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A Descriptive Study of a Turkish Pneumoconiosis Case-Series

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Keywords: Pneumoconiosis; progressive massive fibrosis; occupational lung disease; sandblasters; ceramic workers; miners; dental technician; foundry workers; pulmonary tuberculosis

Abstract

Background: *The study aimed to examine the conditions and factors affecting pneumoconiosis cases to determine the dimensions of the pneumoconiosis problem.* **Methods:** *This retrospective study was conducted in a tertiary research hospital between January 1, 2014, and December 31, 2021. Five hundred ninety-seven patients with pneumoconiosis were included in the study.* **Results:** *Large opacities were detected in 157 cases. When we compared cases with and without Pulmonary Massive Fibrosis (PMF), age and concomitant pulmonary disease were higher in PMF cases, which also showed lower FEV1, FVC, and FEV1/FVC. PMF was more frequent in subjects with long dust exposure duration (more than 20 years) and concomitant pulmonary diseases, particularly tuberculosis. Three occupations, sandblasters, dental technicians, and ceramic workers, showed the earliest onset of pneumoconiosis.* **Conclusions:** *The study presents pneumoconiosis data in a mixed and large population and contributes to the implementation of evidence-based policies and interventions for countries like Turkey striving to cope with the problem of pneumoconiosis.*

1. Introduction

Occupational exposures remain an important cause of underdiagnosed and preventable lung diseases worldwide. As noted in a recent American Thoracic Society (ATS) report, workplace exposures contribute to the burden of chronic respiratory diseases, and there is an urgent need to improve clinical recognition of occupational lung diseases [1]. Introducing new products, such as artificial stones, if industrial hygiene controls are inadequate and enforcement of existing occupational health and safety standards is limited has added to the burden of occupational lung diseases [2]. According to the Global Burden of Disease Study, in 2017, the global prevalence of pneumoconiosis was approximately 527,500 cases, and 60,000 newly diagnosed pneumoconiosis cases were reported [3].

Pneumoconiosis is the lung's accumulation of inorganic dust and fibers that cause a fibrotic tissue reaction [4]. Prevention of the disease, which has no effective treatment, primarily depends on workplace exposure management and health management practices regulated within the relevant legal framework. Although pneumoconiosis is a well-known occupational disease in Turkey, published statistics do not reflect its burden. Occupational disease statistics in Turkey are assembled from insurance records and compensated cases, which prevents the observation of the entire picture of occupational

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lung diseases, rendering the at-risk population uncertain of preventive strategies and perpetuating the cycle of occupational exposure and disease unless the factors causing disease development are identified.

This study aimed to examine the conditions and factors affecting pneumoconiosis cases diagnosed in one of the important referral clinics in Turkey over the last eight years to determine the dimensions of the pneumoconiosis problem, the variables affecting disease development, and the necessary precautions and enable the development of recommendations.

2. Methods

2.1 Database and Study Population

This retrospective study was conducted at the Occupational Diseases Training Clinic of Ankara Atatürk Sanatorium Training and Research Hospital, an essential tertiary referral center for pneumoconiosis in Turkey. The ethics committee approved the study (2012-KAEK-15/2479). The study included all patients with pneumoconiosis admitted to the hospital between January 1, 2014, and December 31, 2021. An occupational history of inorganic dust exposure, radiological findings consistent with pneumoconiosis, and exclusion of other diagnoses established the diagnosis. All available examinations obtained while diagnosing pneumoconiosis during the study period were considered for analysis.

Experienced pulmonary and occupational medicine specialists took the medical histories and performed the physical examinations of all patients. Medical history comprises information on the present illness, past medical and surgical history, tobacco use history, family history, personal or social history, and comprehensive occupational history. The detailed occupational history documented the patients' present and past employment history and identified types of dust exposures at their workplaces. The occupational group was referred to as the job presumed to be the cause of pneumoconiosis by the occupational physicians of the clinic. We used the recorded smoking history to calculate tobacco pack years by multiplying the average number of cigarette packs per day by the total number of smoking years.

Spirometry was performed using the Zan 100 flow-sensitive spirometry device (ZAN Messgerate GmbH, Oberthulba, Germany). The spirometer was calibrated daily, with measurements of temperature and humidity used for calibration. The spirometry results were analyzed based on the acceptability and reproducibility criteria presented in the ATS/European Respiratory Society statement updating the standardization of spirometry. The patients' spirometry measurements were evaluated based on the percentage of the reference values.

Chest X-rays (CXRs) were taken with a digital X-Ray system. CXRs were evaluated by two readers separately and independently according to the International Labour Organization's (ILO) International Classification of Radiographs of Pneumoconioses, and the results were obtained in consensus. Small opacities are described by profusion, shape (rounded or irregular), and size. Small opacity profusion is classified into four categories (0, 1, 2, 3), each divided into three subcategories (0/- to 3/+). ILO profusion scores of 1/0 and above are considered pneumoconiosis. Progressive massive fibrosis (PMF) is defined as a large opacity exceeding 1 cm in diameter assigned to one of three categories according to the ILO International Classification of Radiographs of Pneumoconioses.

2.2 Statistical Analysis

The data of this study were evaluated using the IBM SPSS Statistics 22.0 statistical package program. Categorical data were presented as number (n) and percentage (%), and numerical data were presented as mean and standard deviation. Data were tested for normality with the Kolmogorov-Smirnov test. Kruskal-Wallis and Mann-Whitney U tests were used to analyze the difference in exposure duration between different radiological categories, and Spearman's correlation coefficient was used for correlation analysis. The Kruskal-Wallis test was also used to analyze differences in several parameters according to the occupational group, and the Mann-Whitney U test was used for *post-hoc* analyses. Large opacities and associated factors were evaluated with one-way analysis of variance, with the Tukey test used for post-hoc analyses. The relationship between the size of PMF lesions and pulmonary function tests was evaluated by Spearman correlation analysis. The chi-square test was used to compare categorical data. A p-value of < 0.05 was considered statistically significant.

3. Results

3.1. Demographic Findings

This study included 597 patients with pneumoconiosis who had complete data in the analysis. Almost all patients were male (99.7%), and the mean patient age was 50.5±12.7 years at the time of diagnosis. Ever-smokers comprised 75.4% of the cases and had a median tobacco history of 22.8±15.5 pack-years. Existing pulmonary diseases were present in 231 (38.7%) cases; the most commonly reported diagnoses were chronic obstructive pulmonary disease (COPD; 27.5%), pulmonary tuberculosis (6.5%), and asthma (4.9%). Half of the patients were miners and foundry workers (n=302; 50.6%). The descriptive characteristics of the patients are shown in Table 1.

3.2. Radiologic and Pulmonary Function Test Results

When the CXRs of the pneumoconiosis cases were evaluated according to the ILO radiographic classification, the predominant small opacity was q (35.7%) and p (23.3%). When small opacities were

Table 1. Descriptive characteristics of 597 pneumoconiosis patients.

		Number (n)	Percentage (%)
Gender	Male/Female	595/2	99.7/0.3
Age (years)[#]	50.5±12.7		
Smoking Status	Current smoker	296	49.6
	Former smoker	154	25.8
	Never smoker	147	24.6
Smoking pack years (packs x years) [#]	22.8±15.5		
Occupation	Miner	158	26.5
	Foundry worker	144	24.1
	Welder	85	14.2
	Dental technician	49	8.2
	Stone worker	42	7.0
	Ceramic worker	39	6.5
	Construction worker	24	4.0
	Sandblaster	22	3.7
	Other*	34	5.7
Exposure duration (y, Mean & SD)	19.6±9.2		
Existing pulmonary disease	Chronic Obstructive Pulmonary Disease (COPD)	164	27.5
	Pulmonary tuberculosis	39	6.5
	Asthma	29	4.9
	Pulmonary embolism	17	2.8
	Sarcoidosis	10	1.7
	Lung cancer	8	1.3

**Glass workers, shipyard workers, brick factory workers, metal workers, tin workers, insulation workers, textile workers.*

grouped by size, small opacities between 1.5 mm and 3 mm were detected in 50.1% of the cases. Large opacities were detected in 157 cases, and 70 (44.6%) PMF cases were classified as category A opacities. The patients' radiological findings and respiratory function evaluations are presented in Table 2.

When the exposure duration to dust was compared to the dominant small opacity in patients with irregular dominant small opacities, it was longer than that of patients with rounded opacities (p=0.005). No statistically significant differences were found when comparing small opacity profusion score, small opacity size, and dust exposure duration. However, the mean dust exposure duration was slightly shorter in simple pneumoconiosis cases (p=0.053). There was no correlation between small opacity profusion score, dominant small opacity size, large opacity size, and dust exposure duration. When the relationship between dust exposure duration and spirometric findings was examined, while there was no statistically significant relationship between FEV1 and FVC values and dust exposure duration, FEV1/FVC was found to decrease as the dust exposure duration increased (r=-0.125, p=0.003).

Patients were classified as never smokers and ever smokers, and PFT results were analyzed according to large opacity size, small opacity size, small opacity profusion score, COPD, and pulmonary tuberculosis. Patients without large opacity were found to have higher average FEV1, FVC, and FEV1/FVC values in both smoking groups (ever-smokers and non-smokers) (p<0.001). In both smoking groups, patients with category C large opacities were found

Table 2. Radiological findings and respiratory function evaluations.

		Number (n)	Percentage (%)
Dominant Small Opacity	p	139	23.3
	q	213	35.7
	r	71	11.9
	s	87	14.6
	t	86	14.4
	u	1	0.2
Small Opacity by Size	<1.5 mm	226	37.9
	1.5-3 mm	299	50.1
	>3 mm	72	12.1
Small Opacity Profusion score	Stage 1	232	38.9
	Stage 2	256	42.9
	Stage 3	109	18.3
Large Opacity	None	440	73.7
	A	70	11.7
	B	43	7.2
	C	44	7.4
Pulmonary Function Testing*	FEV_1	77.8±20.5	
	FVC	80.6±18.7	
	FEV_1/FVC	77.9±11.9	

FEV1: Forced expiratory volume in one second.
FVC: Forced vital capacity.
** Presented as mean ± standard deviation.*

to have lower average FEV1, FVC, and FEV1/FVC values (p<0.001). When spirometric findings were compared by small opacity size, FEV1, FVC, and FEV1/FVC were lower as the opacity size increased in both groups (p<0.05). In addition, FEV1 and FEV1/FVC were lower in never-smokers and ever-smokers as the profusion score increased. In the latter group also, FVC was lower, increasing the profusion score. The FEV1, FVC, and FEV1/FVC values of patients with COPD were lower than those of subjects without COPD in both smoking groups. The FEV1, FEV1/FVC values of never-smokers with pulmonary tuberculosis and FEV1, FVC, and FEV1/FVC values of ever-smokers with pulmonary tuberculosis were lower than those of subjects without pulmonary tuberculosis (p=0.029, p=0.010, p<0.001, p<0.001, and p=0.032, respectively) (Table 3).

The size of large opacities was inversely correlated to FEV1, FVC, and FEV1/FVC (r=-0.442 and p<0.001, r=-0.408 and p<0.001, r=-0.191 and p=0.019, respectively). There was a negative correlation between dominant small opacity size and FEV1, FVC, and FEV1/FVC (r=-0.388 and p<0.001, r=-0.353 and p<0.001, r=-0.226 and p<0.001, respectively). FEV1, FVC, and FEV1/FVC were also inversely correlated with small opacity profusion score (r=-0.312 and p<0.001, r=-0.316 and p<0.001, r=-0.147 and p<0.001, respectively).

3.3. Comparison of Simple Pneumoconiosis and Pmf Cases

The age of patients with PMF was higher than that of those without PMF (p<0.001). FEV1, FVC, and FEV1/FVC were lower in PMF cases (p<0.001), and the PMF lesion size was inversely correlated with FEV1, FVC, and FEV1/FVC (r=-0.442 and p<0.001, r=-0.408 and p<0.001, r=-0.191 and p=0.019, respectively). PMF cases did not differ regarding smoking status, pack years, or average dust exposure duration. However, subjects with more than 20 years of exposure to dust were more frequently PMF cases than those with less than 20 years of exposure duration. (p=0.010). Concomitant pulmonary disease was detected in 70.7% of PMF cases compared to 27.3% in simple pneumoconiosis cases, constituting a statistically significant difference between the two groups (p<0.001). The prevalence of COPD was higher in PMF cases (55.4%) than in simple pneumoconiosis cases (17.5%; p<0.001). However, when COPD patients were analyzed according to smoking status, no significant association was found between smoking status and PMF. In addition, PMF was found frequently in patients with tuberculosis (69.2%) compared with those without (23.3%) (p<0.001). 64.7% of pulmonary embolism (PE) cases had PMF, while just 25.2% of those without PE had PMF (p=0.001). There was no statistically significant difference between PMF cases and those without asthma, sarcoidosis, or lung malignancy prevalence (p=0.553, p=0.648, and p=0.125, respectively; (Table 4).

3.4. Demographic, Occupational, Functional, and Radiological Findings by Occupation

In Table 5, we report the main study variables divided by occupation. Sandblasting workers were diagnosed at a younger age (36.8±6.6 years) compared to all other groups, whereas miners were diagnosed at a later age (61.3±12.3 years). Duration of exposure was found to be shorter in sandblasting workers (7.2±6.4 years) and ceramic workers (15.5±7.9 years). The prevalence of PMF was higher in ceramic workers (41.0%), sandblasting workers (40.9%), and dental technicians (40.8%). Welders (4.7%) had the lowest prevalence of PMF. Sandblasting workers (77.8%) had the highest rate of category C opacities, while there were no cases with category C opacities among welders.

Pulmonary diseases were found most frequently in sandblasting workers (72.7%) and least frequently in foundry workers (23.6%) and welders (24.7%). There was a statistically significant difference in the presence of pulmonary diseases among the occupational groups (p<0.001). The highest rate of COPD occurred in miners (41.8%); the highest rate of asthma occurred in sandblasting workers (p=0.007), which also showed the highest prevalence of tuberculosis (p=0.004) and PE (p=0.007).

The frequency of sarcoidosis and lung malignancy did not differ between occupational group.

Table 3. The relationship between pulmonary function test results and large opacity size, small opacity size, small opacity profusion score, COPD, and pulmonary tuberculosis existence according to smoking status.

	PFT results							
	Never smokers				Ever smokers			
Variables	**N**	**FEV1%**	**FVC%**	**FEV1/FVC**	**n**	**FEV1%**	**FVC%**	**FEV1/FVC**
Large opacities								
None	110	88 (77-96)	87 (78-96)	82 (78-87)	330	86 (73-95)	84 (74-94)	81 (75-85)
A	17	77 (61-84.5)	81 (72-86.5)	73.5 (65.5-77)	53	68 (58-82)	77 (63-89)	75 (62-79)
B	11	73 (58-93)	81 (54-92)	74 (69-79)	32	59 (55-78)	70.5 (59-83)	73.5 (60-83)
C	9	47 (34.5-60)	55.5 (49-74)	55.5 (50-78.5)	35	41 (31-58)	54 (42-67)	69 (60-74)
$p^{\#}$		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
Small opacities								
< 1.5 mm	63	92 (79-101)	88 (81-98)	82 (78-85)	163	87 (78-96)	87 (80-97.5)	81 (75.5-86.5)
1.5-3.0	71	80 (65-90)	82 (72-90)	78 (73-84)	228	77 (64-91)	79 (66-93)	79 (71-84)
>3.0	13	67 (56-89)	78 (52-92)	77 (65-91)	59	57 (45.5-69)	63 (51.5-73)	71.5 (62.5-82)
$p^{\#}$		<0.001	0.004	0.024		<0.001	<0.001	<0.001
Small opacities profusion								
Stage 1	61	89 (77-101)	87 (76-98)	83 (78-87)	171	87 (75-95)	88 (79-96)	80 (73.5-85)
Stage 2	63	82 (65-94)	84 (72-91)	78 (69-82)	193	78.5 (64-92)	80 (65-93)	79 (71-84)
Stage 3	23	79.5 (72-89)	81 (72-89)	79 (76-87)	86	65 (50-77)	68 (56-80)	76 (68-82)
$P^{\#}$		0.020	0.128	0.001		<0.001	<0.001	0.006
COPD								
YES	31	58 (40-68)	66 (52-80)	69 (55-73)	133	58 (44-73)	68 (55-84)	67 (59-71)
NO	116	89 (80-96)	88 (81-96)	82 (78-86)	317	86 (75-96)	84 (75-94)	82 (78-86)
P^{*}		<0.001	<0.001	<0.001		<0.001	<0.001	<0.001
TB								
YES	12	67 (40-86)	77 (59-84)	69 (60-79)	27	57 (44-73)	62 (54-78)	75 (60-83)
NO	135	85 (73-95)	86 (76-94)	81 (76-86)	423	80 (66-93)	82 (70-93)	79 (72-84.5)
P*		0.029	0.067	0.010		<0.001	<0.001	0.032

All the results are expressed as median (IQR).
** Kruskal-Wallis, # Mann-Whitney U Test.*

Table 4. Comparison of PMF and simple pneumoconiosis cases.

		PMF			
		Yes	**No**	**p**	**OR**
Age*, Mean+SD		55.8±13.2	48.6±11.7	**<0.001**	
Exposure duration (y)*, Mean+SD		20.7±9.8	19.3±9.0	0.053	
Exposure Duration	< 20 years, n (%)	76 (48.4)	266 (60.5)	**0.009**	**1.63 (1.13-2.35)**
	≥ 20 years, n (%)	81 (51.6)	174 (39.5)		
Smoking pack-years, Mean+SD		23.30±16.0	22.6±15.4	0.837	
Smoking habits, n (%)	Non-smoker	37 (23.6)	110 (25)	0.720	
	Current/Ever Smoker	120 (76.4)	330 (75)		
FEV_1 (%)*		61.5±20.8	83.6±17.0	**<0.001**	
FVC (%)*		69.2±19.6	84.6±16.7	**<0.001**	
FEV_1/FVC*		70.1±12.8	80.6±10.3	**<0.001**	
Pulmonary Disease#	Yes	111 (70.7)	120 (27.3)	**<0.001**	**6.44 (4.30-9.63)**
	No	46 (29.3)	320 (72.7)		
Pulmonary TBC#	Yes	27 (17.2)	12 (2.7)	**<0.001**	**7.41 (3.65-15.03)**
	No	130 (82.8)	428 (97.3)		
Pulmonary embolism#	Yes	11 (7)	6 (1.4)	**<0.001**	**5.45 (1.98-15.00)**
	No	146 (93)	434 (98.6)		
Lung cancer#	Yes	4 (2.5)	4 (0.9)	0.125	-
	No	153 (97.5)	436 (99.1)		
COPD#	Yes	87 (55.4)	77 (17.5)	**<0.001**	**5.86 (3.93-8.74)**
	No	70 (44.6)	363 (82.5)		

 # presents n (%) and chi-square was performed for statistical analyses.
** Mann-Whitney U test.*

4. Discussion

In this study, we have reported the detailed personal, occupational, laboratory, and radiological findings of a large pneumoconiosis cohort in Turkey to determine the factors that accelerate the development and increase the severity of pneumoconiosis in a mixed case group. The evaluation of patients working in different occupations known to cause pneumoconiosis sheds light on the occupational groups that should be prioritized when creating appropriate pneumoconiosis coping programs in countries like ours, which have failed to combat the problem of pneumoconiosis. Therefore, the most important endpoint of our study is the identification of sectors characterized by a high prevalence of pneumoconiosis. In our study population, the three occupations with the earliest onset of pneumoconiosis were sandblasters, dental technicians, and ceramic workers. In addition, the shortest dust exposure duration prior to the diagnosis of pneumoconiosis was noted in sandblasters and ceramic workers. In our study group, PMF was more common in ceramic, dental technicians, sandblasters, and stone workers than in other occupations.

An increased estimated relative risk of PMF was associated with longer dust exposure duration (more than 20 years) and with concomitant pulmonary diseases – particularly tuberculosis, pulmonary embolism, and COPD (unadjusted results). However, we found that smoking and small opacity profusion score were not associated with PMF presence. Several studies have reported on the importance of dust exposure intensity in the development of PMF

Table 5. Characteristics of study group according to occupations.

	Foundry Worker	Miners	Welders	Construction worker	Dental Technician	Ceramic Worker	Sand-blaster	Stone worker	Others	P
Age	47.5±9.8	61.3±12.3	46.9±8.6	50.3±11.9	43.3±11.5	44.2±9.2	36.8±6.6	49.8±10.2	49.4±13.2	**<0.001***
Exposure Duration (y)	18.4±8.1	19.8±7.7	24.3±9.4	23.2±11.4	21.1±9.0	15.5±7.9	7.2±6.4	21.2±9.0	19.6±12.0	**<0.001***
Smoking (pack-years)	22.0±16.0	25.9±16.5	20.2±11.0	28.4±21.7	19.3±13.3	18.6±13.8	18.3±10.9	24.0±15.2	23.8±18.0	0.089*
$FEV_{1\,(\%)}$	84.7±18.6	72.7±20.6	86.6±1.0	77.8±16.6	71.1±22.9	77.4±18.1	66.9±25.2	71.6±22.1	75.1±21.6	**<0.001***
FVC (%)	85.7±17.2	75.4±19.0	88.7±12.5	80.2±14.5	76.6±21.8	81.3±18.0	70.6±21.4	78.1±18.9	77.6±21.7	**<0.001***
FEV_1/FVC	80.8±11.8	74.9±12.8	80.4±8.7	76.4±9.7	77.8±10.1	77.5±10.0	77.0±13.9	74.7±15.3	79.2±11.7	**0.002***
Pulmonary Disease, n (%)	34 (23.6)	77 (48.7)	21 (24.7)	14 (58.3)	22 (44.9)	13 (33.3)	16 (72.7)	21 (50)	13 (38.2)	**<0.001**#
PMF	20 (13.9)	60 (38.0)	4 (4.7)	6 (25.0)	20 (40.8)	16 (41.0)	9 (40.9)	16 (38.1)	6 (17.6)	**<0.001**

[5-9]. In addition to high dust exposure, Ng et al. stated that PMF development was associated with a high score for small opacity profusion and concomitant tuberculosis, although it was not associated with smoking [9]. In a study by Maclaren et al., 1,902 miners were examined retrospectively: exposure to respirable dust, simple pneumoconiosis category, and age were associated with the development of PMF [10]. However, the relationship between the small opacity profusion category and PMF presence is controversial, as some authors have stated that relatively low small opacity profusion scores may lead to PMF due to the conglomeration of small nodules into large masses [11, 12].

Sandblasting often involves applying abrasive particles to a surface such as glass or metal with compressed air for cleaning or decorative purposes. Though the use of free silica in sandblasting activities is prohibited in most developed countries, unfortunately, no general legal regulations on sandblasting have been made in Turkey, except for its use in denim sandblasting. Cases of pneumoconiosis have been described in denim sandblasting workers, and this industry has caused a significant increase in silicosis cases and fatalities in the recent past in Turkey [13]. Bakan et al. reported a prevalence of PMF of 37.4% at the time of diagnosis and a 5-year survival rate of 69% in denim sandblasters [14]. Dramatically, a 4-year follow-up study showed an increased prevalence of pneumoconiosis in denim sandblasters from 55.4% to 95.9%, despite a cessation in dust exposure [15].

In our study, 22 (3.7%) cases were sandblasters; of them, seven worked in glass manufacturing, six worked in denim sandblasting, five worked in metal sandblasting, and four worked in Teflon pan manufacturing. Higher rates of PMF (40.9%) and concomitant pulmonary disease (72.7%) were found in sandblasters than in other occupations, consistent with previous studies [16]. Although the use of free silica in denim sandblasting in our country is well known, its utilization in Teflon-coated pan manufacturing is less studied. All cases in our study who performed sandblasting for Teflon-coated pan manufacturing had PMF lesions, and one case underwent lung transplantation. Our study results show that in order to prevent similar outcomes as those seen in denim sandblasting, it is necessary to be aware that employees in the Teflon sector are also at risk for pneumoconiosis. Lower age at the time of pneumoconiosis diagnosis and high incidence of PMF in freshly crushed silica making occupations may be explained by the piezoelectric properties of silica. [17-19]. Many *in vivo, in vitro,* and population-based studies have demonstrated how activities that produce electrostatically charged free silica, such as sandblasting, are catastrophic to the human lungs. Urgent regulations banning sandblasting activities that involve free silica should be put into effect.

The ceramic manufacturing process begins with the preparation of raw materials such as clay kaolin, quartz, and feldspar as well as auxiliary materials if needed. Silica- and silicate-containing particle exposure primarily occurs during raw material preparation and surface treatment and glazing procedures; however, pneumoconiosis has been reported in all steps [20-22]. In our study, we found early-age pneumoconiosis and a high PMF prevalence in ceramic workers, though we were not able to stratify the risk by work process, as most of the patients stated that they were involved in all components of ceramic production.

Numerous studies have evaluated the changes in lung function that occur with pneumoconiosis. Although it has been reported that obstructive, restrictive, and mixed respiratory function loss accompanies PMF, a detailed evaluation of the distribution of abnormal patterns by radiological category has not been fully documented. In this study, respiratory function findings were reported in detail. We demonstrated lower FEV1, FVC and FEV1/FVC values in both never and ever smokers' groups as the large opacity size and the small opacity size increased. Also we found and small opacity profusion score in both smoking groups. These findings indicate that both obstructive and restrictive pulmonary loss play a role in the pulmonary dysfunction caused by pneumoconiosis. In addition, although there was no statistically significant difference in smoking habit and cigarette pack-years between simple pneumoconiosis and PMF cases, the frequency of COPD in PMF cases was higher than in simple pneumoconiosis cases. Morgan et al. reported that PMF was associated with a significant decrease in FEV1 and

FEV1/FVC during the initial phase, but only minor changes were observed in FVC [23]. In the study by Yeoh et al., obstructive pulmonary function loss was reported in all categories of PMF; however, the prevalence of restrictive and mixed disorders became evident with the disease progression [24].

According to studies conducted in a variety of regions, an increased risk of pulmonary tuberculosis, ranging from 2.8- to 39-fold, accompanies pneumoconiosis [25-27]. Pulmonary tuberculosis causes structural damage that leads to pulmonary dysfunction and higher mortality rates in patients with pneumoconiosis. The National Tuberculosis Control Program has been successfully implemented in Turkey, and the incidence of tuberculosis has decreased from 29.4 per 100,000 in 2005 to 10.6 per 100,000 in 2020. However, the incidence of tuberculosis is not well known among patients with pneumoconiosis [28]. We found that the proportion of PMF cases with pulmonary tuberculosis was 6.5%, similar to the literature. Additionally, the proportion increased as the severity of pneumoconiosis increased. Patients with pneumoconiosis stage 2 and above had a 6-fold higher prevalence of tuberculosis than patients with stage 1, and patients with PMF had a 7-fold higher prevalence of tuberculosis than patients with simple pneumoconiosis. A limited number of studies have been conducted investigating the correlation between pulmonary tuberculosis and the clinical course of pneumoconiosis. In a 13-year observational study, 586 (4.6%) newly diagnosed pulmonary tuberculosis cases were in a cohort of 12,787 patients with pneumoconiosis [29].

This study has a number of strengths, including its setting at a referral center for pneumoconiosis evaluation, the mixed pneumoconiosis case group, and the detailed analysis of respiratory function according to pneumoconiosis severity. In addition, this study sheds light on occupations that have been little studied as causes of pneumoconiosis. This study also has several limitations. The study was conducted in the occupational diseases training clinic of a hospital required by law to report occupational diseases, and thus the characteristics of the participants may affect the results of the study. In our country, neither public authorities nor health service providers take sufficient interest in providing vocational rehabilitation after an occupational disease diagnosis, and adequate human and financial resources are not provided. In addition, after the diagnosis of pneumoconiosis, it is recommended that the person should cease working in pneumoconiosis-inducing jobs and terminate dust exposure. Therefore, the diagnosis of pneumoconiosis often causes employees to lose their jobs. For this reason, even if symptoms have developed, many employees are hesitant to seek health care services.

5. Conclusions

Understanding the prevalence, causes, and severity of pneumoconiosis is the foundation of prevention. When this information cannot be gathered through well-functioning occupational disease reporting systems, it becomes even more important to transform the data collected in occupational disease referral centers into scientific information. In conclusion, the current study presents pneumoconiosis data in a mixed and large population and contributes to the implementation of evidence-based policies and interventions for countries like Turkey that are striving to cope with the problem of pneumoconiosis. For future research, we recommend further exploration of the risks of occupations that have not been well studied but are identified in our study as having a high risk and the assessment of occupational disease prevention programs implemented in workplaces for pneumoconiosis eradication.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Ankara Atatürk Sanatorium Training and Research Hospital (2012-KAEK-15/2479, 03/08/2022).

Informed Consent Statement: Patient consent was waived due to retrospective design.

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