

# Comorbidity of Tinea Pedis and Onychomycosis and Evaluation of Risk Factors in Latino Immigrant Poultry Processing and Other Manual Laborers

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**Objectives:** Latino immigrant workers experience elevated rates of skin disease that result from their working and living conditions. Working in manual occupations exposes workers to a variety of challenges, including occlusive shoes, vigorous physical activity, and wet conditions. These challenges predispose workers to fungal infection. The objectives of this article are to examine the comorbidity of tinea pedis and onychomycosis and to identify possible risk factors among Latino immigrant poultry and nonpoultry workers in western North Carolina.

**Methods:** Data were obtained from a cross-sectional study conducted between June 2009 and November 2010 in rural western North Carolina among 518 manual Latino immigrant workers to assess their occupational injuries. Participants completed a face-to-face interview and a dermatologic examination.

**Results:** Nearly one-third of the participants (32%) were diagnosed as having onychomycosis and more than one-third (37.8%) were

diagnosed as having tinea pedis. There was a greater prevalence of tinea pedis in men than women (71.3% vs 28.7%, respectively). Of the 518 participants, 121 (23.5%) had both conditions. Participants who reported the use of occlusive shoes as “always” or “most of the time” had a higher prevalence of comorbid onychomycosis and tinea pedis than the rest of the group.

**Conclusions:** Comorbidity of tinea pedis and onychomycosis is common among immigrant Latino men and women who perform manual labor. Further studies confirming the presence and type of dermatophyte should be conducted.

**Key Words:** immigrant, Latino, onychomycosis, skin disease, tinea pedis, workers

Dermatophytoses, tinea, and fungal infections are some of the most common diseases in the world.<sup>1</sup> It has been estimated that 20% to 25% of the world’s population is infected with dermatophytes, and the incidence continues to increase.<sup>2</sup> The distribution of dermatophytes varies greatly around the world. The epidemiology of dermatophyte infection is affected by migration patterns, increases in tourism, and changes in socioeconomic conditions in Africa and several countries in Latin America and the Middle East. There are geographical/

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## Key Points

- Comorbidity of tinea pedis and onychomycosis is prevalent among immigrant Latino manual laborers.
- Use of occlusive shoes is associated with a higher risk of developing fungal infections such as tinea pedis and onychomycosis.
- Although the literature shows a high prevalence of these skin conditions, little research, including dermatologic examination, has been conducted to assess possible risk factors among this underserved, hard-to-reach population.

regional associations in the pattern of dermatophytic infections.<sup>3</sup> Changes in the dermatophyte spectrum also have been noticed in the United States. A detailed survey of the causative agents of fungal infections in the United States from 1999 to 2002 found that dermatophytes were the most common fungal pathogens.<sup>4</sup> *Trichophyton rubrum* was the most prevalent pathogen, and an increased incidence of this dermatophyte was observed in finger and toe onychomycosis, tinea corporis, tinea cruris, and tinea manuum or tinea pedis. A similar distribution was reported in Mexico.<sup>5</sup>

Human mobility has been associated with the spread of infection and the number of nonimmigrant residents of and temporary visitors to the United States has increased from approximately 12 million people in 1987 to 37 million in 2007.<sup>6</sup> Such mobility has contributed to Latino populations becoming the largest minority in the United States, with southeastern states in particular experiencing a significant increase in their Latino population.<sup>7</sup> Latinos are concentrated in communities where work is available in manual occupations such as poultry processing, construction, farm work, and the service industry.<sup>8</sup>

Poultry processing workers experience the sixth highest incidence rate of nonfatal occupational illness of any industry.<sup>9</sup> Poultry processing is concentrated in southern states, with Arkansas, Alabama, Georgia, Mississippi, North Carolina, and Texas producing two-thirds of US broiler poultry poundage.<sup>10</sup> Immigrant Latino workers experience high rates of skin disease that result from their living and working conditions.<sup>11</sup> The poultry processing environment exposes workers to a variety of challenges, including the wearing of occlusive shoes (eg, work boots), vigorous physical activity, and working in wet conditions that may predispose them to fungal infections.<sup>12</sup> Quandt et al reported that fungal infections were some of the most common self-reported conditions among poultry processing workers, with 68% reporting foot fungus and 28% reporting nail fungus.<sup>13</sup> Although the literature shows a high prevalence of these skin conditions, little research, including dermatological examination, has been conducted to assess possible risk factors among this underserved, hard-to-reach population.

In a prospective study of 2761 patients with toenail onychomycosis that evaluated the prevalence and factors influencing the presence of comorbid dermatomycoses, tinea pedis was the most common fungal infection, having been found in 933 patients (33.8%).<sup>14</sup> Another cross-sectional study compared athletes and nonathletes from northern Rio Grande do Sul, Brazil. After clinical examination, samples were taken for direct microscopic examination and cultures from individuals who showed signs of onychomycosis and/or tinea pedis. Comparing athletes and nonathletes, the comorbidity of tinea and onychomycosis was 4% and 3%, respectively.<sup>15</sup>

The objectives of the present study were to extend research on the comorbidity of tinea pedis and onychomycosis by examining a large population sample of workers. We identified possible related risk factors among immigrant Latino poultry and nonpoultry workers in western North Carolina.

## Methods

### Sample and Data Collection

Data were collected from a cross-sectional study that assessed occupational injuries among 518 immigrant Latino manual laborers who belonged to an isolated, hard-to-reach population for which no census data existed. The study took place between June 2009 and November 2010 in rural western North Carolina. Community-based sampling was used to recruit participants,<sup>16</sup> and trusted members of the community helped the study team identify and recruit workers. To be eligible for the study, participants had to self-identify as Hispanic or Latino, work >35 hours/week, work as a manual laborer, and be 18 years old or older. Manual labor occupations were defined as any nonmanagerial jobs such as production work (eg, poultry processing), babysitting, lawn care, farm work, and construction. Further details of the recruitment methods are described elsewhere.<sup>17</sup> Participants in the study provided informed consent, and all of the procedures were approved by the Wake Forest School of Medicine institutional review board.

Once participants were recruited, a face-to-face interview and physical examination assessed the workers' demographics, work environment, skin illnesses, and possible exposures to disease. The interview was conducted approximately 1 month before the physical examination. A sampling frame of dwellings where Latinos lived in the study area was developed. A total of 1526 residents were screened, and of the 957 eligible residents, 742 (77.5%) were interviewed; 518 (69.8%) of those interviewed attended a clinic at which the physical examination took place. Only those who attended the clinic were included in these analyses.

### Measures

#### Physical Examination

Participants were examined by two board-certified dermatologists. The skin examination focused on areas (face, neck, arms, hands, and feet) that are most often subjected to occupational exposures. The presence or absence of disease was recorded and further details are described elsewhere.<sup>18</sup>

#### Covariates

Data regarding age, education, and household occupancy were collected as continuous variables and each variable was classified into ordered categories. Diabetes mellitus status was assessed at the time of the physical examination with the question, "Has a doctor ever diagnosed you with diabetes?" The answers were coded 0 for "no" and 1 for "yes." Exposure to wet surfaces was assessed by asking participants, "How many hours per week do you do wet work?" Answers were coded in categories: 0 hours = 0, <1/2 hour = 1, 1/2 to 2 hours = 2, >2 hours = 3. To assess the use of occlusive shoes, participants were asked, "How often do you use nonslip, steel-toed, or closed-top footwear?" Their response choices included "none

of the time,” “some of the time,” “most of the time,” and “all of the time.” For this study, use of occlusive shoes was dichotomized into “all of the time/most of the time” and “some of the time/none of the time.”

**Analysis**

The objectives of the statistical analyses were to estimate the prevalence of onychomycosis, tinea pedis, and the comorbidity of the two skin conditions among Latino manual laborers, and to test for associations between demographic/cultural characteristics and the three conditions. Descriptive statistics were calculated as frequencies and percentages of discrete measures. Bivariate associations between dichotomized outcomes and risk factors were examined using  $\chi^2$  tests of association and Fisher exact tests. Multivariate logistic regression modeling, adjusting for clustering by dwelling and site strata, was used to assess the relation between outcomes and sample characteristics. Predictors that reached a level of significance ( $P < 0.05$ ) in the bivariate analysis were used in the multivariate modeling for only the onychomycosis and tinea pedis outcomes. All of the predictors used in either the onychomycosis or tinea pedis models were used in the modeling of participants with both skin conditions. In the interest of study design, poultry work (yes/no) was included in all of the models. Adjusted odds ratios (AOR), 95% confidence intervals (CIs), and  $P$  values were estimated. Significance was accepted at  $P < 0.05$  and all of the analyses were performed using SAS version 9.3 (SAS Institute, Cary, NC).

**Results**

Among study participants examined by the dermatologist, three-fourths were younger than 40 years (74%; Table 1) and

**Table 1. Descriptive characteristics of study sample**

Characteristic	Overall N = 518 N (col%)	Poultry workers N = 289 (55.8%) N (col%)	Nonpoultry workers N = 229 (44.2%) N (col%)
Age, y			
17–24	85 (16.4)	42 (14.5)	43 (18.8)
25–30	126 (24.3)	64 (22.2)	62 (27.1)
31–40	172 (33.2)	90 (31.1)	82 (35.8)
>40	135 (26.1)	93 (32.2)	42 (18.3)
Sex			
Male	283 (54.6)	160 (55.4)	123 (53.7)
Female	235 (45.4)	129 (44.6)	106 (46.3)
Education level, y			
0–6	302 (58.3)	183 (63.3)	119 (52.0)
7–9	121 (23.4)	60 (20.8)	61 (26.6)
≥10	95 (18.3)	46 (15.9)	49 (21.4)

Col, column.

by design approximately half were poultry workers (55.8%) and half were men (54.6%). A little more than 80% of the workers had 9 years of education or fewer. Poultry workers had fewer years of formal education and were older compared with nonpoultry workers.

Nearly one-third of participants (32%) showed signs of onychomycosis (Table 2) and the majority were poultry workers (63%). Onychomycosis was more prevalent among men, workers between 31 and 40 years old, and those who reported wearing occlusive shoes “all of the time/most of the time.” More than one-third of the participants (37.8%) were diagnosed as having tinea pedis, with a greater prevalence of this condition occurring in men and among those with 6 years of education or fewer.

In evaluating the comorbidity of tinea pedis and onychomycosis, 121 participants (23.5%) had both tinea pedis and onychomycosis (Table 2). Of the 195 patients who had tinea pedis, 62.05% also had onychomycosis. Of the 165 patients who had onychomycosis, 73.3% had tinea pedis (Table 2). Participants who reported wearing occlusive shoes “always/most of the time” had a higher prevalence of both onychomycosis and tinea pedis diagnoses.

In multivariate analyses (Table 3), the effect of gender remained strongly associated with having onychomycosis, tinea pedis, or both. Men had a 73% increased risk of having onychomycosis (AOR 1.73, CI 1.13–2.66), an almost 3 times greater risk of having tinea pedis (AOR 2.9, CI 1.91–4.40), and more than twice the risk of having both diagnoses (AOR 2.25, CI 1.38–3.69). Age and the use of occlusive shoes were significantly associated with onychomycosis. Results for participants between 17 and 24 years old showed a protective effect; they have a lesser risk of having onychomycosis (AOR 0.46, CI 0.22–0.94) than workers 41 years old and older. Age was not predictive for having tinea pedis or having both skin disorders. Workers who wore occlusive shoes had an 82% increased risk of having onychomycosis (AOR 1.82, CI 1.16–2.87) as compared with workers who wore occlusive shoes only some or none of the time. Although educational attainment was not associated with having onychomycosis or tinea pedis, it had marginal effects for individuals with both conditions. Participants with ≥7 years of education had a lower risk of having both disorders simultaneously (AOR 0.61, CI 0.35–1.05 and AOR 0.54, CI 0.27–1.09, respectively) compared with workers having 0 to 6 years of formal education. Workers who wore occlusive shoes all or most of the time had an 80% increased risk of having both skin conditions (AOR 1.8, CI 1.09–2.97) compared with workers who wore occlusive shoes some or none of the time. Poultry work versus other manual labor was not a significant predictor of either condition individually or both types of infection.

**Discussion**

The literature related to the prevalence of skin illnesses and their possible risk factors among manual laborers is

**Table 2. Prevalence and bivariate associations of onychomycosis and tinea pedis with sample characteristics**

Characteristic	Onychomycosis N (col%)			Tinea pedis N (col%)			Both onychomycosis and tinea pedis N (col %)		
	Diseased	Nondiseased	<i>P</i>	Diseased	Nondiseased	<i>P</i>	Diseased	Nondiseased	<i>P</i>
Overall	165 (32.0)	350 (68.0)		195 (37.9)	320 (62.1)		121 (23.5)	394 (76.5)	
Poultry work status			<b>0.0220</b>			0.3296			0.3391
Poultry	104 (63.0)	183 (52.3)		114 (58.5)	173 (54.1)		215 (54.6)	72 (59.5)	
Nonpoultry	61 (37.0)	167 (47.7)		81 (41.5)	147 (45.9)		179 (45.4)	49 (40.5)	
Age, y			<b>0.0395</b>			0.2340			0.1081
17–24	16 (9.7)	69 (19.7)		24 (12.3)	61 (19.1)		12 (9.9)	73 (18.5)	
25–30	45 (27.3)	80 (22.9)		52 (26.7)	73 (22.8)		32 (26.5)	93 (23.6)	
31–40	59 (35.8)	112 (32.0)		67 (34.4)	104 (32.5)		47 (38.8)	124 (31.5)	
>40	45 (27.3)	89 (25.4)		52 (26.7)	82 (25.6)		30 (24.8)	104 (26.4)	
Sex			<b>0.0007</b>			< <b>0.0001</b>			< <b>0.0001</b>
Male	108 (65.5)	173 (49.4)		139 (71.3)	142 (44.4)		86 (71.1)	195 (49.5)	
Female	57 (34.5)	177 (50.6)		56 (28.7)	178 (55.6)		35 (28.9)	199 (50.5)	
Education level, y			0.2438			<b>0.0099</b>			<b>0.0086</b>
0–6	103 (62.4)	196 (56.0)		127 (65.1)	172 (53.7)		84 (69.4)	215 (54.6)	
7–9	38 (23.0)	83 (23.7)		44 (22.6)	77 (24.1)		24 (19.8)	97 (24.6)	
≥10	24 (14.6)	71 (20.3)		24 (12.3)	71 (22.2)		13 (10.7)	82 (20.8)	
People in household			0.8425			0.8681			0.7700
1–2	15 (9.1)	28 (8.0)		17 (8.7)	26 (8.1)		12 (9.9)	31 (7.9)	
3–5	102 (61.8)	225 (64.3)		121 (62.1)	206 (64.4)		75 (62.0)	252 (64.0)	
>5	48 (29.1)	97 (27.7)		57 (29.2)	88 (27.5)		34 (28.1)	111 (28.2)	
Diabetes mellitus diagnosis			0.6719			0.9247			0.7324
Yes	15 (9.1)	36 (10.3)		19 (9.7)	32 (10.0)		11 (9.1)	40 (10.2)	
No	150 (90.9)	314 (89.7)		176 (90.3)	288 (90.0)		110 (90.9)	354 (89.8)	
Work in wet environments, h/d			0.2405			0.8849			0.8837
None	59 (35.8)	143 (40.9)		75 (38.5)	127 (39.7)		48 (39.7)	154 (39.1)	
<2	14 (8.5)	39 (11.1)		19 (9.7)	34 (10.6)		11 (9.1)	42 (10.7)	
>2	92 (55.8)	168 (48.0)		101 (51.8)	159 (49.7)		62 (51.2)	198 (50.2)	
Wear occlusive shoes			<b>0.0006</b>			0.0934			<b>0.0034</b>
All/most of the time	110 (71.9)	173 (55.4)		120 (65.6)	163 (57.8)		82 (72.6)	201 (57.1)	
Some/none of the time	43 (28.1)	139 (44.6)		63 (34.4)	119 (42.2)		31 (27.4)	151 (42.9)	

*P* from  $\chi^2$  test of association or Fisher exact test. Bold indicates significance. Col, column.

limited. This study sought to assess these components as they relate to the comorbidity of onychomycosis and tinea pedis among immigrant Latino manual laborers.

Our findings are supported by the existing literature on comorbid tinea pedis and onychomycosis.<sup>19</sup> Among the factors contributing to these diseases were humidity and occlusive footwear, and comorbid conditions are more common among men than women.<sup>6</sup> In some occupations such as athletics, farm work, and forestry,<sup>15,20,21</sup> employees are at a higher risk than those in other occupations for developing fungal infections.<sup>20</sup> Farmers are at higher risk of developing fungal infections as a result of both contact with many potential sources of fungal infection and conditions in the workplace (eg, wet work, rubber boots) that promote infection with dermatophytes.<sup>22</sup> In our bivariate analysis we showed that onychomycosis is more

prevalent among poultry workers compared with other manual laborers. In the multivariate analysis, however, the association disappeared, which may have happened because the sample consisted of manual laborers who, like those in the poultry industry, are exposed to strenuous environments that put them at higher risk of developing a fungal infection.

Risk factors for the occurrence of tinea pedis and onychomycosis in a Muslim population in Turkey, although geographically and occupationally unrelated to our study, were similar to ours: of the 461 subjects studied, 30% had tinea pedis, 5% had tinea unguium, and 5% had both infections simultaneously.<sup>23</sup> The prevalence of foot dermatomycoses was high among those who practiced ablution three to five times per day and did not dry their feet immediately and among those who wore rubber shoes. The latter finding, like that in our study,

**Table 3. Multivariate logistic regression models of demographics and work-related predictors of onychomycosis and tinea pedis (N = 515)**

Characteristic	Onychomycosis (N = 165; 32%)			Tinea pedis (N = 195; 38%)			Both onychomycosis and tinea pedis (N = 121; 23.5%)		
	AOR	95% CI	P	AOR	95% CI	P	AOR	95% CI	P
Poultry work status									
Poultry	1.34	0.86–2.09	0.1967	1.08	(0.71–1.64)	0.7197	0.98	(0.61–1.59)	0.9371
Nonpoultry <sup>a</sup>	—						—		
Age, y									
17–24	<b>0.46</b>	<b>(0.22–0.94)</b>	<b>0.0323</b>				0.53	(0.24–1.21)	0.1331
25–30	1.35	(0.77–2.36)	0.2949				1.44	(0.77–2.67)	0.2530
31–40	1.15	(0.68–1.93)	0.6109				1.46	(0.82–2.60)	0.1961
>41 <sup>a</sup>	—						—		
Sex									
Male	<b>1.73</b>	<b>(1.13–2.66)</b>	<b>0.0121</b>	<b>2.90</b>	<b>(1.91–4.40)</b>	<b>&lt;.0001</b>	<b>2.25</b>	<b>(1.38–3.69)</b>	<b>0.0013</b>
Female	—			—			—		
Education level, y <sup>a</sup>									
0–6 <sup>a</sup>				—			—		
7–9				0.73	(0.46–1.16)	0.1848	0.61	(0.35–1.05)	0.0732
≥10				0.63	(0.36–1.11)	0.1087	0.54	(0.27–1.09)	0.0850
Wear occlusive shoes									
All/most of the time	<b>1.82</b>	<b>(1.16–2.87)</b>	<b>0.0099</b>	1.10	(0.72–1.68)	0.6668	<b>1.80</b>	<b>(1.09–2.97)</b>	<b>0.0218</b>
Some/none of the time <sup>a</sup>	—			—			—		

<sup>a</sup>Reference category.

AOR, adjusted odds ratio; CI, confidence interval.

demonstrates that the use of occlusive shoes is associated with a higher risk of developing fungal infections such as tinea pedis and onychomycosis. The majority of participants in our sample worked in industries such as production and agriculture, where workers are required to wear occlusive shoes.

The reason that comorbidity of onychomycosis and tinea pedis is more prevalent among men is unknown; however, it is believed that it could be because men are more likely to have nail trauma and wear occlusive shoes than women, who are more likely to wear sandals or other open-toe footwear when not at work.<sup>14,24</sup> This practice also may explain why men present with a 73% increased risk of having onychomycosis, an almost three times greater risk of having tinea pedis and greater than twice the odds of having both diagnoses.

The limitations of our study include the absence of confirmed dermatophytes, either by potassium hydroxide, a test that is done to rapidly diagnose fungal infections of the hair, skin, or nails, or by culture examination or culture. Amichai et al showed that a trained dermatologist can correctly diagnose onychomycosis by clinical examination.<sup>25</sup> Lack of access to the participants' places of employment was another limiting factor because it prevented direct assessment of variables related to work exposure. Nonetheless, to our knowledge, ours is the only study that has been able to assess comorbid onychomycosis and tinea pedis among an underserved, hard-to-access working

population. As such, it adds to the literature on skin disease in underserved populations.

## Conclusions

The results of this clinical epidemiologic study of immigrant Latino manual laborers showed that the comorbidity of these dermatophyte infections is common in this population and that its prevalence is significantly higher than in that of the overall population. Further studies confirming the presence and type of dermatophyte by examination with potassium hydroxide should be conducted. Additional research is needed to identify specific variables in the workplace that may increase the risks of tinea pedis and onychomycosis infections and therefore help prevent their development among manual laborers.

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