ERJ Express. Published on June 25, 2008 as doi: 10.1183/09031936.00093507

An epidemic of silicosis among former denim-sandblasters.

Metin Akgun[1], Omer Araz[1], Ibrahim Akkurt[2], Atilla Eroglu[3], Fatih Alper[4], Leyla Saglam[1], Arzu Mirici[5], Metin Gorguner[1], Benoit Nemery[6]

[1]Dept of Chest Diseases, Ataturk University, Erzurum, Turkey

[2]Dept of Chest Diseases, Cumhuriyet University, Sivas, Turkey

[3]Dept of Chest Surgery, Ataturk University, Erzurum, Turkey

[4]Dept of Radiology, Ataturk University, Erzurum, Turkey

[5]Dept of Chest Diseases, 18 Mart University, Canakkale, Turkey

[6]Dept of Public Health, Katholieke Universiteit Leuven, Leuven, Belgium

Short title: Silicosis among former denim sandblasters

Correspondence:

Dr. Metin Akgun
Aziziye Arastirma Hastanesi
Gogus Hastaliklari Anabilim Dali
25070, Palandoken
ERZURUM-TURKEY

e-mail: akgunm@gmail.com; **Fax:** +90 (442) 316 63 40

Summary

Sandblasting denims using silica has emerged as a new cause of silicosis in Turkey. Following the discovery of several cases of silicosis in (young) workers who had done this, the frequency and main occupational risk factors of silicosis among former denim-sandblasters in the region of Erzurum were evaluated.

Demographic characteristics and information on working conditions were obtained by questionnaire and interview; spirometry was done, and chest x-rays were evaluated according to ILO classification of pneumoconioses in 157 former denim-sandblasters.

They were all males with a mean age of 23 y (range 15-44 y). They had worked for a mean of 36 months (range 1-120 months), starting at a mean age of 17 y (range 10-38 y). Most subjects (83%) had respiratory symptoms, especially dyspnea (52%), but also chest pain (46%). Radiological evidence of silicosis (ILO score 1/0 or higher) was present in 77 subjects (53% of 145 subjects with interpretable chest x-ray). These subjects had lower FEV_1 and FVC. The risk of silicosis correlated with seniority working as a foreman, exposure duration and number of workplaces.

Considering the high prevalence rate of silicosis in such workplaces, further problems are inevitable in the future unless effective measures are taken.

Key words: Denim, jean, textile industry, sandblasting, silicosis, Turkey

Introduction

Silicosis is an ancient and well-known occupational lung disease caused by inhalation of free crystalline silica. Certain occupations expose the individual to high concentrations of silica, which is fibrogenic to the lungs, resulting in radiographic and pathological abnormalities. Although silicosis is considered a preventable condition, it continues to occur worldwide, especially in low-income countries with high tuberculosis burden, but it is still being reported even in high-income countries (1-3).

Workers engaged in occupations such as tunneling, mining, sandblasting, and quarrying are inevitably exposed to silica-containing minerals due to their ubiquity in the earth's crust. Besides these well-known sources of silica, there are many other less-known sources (4). Newer, sometimes unusual or unexpected, sources of silicosis continue to be reported, for example exposure to fine dust from heat-dried mud used in Tatami mat manufacturing in China (5) and dental supply factory workers using quartz- and cristobalite-containing fillers in the USA (6). Recently, exposure to silica in the textile sector has been reported as a novel and unusual source of silicosis in Turkey, as a result of sandblasting denims (or jeans) (7).

In denim sandblasting, workers are exposed to silica because they project silica-containing sand, as an abrasive, onto denim surfaces to produce a "worn-out" appearance. This kind of exposure seems to be more hazardous than many previously known sources, presumably because of a very intense exposure due to long hours of work under very poor hygiene conditions without any serious respiratory protection.

After the diagnosis of the first two cases of silicosis in 2004, the number of cases investigated at our outpatient clinic showed a rapid increase in the following years: 4 cases in 2005, 27 cases in 2006 and 42 cases until July 2007. Some of these initial cases, including two teenagers who died of silicosis, have been published (8, 9). In addition, reports of new cases have continued to be made from other centers in Turkey (9-11).

All our patients with silicosis had worked in industrial cities far away from our center, e.g. in Istanbul 1224 km to the West from Erzurum (***Figure 1***). The total number of workshops, many of which were unregistered, and the number of workers at risk were unknown. However, according to our patients, there were hundreds of such workplaces in Istanbul and in our region alone, in the Eastern part of Turkey, there were several hundreds former workers.

In this study, ex-workers in our region were contacted to estimate the frequency of silicosis among them, to better characterize the extent of the problem, and to obtain more reliable data about the workplaces and working conditions.

SUBJECTS AND METHODS

Study population

For this study, the origins of the cases were determined based on the records of the outpatient clinic (Ataturk University, Aziziye Research and Teaching Hospital, Erzurum, Turkey). Although there were some cases from Erzurum city and two adjacent cities, Bingol and Kars, more than 90% of the cases came from Bingol city, especially from Karliova County. These cases were mostly from two villages: Taslicay and Toklular. Therefore, these two villages with a total population of 2281 (450 households) were selected for further case finding. With the collaboration of the Mayor of Karliova, the population of those villages was informed about the association of sandblasting jeans and silicosis and all those who had ever worked in sandblasting workshops were invited to our outpatient clinic, with free transport being provided (102 and 105 kilometers from Toklular and Taslicay, respectively). The recruitment lasted from 1 May 2007 to 20 June 2007. In these two villages alone, around 500 males, i.e. at least one person from each household, were estimated to have been employed in this sector. However, not all potential subjects participated in the survey: some had already applied to our clinic or other health care centers before, some were serving their mandatory military service (the age of recruitment is 20), and some were out of the city in order to make a living. The study included 14 cases who had previously applied to our health care center (out of 49 cases that we had previously diagnosed from these villages).

All the participants gave their written informed consent, and the study protocol was approved by the local ethics committee.

Study procedure

The procedure involved four steps. First, a standard questionnaire was administered to determine the age, smoking history, symptoms, age at first exposure to sandblasting, total exposure duration, duration since first exposure, the number of workplaces worked, number of sandblasting devices used in the workplace, status (rank) at work (chief foreman, foreman, or apprentice), time spent at work, the types of protective measures taken, and whether they slept over at the workplace. In the questionnaire, the symptoms that had started after exposure and had existed for at least 1 month before the study were questioned. Dyspnea was defined as recurrent difficulty breathing or shortness of breath at rest or with exertion, and chronic cough was defined as cough with or without sputum production present for at least two months. Second, a personal interview was conducted with each of the participants to obtain additional information such as working conditions, which were not included in the questionnaire. Third, pulmonary function test was carried out using a computerized spirometer (Vmax22, SensorMedics Corp., Yorba Linda, CA). The values of forced expiratory volume in one second (FEV_1), forced vital capacity (FVC) and FEV_1/FVC ratio were recorded. FEV_1 and FVC values were also expressed as percentage of predicted value for age, gender, and height (12). Fourth, posteroanterior chest radiographs of all the participants were taken at maximal inspiration, and these were later evaluated according to the International Labour Office (ILO) international classification of radiographs of pneumoconioses (13, 14). After an initial evaluation made by a radiologist (F.A.) and a chest physician (M.G.), the films were also evaluated by a chest physician (I.A.), an experienced reader with 13 years experience in reading using the ILO classification, and a final consensus between these three experts was reached.

Small opacities were classified into four main categories (0 to 3) and 12 subcategories, and the films with 1/0 or higher profusion were considered to indicate silicosis (4, 13, 14). The ILO categories and subcategories were used as indices of disease severity. A further analysis was also performed by using the films with 1/1 or higher profusion as a criterion of silicosis.

Statistical analysis

The data were analyzed using the SPSS version 11 statistical software (SPSS Inc., Chicago, IL). Correlations between disease severity and the other parameters were calculated using Spearman's rank order correlation coefficients. Correlation between total exposure duration and number of workplaces worked was calculated using Pearson's correlation coefficient. Pearson Chi-square test was used to compare categorical values. Multivariate analysis was performed by step-wise logistic regression analysis to determine which variables were independent risk factor for silicosis.

Results

The study included 157 male subjects, who had worked in denim sandblasting between 1991 and 2006. In the studied population, the total number of workers employed by denim-sandblasting companies increased substantially from the mid 1990s on, with a maximum reached in 2002 (***Figure 2a***).

Characteristics of the cases are presented in ***Table 1***. Their mean age was 23 years (range 15-44 y). Two-thirds were smokers or ex-smokers, with a mean cumulative smoking history of 7 packyears (range 1-23 packyears). Most subjects had started working in sandblasting before 20 y of age (***Figure 2b***), resulting in a mean age at first exposure of 17 y (range 10-38 y). The total duration of work in sandblasting was 36 months on average (range 1-120 months), and the mean time since last exposure was 43 months (range 10-144 months).

The information obtained through the interviews with the workers can be summarized as follows: 1) No individuals were still actively working in this sector at the time of the study. As soon as it had been publicized that the work had caused a fatal disease in one young man, all the others quit working in this sector. However, such workplaces were and are still in operation. In addition to Turkish workers, illegal aliens from Romania, Azerbaijan, Georgia, and other nations were employed in such places. 2) Almost all of the cases were unregistered and uninsured.. 3) Most of the workplaces (figure 3) where they had worked were unregistered or unlicensed. 4) In most workplaces, they worked in two shifts: day and night. While some were working, the other group used to sleep in an area behind a screen where they were still exposed to the dust indoors. 5) They usually worked 10 hrs a day for 6 days a week. Occasionally, when there were more production orders, they used to work 12 hours a day 7 days a week. 6) The number of sandblasted jean clothes produced varied with the size of clothing item. For example, a typical worker could sandblast 250-500 pants a day and 3000-5000 skirts, bras, …etc. (***Figure 3***). 7) The workers were generally provided with one mask a day (two masks in some places, none in some workplaces) to cover their mouths and noses while sandblasting. 8) Many workplaces were using sifted sea sand and most of the workplaces had no ventilation. In some workplaces, to avoid wasting the sand, the doors and windows were tightly closed. 9) The workers had three ranks: apprentice, foreman, and chief foreman. Younger workers would usually start as apprentices and be promoted to foremen after gaining a few months of experience. The chief foremen were usually those who had longer work experience. The actual sandblasting was performed by the foremen. While the apprentices carried the material to the foremen, the chief foremen inspected the work done. In one workplace with 4 sandblasting devices, for example, there were 8 foremen (working in two shifts), as many as 8 apprentices, and 1-2 chief foremen. 10) Although other methods were sometimes used for creating a worn-out appearance (sandpaper; chemical procedures using potassium permanganate; laser technology to produce drawings), sandblasting was the preferred method because it is quicker, more reliable and cheaper.

Based on the replies to the questionnaire, most participants (n=131, 83%) were symptomatic (***Table 2***). The most common symptom was dyspnea (n=81, 52%) and chest pain came as an unexpected second most common symptom (n=72, 46%). Weight loss was also frequently reported (n=24, 15%) with an average loss of 10 ± 5 % (range 4.6-25%) of total body weight. Non-respiratory complaints, including upper airway and musculo-skeletal complaints, were also not uncommon.

All the participants underwent chest x-ray. However, two films were unavailable during ILO reading and ten films were judged to be of poor quality, thus leaving 145 participants for radiological evaluation. Of these, 77 (53.1%) were diagnosed as silicosis on the basis of the presence of small opacities with a profusion of 1/0 or more according to the ILO classification (***Table 3***). Compared to the subjects without silicosis (***Table 4***), those with silicosis had worked in more workplaces (3.0 versus 2.2, $p<0.05$), for a longer time (41 months versus 32 months, $p<0.05$), more frequently as foremen (95% versus 75%, $p<0.001$) and for a longer time as foremen (46 versus 26 months, $p<0.01$), and also had a longer latency period (86 months versus 73 months, $p<0.05$). The number of sandblasting devices was significantly lower for silicotics than non-silicotics (3.7 versus 4.2, $p<0.05$). In the further analysis, in which a profusion of small opacities of 1/1 or higher was used to indicate silicosis, working as foreman (100% versus 76%, $p<0.001$), duration of working as foreman (50 months versus 29 months, $p<0.01$) and number of workplaces (3.3 versus 2.2, $p<0.01$) were significantly higher in silicotics (n=58, 40%) compared with non-silicotics. However, when logistic regression analysis was applied, no independent risk factor emerged for silicosis regardless of which of the two different definitions of silicosis were adopted.

Subjects with silicosis had lower values of FEV_1 and FVC, but similar FEV_1/FVC ratio than those without silicosis. Among those with silicosis, disease severity (defined according to ILO score) was significantly positively correlated with the number of workplaces worked ($r=0.32$, $p<0.01$), total exposure duration ($r=0.25$, $p<0.01$), and especially the total exposure duration working as a foreman ($r=0.48$, $p<0.001$). Also, total exposure duration was significantly correlated with number of workplaces worked ($r=0.39$, $p<0.001$). On the other hand, the disease severity was significantly negatively correlated with all the pulmonary function test parameters (r values between -0.36 and -0.46, $p<0.001$) except FEV_1/FVC.

Discussion

Denim (or jean) sandblasting has recently emerged as a new cause of silicosis, at least for Turkey. The main reason for the large number of cases in our region is the high rate of unemployment of our region, thus causing migration of people, including young men, to big cities to carry out jobs without regard for working conditions. All the subjects had moved to Istanbul with the help of a friend from their villages. Whenever one of these men found a job, he would invite someone else, thus establishing a chain process. With half the participating subjects (77/157) having radiological evidence of silicosis, the frequency of disease in this group of subjects is alarmingly high, especially considering the relatively short exposure duration.

The number of workers in this occupation showed a rapid increase with the new millennium, followed by case reports of silicosis in this occupation, starting from 2004 (7) and continuing (8-11). The first cases had proven difficult to diagnose because pneumoconiosis was not obviously associated with work in the textile sector. Little information was available about such workplaces, working conditions and the dust levels, thus making the management of the disease challenging. In this study, some important aspects of the workplaces and effects of the working conditions on the workers' health were clarified. However, the dust levels and other characteristics (such as size and exact composition of particles) could not be evaluated. Nevertheless, considering the dramatic picture observed in this study, it can be safely concluded that the dust levels in such workplaces must be very high. In addition, the cumulative exposure of these workers was probably also substantial as a result of long daily and weekly working times with, for some subjects, even exposure while sleeping in their dusty workplaces. The young age of many of these workers is possibly also an aggravating factor.

In this study, the diagnosis of pneumoconiosis was based only on chest x-ray findings in addition to exposure history. Although chest radiograph remains the most convenient imaging modality to diagnose silicosis and to monitor its progression, the number of subject with silicosis in our study group could be higher than detected because chest radiographs have some limitations for assessing pneumoconiosis (4). Conventional or spiral computerized tomography (CT) or thin-section CT or combined use of CT and thin-section CT have been shown to detect some cases who are undetectable by chest x-ray (ILO profusion score <1/0) (15, 16). This is partially supported by the higher rate of subjects with respiratory symptoms (83.4%) than the rate of radiologically identified silicosis, keeping in mind that some participants may have had dust-induced bronchitis or that some may have exaggerated their symptoms because of anxiety. On the other hand, low-grade silicosis, only detected at CT, rarely causes respiratory symptoms and it is also possible that some radiologically diagnosed cases of silicosis were incorrect, since smoking, obesity or other lung conditions, such as tuberculosis or exposure to biomass, could have led to some false positive diagnoses. However, such misdiagnoses are unlikely to have been numerous. Although inhalation of cotton or other textile dust is a possibility, the magnitude and, hence, role of such exposure is likely to be small because the main aim of the sandblasting procedure is simply to fade the color of the jeans.

Workers who are exposed to high concentration and longer duration of exposure (17, 18) and who are younger (17, 19) are reported to be more likely to have more progressive radiographic findings than their counterparts. As indicated above, the cases diagnosed as silicosis in this study had had longer exposure duration and possibly high cumulative exposures. Although all three types of work (apprentice, foreman, and chief foreman) were exposed either through their own sandblasting device or that of others, it appeared that only the primary exposure of the foremen (***Figure 3)*** was highly associated with the development of silicosis. In addition, total exposure duration and especially the exposure duration as a foreman were highly correlated with silicosis development. Although younger age has been shown as a risk factor for the development of silicosis, such association could not be established in our study, which may have been because the youngest subjects were working as apprentices and they had no primary or heavy exposure as did the foremen. Thus, they only had secondary exposures. Nevertheless, young age may be responsible for the high frequency of silicosis found in these denim sandblasters due to intrinsic factors such as incomplete maturation of clearance systems or an incomplete lung growth or due to extrinsic factors including their general lack of work experience, unawareness of workplace hazards and how they can be avoided, or their eagerness to do well at work. However, it is not clear which factors are more responsible for the development of silicosis in younger workers. Because most of our cases were young, the manifestation of silicosis in some cases might be explained by predominance of other risk factors than age.

The other parameters that were associated with disease severity were increased number of workplaces worked and decreased number of sandblasting devices in the workplace. It is reasonable to consider that not all the workplaces had equal dust levels because their size, the number of sandblasting devices, ventilation systems, working hours and other protective measurements may vary. The higher the number of workplaces worked, the higher the probability of having worked in places with poor working conditions; thus, some of the workers may have continually changed their workplaces. The apparent paradox that the number of sandblasting devices was inversely related to the risk of silicosis can be explained by the fact that workplaces with more devices not only are more spacious (hence lower dust concentration), but also provide somewhat better working conditions, because unregistered or uninsured workers cannot be employed in workplaces with more sandblasting devices and such larger workplaces are more difficult to keep concealed from inspections.

As expected, the main symptom in our study group was dyspnea because it is the main symptom of silicosis, first noted during exertion and then later at rest. Chest pain and weight loss are unusual characteristics of silicosis, and they are mostly attributed to the other conditions that may be associated with silicosis such as tuberculosis and lung cancer (20), but they were prominent in some of our cases. Although we have previously encountered some tuberculosis cases, misdiagnosed (7) or bacteriologically proven, in this study we did not evaluate the cases for tuberculosis. Back pain, joint and extremity pain were also detected. One may speculate that chest or back pain may be associated with pleural involvement and/or traction of parenchymal fibrosis. However, it is also possible that these symptoms were associated with musculoskeletal problems resulting from poor ergonomic conditions. Other interesting findings were non-respiratory symptoms such as eye, nasal, and ear problems. These kinds of symptoms are more likely to be underestimated due to the predominant respiratory and pulmonary symptoms. Lack of protective measures except a simple mouth-nasal mask and the loud noise in the workplaces may account for the development of such symptoms.

The radiological disease severity was strongly correlated with both FEV_1 and FVC, but not with FEV_1/FVC, thus strengthening the plausibility of the radiological findings. Some studies have shown associations between deteriorating lung function and nodular profusion and coalescence (21, 22). Because our study group was mainly composed of light to moderate smokers, these changes may be attributed to silica exposure alone.

We also performed a further analysis by using a stricter cut-off value for silicosis (profusion of small opacities of 1/1 or higher) since it has been shown that a significant number (up to 11%) of subjects without known exposure to dust have 1/0 small opacities (23). This approach is sometimes used to increase specificity at the expense of decreased sensitivity (23, 24). With this approach our case numbers decreased from 77 (53%) to 58 (40%), fewer parameters were found to be significant (working as foreman, duration of working as foreman and number of workplace), but no single independent risk factor emerged again. Nevertheless, the number of cases with silicosis remained very high.

This study has also some limitations. We were not able to recruit all those who had worked in sandblasting in the two villages, and it is conceivable that the more affected came to our clinic. We tried to avoid such a selection bias by inviting all exposed subjects and providing free transport and procedures. By doing so we were able to recruit a reasonably high proportion of the target population (157 subjects out of an estimated 500), with those not attending often simply being away from home at the time of the survey. The fact that only 14 of the 49 already diagnosed cases attended the survey pleads somewhat against a major selection bias towards participation by the most affected subjects. Our study group may not be representing the whole population of denim sandblasters. The workers from our two villages may have worked in workplaces with worse conditions or they may have started at a younger age than those from other regions or they may even have some genetic predisposition to develop disease. However, there are no indications for any of these possibilities. So, although selection bias cannot be excluded and may have somewhat distorted the association between silicosis and denim sandblasting, this does not invalidate the present findings showing a high frequency of silicosis among denim sandblasters. Another limitation of the study is lack of knowledge on exact dust types, contents, and concentrations in the workplaces. Although we had no possibility to obtain such information, it would be very difficult to reach valid conclusions because many workplaces have different sizes and working conditions. This heterogeneity is probably also responsible for the absence of any independent risk factor among our parameters.

Although whole-lung lavage may be used with the aim of slowing the progression of disease by removing large quantities of dust particles, inflammatory cells, and cytokines from the lung (25), and although lung transplantation may be an option for patients with end-stage disease, silicosis is still considered incurable, and thus focusing on prevention of exposure to silica is mandatory (1, 2, 26). However, this is difficult because there are several problems that need to be solved. The rapid growth in the textile sector, the high rate of unemployment, the lack of awareness of the employers and employees all combine against prevention (27). In addition, a serious problem is the lack of inspection of such workplaces. At the 2006 annual congress of the Turkish Thoracic Society, this issue was extensively evaluated with the contributions of officials from the Turkish Ministry of Labor (9), and in 2007, the ministry prepared a national program for the prevention of pneumoconiosis to be piloted in denim sandblasting areas (28). However, the objectives described in this program (increasing social awareness until 2010, achieving full management of the issue by 2015) are too modest and will not provide an early solution to the problem. Because of the high risk of silicosis in sandblasters and the difficulty in controlling exposures, the use of crystalline silica for blast cleaning operations was prohibited in Great Britain in 1950 [Factories Act 1949] and in other European countries in 1966; this legislative measure has been followed by a reduction in silicosis incidence.

In addition, although no cases have been reported from other countries so far, the problem of denim sandblasting should not be considered as unique to Turkey. It is not impossible that we have only described the tip of a more global iceberg. As indicated above, there are workers from various countries working in Turkish textile factories and workshops, and it is likely that this type of “technology” will be applied in other countries with poor implementation of safety and health at work. Another global concern is that most of the produced sandblasted jeans are worn outside of Turkey.

In conclusion, the epidemic of silicosis due to exposure to silica in sectors like denim sandblasting may exceed the estimations. Although we were able to establish contact with only a small proportion of the ex-workers, the evaluations revealed a significant effect of silica exposure. Because currently in our region, there are no actively working individuals in this sector, the storms seem to have calmed down. Considering the number of workers that could not be contacted (in our region and nationwide), the number of workers with under-recognized disease that is in process but with no radiologic manifestation yet, the number of currently operating sandblasting factories, and the size of the textile industry in Turkey and its continuing trend for expansion, a problem of greater magnitude and severity may be inevitable unless effective measures are taken urgently.

Conflict of Interest

None declared.

Acknowledgements

The authors wish to thank Mr. Muzaffer Gölen, the mayor of Karliova Municipality, the producers of ARENA television program, Mr. Ugur Dundar, the host of the program, and Ms. Hatice Demircan, the reporter of the program, Mr. Murat Sis and Mr. Celal Ercin, the cameramen of the program, the staff of Radiology and Chest Diseases Departments of Ataturk University, Aziziye Research and Teaching Hospital. The authors also thank Mrs. Safak Ugur for editorial help.

References

1. Rees D, Murray J. Silica, silicosis and tuberculosis. Int J Tuberc Lung Dis 2007; 11: 474-484.
2. Wagner GR, Asbestosis and silicosis. Lancet 1997; 349: 1311-1315.
3. Wagner GR. The inexcusable persistence of silicosis. Am J Public Health 1995; 85: 1346-1347.
4. Ooi CGC, Arakawa H. Silicosis. *In*: Gevenois PA, De Vuyst P, eds. Imaging of Occupational and Environmental Disorders of the Chest. Springer, Berlin, 2006; pp. 177-193.
5. Xiao GB, Morinaga K, Wang RY, Zhang X, Ma ZH. World at work: manufacturing 'tatami' mats in China. Occup Environ Med 2004; 61: 372-373.
6. de la Hoz RE, Rosenman K, Borczuk A. Silicosis in dental supply factory workers. Respir Med 2004; 98: 791-794.
7. Akgun M, Gorguner M, Meral M, Turkyilmaz A, Erdogan F, Saglam L, Mirici A. Silicosis caused by sandblasting of jeans in Turkey: a report of two concomitant cases. J Occup Health 2005; 47: 346-349.
8. Akgun M, Mirici A, Yilmazel Ucar E, Kantarci M, Araz O, Gorguner M. Silicosis in Turkish denim sandblasters. Occup Med 2006; 56: 554-558.
9. Cimrin A, Sigsgaard T, Nemery B. Sandblasting jeans kills young people. Eur Respir J 2006; 28: 885-886.
10. Sahbaz S, Inonu H, Ocal S, Yilmaz A, Pazarli C, Yeginsu A, Filiz N, Seyfikli Z. Denim sandblasting and silicosis: two new subsequent cases in Turkey. Tuberk Toraks 2007; 55: 87-91.
11. Horzum G, Oruc K, Calisir HC. Diagnosis through occupational history: a case of silicosis caused by sand rodeo. Akciger Dergisi 2006; 12: 183-187.

12. Quanjer PH, Tammeling GJ, Cotes JE, Pedersen OF, Peslin R, Yernault JC. Lung volumes and forced ventilatory flows. Eur Respir J 1993; 6: Suppl. 16 5–40.

13. International Labour Office (ILO). Guidelines for the use of the ILO international classification of radiographs of pneumoconioses, revised edition 1980. ILO occupational safety and health series, no 22 (rev 80), Geneva.

14. International Labour Office (ILO). Guidelines for the use of the ILO International Classification of Radiographs of Pneumoconioses, rev edn 2000. ILO occupational safety and health series, no 22 (rev), Geneva.

15. Begin R, Ostiguy G, Fillion R, Colman N. Computed tomography in the early detection of silicosis. Am Rev Respir Dis 1991; 144: 697-705.

16. Gevenois PA, Pichot E, Dargent F, Dedeire S, Vande Weyer R, De Vuyst P. Low grade coal worker's pneumoconiosis. Comparison of CT and chest radiography. Acta Radiol 1994; 35: 351-356.

17. Hughes JM, Jones RN, Gilson JC, Hammad YY, Samimi B, Hendrick DJ, Turner-Warwick M, Doll NJ, Weill H. Determinants of progression in sandblasters' silicosis. Ann Occup Hyg 1982; 26: 701-712.

18. Miller BG, Hagen S, Love RG, Soutar CA, Cowie HA, Kidd MW, Robertson A. Risks of silicosis in coalworkers exposed to unusual concentrations of respirable quartz. Occup Environ Med 1998; 55: 52-58.

19. Lee HS, Phoon WH, Ng TP. Radiological progression and its predictive risk factors in silicosis. Occup Environ Med 2001; 58: 467-471.

20. Cowie RL, Murray J, Becklake MR. Pneumoconioses. *In*: Mason RJ, Murray JF, Broaddus VC, Nadel JA, eds. Murray & Nadel's Textbook of Respiratory Medicine, 4th ed, Saunders, Philadelphia, 2005; pp. 748-1782.

21. Bergin CJ, Müller NL, Vedal S, Chang-Yeung M. CT in silicosis: correlation with plain films and pulmonary function tests. AJR Am J Roentgenol 1986; 146: 477-483.

22. Ooi GC, Tsang KW,Cheung TF, Khong PL, Ho IW, Ip MS, Tam CM, Ngan H, Lam WK, Chan FL, Chan-Yeung M. Silicosis in 76 men: qualitative and quantitative CT evaluation: clinical-radiologic correlation study. Radiology 2003; 228: 816-825.

23. Epstein DM, Miller WT, Bresnitz EA, Levine MS, Gefter WB. Application of ILO classification to a population without industrial exposure: findings to be differentiated from pneumoconiosis. AJR Am J Roentgenol 1984; 142: 53-58.

24. Akkurt I, Onal B, Demir AU, Tuzun D, Sabir H, Ulusoy L, Karadag KO, Ersoy N, Coplu L. Respiratory health in Turkish asbestos cement workers: the role of environmental exposure. Am J Ind Med 2006; 49: 609-616.

25. Wilt JL, Banks DE, Weissman DN, Parker JE, Vallyathan V, Castranova V, Dedhia HV, Stulken E, Ma JHK, Ma JYC, Cruzzavala J, Shumaker J, Childress CP, Lapp L. Reduction of lung dust burden in pneumoconiosis by whole-lung lavage. Occup Environ Med 1996; 38: 619-624.

26. De Vuyst P, Camus P. The past and present of pneumoconioses. Curr Opin Pulm Med 2000; 6: 151-156.

27. Cimrin A. ‘Silicosis’ over again; causes and responsibilities. Tuberk Toraks 2007; 55: 118-122.

28. National pneumoconiosis prevention action plan. Date issued: 7 December 2006. Available at http://isggm.calisma.gov.tr/. Date last accessed: 2 July 2007.

Table 1. Demographic and exposure characteristics and pulmonary function test results of 157 subjects with a previous experience in sandblasting

	Mean ± SD (range) or n (%)
Age (years)	23 ± 6 (15-44)
Age at first exposure to sandblasting (years)	17 ± 6 (10-38)
Total exposure duration (months)	36 ± 25 (1-120)
Duration since the last exposure (months)	43 ± 28 (10-144)
Latency period (time elapsed since the beginning of exposure) (months)	79 ± 35 (12-192)
Number of various workplaces worked	3 ± 2 (1-12)
Number of sandblasting devices at the workplace	4 ± 1 (2 - 12)
Smokers or ex-smokers	106 (67.5%)
Smoking as pack-years in smokers	7.3 ± 4.4 (1-23)
Sleeping over at the workplace	129 (82.2%)
Working as a foreman	126 (80.3%)
Seniority in working as a foreman (months)	33 ± 28 (0-117)
FEV_1 (L)	3.92 ± 0.87
FEV_1 (% predicted)	97.4 ± 22.5
FVC (L)	4.53 ± 0.93
FVC (% predicted)	95.6 ± 21.9
FEV_1/FVC (%)	86.8 ± 9.6

Table 2 Symptoms in 157 subjects with a previous experience in sandblasting

	n (%)
Asymptomatic	26 (16.6)
Symptomatic	131 (83.4)
Dyspnea	81 (51.6)
Chest pain	72 (45.9)
Chronic cough	30 (19.1)
Weight loss	24 (15.3)
Malaise	20 (12.7)
Back pain	17 (10.8)
Sputum	11 (7.0)
Joint or extremity pain	7 (4.5)
Other complaints*	22 (14.0)

* Other complaints in decreasing frequency (eye complaints, nasal complaints including epistaxis, hearing loss, mouth or throat dryness, headache, dizziness, diffuse pain and hemoptysis)

Table 3 Chest x-ray results according to ILO classification in 145 subjects* with a previous experience in sandblasting

	n (%)	Total exposure duration (months)	Latency period (months)
Profusion of small opacities			
Category 0 **0/-** (*n=52*), **0/0** (*n=3*), **0/1** (*n=13*)	68 (46.9)	32 ± 27	73 ± 34
Category 1 **1/0** (*n=19*), **1/1** (*n=9*), **1/2** (*n=7*)	35 (24.1)	42 ± 23	98 ± 33
Category 2 **2/1** (*n=4*), **2/2** (*n=2*), **2/3** (*n=10*)	16 (11.0)	45 ± 30	92 ± 36
Category 3 **3/2** (*n=8*), **3/3** (*n=6*), **3/+** (*n=12*)	26 (17.9)	38 ± 19	66 ± 28
Large opacities	14 (9.6)		
Type A Type B Type C	6 3 5		

* A total of 145 cases were evaluated according to ILO classification (two chest x-rays were unavailable and 10 chest x-rays were of poor quality). Latency period is time elapsed since the beginning of exposure.

Table 4 Comparison of demographic and exposure characteristics and pulmonary function test results of the subjects with or without silicosis

	No silicosis (n=68)	With silicosis (n=77)	*P* value
Age (years)	23 ± 6	23 ±5	0.95
Age at first exposure to sandblasting (years)	17 ±6	16 ±5	0.28
Total exposure duration (months)	32 ±27	41 ±23	**<0.05**
Duration since the last exposure (months)	41 ±28	44 ±28	0.51
Latency period (time elapsed since the beginning of exposure) (months)	73 ± 34	86 ± 35	**<0.05**
Number of various workplaces worked	2.2 ±1.3	3.0 ±0.7	**<0.05**
Number of sandblasting devices at the workplace	4.2 ±1.5	3.7 ±0.7	**<0.05**
Smokers or ex-smokers	43 (63%)	57 (74%)	0.16
Smoking as pack-years in smokers	6.8 ±4.3	7.9 ±4.6	0.23
Sleeping over at the workplace	58 (85%)	67 (87%)	0.77
Working as a foreman	51 (75%)	73 (95%)	**<0.001**
Seniority in working as a foreman (months)	26 ±28	46 ±25	**<0.01**
Symptomatic	57 (84%)	66 (86%)	0.75
FEV_1 (L)	4.22 ±0.71	3.66 ±0.96	<0.001
FEV_1 (% predicted)	105.6 ±18.7	89.8 ±23.4	<0.001
FVC (L)	4.84 ± 0.74	4.27 ±1.04	<0.001
FVC (% predicted)	103.4 ±19.9	88.5 ±21.1	<0.001
FEV_1/FVC (%)	87.6 ± 9.5	86.3 ± 9.5	0.44

Legends

Figure 1. Map of Turkey showing the cities, Bingol, Erzurum and Istanbul, and the villages, Toklular and Taslicay, involved in the study.

Figure 2a. Number of subjects reporting being employed in denim sandblasting workshops in each calendar year.

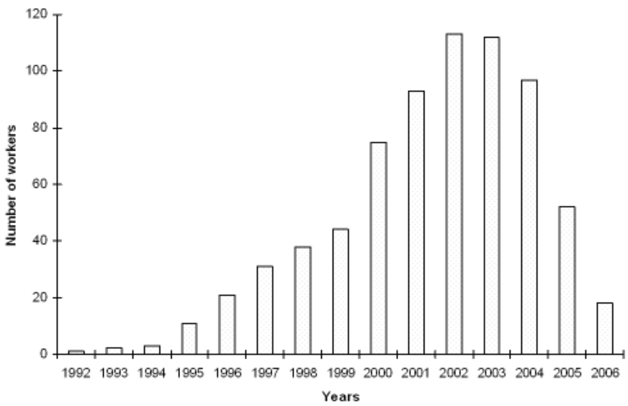

Figure 2b. Distribution of age at first exposure of ex-workers of denim sandblasting. The low number of workers around 20 y may be accounted for by leaving work because of mandatory military service. The first peak is of apprentices and the second peak is of foremen.

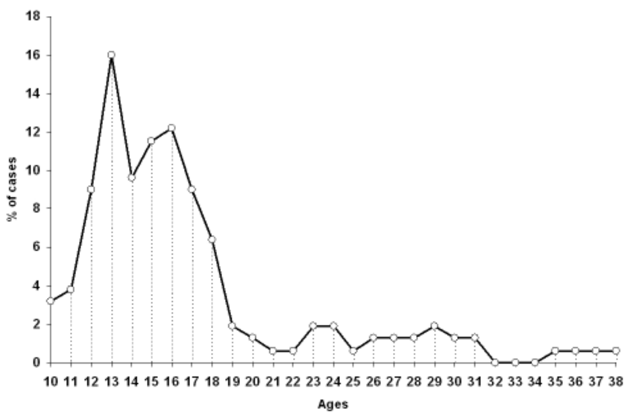

Figure 3. Various images of the workplaces. The number of sandblasting devices varies between 2 and 12. The number of clothing items sandblasted a day by one worker is as high

as 5000 depending on the size of the item. The pictures were obtained from a TV program (ARENA) with kind permission of the Coordinator of the program from two National Turkish Television Channels, Kanal D and CNN Turk.

Figure 4. Two chest x-rays belonging to two different ex-sandblasters of denims.