4103/ijmbs.ijmbs_29_19)
- [27] S. Agrawal, A. Singal, C. Grover, S. Das, and S. Madhu. "Clinico-mycological study of onychomycosis in Indian diabetic patients." *Indian Dermatology Online Journal*, vol. 14, no. 6, pp. 807–813, 2023. [https://doi.org/10.4103/idoj.idoj\\_642\\_22](https://doi.org/10.4103/idoj.idoj_642_22)
- [28] V. Tshisevhe, B. Mitton, and L. Skosana. "Invasive *Geotrichum klebahnii* fungal infection: A case report." *Advances in Medicine*, vol. 3, no. 11, p. 000287, 2021. <https://doi.org/10.1099/acmi.0.000287>
- [29] L. Shi, Y. Feng, and D. Shi. "Two cases of superficial fungal infection caused by non-albicans *Candida* species manifest greenish-black discoloration." *Journal of Infection and Resistance*, pp. 665–672, 2024. <https://doi.org/10.2147/idr.s438079>
- [30] J. M. Pearce. "The unexpected reason firms should institute policies to remove email signatures: Quantifying human mortality costs of email signature-based reputation signaling." *Science & Finance*, vol. 9, p. 100516, 2025. <https://doi.org/10.1016/j.sfr.2025.100516>
- [31] O. Alfalah, I. Eljazwi, and N. Buzaid. "Profiles of diabetes care, control and complications in Benghazi, Libya 2020: A cross sectional study." *International Journal of Medicine & Basic Sciences*, vol. 13, no. 03, pp. 142–147, 2021. [https://doi.org/10.4103/ijmbs.ijmbs\\_45\\_21](https://doi.org/10.4103/ijmbs.ijmbs_45_21)
- [32] N. Alhammadi, et al. "Prevalence and factors associated with tinea pedis among diabetic patients in Saudi Arabia: a descriptive cross-sectional study." *Cureus*, vol. 15, no. 12, 2023. <https://doi.org/10.7759/cureus.51210>
- [33] S. Shahabudin, N. Azmi, M. Lani, M. Mukhtar, and M. Hossain. "Candida albicans skin infection in diabetic patients: An updated review of pathogenesis and management." *Journal of Medical Mycology*, vol. 67, no. 6, p. e13753, 2024. <https://doi.org/10.1111/myc.13753>
- [34] R. Altınbaş. "Is diabetes a risk factor in fungal infections? Diabetes and fungal infections." *Therapeutic Insights: Diabetes*, vol. 3, no. 3, pp. 114–123, 2024. <https://doi.org/10.5281/zenodo.15032404>
- [35] M. Alexander, E. Cho, E. Gliozheni, Y. Salem, J. Cheung, and H. Ichii. "Pathology of diabetes-induced immune dysfunction." *International Journal of Molecular Sciences*, vol. 25, no. 13, p. 7105, 2024. <https://doi.org/10.3390/ijms25137105>
- [36] T. Abourghiba, M. Almsalati, and Z. Alghadem. "Investigations of the prevalence of *Candida* infections in diabetes mellitus patients in Tripoli." *Libyan Journal of Science*, vol. 24, no. 1, pp. 19–29, 2021.
- [37] S. Baiu, W. Bridan, and H. Kalfa. "Fungi as pathogens of onychomycosis among diabetic patients." *Journal of Applied and Environmental Microbiology*, vol. 4, no. 2, pp. 30–33, 2016. <https://doi.org/10.12691/jaem-4-2-1>
- [38] Y. Gong, C. Li, C. Wang, J. Li, M. Ding, and D. Chen. "Resistance, D. Epidemiology and mortality-associated factors of invasive fungal disease in elderly patients: a 20-year retrospective study from Southern China." *Journal of Infection and Public Health*, pp. 711–723, 2020. <https://doi.org/10.2147/idr.s242187>
- [39] M. Eba, et al. "Onychomycosis in diabetic patients in Fako Division of Cameroon: prevalence, causative agents, associated factors and antifungal sensitivity patterns." *BMC Research Notes*, vol. 9, no. 1, p. 494, 2016. <https://doi.org/10.1186/s13104-016-2302-1>
- [40] S. Kandregula, A. Behura, C. Behera, D. Pattnaik, A. Mishra, B. Panda, and C. Behera. "Clinical significance of fungal infections in diabetic foot ulcers." *Journal of Clinical and Experimental Dermatology Research*, vol. 14, no. 7, 2022. <https://doi.org/10.7759/cureus.26872>
- [41] D. Navarro-Pérez, J. Lázaro-Martínez, S. García-Oreja, T. Pérez-Pérez, F. Álvaro-Afonso, and A. Tardáguila-García. "Prevalence and risk factors predicting onychomycosis in patients with and without diabetes mellitus in Spain: A cross-sectional study." *Journal of Fungi*, vol. 10, no. 11, p. 790, 2024. <https://doi.org/10.3390/jof10110790>