International Journal of Occupational Medicine and Environmental Health 2009;22(1):43–50
DOI 10.2478/v10001-009-0008-5

OCCUPATIONAL EXPOSURE TO WOOD DUST AND HEALTH EFFECTS ON THE RESPIRATORY SYSTEM IN A MINOR INDUSTRIAL ESTATE IN BURSA/TURKEY

ERDINÇ OSMAN[1] and KAYIHAN PALA[2]

[1] Bursa City Health Directorate, Bursa/Turkey
Department of Communicable Disease
[2] Uludag University, Bursa/Turkey
Faculty of Medicine Department of Public Health

Abstract
Objectives: The aim of this study was to estimate occupational exposure to wood dust in the furniture industry in a minor industrial estate in Bursa/Turkey. **Materials and Methods:** The study was conducted between October 2006 and May 2007. In this study, a total of 656 persons, 328 woodworkers and 328 controls were included. A questionnaire was used in the study. Physical examination and the pulmonary function tests (MIR-Spirobank G) of the workers were performed. A portable Aircheck 2000 pump was used to collect the specimens of wood dust from the workplaces. NIOSH Method 0500 was employed for the gravimetric measurements of dust. **Results:** The average dust concentration at the workplace was 2.04±1.53 mg/m^3. It was reported that 176 of workers (53.7%) had blocked nose while working, 141 (43.0%) had redness of the eyes, 135 (41.2%) had itching eyes and 78 (23.8%) had runny nose. No symptoms were observed in the control group while they were working at the workplace. The mean FEV_1 and FVC values of woodworkers, among both smokers and non smokers, were significantly low, although the FEV_1/FVC value was high ($p < 0.05$). An increase both in FEV_1 and FVC values was detected among the woodworkers who had a working period less than 10 years and were exposed to wood dust at concentrations over 4 mg/m^3 compared to the woodworkers who were exposed to wood dust at less than 4 mg/m^3 ($p < 0.05$). **Conclusions:** As a result, in this study it was pointed out that the exposure to wood dust adversely influenced the workers respiratory functions. Besides, in this study a question associated with the healthy worker effect that can adversely influence health of workers exposed to wood dust at less than (4 mg/m^3) is revealed.

Key words:
Wood dust, Occupational exposure, Pulmonary function tests

INTRODUCTION

It is estimated that at least 2 million people are exposed to wood dusts every day [1,2] around the world. In general, wood dust exposure deteriorates pulmonary functions, increases the prevalence of respiratory diseases, exacerbates existing illnesses, increases cancer incidence and deaths [1–7]. International Agency for Research on Cancer (IARC) reports that wood dust causes cancer and included it in 1995 into Group 1 carcinogens [1]. Besides, wood contains many microorganisms (including fungi), toxins and chemical substances and they may significantly affect human health [1,2,8–10]. It is recognised that those agents may cause irritation of oral cavity and throat, tightness of the chest, irritant dermatitis, urticaria, alveolitis, deterioration of pulmonary functions, and a reduction of FEV_1 [1,2,7,10–16].

Basic tools for evaluating the effect of exposure on respiratory system include pulmonary function tests [1,2]. Many

Received: September 26, 2008. Accepted: March 4, 2009.
Address reprint requests to K. Pala, Department of Public Health, Uludag University Faculty of Medicine, 16059 Gorukle, Bursa, Turkey (e-mail: kpala@uludag.edu.tr).

studies on workers in furniture manufacturing sector evidenced that upper and lower respiratory system symptoms increased in people exposed to wood dust [3,16–23]. Also, these symptoms are related to the exposure levels and seen frequently in cases of exposures higher than 5 mg/m^3 [3,17].

Woodworking industry has developed in Turkey; however, studies on exposures to wood dust are limited. The threshold value for hard wood dust exposure as specified in the regulation on 'Health and Safety Measures for Working with Carcinogenic and Mutagenic Materials', which was put into effect in 2003 in Turkey, is 5 mg/m^3 [24]. United States National Institute of Occupational Health and Safety (NIOSH) recommends that wood dust concentration should not exceed 1 mg/m^3 in the working atmosphere for a 8-hour working period [25]. The threshold value in Turkey is higher than that specified by NIOSH and scientific studies on the effects of this higher threshold value are required.

The aims of this study were to estimate occupational exposure to wood dust in the furniture industry in a minor industrial estate in Bursa/Turkey, and to compare the pulmonary function of workers working in furniture industry with those of controls and to evaluate the influence of such occupational exposure.

MATERIALS AND METHODS

The research is a cross-sectional descriptive epidemiological study performed between 04 October 2006 and 30 May 2007 in Bursa Beşevler Minor Industrial Zone. Bursa is situated in western Turkey and it is fourth largest city in Turkey. Bursa Beşevler Minor Industrial Zone was established in Nilüfer District on an area of 1.243.000 m^2 in 1979. It comprises 2800 minor factories belonging to four main sectors (automotive supply industry, metal and furniture manufacturing and sale). There are 45 small furniture manufacturing factories in it and 333 male workers are employed in them.

It was planned to include all workers in the study. However, four workers could not be seen despite three visits to their workplaces, while one refused to participate. Finally 328 workers (98.5%) were included. Three hundred twenty eight male workers working in furniture sale stores were selected as the control group. Although they are employed in the furniture business, they have not been exposed to wood dust.

A questionnaire containing 25 questions was used in the study. The questionnaire included questions relating to the workers' demographic data, smoking status, medical history, occupational background, personal protective equipment usage status and complaints about work. The questionnaire was filled during face-to-face interviews.

Pulmonary function test by spirometry

Pulmonary function tests were performed by the researchers at least three times for each subject in a sitting position with closed nostrils using MIR — Spirobank G (Italy) spirometer and with a different mouthpiece for each subject. A practical presentation about the test and the way it is done was performed for the subjects before the test. The tests were performed according to the test procedure of The European Respiratory Society [26]. FEV_1, FVC, FEV_1/FVC and FEF_{25-75} values were measured three times and the best result of the three measurements was recorded.

Wood dust measurement

Portable Aircheck 2000 (SKC Inc, Aircheck 2000, Valley View Road, PA USA) pump was used for collecting airborne wood dust sample from the workplaces. NIOSH Method 0500, Gravimetric measurement method was used in dust measurements [27]. The following formula recommended in NIOSH Method 0500 was used to estimate wood dust level in the atmosphere:

$$C = \frac{(W_2 - W_1) - (B_2 - B_1) \times 10^3}{V} \text{ mg/m}^3 \qquad (1)$$

Where:

C — Total dust concentration,

W_1 — Empty filter weight before dust collection process (mg),

W_2 — Filter weight after dust collection process (mg),

B_1 — Average Empty filter weight (mg),

B_2 — Average filter weight after dust collection process (mg),
V — Volume (litre).

A PVC 37 mm dia. filter (SKC Inc., 5.0 μm) was used to collect wood dust. To collect the sample, a pump was placed on a worker working in a randomly selected point at the workplace and the flow rate was set at 2 l/min [27]. Samples were collected from wherever the worker went during 8 hours without interruption. The dust amount for this randomly selected worker was assumed to be the same for all workers working at the same workplace and factory. For the control group, dust measurements were done in three workplaces in which the number of workers was highest and the average was accepted for all subjects of the control group. Dust collection apparatus was calibrated after each three measurements. The filter was weighted with the help of a GecAvery (Model VA 304–x0.0001) balance with a precision of 0.0001 g before and after dust collection process.

Ethics

The study was accepted by the Ethical Committee of Uludag University's Faculty of Medicine (2006–19/20).

Statistical analysis

The data were evaluated by SPSS (Version 13.0) statistics software. In the statistical analysis chi-square and student's t-test were used. Statistically significant level was set at $p < 0.05$.

Limitations of the study

The effects of wood dust on respiratory system only were considered in this study. Its carcinogenic and toxic effects were disregarded.

The amount of dust to which only one worker was exposed was used for all workers working at the same workplace for determining workers' occupational exposure to wood dust. Exposure level for each worker working in that place could not be determined due to shortage of the financial resources. Dust measurements were performed only for three working places for the control group for the same reason.

RESULTS

In total, 656 workers, 328 of them working in factories (study group) and the remaining employed in stores (control) were included in the study. Some characteristics of the subjects are seen in Table 1.

Average weekly working time of the workers was 50.3±2.2 hours. Most frequently used wood and/or wooden product types were medium-density fibreboard (MDF) (68.6%; n = 225), beech (11.6%; n = 38), pine (10.4%; n = 34) and fibreboard (6.1%; n = 20). None of these workplaces were provided with a ventilation system.

Most frequently used personal protective equipment were dust mask (17.4%) and goggles to protect the eyes (10.7%). Overall and working clothes were used by 7.6% and 3.4% of the workers, respectively.

Average wood dust concentrations measured at the workplaces of subjects and controls were 2.04±1.53 mg/m^3

Table 1. Some characteristics of the subjects

Characteristics	Furniture workers (n = 328)		Controls (n = 328)	
	n	%	n	%
Age groups (years)				
16–35	182	55.5	162	49.4
36–55	127	38.7	142	43.3
56+	19	5.8	24	7.3
Education				
8 years or less	225	68.6	221	67.3
Occupational training				
Yes*	146	44.5	38	11.6
Marital status				
Married*	226	68.9	291	88.7
Health insurance				
No insurance*	13	4.0	95	29.0
Smoking habit				
Exsmoker	27	8.2	23	7.0
Current smoker	186	56.7	210	64.0
Working time				
10 years and over*	203	61.9	158	48.2

* $p < 0.05$

Table 2. Wood dust levels measured in the study

Dust level (mg/m^3)	Working group		Control Group	
	n	%	n	%
0–0.99	102	31.1	328	100.0
1–1.99	78	23.8	–	–
2–2.99	65	19.8	–	–
3–3.99	44	13.4	–	–
4–4.99	8	2.4	–	–
5+	31	9.5	–	–
Total	328	100.0	328	100.0

Table 3. Complaints of the workers according to the working years

Complaints	Working years				P
	Less than 10 years (n = 110)		10 years or more (n = 218)		
	n	%	n	%	
Itching eyes	30	27.3	105	48.2	0.000
Redness of the eyes	30	27.3	111	50.9	0.000
Rhinorrhea	3	2.7	18	8.3	0.039
Nasal blockade	39	35.5	137	62.8	0.000
Runny nose	19	17.3	59	27.1	0.032

and 0.0006 ± 0.00025 mg/m^3, respectively ($p < 0.001$). Wood dust levels are seen in Table 2.

One hundred seventy six of the workers (53.7%) stated that they had experienced blocked nose, 141 of them (43.0%) had red eyes, 135 (41.2%) had itching eyes and 78 (23.8%) runny nose. The complaints of itching eyes, redness of the eyes, rhinorrhea, blocked and runny nose were more frequent among workers working for ten years or more than those working for less than ten years (Table 3). In the control group, no health complaints during work were reported.

The subjects said that these complaints did not exist before and occurred after they had started to work at places in which woods and wooden materials were processed. According to the workers, with the exception of one, who had asthma treatment and suffered breath-arrest, their symptoms decreased during weekends and holidays.

Mean values of the FEV_1 and FVC in the furniture workers were significantly lower than those in the control group; however, FEV_1/FVC values were higher. Spirometric values obtained for the woodworking and control group are seen in Table 4.

When the relation between personal protective equipment usage of the workers and the spirometric values were analysed, $FEF_{25–75}$ was found to be significantly higher for

Table 4. Spirometric parameters of exposed workers and the controls

Groups	FEV_1	FVC	FEV_1/FVC	$FEF_{25–75}$
Controls (n = 328)	96.4 (94.9–98.0)	85.0 (83.6–86.5)	93.7 (93.1–94.3)	118.5 (115.6–121.4)
Furniture workers (n = 328)	89.4 (87.6–91.1)***	78.2 (76.6–79.7)***	95.9 (95.3–96.5)***	112.5 (109.6–115.5)**
Non–smokers				
Controls (n = 95)	96.0 (93.0–99.0)	84.5 (81.7–87.4)	93.7 (92.5–94.8)	118.0 (113.0–122.9)
Furniture workers (n = 115)	90.1 (87.5–92.7)**	79.0 (76.6–81.4)**	96.1 (95.2–97.1)***	113.5 (108.9–118.1)
Current or exsmokers				
Controls (n = 233)	96.6 (94.8–98.4)	85.2 (83.6–86.9)	93.7 (93.0–94.5)	118.7 (115.1–122.3)
Furniture workers (n = 213)	89.0 (86.7–91.3)***	77.8 (75.7–79.8)***	95.8 (95.0–96.5)***	112.0 (108.2–115.8)*

FVC, FEV_1, FEV_1/FVC and $FEF_{25–75}$ are mean (CI 95%) % predicted.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Table 5. Spirometric parameters of the exposed workers according to the dust levels at their workplaces

Working time	Dust level (mg/m^3)	FEV_1	FVC	FEV_1/FVC	FEF_{25-75}
Less than 10 years (n = 125)	< 4 (n = 111)	87.0 (84.0–89.9)	76.7 (73.9–79.5)	96.8 (95.8–97.9)	108.7 (104.1–113.3)
	≥ 4 (n = 14)	96.7* (90.6–102.7)	85.0* (79.2–90.8)	97.2 (95.2–99.3)	115.8 (104.1–127.5)
	< 5 (n = 113)	87.2 (84.3–90.1)	76.9 (74.1–79.7)	96.9 (95.8–97.9)	109.2 (104.6–113.9)
	≥ 5 (n = 12)	96.2 (89.2–103.2)	84.9 (78.0–91.7)	96.8 (94.5–99.1)	111.9 (99.8–124.0)
10 years or more (n = 203)	< 4 (n = 178)	89.9 (87.5–92.3)	78.1 (76.0–80.3)	95.6 (94.9–96.3)	114.0 (109.8–118.2)
	≥ 4 (n = 25)	92.4 (86.0–98.8)	81.1 (75.8–86.5)	93.2* (90.6–95.9)	117.0 (104.2–129.8)
	< 5 (n = 184)	90.2 (87.8–92.6)	78.3 (76.2–80.4)	95.6 (94.9–96.3)	114.3 (110.2–118.5)
	≥ 5 (n = 19)	90.8 (84.7–97.0)	80.3 (74.7–85.8)	92.6* (89.6–95.5)	114.9 (100.6–129.1)

* $p < 0.05$.

the workers who used dust mask < 0.001). There was no statistically significant relationship between other personal protective equipment and spirometric values.

Spirometric values for the furniture workers according to the dust levels in their working places and their working time are given in Table 5.

DISCUSSION

Average wood dust amount to which the workers were exposed in their working places was 2.04±1.53 mg/m^3. Surprisingly, no ventilation system existed at any of those workplaces. As much as 9.5% of the workers were exposed to wood dust at concentrations exceeding the threshold value specified for Turkey (5 mg/m^3). Kauppinen et al. [28] conducted a study including 3.6 million workers from 25 European countries who were thought to be affected by wood dust. They detected that 16% of the workers were exposed to respirable wood dust at various levels higher than 5 mg/m^3. As much as 79% of the workers were exposed to respirable wood dust at level higher than 0.5 mg/m^3, the maximum admissible respirable wood dust level recommended by The Scientific Committee for Occupational Exposure Limits. The percentage of those exposed to wood dust higher than 5 mg/m^3 in our study is lower than that in the study by Kauppinen. This may be caused by the fact that the subjects of our study included furniture workers employed only in one industrial zone.

We found that most frequent health complaints were itching eyes, redness of the eyes, nasal blockade and runny nose. Other studies also found that complaints concerning eyes and nose were most frequent [9,11,19,20,22,30]. We also have found that, the complaints of redness of the eyes, rhinorrhea, nasal blockade, runny nose and sore throat were more frequent among the workers working for 10 years or more compared with those working for less than 10 years. Milanowski et al. [19] found in their study on carpenters in Poland, in which they compared the workers working for 5 years or more with those working for less than 5 years that the complaints about eye, skin and nose did not increase with longer exposure time.

It was found in the study that mean FEV_1 and FVC values of the furniture workers were significantly lower than those of the control group; however, FEV_1/FVC values were higher. In their studies Meo et al. [29] and Milanowski et al. [19] found decreases in FEV_1 and FVC of the workers exposed to wood dust compared with the control group. Mandryk et al. [30] found lower FEV_1, FVC and FEF_{25-75} values for sawmill workers in their study. The findings obtained from our study are concordant with literature data. Exposure to wood dust caused decreases in pulmonary functions of the workers.

In comparing of smokers and non-smokers for FEV_1 and FVC, we found decreases in FEV_1, FVC and FEF_{25-75} for the smokers. Milanowski et al. [19] found decreases in FEV_1 and FVC values for both smokers and non-smokers in their study. Liou et al. [31] found lower FEF_{25-75}

values for both smokers and non-smokers exposed to wood dust compared with the control group in their study conducted in Taiwan.

Considering comparisons between workers' protective mask using status and pulmonary function tests for the working group, we found a significant decrease only in FEF_{25-75} values for the subjects who did not use mask. Erkinjuntti-Pekkanen et al. in their study performed on welders in New Zealand [32] found significantly lower annual FEV_1 and FVC values for the workers who did not use personal protective equipment, compared with those using them. Wang et al. [33] in their study conducted in America among coal miners found lower FEV_1 values for workers who did not use respiratory protective equipment.

In our study, we found increases in FEV_1 and FVC values for the workers working for less than 10 years and exposed to wood dust at concentrations higher than 4 mg/m^3 compared with those exposed to wood dust at lower levels (Table 5). In fact, this is an unexpected finding. We also found lower FEV_1/FVC values for the workers working for more than 10 years and who were exposed to wood dust at concentrations higher than 4 mg/m^3 and 5 mg/m^3 compared with those exposed to wood dust at lower values. In previous studies, Schlünssen et al. [15] found decreases in FEV_1 and FVC values for ex-smoker workers who were exposed to wood dust at higher levels compared with those exposed to wood dust at lower levels while any significant variation was not seen in any pulmonary function parameter for other workers in Denmark. Whitehead et al. [34] found lower FEV_1/FVC values for the workers who were exposed to wood dust at higher values compared with those exposed at lower levels in their study. Such correlation could not be found between pulmonary function tests and cumulative dust concentrations in the study of Bodahana et al. [35]. Vedal et al. [36] found statistically significantly lower FEV_1 and FVC values for the workers who were exposed to dust at high levels compared with those exposed to it at lower values in their study on the workers working with Western Red Cedar wood in Canada. In our study, we believed that this unexpected finding may be explained by the healthy worker effect. The healthy worker effect in these particular circumstances is the fact that the workers, whose health had deteriorated from exposure to wood dust were excluded from the employment. More detailed studies may be necessary to clarify that point.

As a result, this study shows that exposure to wood dust detrimentally affects workers' pulmonary functions. A question was raised in connection with the healthy worker effect discussed in this study whether workers' health may be detrimentally affected at concentrations lower than threshold value for exposure to wood dust specified in Turkey (4 mg/m^3). More detailed studies on exposure to wood dust in Turkey should be undertaken.

ACKNOWLEDGEMENTS

This study was supported by Uludag University Rectorship. We would like to thank Uludag University Science-Literature Faculty Chemistry Department for their kind help during dust measurements and The Chamber of Furniture Manufacturers in Minor Industrial Zone in Bursa/Turkey.

REFERENCES

1. World Health Organization, International Agency For Research On Cancer. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Wood Dust and Formaldehyde*. WHO 1997. Available from: URL: http://monographs.iarc.fr/ENG/Monographs/vol62/volume62.pdf.
2. U.S. Department of Health and Human Services, Public Health Service National Toxicology Program. *Final Report on Carcinogens Background Document for Wood Dust. Department 2000*. Available from: URL: http://ntp.niehs.nih.gov/ntp/newhomeroc/roc10/WD.pdf.
3. Schlünssen V, Schaumburg I, Andersen NT, Sigsgaard T, Pedersen OF. *Nasal Patency is Related to Dust Exposure in Woodworkers*. Occup Environ Med 2002;59:23–9.
4. Demers PA, Teschke K, Kennedy SM. *What to Do About Softwood? A Review of Respiratory Effects and Recommendations Regarding Exposure Limits*. Am J Ind Med 1997;31:385–98.
5. Cormier Y, Merlaux A, Duchaine C. *Respiratory Health Impact of Working in Sawmills in Eastern Canada*. Arch Environ Health 2000;55(6):424–30.

6. Demers PA, Stellman SD, Colin D, Boffetta P. *Non-malignant Respiratory Disease Mortality Among Woodworkers Participating in the American Cancer Society Cancer Prevention Study-II (CPS-II).* Am J Ind Med 1998;34:238–43.
7. *Psychosocial and Organizational Factors. Encyclopaedia of Occupational Health and Safety.* 4th ed. Vol II. Geneva: International Labour Office; 1998. p. 2–34.
8. Mandryk J, Alwis KU, Hocking AD. *Work-Related Symptoms and Dose-Response Relationships for Personal Exposures and Pulmonary Function among Woodworkers*. Am J Ind Med 1999;35:481–90.
9. Douwes J, McLean D, Slater T, Pearce N. *Asthma and Other Respiratory Symptoms in New Zealand Pine Processing Sawmill Workers*. Am J Ind Med 2001;8:608–15.
10. Edman K, Löfstedt H, Berg P, Erıksson K, Axelsson S, Bryngelsson I, et al. *Exposure Assessment to α and β-Pinene, Δ3-Carene and Wood Dust in Industrial Production of Wood Pellets*. Ann Occup Hyg 2003;47(3):219–26.
11. Alwis KU, Mandryk J, Hocking AD. *Exposure to Biohazards in Wood Dust: Bacteria, Fungi, Endotoxins, and (1→3)-β-D-Glucans*. Occup Environ Hyg 1999;14(9):598–608.
12. Chung KYK, Cuthbert J, Revell GS, Wassel SG, Summers N. *A Study on Dust Emission, Particle Size Distribution and Formaldehyde Concentration During Machining of Medium Density Fibreboard*. Ann Occup Hyg 2000;44(6):455–66.
13. Hursthouse A, Allen F, Rowley L, Smith F. *A Pilot Study of Personnel Exposure to Respirable and Inhalable Dust During the Sanding and Sawing of Medium Density Fibreboard (MDF) and Soft Wood*. Int J Environ Health Res 2004;14(4):323–6.
14. Priha E, Pennanen S, Rantio T, Uitti J, Liesivuori J. *Exposure to and Acute Effects of Medium-Density Fiber Board Dust*. J Occup Environ Hyg 2004;1:738–44.
15. Schlünssen V, Schaumburg I, Taudorf E, Mikkelsen AB, Sigsgaard T. *Respiratory Symptoms and Lung Function Among Danish Woodworkers*. J Occup Environ Med 2002;44: 82–98.
16. Alwis KU. *Occupational Exposure to Wood Dust. Department of Public Health and Community Medicine Faculty of Medicine the University of Sydney, New South Wales, Australia 1998*. Available from: URL: http://ses.library.usyd.edu.au/bitstream/2123/392/1/adt-NU1999.0018front.pdf.
17. Fransman W, Mclean D, Douwes J, Demers PA, Leung V, Pearce N. *Respiratory Symptoms and Occupational Exposures in New Zealand Plywood Mill Workers*. Ann Occup Hyg 2003;47(4):287–95.
18. Hessel PA, Herbert A, Melenka LS, Yoshida K, Michaelchuk D, Nakaza M. *Lung Health in Sawmill Workers, Exposed to Pine and Spruce*. Chest 1995;108:642.
19. Milanowski J, Gora A, Skorska C, Traczyj-Krysinska E, Mackievicz B, Sitkowska J, et al. *Work-Related Symptoms Among Furniture Factory Workers in Lublin Region (Eastern Poland).* Ann Agric Environ Med 2002;9:99–103.
20. Arbak P, Bilgin C, Balbay O, Yeşildal N, Annakkaya AN, Ulger F. *Respiratory Symptoms and Peak Expiratory Flow Rates Among Furniture-Decoration Students*. Ann Agric Environ Med 2004;11:13–7.
21. Chan-Yeung M, Ashley MJ, Corey P, Wilson G, Dorken E, Grzybowski S. *A Respiratory Survey of Cedar Mill Workers. I. Prevalence of Symptoms and Pulmonary Function Abnormalities*. J Occup Med 1978;20(5):323–7.
22. Pisaniello DL, Connell KE, Muriale L. *Wood Dust Exposure During Furniture Manufacture — Results from an Australian Survey and Considerations for Threshold Limit Value Development*. Am Ind Hyg Assoc J 1991;52(11):485–92.
23. Halpin DM, Graneek BJ, Lacey J, Nieuwenhuijsen MJ, Williamson PA, Venables KM, et al. *Respiratory Symptoms, Immunological Responses, and Aeroallergen Concentrations at a Sawmill*. J Occup Environ Med 1994;51(3):165–72.
24. *Regulation on Protection of Workers from Risks Related to Exposure to Carcinogen and Mutagen Substances at Work 2003*. Available from: URL: http://www.isguvenligi.net/mevzuat/4857_isig_yonetmelikleri/kansorejen_mutajen_mcsgoh.pdf [in Turkish].
25. McCammon C. *NIOSH Health Hazard Evaluation Report 93-700.* 1993. Available from: URL: http://www.cdc.gov/niosh/hhe/reports/pdfs/1993-0700-2335.pdf.
26. Miller MR, Hankinson J, Brusasco V, Burgos F, Casaburi R, Coates A, et al. *Standardisation of Spirometry*. Eur Respir J 2005;26(2):319–38.
27. *NIOSH Manual of Analytical Methods (NMAM). Particulates Not Otherwise Regulated, Total: Method 0500.* 1994. Available from: URL: http://www.cdc.gov/NIOSH/nmam/pdfs/0500.pdf.

28. Kauppinen T, Vincent R, Liukkonen T, Grzebyk M, Kauppinen A, Welling I, et al. *Occupational Exposure to Inhalable Wood Dust in the Member States of the European Union*. Ann Occup Hyg 2006;50(6):549–61.
29. Meo SA. *Lung Function in Pakistani Wood Workers*. Int J Environ Health Res 2006;16(3):193–203.
30. Mandryk J, Alwis KU, Hocking AD. *Effects of Personal Exposures on Pulmonary Function and Work-Related Symptoms Among Sawmill Workers*. Ann Occup Hyg 2000;44(4): 281–9.
31. Liou SH, Cheng SY, Lai FM, Yang JL. *Respiratory Symptoms and Pulmonary Function in Mill Workers Exposed to Wood Dust*. Am J Ind Med 1996;30(3):293–9.
32. Erkinjuntti-Pekkanen R, Slater T, Cheng S, Fishwick D, Bradshaw L, Kimbell Dunn M, et al. *Two Year Follow Up of Pulmonary Function Values Among Welders in New Zealand*. Occup Environ Med 1999;56:328–33.
33. Wang ML, Petsonk EL, Beeckman LA, Wagner GR. *Clinically Important FEV1 Declines Among Coal Miners: an Exploration of Previously Unrecognised Determinants*. Occup Environ Med 1999;56:837–44.
34. Whitehead LW, Ashikaga T, Vacek P. *Pulmonary Function Status of Workers Exposed to Hardwood or Pine Dust*. Am Ind Hyg Assoc J 1981;42:178–86.
35. Bohadana AB, Massin N, Wild P, Toamain J, Engel S, Goutet P. Symptoms, *Airway Responsiveness, and Exposure To Dust in Beech and Oak Wood Workers*. J Occup Environ Med 2000;57:268–73.
36. Vedal S, Chan-Yeung M, Enarson D, Fera T, Maclean L, Tse KS. *Symptoms and Pulmonary Function in Western Red Cedar Workers Related to Duration of Employment and Dust Exposure*. Arch Environ Health 1986;41(3):179–83.