

Prevalence, Risk Factors and Treatment of Occupational Onychomycosis among Carpet Manufacture Workers in Egypt

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Abstract

Background: Onychomycosis is a chronic fungal infection of the nail, characterized by nail discoloration, subungual hyperkeratosis, and onycholysis. The involved pathogens are dermatophytes, yeasts (*Candida*), and non-dermatophyte molds (NDMs). Onychomycosis occurs worldwide and accounts for up to 50% of all nail infections and 30% of all superficial fungal infections of the skin. Onychomycosis represents a therapeutic challenge because of the high recurrence rate. Moreover, it requires long treatment duration and systemic rather than topical antifungal agent because onychomycosis-related subungual hyperkeratosis limits the penetration with topical antifungal drugs, in addition to the slow nail growth, the physical presence of nail plate interfering with nail bed access, and the difficulty in finding compounds with adequate pharmacologic profile for nail penetration.

Aim of Study: To assess prevalence of onychomycosis and risk factors associated with carpet industry workers.

Patients and Methods: A comparative cross sectional study was conducted between March 2021 to March 2022 among 65 workers from carpet manufacturing set in 10th of Ramadan city, which was selected randomly out of total three factories in the city and a comparison group of matched administrative workers. Diagnosis of cases and evaluation of therapeutic response was done by onychomycosis severity index score. Potassium hydroxide microscopy and culture were performed at baseline and at the end of the study.

Results: Prevalence of onychomycosis among exposed workers was 24.6% versus 3.3% among controls (general population) ($p < 0.001$), 75% of exposed workers had multiple fingernails OM, 50% of them had candidal onychomycosis (CO) and 31.3% proximal subungual onychomycosis (PSO), while the two cases of controls had single toenail distal and lateral subungual onychomycosis (DLSO). Old age found to be significant among onychomycosis (OM) cases, all OM cases involved in wool fibers washing and processing (56.3%) or yarn dying (43.7%) versus 8.2% and 10.2% respectively of non-infected group. Risk factors included prolonged hand immersion in water (62.5%), history of previous treatment (31.3%), and exposure to irritating chemicals and detergents (37.5%), that were statistically significant among studied cases.

Conclusions: Onychomycosis is a common health problem among carpet weaving workers, especially manual workers due to wet processes and exposure to chemical dyes without using PPE, so protective measure should be taken after treatment of the problem.

Key Words: Carpet weaving – Onychomycosis – Fungal – Mycology.

Introduction

ONYCHOMYCOSIS is a chronic fungal infection of the nail, characterized by nail discoloration, subungual hyperkeratosis, and onycholysis. The involved pathogens are dermatophytes, yeasts (*Candida*), and non-dermatophyte molds (NDMs) [1]. Onychomycosis occurs worldwide and accounts for up to 50% of all nail infections and 30% of all superficial fungal infections of the skin [2].

Dermatophytes such as *Trichophyton* (*T.*) *rubrum* and *T. mentagrophytes* are the most common agents of onychomycosis, with higher prevalence of the infection in toenails than in fingernails. *Candida* (*C.*) *albicans* affects almost exclusively the fingernails, and accounts for 10% of toenail onychomycosis [3,4].

Onychomycosis is classified into five clinical types, according to the fungal invasion of the nail: Distal and/or lateral subungual onychomycosis (DLSO) which appeared when onycholysis, discoloration, subungual hyperkeratosis and thickening affecting the distal and/or lateral nail. White superficial onychomycosis (WSO) is white spots on or in the nail plate with textural changes. Proximal subungual onychomycosis (PSO), appeared if discoloration and onycholysis affected the proximal part of the nail. Candidal onychomycosis (CO) is characterized by markedly thickened and roughened nail plates. Total dystrophic onychomycosis (TDO) involves the entire nail bed and nail plate with

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thickening and roughening or destruction of nail plate [5].

A disease occurring due to a factor that is being exposed in that occupation is defined as occupational disease. It is necessary to know which occupations carry a risk for the development of different problems, to be able to determine the suitable protective measures and to take precautions. Carpet weaving industry is one of these occupations including many health hazards, wet processes, exposure to various chemical dyes during yarn preparation or synthetic materials for the primary and secondary packing of piles are some of observed hazards, increased prevalence of respiratory symptoms and hyperkeratotic nodules or plaques (carpet nodule) on fingers, probably due to continuous trauma, are some of the observed health problems in carpet weavers [6,7].

Onychomycosis represents a therapeutic challenge because of the high recurrence rate. Moreover, it requires long treatment duration and systemic rather than topical antifungal agent because onychomycosis-related subungual hyperkeratosis limits the penetration with topical antifungal drugs, in addition to the slow nail growth, the physical presence of nail plate interfering with nail bed access, and the difficulty in finding compounds with adequate pharmacologic profile for nail penetration [8].

Aim of study was to assess prevalence of onychomycosis, its risk factors associated with carpet industry workers and treatment of affected workers.

Material and Methods

Study group:

The study was carried out at one of the carpet manufacturing set in 10th of Ramadan city, which was selected randomly out of total three factories in the city, all workers included in carpet processing and exposed to industrial health hazards were included in the study after approval by the institutional review board (IRB) of Medical School at Zagazig University, Egypt. Signed written consent was obtained from each worker before enrollment after extremely detailed information about nature of the study. Patients with cardiac problems, hyperlipidemia, those on drugs whose plasma concentrations are likely to be increased by the concurrent intake of oral itraconazole, liver or kidney function impairment, immune suppression, and those who received treatment for onychomycosis within the last 3 months before enrollment were excluded from the step of treatment of our study.

Methods:

This was an observational comparative cross sectional study that included 65 workers of carpet industry and a comparative sample of matched adult males from the workers of administrative jobs in the 10th Ramadan industrial city and who do not exposed to the industrial process of carpet industry or similar hazards (all was 60 workers).

The assessment of patients was conducted and consisted of an interview, clinical examination and collection of specimens for microbiological studies. All subjects completed a questionnaire that contained a demographic data, occupational history, specific data related to risk factors for onychomycosis (site of occupation, exposure to chemical dyes or wet processes) the clinical appearance according to site of lesion (DLSO, PSO and CO). Then the diagnosed cases received treatment with the guidance of a dermatology consultant, combined pulsed itraconazole and a tretinoin at the same doses for 3 months that proved to give best therapeutic results for onychomycosis.

Assessment of studied cases:

Confirmed diagnosis based on onychomycosis severity index (OSI) score (as proposed by Carney et al. [9]), and aided by dermoscopy using (Dermalite 4 Gen Pro II), along with mycological assessment by direct potassium hydroxide (KOH) 40% microscopy and culture at the baseline and at the end of therapy.

Treatment efficacy endpoint was defined by complete cure that includes both clinical cure (clinically completely normal nails as shown by reduction of OSI score to zero) and mycological cure (negative KOH microscopy and negative culture). Adverse effects were also evaluated.

Statistical analysis:

Data were entered, checked, and analyzed using SPSS (statistical package for social science) version 24. Data were expressed as mean \pm standard deviation (SD) for quantitative variables and number and percentage for qualitative variables. Independent sample *t*-test, Chi-square test (X²), Fisher exact test and Wilcoxon-signed rank test and regression analysis were used as appropriate. *p*-values <0.05 were considered significant.

Results

All workers were males with age ranged from 34 to 64 years. There was no statistically-significant difference in the age between exposed group and their controls. Most of studied workers were of

urban residence and worked for more than 5 years in the factory with no significant difference between both groups.

Prevalence of confirmed onychomycosis among exposed workers was 24.6% versus 3.3% among controls (general population) with statistically significant difference between them, 75% of exposed workers had multiple fingernails OM,

50% of them was CO and 31.3% PSO, while the two cases of controls had single toenail DLSSO with significant difference between both groups. The commonest fungal isolates among exposed workers was candida species (62.5%), 31.1% dermatophytes and 12.5% mixed infection (C. albicans, and Scopulariopsis) versus 50% dermatophytes and 50% candida species among controls, with no significant difference (Table 1).

Table (1): Basic characteristics of the studied groups and prevalence of onychomycosis.

Variable	Exposed group N=65		Control group N=60		χ^2 t-test*	P
	No.	%	No.	%		
<i>Age (yr):</i>						
mean \pm SD		45.3 \pm 5.79		45.8 \pm 7.84	20.9*	<0.001 S
Range		34-64		40-62		
<i>Duration of work:</i>						
\leq 5 years	13	20.0	15	25.0	0.54	0.76 NS
>5 years	52	80.0	45	75.0		
<i>Residence:</i>						
Urban	16	24.6	18	30.0	1.69	0.43 NS
Rural	49	75.4	42	70.0		
Confirmed onychomycosis	16	24.6	2	3.3	Fisher	<0.001 HS
<i>No and site of diseased nails:</i>						
Single fingernail	4	25.0	0	0.0	15.4	<0.001 HS
Multiple fingernails	12	75.0	0	0.0		
Single toenail	0	0.0	2	100.0		
<i>Clinical types:</i>						
CO	8	50.0	0	0.0	34.9	<0.001 HS
PSO	5	31.3	0	0.0		
DLSSO	3	18.8	2	100.0		
<i>Fungal isolates on culture:</i>						
Yeasts (Candida species)	10	62.5	1	50.0	Fisher	0.206 NS
Dermatophytes	5	31.3	1	50.0	Fisher	0.21 NS
Mixed	2	12.5	0	0	Fisher	0.96 NS

NS: p-value >0.05 is not significant.
 HS: p-value<0.001 is High significant.

PSO : Proximal subungual onychomycosis.
 DLSSO : Distal and lateral subungual onychomycosis.
 CO : Candidal onychomycosis.

Regarding risk factors for OM, old age found to be significant among OM cases, all cases involved in wool fibers washing and processing (56.3%) or yarn dying (43.7%) versus 8.2% and 10.2% respectively of non-infected group, and most of the non-infected group were involved in mechanical operation or final clipping step of the product. Risk factors included prolonged hand immersion in water (62.5%), history of previous treatment (31.3%), and exposure to irritating chemicals and detergents (37.5%), that were statistically

significant among studied cases. Each of both groups had 2 patients with nail psoriasis that was co-infected with dermatophytes. 68.7% of the studied cases didn't used protective gloves during manual work, that was statistically significant higher prevalence than those non-infected, all risk factors still significantly related to occurrence of OM after applying multiple regression analysis except old age and receiving previous antifungal treatment (Tables 2,3).

Table (2): Association of risk factors with occurrence of onychomycosis among exposed workers.

Variable	Positive OM N=16		Free of OM N=49		χ^2 t-test	P
	No. (45)	%	No. (45)	%		
<i>Age (yr):</i>						
Mean \pm SD	53.1 \pm 5.79		45.8 \pm 7.84		20.9	<0.001 S
Range	44-64		34-55			
<i>Duration of work:</i>						
\leq 5 year (n=13)	3	18.8	10	20.4	0.54	0.76 NS
>5 years (n=52)	13	81.2	39	79.6		
<i>Role in manufacturing process:</i>						
Scouring (wool fiber washing)	9	56.3	4	8.2	34.9	<0.001 HS
Yarn dyeing	7	43.7	5	10.2		
Final clipping	0	0	32	65.3		
Operators	0	0	8	16.3		
<i>Position in the factory:</i>						
Senior	1	6.3	16	32.7	4.99	0.08 NS
Manual worker	15	93.7	30	61.2		
Safety engineer	0	0.0	3	6.1		
<i>Risk factors:</i>						
Prolonged immersion of hands in water	10	62.5	0	0.0	Fisher	<0.001 HS
Previous treatment	5	31.3	0	0.0	Fisher	<0.001 HS
Irritating chemicals or detergents use	10	37.5	1	2.01	Fisher	<0.001 HS
Psoriasis	2	12.5	2	4.1	Fisher	0.988 NS
Use of PPE (protective gloves)	5	31.3	32	65.3	5.16	0.02 S

NS: *p*-value >0.05 is not significant.HS: *p*-value <0.001 is High significant.

OM: Onychomycosis.

PPE: Personal protective equipment.

Table (3): Logistic regression analysis for significant risk factors of onychomycosis among carpet manufacture workers.

Predictors	B	S.E.	Wald	<i>p</i> -value	OR	95.0% C.I.	
						Lower	Upper
Old age	0.002	0.342	0.125	0.221	1.12	0.23	1.99
Scouring workers	0.001	0.55	0.104	0.02	2.22	0.85	4.15
Yarn dyeing workers	0.0008	0.651	0.111	0.01	0.76	0.15	0.98
Prolonged hands immersion in water	0.1002	0.020	0.801	0.01	4.35	1.66	6.18
Irritating chemicals	0.001	0.324	0.234	0.02	3.15	1.22	7.13
Previous treatment	0.011	0.342	0.111	0.112	0.56	0.23	1.12
Not using PPE	0.005	0.234	0.213	0.03	1.23	0.96	2.13

As regard response to treatment:

Mycological cure which is negative direct KOH microscopy and negative culture found among 77.8% of studied cases. Clinical cure which defined as clinically completely normal nail (i.e reduction of OSI score to zero) found in 14 patients (77.8%), OSI score was calculated in the most severe nail. There was a statistically significant decrease in score assessed before and after treatment (score before-score after) (Table 4).

As regard adverse effects of therapy, no adverse effects were reported except for cheilitis among 5 patients (27.8%). No drug-drug interactions between it raconazole and acitretin was noted in the treated group. Regarding recurrence, Recurrence is defined as either relapse (same infection after incomplete cure) or reinfection (same infection after complete cure). Onychomycosis relapsed in 1 patient (Recurrence rate: 7.1%), after 6-months follow-up. That recurrent case was *Candida* (Table 4).

Table (4): Therapeutic response (clinical and mycological cure) and recurrence rate among the studied groups.

Clinical cure (Onychomycosis Severity Score)	Diagnosed cases (n=18)	
<i>Score before treatment:</i>		
Mean ± SD	21.7± 10.84	
Range	(4-35)	
Median	21	
<i>Score aftertreatment:</i>		
Mean ± SD	2.2±3.81	
Range	(0-12)	
Median	0.5	
	* <i>p</i> <0.001	
	No.	%
<i>Mycological cure (Cuture results):</i>		
+ve	4	22.2
-ve	14	77.8
	No.=14	%
<i>Recurrence (Follow-up culture results):</i>		
+ve (recurrence)	1	7.1
-ve	13	92.9

*High Statistically significant difference (*p*-value<0.001)*= Wicoxon rank-signed test.

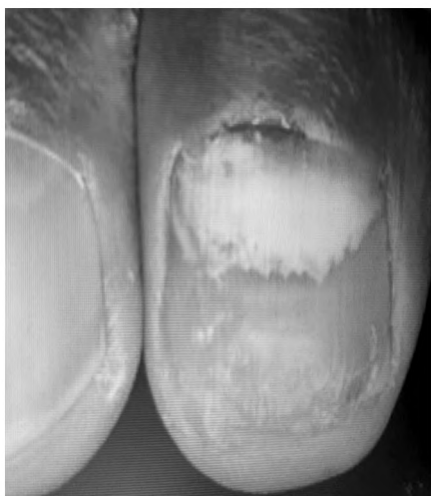


Fig. (1): A case of PSO.



Fig. (2): A case of DLSO.



Fig. (3): A case of DLSO.



Fig. (4): A case of CO.

Discussion

Skin is mechanically protective layer as well as cosmetically significant anatomical structure. SFIs involve only outer layer of skin including hair and nail. Fungi are everywhere and no geographical area or any group of people is spared from this organism Klionsky et al. [10]. Therefore accurate diagnosis and treatment of the active disease as well as the reduction of the re-infection by continued screening, follow up of relatives, treating asymptomatic carriers and disinfecting their environment is mandatory Kannan et al. [11].

Onychomycosis had been observed to be one of the most common nail diseases in carpet manufacture workers at 10th of Ramadan city, Egypt. In the present survey, a total of 65 workers were examined for onychomycosis and confirmed cases were treated and followed-up over 12 months (March 2021 March 2022).

All workers included in the study were males with age ranged from 34 to 64 years. There was no statistically-significant difference in the age between exposed group and their controls. Most of studied workers were of urban residence and worked for more than 5 years in the factory with no significant difference between both groups.

In the contrary to study results by Bedaiwy et al. [12], onychomycosis was found to be more common in females (86%) than males (14%). A similar female predominance (62.9%) was reported by Afshar et al. [13]. This can be attributed to the fact that females do household wet work as laundry and house cleaning. On the other hand these results differ from some other studies which showed that onychomycosis was more common in males than females [14].

The present study found that the prevalence of onychomycosis among carpet weaving workers exposed to hazards was 24.6% versus 3.3% among their controls (general population, that could be attributed to occlusive shoes wearing for long hours every day) with statistically significant difference between them, in consistency with the reported prevalence by Gill and Marks [15] and Perea et al. [16], 2%-8% in general population and 6.4% found by Nermeen et al. (2018) [17], while M. Bedaiwy et al. [12] reported prevalence 16% of occupational onychomycosis among manual hand workers.

Our study revealed that 75% of exposed workers had multiple fingernails OM versus 3.3% of toenail infection among non-exposed workers, 50% of them was CO and 31.3% PSO, while the two cases

of controls had single toenail DLSO with significant difference between both groups. The commonest fungal isolates among exposed workers was candida species (62.5%), 31.1% dermatophytes and 12.5% mixed infection (*C. albicans*, and *Scopulariopsis*) versus 50% dermatophytes and 50% candida species among controls, with no significant difference.

This is in agreement with Bedaiwy et al. [12], who found that fingernails were involved in 68% of patients while, toenails were involved in 32% of patients. These results were nearly similar to the results of a study in Indonesia Bramono & Budimulja [18], where fingernails were involved in 56.5% of patients and toenails in 17% of patients. On the other hand Mudita et al. [19] found that toe nails were affected in 56.9%, finger nails in 32.3% and both nails in 10.8% of patients.

Also in consistent with our results Bedaiwy et al. [12] found that the predominant clinical type of onychomycosis was candidal onychomycosis (52%) and followed by distal-lateral subungual onychomycosis (35%) and the least common was total dystrophic onychomycosis (11%). Reports from India showed that candidal onychomycosis (58.82%) was the predominant clinical type followed by distal subungual onychomycosis (38.72%) [20]. While the results shown by Gill and Marks [15] stated that tinea unguium is much more frequent within workers of some occupations that had to wear occlusive shoes for a long time every day. It is well-known that these conditions constitute important risk factors for the development of fungal infection.

This study revealed that old age is a significant risk factors among OM cases, all cases involved in wool fibers washing and processing (56.3%) or yarn dyeing (43.7%) versus 8.2% and 10.2% respectively of non-infected group, and most of the non-infected group were involved in mechanical operation or final clipping step of the product. Risk factors included prolonged hand immersion in water (62.5%), history of previous treatment (31.3%), and exposure to irritating chemicals and detergents (37.5%), that were statistically significant among studied cases. Each of both groups had 2 patients with nail psoriasis that was co-infected with dermatophytes. 68.7% of the studied cases didn't used protective gloves during manual work, that was statistically significant higher prevalence than those non-infected.

Both Gill and Marks [15] and Perea et al. [16], also reported that the prevalence of OM increased with age and onychomycosis affects toenails more

frequently than fingernails. Similar observation was reported by Jayatilake et al. [21] who observed that onychomycosis prevalence increases with age reaching its maximum 40-60 years old. On the contrary Grover [22] reported a high prevalence in the age group of 20-40 years.

Also in agreement with our results Bedaiwy et al. [12] proved that 52% of candida OM was seen among patients whose occupations involved wet work and required prolonged water immersion per day more than 2 hours.

In the present study, we choosed combined pulsed itraconazole/acitretin therapy in the treatment of different types of onychomycosis, that showed mycological cure among 77.8% of the treated cases. This clearance rate was nearly close to that reported by Raritan [23] which demonstrated a mycological cure rate of 61% for fingernails and 54% for toenails.

On the other hand, our clearance rate was much higher than that reported by Gupta and Stec [24] who showed mycological cure in 54% of their patients, and Zhang et al. [25] who showed mycological cure in 41% of a group of patients who received itraconazole-pulse therapy alone. Our higher response may be attributed to the prevalence of fingernail onychomycosis in our study which has a better therapeutic outcome, compared to toenail disease in the other study.

In this study, mycological recurrence was reported in 1 patient (7.1%) among the 14 patients that showed mycological cure at the end of treatment duration. This recurrence rate is much lower than that reported by Shemer et al. [26] (48.8%), which is probably because most of the cases in our study had fingernail onychomycosis, in contrast to toenail onychomycosis in the other study, which required longer duration of treatment.

Conclusions:

Onychomycosis is a common health problem among carpet weaving workers, especially manual workers due to wet processes and exposure to chemical dyes without using PPE, so protective measure should be taken after treatment of the problem.

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Conflict of interest: Nil.

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انتشار وعوامل الخطر وعلاج فطار الأظافر المهني بين عمال صناعة السجاد في مصر

خلفية الدراسة: فطار الأظافر هو عدوى فطرية مزمنة للظفر، تتميز بتغير لون الظفر، فرط التققرن تحت اللسان، وانحلال الأظافر، مسبباته هي النباتات الجلدية والخمائر (المبيضات) والعفن غير الجلدي. يحدث فطار الأظافر في جميع أنحاء العالم ويمثل ما يصل إلى ٥٠٪ من جميع التهابات الأظافر و ٣٠٪ من جميع التهابات الفطرية السطحية للجلد، يمثل فطار الأظافر تحدياً علاجياً بسبب ارتفاع معدل التكرار. علاوة على ذلك، فإنه يتطلب مدة علاج طويلة وعاملاً مضاداً للفطريات جهازياً بدلاً من موضعي لأن فرط التققرن تحت الفطريات المرتبط بفطار الأظافر يحد من الاختراق بالأدوية المضادة للفطريات الموضعية، بالإضافة إلى نمو الأظافر البطيء، والوجود المادي لصفحة الظفر التي تتداخل مع الوصول إلى سرير الظفر، وصعوبة العثور على مركبات ذات ملف دوائي مناسب لاختراق الأظافر للظفر، تتميز بتغير لون الظفر، فرط التققرن تحت اللسان، وانحلال الأظافر. مسببات الأمراض المعنية هي النباتات الجلدية والخمائر (المبيضات) والعفن غير الجلدي. يحدث فطار الأظافر في جميع أنحاء العالم ويمثل ما يصل إلى ٥٠٪ من جميع التهابات الأظافر و ٣٠٪ من جميع التهابات الفطرية السطحية للجلد. يمثل فطار الأظافر تحدياً علاجياً بسبب ارتفاع معدل التكرار، علاوة على ذلك، فإنه يتطلب مدة علاج طويلة وعاملاً مضاداً للفطريات جهازياً بدلاً من موضعي لأن فرط التققرن تحت الفطريات المرتبط بفطار الأظافر يحد من الاختراق بالأدوية المضادة للفطريات الموضعية، بالإضافة إلى نمو الأظافر البطيء، والوجود المادي لصفحة الظفر التي تتداخل مع الوصول إلى سرير.

الهدف من الدراسة: تقييم مدى انتشار فطار الأظافر وعوامل الخطر المرتبطة به وعلاج المصابين بين عمال صناعة السجاد بمدينة العاشر من رمضان.

المرضى طرق الدراسة: شملت الدراسة العرضية المقارنة ٦٥ عاملاً من مصنع السجاد في مدينة العاشر من رمضان ٦٠ عاملاً بالوظائف الادارية خلال ١٢ شهراً بداية من مارس ٢٠٢١ إلى مارس ٢٠٢٢، تم اختيار المصنع عشوائياً من إجمالي ثلاثة مصانع في المدينة. تم تشخيص الحالات وتقييم الاستجابة العلاجية من خلال درجة مؤشر شدة فطار الأظافر. تم إجراء الفحص المجهرى لهيدروكسيد البوتاسيوم والاستزراع عند خط الأساس وفي نهاية الدراسة.

نتائج الدراسة: كان انتشار فطار الأظافر بين العمل المعرضين ٢٤.٦٪ مقابل ٣٣٪ بين الضوابط (العمال الإداريين) ($p < 0.001$)، وكان لدى ٧٥٪ من العمال المعرضين أظافر متعددة فطار الأظافر، و ٥٠٪ منهم كانوا الفطريات الفطرية المبيضات و ٣١.٣٪ الفطريات الفطرية القريبة، في حين أن حالتى الضوابط كان لهما أظافر واحدة الفطريات الفطرية القاصية والجانبية. وتبين أن الشبخوخة مهمة بين حالات فطار الأظافر، وجميع حالات فطار الأظافر المشاركة في غسل ومعالجة ألياف الصوف (٥٦.٣٪) أو الغزل الذي يموت (٤٣.٧٪) مقابل ٨.٢٪ و ١٠.٢٪ على التوالي من المجموعة غير المصابة. وشملت عوامل الخطر الغمر اليدوى لفترات طويلة في الماء (٦٢.٥٪)، وتاريخ العلاج السابق (٣١.٣٪)، والتعرض للمواد الكيميائية والمنظفات المهيجة (٣٧.٥٪)، والتي كانت ذات دلالة إحصائية بين الحالات التي تمت دراستها.

الاستنتاج: يعد فطار الأظافر مشكلة صحية شائعة بين عمال نسج السجاد، وخاصة العمال اليدويين بسبب العمليات الرطبة والتعرض للأصباغ الكيميائية دون استخدام معدات الوقاية الشخصية.

التوصيات: استخدام معدات الوقاية الشخصية والتشخيص المبكر من أهم عوامل القضاء على هذه الظاهرة.