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Research article

The prevalence of onychomycosis in patients with chronic renal failure undergoing dialysis: A cross-sectional study

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ABSTRACT

Onychomycosis is one of the most common cutaneous symptoms in patients with chronic renal failure. In the present study, we aimed to investigate the prevalence and determine the factors likely associated with developing onychomycosis among dialysis patients. This cross-sectional study was conducted between 2022 and 2023 with 312 chronic renal failure patients undergoing dialysis visiting the dialysis departments of Guilan University of Medical Sciences. Participants were selected by consecutive sampling method. A dermatologist subjected the patients to a detailed clinical assessment of the fingernails and toenails to find evidence of Onychomycosis. Periodic acid-Schiff (PAS) staining was performed in case of suspicion of Onychomycosis. A total of 312 inpatients were investigated during the time frame of the present study. Among study patients, 62.5% were male, the average age of the patients was 59.3 ± 13.9 years, and the mean duration of dialysis was 37.5 ± 38.5 months. A total of 12.8% (n = 40) of patients undergoing dialysis had Onychomycosis. Diabetes mellitus was present in 37.5% of dialysis patients. Diabetes and Onychomycosis were significantly associated, so the prevalence rate of Onychomycosis in diabetic patients was almost twice that of non-diabetic patients (17.9% vs. 9.7%; $P < 0.001$). Logistic regression analysis revealed that age, sex, education level, and type of dialysis access were the predictors of Onychomycosis development. Onychomycosis puts people at risk for more severe infections, including erysipelas, cellulitis, and amputations; thus, dialysis patients need to learn how to take care of their toenails properly.

1. Introduction

Onychomycosis is a prevalent fungal infection of the toenails and fingernails caused by a diverse array of fungi. Dermatophytes, yeasts, and non-dermatophyte molds (NDMs) are this infection's most common causative agents [1,2]. Onychomycosis affects approximately 10% of the population worldwide, 20% over 60 years, about 50% of people aged >70 years, and up to one-third of

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diabetic patients [3]. Aging, immunosuppression, diabetes mellitus, peripheral vascular disease, and skin conditions such as hyperhidrosis, psoriasis, onychogryphosis, and nail damage are risk factors linked to developing onychomycosis [4]. Recent studies have indicated an increased incidence of onychomycosis in AIDS patients [5]. Additionally, individuals with chronic kidney disease (CKD) are considered a high-risk group for developing onychomycosis [4]. Cutaneous manifestations are observed in nearly all patients with progressive kidney failure. These manifestations can be attributed to uremia, metabolic disorders, dialysis, and drug side effects [6]. Cutaneous manifestations in kidney failure are diverse, encompassing a broad spectrum [6–8]. The literature remarked that the frequency of onychomycosis in patients who underwent hemodialysis is higher than that of healthy individuals, with a 19–51.9% prevalence [4,9–14]. Also, a previous study conducted in Porto Alegre, Brazil, found that the prevalence of onychomycosis in patients with chronic renal failure (CRF) undergoing hemodialysis was 39% [15]. The most common fungi isolated from patients in that study were dermatophytes (69.23%), Candida spp. (15.38%), and non-dermatophyte molds (15.38%). The study also found that the risk of onychomycosis increased by 1.9% for each additional year in age and that diabetic patients were 88% more likely to develop onychomycosis than non-diabetic individuals. The prevalence of onychomycosis may also vary across regions, with individual dietary habits, living environment, climate, socioeconomic and nutritional status, and racial differences [1]. Despite the growing body of research on onychomycosis in dialysis patients and the increasing prevalence of onychomycosis among patients with chronic renal failure [4,14], there is still a lack of information on the prevalence of this infection in specific populations, such as patients in Iran. The aim of the present study was to investigate the prevalence of onychomycosis among dialysis patients and determine the factors likely to be associated with its development.

2. Materials and methods

2.1. Study design, setting, and population

The present cross-sectional study was conducted on patients referred to the dialysis departments of Guilan University of Medical

Table 1
The demographic and clinical features of patients on hemodialysis.

Baseline characteristics	Number of patients	Patients with Onychomycosis	Patients without Onychomycosis	P-Value
Gender				0.484
Women	117 (37.5)	17 (14.5)	100 (85.5)	
Men	195 (62.5)	23 (11.8)	172 (88.2)	
Age				0.115
>50	68 (21.8)	5 (7.4)	63 (92.6)	
50-59	69 (22.1)	7 (10.1)	62 (89.9)	
60-69	99 (31.7)	19 (19.2)	80 (80.8)	
>70	76 (24.4)	9 (11.8)	67 (88.2)	
Mean ± SD	59.3 ± 13.9	63.07 ± 9.487	58.8 ± 14.392	0.16
Residence				0.599
Rural	68 (21.8)	10 (14.7)	58 (85.3)	
Urban	244 (78.2)	30 (12.3)	214 (87.7)	
Education level				0.328
illiterate	93 (29.8)	9 (9.7)	84 (90.3)	
High school	77 (24.7)	11 (14.3)	66 (85.7)	
Diploma	71 (22.8)	7 (9.9)	64 (90.1)	
College Education	71 (22.8)	13 (18.3)	58 (81.7)	
Duration of hemodialysis				0.568
<6 months	150 (48.1)	20 (13.3)	130 (86.7)	
6 months to <2 years	106 (34.0)	11 (10.4)	95 (89.6)	
2 years to <5 years	56 (17.9)	9 (16.1)	47 (83.9)	
Mean ± SD (Range) month	37.5 ± 38.5	38.0 ± 40.496	37.4 ± 38.273	0.923
BMI				0.360
<18.5	20 (6.4)	2 (10.0)	18 (90.0)	
18.5 to 24.9	144 (46.2)	18 (12.5)	126 (87.5)	
25 to 29.9	121 (38.8)	15 (12.4)	106 (87.6)	
30 to 34.9	23 (7.4)	5 (21.7)	18 (78.3)	
>35	4 (1.3)	0 (0)	4 (100.0)	
Comorbidity	205 (65.7)	29 (14.1)	176 (85.9)	0.332
Presence of Diabetes				0.036
Yes	117 (37.5)	21 (17.9)	96 (82.1)	
No	195 (62.5)	19 (9.7)	176 (90.3)	
HTN				0.677
Yes	162 (51.9)	22 (13.6)	140 (86.4)	
No	150 (48.1)	18 (12.0)	132 (88.0)	
Types of Dialysis Access				0.175
Permicate	134 (42.9)	22 (16.4)	112 (83.6)	
Fistula	170 (54.5)	18 (10.6)	152 (89.4)	
Graft	8 (2.6)	0 (0)	8 (100)	

Sciences between 2022 and 2023. This study was conducted to investigate the prevalence of onychomycosis among dialysis patients. The research findings are reported in compliance with the STROBE recommendations for reporting cross-sectional studies (Supplementary File 1). Participants were selected by consecutive sampling method. Patients who consented to participate were included in the study to examine skin manifestations. Then, hand and foot examinations were performed by a dermatologist to find evidence of onychomycosis. Periodic acid-Schiff (PAS) staining was performed in case of suspicion of onychomycosis. Patients who were unwilling to take part in the study were excluded. Based on a similar study [4], the required sample size was calculated to be 300 patients, taking into account the frequency of onychomycosis (26.6%), 95% confidence, and a maximum error of 0.05, and using $n = Z^2p\,(1 - p)/e^2$.

The inclusion criterion was that at least three months had elapsed since the start of dialysis. Individuals with a history of collagen vascular disease, active infection, malignancy, alcohol misuse, cirrhosis, human immunodeficiency virus infection, or immunosuppressant use were excluded from the study. Patients were divided into two groups: Patients with onychomycosis and patients without onychomycosis. The demographic and clinical characteristics were extracted for both groups. The extracted data included gender, age, residence, education level, duration of hemodialysis, comorbidity, presence of diabetes, and HTN.

2.2. Statistical analysis

The data were analyzed using the SPSS software package (version 24.0, SPSS Inc., Chicago, IL, USA). A p-value <0.05 was considered statistically significant. The comparison of two groups (Patients with onychomycosis and Patients without onychomycosis) was conducted through the Chi-square test, Fisher's exact test, and Mann–Whitney *U* test. Multiple logistic regression analyses were conducted to identify variables associated with onychomycosis infection. Receiver operating characteristic (ROC) curve analysis was used to evaluate the performance of the multivariate logistic regression model for predicting onychomycosis.

2.3. Ethics approval

The present research was part of a MD thesis, which the research deputy of the Guilan University of Medical Sciences supported. Also, this research was approved by the Ethics Committee of Guilan University of Medical Sciences (IR.GUMS.REC.1401.347). Written informed consent was obtained from all participants before the start of the study.

3. Results

Of the 338 patients invited to participate in this study, 312 (92.3%) were willing to participate. A total of 312 inpatients were investigated during the time frame of the present study. Among study patients, 62.5% were male, the average age of the patients was

Table 2
Logistic regression analysis of factors influencing Onychomycosis.

		B	SE.	P-Value	OR	95% CI. for OR	
						Lower	Upper
First Step	Age (Year)	0.053	0.018	0.003	1.055	1.018	1.093
	Dialysis duration (months)	0.001	0.005	0.842	1.001	0.991	1.011
	Duration of doing Dialysis (Minute)	0.000	0.009	0.981	1.000	0.982	1.017
	Sex (Female vs Male)	−0.589	0.727	0.418	0.555	0.134	2.308
	JOB	0.218	0.401	0.586	1.244	0.567	2.728
	Education level			0.002			
	Education level (High school and Diploma vs. illiterate)	1.125	0.536	0.036	3.082	1.079	8.804
	Education level (College Education vs. illiterate)	2.462	0.715	0.001	11.732	2.886	47.683
	Place of residence	−0.855	0.478	0.073	0.425	0.167	1.084
	Access type (permicat compared to fistula and graft)	0.979	0.419	0.020	2.662	1.170	6.054
	BMI			0.500			
	<18.5 vs BMI >30	19.144	19802.530	0.999	206084948.804	0.000	.
	18.5 to 24.9 vs BMI >30	19.834	19802.530	0.999	410773898.297	0.000	.
	25 to 29.9 vs BMI >30	19.598	19802.530	0.999	324489491.764	0.000	.
	30 to 34.9 vs BMI >30	20.664	19802.530	0.999	942864066.442	0.000	.
	diabetic	0.886	0.408	.030	2.426	1.090	5.399
	HTN	0.115	0.395	.770	1.122	0.518	2.432
	Constant	−25.059	19802.530	.999	0.000		
Last Step (Adjusted Model)	Age	0.059	0.017	0.000	1.061	1.026	1.096
	Sex (Female vs Male)	−1.082	0.436	.013	0.339	0.144	.796
	Education level			.001			
	Education level (High school and Diploma vs. illiterate)	1.097	0.516	.033	2.996	1.090	8.234
	Education level (College Education vs. illiterate)	2.493	0.670	.000	12.100	3.253	45.006
	Access type (permicat compared to fistula and graft)	0.770	0.367	0.036	2.160	1.051	4.436
	Constant	−5.319	1.231	0.000	0.005		

B: nonstandard coefficients; S.E.: standard error; CI: confidence interval; OR: Odds Ratio.

59.3 ± 13.9 years, and the mean duration of dialysis was 37.5 ± 38.5 months. Of the patients, 93 (29.8 %) were illiterate, and 244 (78.2%) lived in the Urban region. Diabetes mellitus was present in 37.5% of dialysis patients, and 51.9% had hypertension. A total of 12.8% (n = 40) of patients undergoing dialysis had onychomycosis.

Onychomycosis was diagnosed in 12.8% of dialysis patients. Based on the groups in our study, the patient's clinical and demographic features were evaluated and shown in Table 1. As demonstrated in Table 1, there was no significant association between the presence of onychomycosis and demographic information. However, the mean age of patients with onychomycosis was higher than those without onychomycosis (63.07 ± 9.487 vs 58.76 ± 14.392). Also, the average duration of dialysis between infected and non-infected people has not had a statistically significant difference.

Diabetes and onychomycosis were significantly associated, so the prevalence rate of onychomycosis in diabetic patients was almost twice that of non-diabetic patients (17.9% vs. 9.7%; P < 0.036). The results of backward stepwise LR logistic regression analysis with the Hosmer-Lemeshow goodness of fit test (Chi-square = 2.36, df = 8, P = 0.968) are given in the first step (Unadjusted Model) and last step (Adjusted Mode) in Table 2. According to the information in this table in the last step, among the studied variables, age (OR = 1.061, P < 0.001), sex (female Vs. male) (OR = 0.339, P < 0.001), the education level (high school and Diploma vs. illiterate) (OR = 2.99, P = 0.033), and education level (college education vs. illiterate) (OR = 12.10, P < 0.001) and method of access to dialysis with Permicat (OR = 2.16, P = 0.036) were the predictors of onychomycosis. According to the obtained odds ratio, this disease's risk increases with age and education level. In addition, access to dialysis with Permicat increases the chance of acquiring this disease. Also, men had a lower chance of getting the disease than women. Also, based on the ROC diagram, the prediction level (AUC = 0.039 ± 0.710, P < 0.001, 95% CI AUC: 0.786–0.634) was acceptable and significant [Fig. 1].

4. Discussion

Fungal infections are the most common worldwide, affecting people of all ages, reducing patients' quality of life, and imposing a high economic burden on patients and societies. Little information is available about the prevalence of onychomycosis in dialysis patients, although an increased frequency of onychomycosis has been found among patients with chronic renal failure undergoing dialysis. In the present study, Diabetes mellitus was present in 37.5% of dialysis patients. A total of 12.8% (n = 40) of patients undergoing dialysis had onychomycosis, and the prevalence rate of onychomycosis in diabetic patients was almost twice that of non-diabetic patients. A systematic review study estimating the risk of developing onychomycosis among special populations showed the highest disease incidence in patients who underwent dialysis (11.93%) [14]. Abdelaziz et al. reported a lower prevalence in Egyptian patients (7.6%) [16]. However, a previous study conducted in Porto Alegre, Brazil, found that the prevalence of onychomycosis in patients with CRF undergoing hemodialysis was 39% [15]. Also, in a study by Kuvandik et al., 26.6% of hemodialysis patients were diagnosed with onychomycosis, and 68.9% were diabetic [4]. It has been hypothesized that the high prevalence of onychomycosis among hemodialysis patients is due to the impairment of cellular immunity and a marked reduction in the number and function of both B and T lymphocytes [17]. Concurrent illnesses that affect peripheral circulation, such as diabetes, angiopathy, and vascular stasis, raise or even double this risk. Reduced circulation causes tissue hypoxia or a loss of sensibility and raises the risk of damage [18]. Given that onychomycosis puts people at risk for more severe infections, including erysipelas, cellulitis, and amputations, dialysis patients must learn how to properly take care of their toenails.

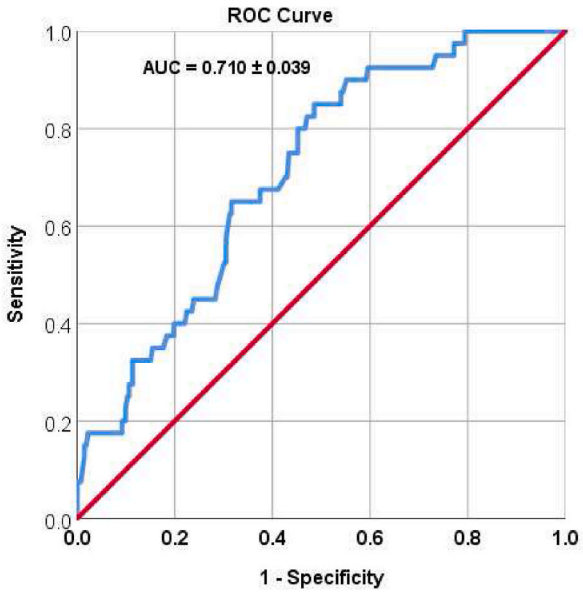

Fig. 1. ROC curve for the predicting of Onychomycosis.

While patients with onychomycosis had older median ages than individuals without onychomycosis, the difference was not statistically significant. Several studies report that onychomycosis is an age-related infection. Similarly, an observational study in two large aged-care facilities in New Zealand showed that about half (47.7%) of all dermatological problems were caused by onychomycosis [19]. In elderly patients, the increased risk of onychomycosis is probably related to multiple comorbidities, increased prevalence of peripheral vascular disease and decreased blood circulation, slow growth of nails, accumulated trauma to nails, and frequent nail dystrophy [15].

The results of a study on the prevalence of onychomycosis in men and women showed that women have a higher chance of developing onychomycosis compared to men. This result is consistent with some studies, such as a study by Bedaiwy et al. [20], which showed a higher incidence of onychomycosis in women (86%) than men (14%). However, other studies have reported conflicting results, such as a study by Gupta et al. [21], which found a higher frequency of onychomycosis in males (65%) compared to females (35%). In a study by Babayani et al. [22], the percentage of men (58.23%) was higher compared to women (41.77%). These differences may be due to variations in study design, population characteristics, and diagnostic methods. More research is needed to determine the true prevalence of onychomycosis in men and women.

The relationship between education level and onychomycosis development appears complex and inconsistent. While some studies, like those in Calcutta, India [23] and Poland [24], suggest a possible correlation, others, including those in Turkey, have not found a significant link. This inconsistency highlights the need for further research to determine definitively the impact of education on onychomycosis risk. Interestingly, our present study yielded somewhat contradictory results, indicating that the risk of onychomycosis might increase with higher education levels. This unexpected finding highlights the need for further investigation to elucidate the underlying mechanisms and reconcile these seemingly opposing observations. Onychomycosis rarely occurs in healthy nails [22]. Perhaps our results can be explained by the potential impact of excessive handwashing and sanitizer use on skin health. Frequent cleansing, as recommended during the COVID-19 pandemic (when our study was conducted), could disrupt skin pH, strip away protective lipids, and compromise the skin barrier, creating a breeding ground for fungal invaders. Given that our participants were sampled during this period, it is tempting to speculate that individuals with higher education levels, possibly more inclined to follow health guidelines diligently, may have inadvertently created an environment conducive to nail fungus growth.

Some studies have reported that onychomycosis is more common in rural areas than urban areas. Although most of the onychomycosis patients in the current research resided in rural regions, there was no statistically significant difference between these two groups. People living in rural areas are generally engaged in agricultural and animal husbandry activities and are usually in unfavorable health conditions due to direct contact with soil, mud, animals, and birds and are usually susceptible to fungal infections [25].

Several predisposing factors are associated with an increased prevalence of onychomycosis. Immunosuppression for any reason increases the risk of nail infection. Hyperglycemia and insulin deficiency alter cellular immunity, increasing susceptibility to fungal colonization, skin fungal infection, and onychomycosis. The present findings showed a significant association between onychomycosis and diabetes. Many studies have been conducted regarding the prevalence of onychomycosis in diabetic patients, including a study conducted in Turkey that reported that hemodialysis patients with DM had more remarkable dystrophic nail changes and onychomycosis prevalence than HD patients without DM [4]. In a study conducted in India, the probability of developing onychomycosis in diabetic people was 2.5 times higher than in the control group, and blood pressure was also considered as a predisposing factor [26]. Also, a study conducted in the US reported that the risk of onychomycosis in people with diabetes was 1.9–2.8 times higher than in the general population [27].

4.1. Implications for future study

The findings of this study suggest that onychomycosis is a common problem among dialysis patients and that diabetes mellitus, age, sex, education level, and type of dialysis access are associated with its development. Future research should investigate the underlying mechanisms of these associations and develop targeted prevention and treatment strategies for dialysis patients with onychomycosis. Additionally, future research should be conducted in larger and more diverse populations to confirm the findings of this study.

4.2. Limitations and strengths

Onychomycosis is a common fungal infection of the nails that can be difficult to treat, especially in patients with renal failure. This study is the first comprehensive study in Iran to investigate the risk factors for onychomycosis in a large cohort of patients with renal failure. Our findings will help to identify patients at high risk for Onychomycosis so that they can be targeted for preventive measures and early treatment. One limitation of our study is the small sample size of the onychomycosis group. This limits the power of the subgroup analysis to detect significant associations between risk factors and onychomycosis. Another limitation of our study was the exclusion of dialysis patients with established risk factors for onychomycosis. This could potentially introduce selection bias into our findings and lead to overestimating the apparent risk associated with the remaining risk factors identified in our study. Therefore, caution should be exercised when interpreting our findings in the context of the broader dialysis population. In future studies, we plan to conduct subgroup analyses with larger sample sizes to confirm our findings and to explore the risk factors for onychomycosis in patients with renal failure in more detail.

5. Conclusions

In this study, the frequency of onychomycosis was higher in dialysis patients. Diabetes, sex, age, education level, and method of

access to dialysis with Permicat were the predictors of onychomycosis development. Given that onychomycosis predisposes patients to more severe infections such as erysipelas, cellulitis, and amputations, dialysis patients must be instructed in the care and hygiene of their toenails. In addition, education of dialysis patients about the importance of nail care should be an essential component in their management.

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Data availability statement

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declaration of interest's statement.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

CRediT authorship contribution statement

Hojat Eftekhari: Data curation. **Yalda Haghdar Saheli:** Conceptualization. **Mohammad Taghi Ashoobi:** Project administration. **Mahsa Mahjoob:** Investigation. **Ehsan Kazemnezhad Leyli:** Methodology, Formal analysis. **Parissa Bagheri Toolaroud:** Writing – review & editing, Writing – original draft, Validation, Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e25737.

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