# Frequency of Pneumoconiosis and Related Factors in Ceramic Workers Admitted between 2016 - 2018 to the Occupational Diseases Clinic of a University Hospital in Turkey

***Seher Kurtul*[1] , Funda Kaya Ak[2] , Meral Türk[2]***

*1) Clinic of Occupational Disease, Bozyaka Training and Research Hospital, Izmir, Turkey*
*2) Department of Occupational Disease, Ege University Faculty of Medicine, Izmir, Turkey*

*Author for Correspondence:* seherkurtul79@gmail.com

## ABSTRACT

Accumulation of metals and dust may lead to pneumoconiosis in long-term workers in the ceramic industry. This study aimed to evaluate the prevalence of pneumoconiosis and the affecting individual, occupational, medical, and socioeconomic factors in ceramic industry workers admitted to the clinic of the occupational disease of a university hospital.

This cross-sectional study evaluated the medical records of 216 ceramic workers admitted to the Occupational Diseases clinic of a university hospital in Turkey, between May 2016 and June 2018. The sociodemographic characteristics, detailed occupational history, physical examination findings, respiratory function test results, and radiological results (chest x-ray and/or High-Resolution Computed Tomography-HRCT) of the workers were documented. Chest x-rays were evaluated by two occupational disease specialists with ILO pneumoconiosis certification.

According to gender, 213 patients were male and 3 female. Pneumoconiosis was detected in 34 (11.1%) of the patients, all were male. There was a statistically significant correlation between total time of dust exposure and pneumoconiosis diagnosis ($p=0.002$). In total, 80.6% of patients were asymptomatic at presentation to the clinic. According to the evaluation of the standard chest radiography of the cases, most of the opacities were characterized as p (120, 55.6%) or q (13, 6.0%) and observed in mid and upper zones; 10 patients showed s opacity (4.6%) and 1 patient showed r opacity (0.5%). Spirometry results of the cases who were categorized according to the results of ILO radiological assessment were compared and no statistically significant difference was found between the groups ($p>0.05$). When the HRCT results of 196 workers were evaluated, 142 cases (65.7%) were shown reticular opacity, 87 (40.3%) nodule, and 2 cases (0.9%) large opacity.

These results emphasize the importance of conducting follow-up studies in workers exposed to respirable particles in the ceramic industry and reforming health policies related to pneumoconiosis.

**Keywords:** Pneumoconiosis, Ceramic Sector, Occupational Disease

## ABBREVIATION

HRCT: High-Resolution Computed Tomography
ILO: The International Labor Organization
WHO: World Health Organization
SSI: Social Security Institution
BMI: Body Mass Index
FEV1: Forced Expiratory Volume
FVC: Forced Vital Capacity

## INTRODUCTION

The International Labor Organization (ILO) defines pneumoconiosis as the accumulation of dust in the lungs due to occupational and environmental causes and resulting tissue reaction [1]. The main cause of pneumoconiosis is exposure to dust in the workplace; environmental exposure rarely causes these diseases. The most common pneumoconiosis are asbestosis, silicosis, and coal workers' pneumoconiosis. Pneumoconiosis leads to respiratory failure in serious cases, disability in workers, and early death. Each year, approximately 125,000 cases of global deaths resulted from pneumoconiosis according to the Global Burden of Disease Study 2010 [2]. Since the discovery of pneumoconiosis in the 19th century, the prevention of occupational diseases mainly concentrated on the control of dust-caused occupational hazards. The Joint ILO/WHO Committee on Occupational Health established the ILO/WHO Global Program for the Elimination of Silicosis following the recommendation of the 12th Session in 1995, which aimed to call on the world to take steps for silicosis prevention [3].

According to Dust Prevention Regulations enforced in Turkey, in workplaces containing asbestos, its forms, and quartz dust, considering the health status of workers based on risk assessments and measurements, the frequency of chest x-ray is determined by the occupational physician and standard chest x-ray of workers is assessed by a certified reader according to ILO pneumoconiosis radiography classification. According to this assessment, the employer is responsible for follow-up periodical examination of workers classified as Category 0 and referral to official health care providers authorized by the Social Security Institution (SSI) for those classified as Category 1 and higher. The occupational physician, responsible for health surveillance, according to the results of examinations and test results, determines all sorts of protective and preventive measures and provides recommendations, even including not allowing workers to work due to exposure to dust.

According to the 2016 statistics of the SSI in Turkey, 197 of 597 workers diagnosed with occupational disease were pneumoconiosis cases [4]. The number of notified pneumoconiosis cases as in other occupational diseases was relatively low due to limitations such as the fact that presentation to authorized health care providers required social security institution referral, that occupational specialist doctors didn't have authorized access to workplace information, and that there was a limited number of specialists. Therefore, considering the number of unnotified pneumoconiosis cases, pneumoconiosis still holds relevance in our country. Although there is insufficient statistical data on the prevalence of pneumoconiosis based on industry, many studies have shown that various industries such as textile, mining, metal, dental prostheses, and ceramic industries carry a significant risk of pneumoconiosis [5]. It is reported that there are over 200,000 workers employed in industries with pneumoconiosis risk in Turkey [6].

The ceramic industry carries many occupational hazards, especially particles. The main raw materials in the ceramic industry include clay, silica, aluminium, magnesium, titanium, iron oxide, and zirconium. The silica content of the clay used in ceramic production varies between 23-58% and it has been shown that 80% of workers are at risk of potential occupational lung disease [7]. In addition, the ceramic industry carries many occupational hazards including exposure to solvents, chemicals, and metals (lead, cadmium, chrome, arsenic, copper, nickel, cobalt, manganese and tin) [8]. These metals and particles accumulated especially in long-term workers in the ceramic industry may cause pneumoconiosis and therefore, these workers must be more carefully monitored. Various studies have reported the prevalence of pneumoconiosis in ceramic workers between 4.7-6.6% [9,10].

Official numbers announced by the SSI concerning occupational diseases don't reflect the real current situation. The determination of real numbers is important for taking the required precautions at the workplaces. In addition, the diagnose of occupational diseases is necessary for the protection of workers' right to compensation. As a preventable disease, the development of pneumoconiosis continues to be a problem in developing countries. The diagnosis of one Pneumoconiosis can provide the possibility to change the poor working conditions for those sharing the same workplace. This study aimed to determine the frequency of pneumoconiosis and related socioeconomic and occupational factors among ceramic industry workers who applied to the clinic of the occupational disease of a university hospital.

## MATERIALS AND METHODS

This cross-sectional study was conducted by examining the medical records of 216 ceramic workers who applied to the Occupational Diseases Clinic of a university hospital situated in the west region of Turkey, between May 2016 and June 2018 with the referral of their occupational physicians. Among the workers who applied; those who were working in the ceramic sector and completed the radiological investigations (chest X-ray) were included. Other workers applying to the clinic with respiratory symptoms working in other sectors were excluded.

Appropriate ethics committee approval was obtained before the start of the study. Data of the workers was accessed through the occupational disease clinic's database.

Physical examination and measurements (height/weight) was performed by an occupational disease specialist. Body mass index (BMI) was calculated by dividing body weight (in kg) by height (in meters). Sociodemographic characteristics, detailed occupational history, physical examination findings, and respiratory function test results were documented.

*Spirometry Measurements*

Spirometry was measured by an experienced respiratory function test technician. Respiratory function parameters including forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and FEV1/FVC ratio was evaluated. Spirometric data of the cases were automatically analyzed by American Thoracic Society standards according to gender, age, and height [11].

*Radiologic Assessment*

All cases underwent chest x-ray which was evaluated by two occupational disease specialists with ILO pneumoconiosis certification and classified according to ILO 2011 pneumoconiosis radiography classification. According to ILO classification, the workers were classified into 4 categories: Category 0 (profusion scores 0/-, 0/0, 0/1), Category 1 (profusion scores 1/0, l/l, 1/2), Category 2 (profusion scores 2/1, 2/1, 2/3), and Category 3 (profusion scores 3/2, 3/3, 3/4). Based on this classification and consensus, cases with profusion over 1/0 opacity were accepted as pneumoconiosis [12]. In addition, in our clinic, due to the application of suspected pneumoconiosis cases thought to have 1/0 profusion in chest x-ray taken during periodic workplace examination, high-resolution tomography (HRCT) was performed and the results were evaluated in detail by a radiologist. HRCT results were grouped according to Hering and Klaus classification [13].

*Statistical Analysis*

SPSS 18.0 program was used for analyzing the data. For descriptive data, categorical variables were expressed as number and percentage, while numerical variables were expressed as mean, median, standard deviation, minimum, and maximum. A Chi-square test was used to compare independent categorical variables. For numerical variables, two-way comparisons were assessed with Student's t-test, multiple group comparisons with One-Way ANOVA, and Kruskal Wallis test was used to assess data with non-normal distribution. The value of $p<0.05$ was accepted as statistically significant.

## RESULTS

According to gender, 98.6% (n=213) of the ceramic workers were male, the mean age was 39.6±8.2 (22-72) years and 87% were married. The educational status of 49.1% was elementary school and lower, 96.3% had income over minimum wage. BMI of 51.9% was between 25-29. The majority of workers (79.2%) had a smoking history (53.7% active smokers, 25.5% used to smoke). The mean age of initial employment was 18,00±4,53 years but the mean age of initial exposure to dust was 26,88±6,72 years. Total exposure time was 12.43±7.85 years. When we evaluated the ceramic workers according to the units they worked in, the most common units were the foundry, glazing, warehouse and shaping. A large majority (87%) of the workers stated that they used masks.

According to evaluation of standard chest x-rays according to ILO standards, 82.9% had profusion subclassification Category 0 [ 0/0 (74, 34.3%), 0/1 (105, 48.6%)]; 11.6% of workers Category 1 [ 1/0 (11, 5.1%); 1/1 (11, 5.1%); 1/2 (3, 1.4%)]; 4.6% of workers Category 2 [2/1 (1, 0.5%), 2/2 (7, 3.2%), 2/3 (2, 0.9%)]. In addition, pleural thickening was seen in 7 (3.2%) and pleural plaque in 1 (0.5%) worker. In total, the majority of opacities were p (120, 55.6%) or q (13, 6.0%) and were observed in the middle and upper zones, in 10 cases s opacity (4.6%) and in 1 case r opacity (0.5%) were observed. Radiological graph and categorical distribution according to standard ILO evaluation of PA chest radiography is presented in Fig. 1.

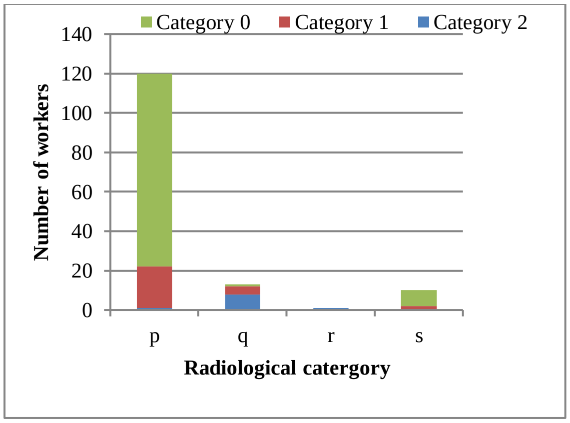


**Fig.1:** Results of radiological evaluation according to ILO standards in ceramic workers

When HRCT results of 196 workers (20 ceramic workers had no HRCT) were evaluated, reticular opacity was seen in 142 workers (65.7%), nodules in 87 workers (40.3%) and large opacity in 2 workers (0.9%). In addition, 30 workers (13.9%) had emphysema, 26 workers (12.0%) lymphadenopathy, 12 workers (5.6%) ground-glass, and 8 workers (3.7%) had bronchiectasis in HRCT.

The spirometric data and mean, minimum and maximum values of the workers calculated according to the percentage of expected values were FEV1 94.57±14.28%, FVC 97.52±12.43%, and FEV1/FVC 79.64 ± 6.63%. There was no statistically significant difference between the spirometric data of workers and the categories of ILO radiological evaluation ($p>0.05$) (Table 1). At the time of admittance to the clinic, 80.6% of the workers were asymptomatic. The percentage of workers with respiratory complaints was determined as 12%. Respiratory complaints included shortness of breath (7.4%), coughing (3.7%), and phlegm (0.9%). While this rate was 2.3% in non-smokers, it was up to 9.7% in smokers ($p=0.830$). Respiratory symptoms were not statistically correlated with total exposure time to dust ($p=0.542$), the mean age of initial employment ($p=0.248$), and mask use ($p=0.542$). Additionally, 5.6% of workers had musculoskeletal symptoms, 0.9% cardiovascular, 0.5% dermatologic, and 0.5% hearing-related symptoms.

**Table 1:** Comparison of respiratory function test parameters according to ILO categorization in ceramic workers

| Respiratory function test (%mean ±SD) | Category 0 (0/0, 0/1) | Category 1 (1/0, 1/1, 1/2) | Category 2 (2/1, 2/2, 2/3) | P* |
|---|---|---|---|---|
| FEV1 | 94.40±14.80 | 94.41±9.57 | 98.1±16.18 | 0.573 |
| FVC | 97.55±12.90 | 96.81±9.58 | 98.9±11.8 | 0.803 |
| FEV1/FVC | 79.50±6.73% | 80.91±6.32% | 80.9±5.53% | 0.730 |

* One-way Anova test

Of the 216 ceramic workers admitted to the clinic, 34 (11.1%) were detected to have pneumoconiosis according to ILO standards. All pneumoconiosis cases were male and their mean age was 43.06±6.44; 88.2% were married. The educational status of 58.8% was elementary school and lower. All pneumoconiosis cases had income over minimum wage. BMI of 52.9% was between 25-29. Smoking history was obtained from 58.8% (23.5% active smokers, 26.5% used to smoke). The mean age of initial employment was 18,41±4,71 years and the mean age of initial exposure to dust was 26,70±5,13 years. Total exposure time to dust was 16.20±7.56 years. When we evaluated the cases according to the units they worked in, the most common units were the glazing, foundry, shaping and maintenance and repairs. A large majority (97.1%) of the cases stated that they used masks.

According to ILO radiological evaluation, the opacities in the 34 workers diagnosed as pneumoconiosis were as follows: p (19, 55.9%), q (11, 32.4%), s (3, 8.8%) and r (1, 2.9%); large opacity (A) was observed in 2 (5.8%) cases.

The mean age was significantly higher in workers diagnosed with pneumoconiosis (p=0.008) (Table 2). There was a significant correlation between total exposure time to dust and pneumoconiosis diagnosis (p=0.002) (Table 3).

**Table 2:** Distribution of sociodemographic characteristics, risky behaviour and pneumoconiosis diagnosis in ceramic workers

| Sociodemographic characteristics and habits | Pneumoconiosis (+) Number (%)ˣˣ mean ±SD | Pneumoconiosis (-) Number (%)ˣˣ mean ±SD | Total Number (%)ˣˣ mean ±SD | p |
|---|---|---|---|---|
| **Age (mean ±SD)** | 43.06±6.44 | 39.01±8.34 | 39.64±8.2 (22-72) | 0.008‡ |
| **Gender** | | | | -1 |
| **Male** | 34(%100) | 179(%98.3) | 213(%98,6) | |
| **Female** | 0 | 3(%1.6) | 3(%1,4) | |
| **Marital status** | | | | 0.357‡‡ |
| **Married** | 30(%88.2) | 162(%89) | 188(%87) | |
| **Single** | 4(%11.7) | 20(%10.9) | 28(%13) | |
| **Educational status** | | | | 0.449‡‡ |
| **Elementary or lower** | 20 (58.8%) | 86 (47.3%) | 106 (49.1%) | |
| **High school** | 10 (29.4%) | 72 (39.6%) | 82 (38.0%) | |
| **University and above** | 4 (11.8%) | 24 (13.2%) | 28 (13.0%) | |
| **Smoking** | | | | 0.878‡‡ |
| **Never smoked** | 8 (23.5%) | 37(20.3%) | 45 (20.8%) | |
| **Quit** | 9 (26.5%) | 46(25.3%) | 55 (25.5%) | |
| **Active smoker** | 17 (50.0%) | 99(54.4%) | 116 (53.7%) | |
| **Body mass index** | | | | 0.924‡‡ |
| **<25** | 7 (20.6%) | 43 (23.6%) | 50 (23.1%) | |
| **25-29** | 18 (52.9%) | 94 (51.6%) | 112 (51.9%) | |
| **≥30** | 9 (26.5%) | 45 (24.7) | 54(25.0%) | |
| **Monthly income** | | | | 0.362‡‡ |
| **Minimum wage** | 0 | 8 (4.4%) | 8 (3.7%) | |
| **Over minimum wage** | 34 (100%) | 174 (95.6%) | 208 (96.3%) | |

ˣcolumn percentage, ˣˣrow percentage, ‡ student's t-test, ‡‡ Chi-square test, -1= Chi-square inapplicable

There was no statistically significant correlation between pneumoconiosis diagnosis and marital status, education, smoking, body mass index, and income. The mean age of initial employment and mean age of initial exposure to dust were similar in pneumoconiosis cases and healthy workers and no significant differences were observed. There was no significant difference between the working units. According to the use of masks, there was no significant difference between pneumoconiosis cases and healthy workers (p=0.09).

In addition to pneumoconiosis, according to examinations and test results, some ceramic workers were diagnosed with hearing loss (47, 21.8%), respiratory disease aside from pneumoconiosis (2, 0.9%), musculoskeletal disorders (24, 11.1%), dermatitis (2, 0.9%), and depression (2, 0.9%), due to occupational causes.

**Table 3:** Distribution of occupational characteristics and pneumoconiosis diagnosis in ceramic workers

| Occupational characteristics | Pneumoconiosis (+) Number (%)×× mean ±SD | Pneumoconiosis (-) Number (%)×× mean ±SD | Total Number (%)×× mean ±SD | p |
|---|---|---|---|---|
| **Age of initial employment** | 18,41±4,71 | 17,92±4,51 | 18,00±4,53 | 0,570 |
| **Age of initial exposure to dust** | 26,70±5,13 | 26,91±6,99 | 26,88±6,72 | 0,867 |
| **Total exposure time to dust (years)** | 16.20±7.56 | 11.73±7.72 | 12.43±7.85 | 0.002 |
| **Unit of work** | | | | -¹ |
| **Glazing** | 7 (20.6%) | 26 (14.3%) | 33 (15.3%) | |
| **Furnace** | 2 (5.9%) | 18 (9.9%) | 20 (9.3%) | |
| **Foundry** | 6 (17.6%) | 34 (18.7%) | 40 (18.5%) | |
| **Warehouse** | 4 (11.8%) | 28 (15.4%) | 32 (14.8%) | |
| **Administrative** | 2 (5.9%) | 17 (9.3%) | 19 (8.8%) | |
| **Maintenance and repairs** | 5 (14.7%) | 22 (12.1%) | 27 (12.5%) | |
| **Shaping** | 6 (17.6%) | 24 (13.2%) | 30 (13.9%) | |
| **Quality control** | 2 (5.9%) | 13 (7.1%) | 15 (6.9%) | |
| **Mask use** | | | | 0.09 |
| **Yes** | 33 (97.1%) | 155 (85.2%) | 188(87.0%) | |
| **No** | 1 (2.9%) | 27 (14.8%) | 28 (13.0%) | |

-¹= Chi-square inapplicable, ×column percentage, ××row percentage

## DISCUSSION

Although Turkey is one of the most important ceramic-producing countries due to its raw materials reserve, there are few studies on workers in the ceramic industry. Our study, with 34 (11.1%) cases that have radiological findings compatible with pneumoconiosis among ceramic workers, demonstrates pneumoconiosis persists in workers of the ceramic industry in Turkey.

The majority of ceramic workers who applied to the clinic of the occupational disease were men because the ceramic industry with many occupational risk factors is categorized as a ‘very dangerous workplace’ and therefore, the proportion of women is lower than men. The workers were in the middle-age group, with low education level and income.

In our study, the frequency of pneumoconiosis was higher than the study conducted in a ceramic factory in Manisa province where the rate was 6.57% [9]; this may be related to the fact that the workers who applied were referred by their occupational physicians doubting pneumoconiosis concerning them. The mean age and total exposure time of pneumoconiosis cases in our study were higher compared to healthy workers. Silicosis prevalence in the ceramic industry was shown to increase with total exposure time [14]. In our study, the mean total exposure time in pneumoconiosis cases were 16±7.5 years, while the literature reports that even an eight-years working period is sufficient for the development of silicosis [15]. A study conducted in the United Kingdom in 1989 reported a mean exposure time of 35±10 years in 276 ceramic workers [16]. Furthermore, dust concentration and occupational health and safety are important factors in the development of pneumoconiosis. Parallel to dust exposure in the workplace, mask use was relatively high (87%) among workers, and there was no significant difference between pneumoconiosis and healthy workers. Although this finding gives the assumption that wearing a mask is ineffective in protecting against dust exposure, the fact that mask use was evaluated according to the workers’ statements may have led to this result. Improper mask use may also have caused dust leakage and reduced the mask’s protective barrier against dust [17]. Educating workers on mask conformity and proper use reduces leakage from 32.1% to 10.5% [18].

In total, 80.6% of patients were asymptomatic when presenting to the clinic. Of the symptomatic patients (12%), respiratory symptoms were foremost. In our study, of the 82.9% of cases who had respiratory symptoms, 80.7% were active or previous smokers, and those with a smoking history had a higher prevalence of respiratory symptoms. Studies have shown that smoking history has a synergistic effect on dust and smoke exposure [19-21]. These results once again emphasize the importance of quitting smoking on protecting health in workers. According to the results of the statistical analysis, there was no significant correlation between respiratory symptoms and pneumoconiosis development. However, Myers *et al.* showed that workers exposed to silica had respiratory symptoms such as cough and shortness of breath without having silicosis, and that silica exposure causes occupational bronchitis without the development of silicosis [22]. Aside from dust in the ceramic industry, solvents, chemicals and metals, noise, and ergonomic risk factors are also important risk factors. For this reason, it is also important to evaluate other systemic diseases aside from pneumoconiosis in ceramic workers. Consistent with previous studies, in our study, along with pneumoconiosis diagnosis, hearing loss due to exposure to noise in the workplace and musculoskeletal disorders due to working conditions and organization were also observed in workers [23,24].

It is known that in simple silicosis, 2-5 mm small nodules mostly observed in the upper lobes are accompanied by calcifications [25]. Our study also revealed that over ten years of exposure lead to chest x-rays compatible with silicosis. Therefore, the most common radiological findings in pneumoconiosis cases were small nodular “p” opacities. In addition, in pneumoconiosis cases, 32.4% had “q”, 8.8% “s”, and 5.8% had “A” large opacities and 70.5% of pneumoconiosis cases were Category 1, 29.5% were Category 2, and there were no Category 3 cases. The fact that large opacities were observed in few patients and that pneumoconioses were detected in the early term suggests this is due to periodical health surveillance of workplaces in recent years.

According to the evaluation of respiratory function test parameters in our study, there was no decrease in spirometric measurements in pneumoconiosis cases. Studies conducted on this subject have varied results. In another study by Jaakola on ceramic workers, long-term exposure to respirable particles was shown to lead to decreased pulmonary function [21]. Although silicosis cases with advanced radiological findings had a tendency for poor respiratory function results, respiratory function tests were not correlated with radiological categories. Respiratory function tests may be normal despite the development of radiological findings [26]. Saad *et al.* found that respiratory function parameters were within normal intervals in their study on ceramic workers [27].

Our study had some limitations. Our study did not include all workers of a workplace, that the cases comprised of workers who were referred to our clinic with suspected pneumoconiosis, environmental and individual dust measurements belonging to a workplace were inaccessible, and that dust exposure and occupational history was evaluated according to workers’ statements.

## CONCLUSION

There is limited data on pneumoconiosis status and respiratory exposure in the ceramic industry in Turkey. This is due to low diagnosis and notification rates by health employees and institutions and the lack of comprehensive epidemiological studies and surveillance programs. These results emphasize the importance of conducting follow-up studies in patients exposed to respirable particles in the ceramic industry and reforming health policies related to pneumoconiosis. As well as the monitoring of exposure in workplaces and control measures, employees should also be periodically followed in terms of the health effects of dust. Periodical health surveillance should include respiratory examination, questioning of symptoms, spirometry, and chest x-ray. Widespread smoking in employees is noteworthy. The smoking of workers working in dusty areas should definitely be prevented.

## ETHICAL ISSUES

Ethical issues such as plagiarism have been observed by the authors.

## CONFLICT OF INTEREST

All authors have no conflicts of interest to declare.

## AUTHORS’ CONTRIBUTIONS

All authors participated in drafting the paper and gave final approval of the version to be submitted. Study conception and design: SK and MT; Acquisition of data: SK and FKA;
Analysis and interpretation of data: SK and FKA;
Drafting of the manuscript: SK, MT, FKA;
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