Relationship between Employees' Perception of Airborne Wood Dust and Ventilation Applications in Micro-Scale Enterprises Producing Furniture

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Excessive inhalation of airborne wood dust has a negative impact on employees' health and is a common issue. There are available hazard control methods to protect workers from exposure to airborne wood dust. These methods include ventilation of the workplace and the use of personal protective equipment against dust. In this study, micro-scale furniture manufacturing enterprises were investigated because the sector and the scale of the enterprise are among the factors affecting the exposure to dust. A structured questionnaire was conducted by face-to-face interview method in this study. In addition, workplaces and working conditions of 53 enterprises were observed during on-site visits to conduct the questionnaires. The relationship between categorical variables was investigated using the Chi-square test. Among the interviewed employees, 9.4% were not concerned about the harmful impact of solid wood dust on health. The least used ventilation method was local exhaust ventilation, and at any interviewed site the occupational exposure limit value to dust was unknown. Medium density fibreboard was the most preferred raw material. Because wood dust was generally underestimated as an occupational health risk factor, this study concludes that ventilation applications that reduce exposure to dust were also insufficient.

Keywords: Wood dust; Ventilation; Furniture; Micro-scale enterprises

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INTRODUCTION

One of the basic exposure and occupational hazard factors is dust. The main reason for the release of harmful dust at the workplace is material processing. Wood processing methods, such as sawing, sanding, and drilling result in dust formation (Mikkelsen *et al.* 2002; Baran and Teul 2007; Rogoziński *et al.* 2015). Workers in furniture and cabinetmaking industries are usually exposed to hardwood dust. The size distribution and airborne concentration of wood dust depends on the type of machinery, work, accessories, tools, and water content in the raw material (Martin and Zalk 1997). Yuan *et al.* (2014) classified wood dust into two major groups: cutting and sanding dust particulates.

Although wood dust, noise, chemicals, and poor lighting are well-known work atmosphere risk factors, they have not been controlled effectively (Reinhold *et al.* 2015). In enterprises producing furniture out of medium density fiberboard (MDF) and chipboard, wood dust is the most common problem (Top *et al.* 2018a). Sripaiboonkij *et al.* (2009) reported that carpenters and workers in the furniture industry are among the occupational groups that are most commonly exposed. A large number of nano and micro particles are generated in the woodworking industries, and these particles may pose risks to human health depending on their size and content (Pavlovska *et al*. 2016).

Inhalation is the most common way for dust to enter the body. When the mechanisms used by the respiratory system to clean and protect itself are overloaded, excessive inhalation of the dust can cause various health effects. The severity of these effects varies depending on the chemical composition of the inhaled dust, the density of the particles in the air suspension, the storage location of dust in the respiratory system and duration of exposure (Barbosa *et al.* 2018). The American Conference of Industrial Hygienists (ACGIH) set a threshold limit value (TLV) of exposure to hardwood as 1 mg per 1 m^3 of air. This limit value is set for the 8 h time-weighted average (TWA) and 5 mg/m^3 for softwood. This TLV was based on the expectation that exposure to the upper limit value or less will not have adverse health effects (Martin and Zalk 1997).

The International Agency for Research on Cancer has classified hardwood dust as a human carcinogenic substance (American Cancer Society 2018). Alonso-Sardón *et al*. (2015) showed that nasal adenocarcinoma rates among workers exposed to wood dust were higher compared to other groups. However, Hancock *et al.* (2015) reported that there is a significant relationship between lung cancer and exposure to wood dust. Wood dust can lead to other health hazards than cancers. These include: (i) skin dermatitis related to wood dust exposure, (ii) respiratory allergies that are familiar with exposure to wood dust and allergic asthma, (iii) respiratory symptoms unrelated to allergies such as itching, dryness and repeated episodes of cough and wheezing linked to wood dust, and (iv) decreased lung function resulting in decreased pulmonary function (Eldridge 2019).

To protect employees from adverse conditions at the workplace, the following hazard control mechanisms should be ensured: elimination, substitution, engineering controls, administrative controls, and personal protective equipment (PPE). However, small and medium-sized enterprises (SMEs) are at a disadvantage in implementing these measures. Studies reported that SMEs face more obstacles regarding occupational safety and health compared to large enterprises (Lamm 1997; Gardner *et al*. 1999; Stevens 1999; Tait and Walker 2000; Jørgensen *et al*. 2010). As a consequence, the risk of job-related hazards is higher in SMEs, and the ability to control risks is lower. The exposure to chemical and physical risks is higher in SMEs than in larger companies (Sørensen *et al*. 2007).

Among the engineering control methods, ventilation is a mechanical system that brings in fresh outdoor air and removes the contaminated indoor air from a building. This can be achieved by natural or mechanical ventilation (Canadian Center for Occupational Health and Safety 2019a). There are two mechanical ventilations, (i) general and (ii) local exhaust ventilation (LEV). General ventilation controls the amount of heat or reduces the concentration of the air pollutants. A properly designed ventilation is a back-up to control exposure to airborne substances. The LEV engineering system captures contaminants at their source and transports them away from the workers' breathing zone (WorkSafe 2019).

A ventilation system does not ensure that airborne pollutants are under control (World Health Organization 1999). Black *et al.* (2007) reported that the amounts of wood dust generated in plants operating under local ventilation were higher than the limit values. Further, Löfstedt *et al.* (2017) reported that in 45% of the measurements, the level of wood dust was higher than the Swedish occupational exposure limit (2 mg/m^3) at the plants surveyed.

In 2013, "anti-dust regulation" was introduced in Turkey. According to this regulation, the employer is required to install all necessary protective and preventive methods, avoiding the exposure of employees to dust. In the same regulation, the requirement of dust measurements and the comparison of test results with occupational exposure limit values were formulated (5 mg/m^3 for inhalable hardwood dust in Turkey) (Official Gazette of the Republic of Turkey 2013).

This study investigated the relationship between the workers' perceptions towards airborne wood dust and ventilation applications in micro-scale enterprises manufacturing furniture.

EXPERIMENTAL

Materials

Micro-scale enterprises producing furniture have been selected as a research subject in Trabzon, Turkey, as the occupational disease and accident rate of the small scale enterprises are higher than average (Park *et al.* 2002), and the wood industry generates higher wood dust exposure in small enterprises than in larger ones (Mikkelsen *et al.* 2002). According to the results of the latest Census of Industry and Business carried out by the Turkish Statistical Institute (TUIK 2002), micro-scale enterprises comprise 96.6% of all-sized enterprises included in the furniture industry in Turkey and 97.9% in Trabzon. In the UK, 69% of enterprises in the furniture and wood products sector employ less than 10 employments (Black *et al.* 2007). As micro-scale enterprises constitute the largest ratio of the national economy, they represent an important pillar of the economy.

In the Turkish furniture industry, enterprises producing with traditional methods are predominantly small-sized (Republic of Turkey Ministry of Trade 2018). "Manufacture of furniture; manufacturing not elsewhere classified" is one of the sub-sectors of the manufacturing industry in accordance with the Statistical Classification of Economic Activities Rev.3.1. According to this classification, the manufacture of furniture is indicated by 36 and does not include only the enterprises producing furniture (United Nations 2019). The enterprises related to furniture are shown in the range of 3611 to 3615. The rest of sector 36 includes "manufacturing not elsewhere classified". If "manufacturing not elsewhere classified" is excluded from the sector 36, the number of employment in Turkey is 93853. This number shows the registered employment. However, some of the employees are not registered in Turkey. Guney and Celik (2017) reported that informal employment in the manufacturing sector was 20% in 2016. Considering the number of unregistered workers, it is estimated that more than 100000 people are employed in sector 36 and exposed to airborne wood dust in Turkey.

Methods

A face-to-face interview and observation method were used to collect data. Questions were prepared as open-ended, multiple-choice, or with two options (yes-no). A structured questionnaire was thereafter conducted randomly at the selected 53 enterprises. One employee or employer in each enterprise was interviewed to assess the personal perception of the ventilation and exposure to wood dust in their work atmosphere. The average employment per enterprise in the surveyed area was 2.7 (Top *et al.* 2018b). The percentages of cases were calculated by dividing each multiple count of responses by the number of enterprises (here n=53) interviewed. The study was conducted in July 2019. During the on-site visit, the researcher has observed the work environment and the ventilation ways in each enterprise.

The relationship between categorical variables was analysed by using the Chi-square independence test. The hypothesis was accepted or rejected according to the continuity correction value when the degree of freedom was 1. In the Chi-square tests with a degree of freedom greater than one, the hypothesis (H_o) was accepted at $p>0.05$ or rejected at $p < 0.05$ according to the Pearson Chi-square tests value. The H_o hypothesis used in decision making was established as "H_o: There is no relationship between categorical variables".

RESULTS AND DISCUSSION

In the enterprises surveyed, 90.6% of the employees thought that airborne wood dust released during the mechanical processing of wood or/and engineered wood was health-endangering, while 9.4% thought that no health risk existed. During the implementation of the questionnaire, some of the employees differentiated between dust from solid wood and dust from engineered wood. They stated that the dust from engineered wood was harmful to health, but solid wood dust had no adverse health effect. However, certain tree species have been associated with health effects (Canadian Center for Occupational Health and Safety 2019b). Employees stated that dust could cause health issues, as shown in Fig. 1. The most common and the least adverse effects known by the employees were pulmonary diseases and carcinoma, respectively. Exposure to wood dust causes symptoms of disease in the skin, eyes, nose, and respiratory tract (Löfstedt *et al.* 2017). The causal role of wood dust in the onset of sinonasal cancers has been solidly established by numerous epidemiological studies, and the magnitude of the risk was particularly high for adenocarcinoma induced by exposure to hardwood dust (Carton *et al.* 2002). Therefore, wood dust is considered carcinogenic to humans (American Cancer Society 2018).

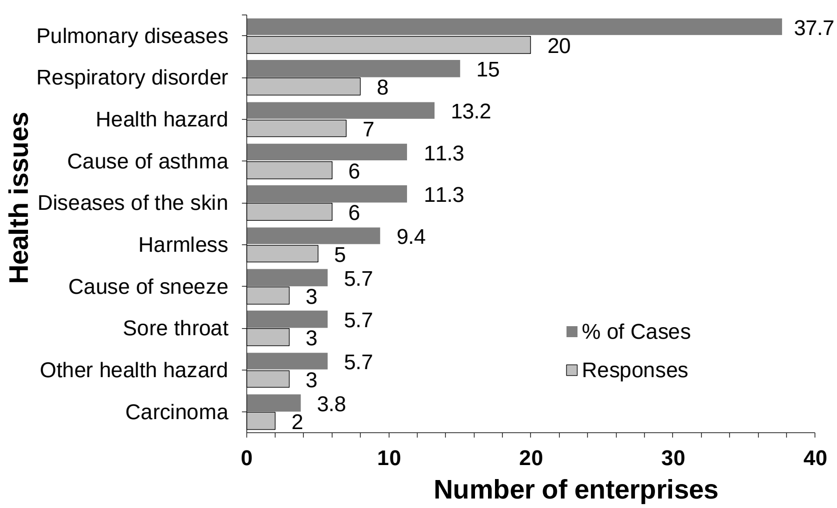

Fig. 1. Health issues caused by wood dust according to employees

In response to the question, ''How does wood dust discomfort you while working?" the disturbances stated by employees were as in Fig. 2. The most frequently repeated answer was that wood dust while working was not perceived as disturbing. The frequency values in Fig. 2 have been grouped as those affected by dust and those were not affected by dust. Its relationship with the following variables was investigated afterwards. No significant relationship was found between dust disturbance perception of workers while working and raw materials (MDF, chipboard and massive wood) used in the production according to Chi-square independence test result ($p_{(0.775)} > 0.05$). In addition, no significant relationship was found between workers' dust disturbance while working and the dustiness of work atmosphere as well as the adequacy of ventilation methods used according to Chi-square independence test results ($p_{(0.661)} > 0.05$; $p_{(0.159)} > 0.05$) (with Yates correction for continuity), respectively. According to the Mann-Whitney U test ($p_{(0.159)} > 0.05$), the difference between workers' dust disturbance and the numbers of machines in the enterprises was not significant. Approximately half of the employees believed that exposure to wood dust during work had no effect on their health. Those who stated that they were affected by wood dust while working stated that they had issues such as sore throat, skin disorders, nasal congestion, and respiratory disorder. These are consistent with the results of Osman and Pala (2009), who reported the same health complaints such as nasal blockage, runny nose and sore throat.

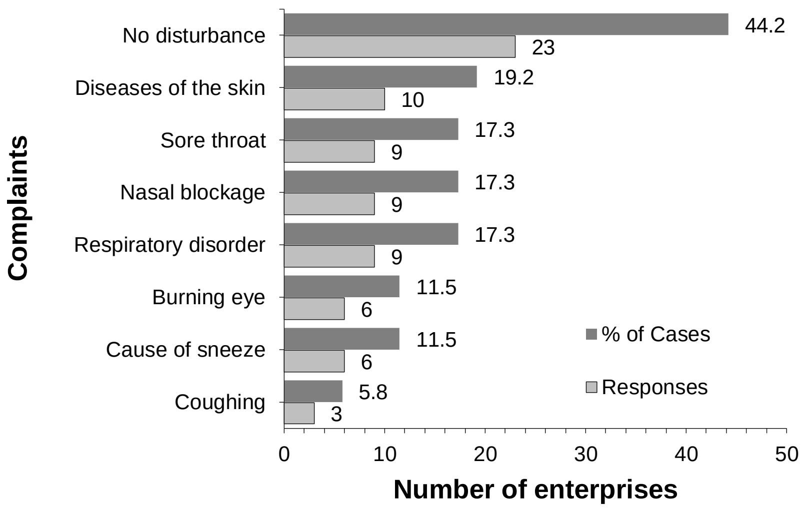

Fig. 2. Workers' own complaints from wood dust while working

The distribution of the answers given to the question asked to determine the knowledge of employees about the hazards of wood dust on the safety at workplace was obtained as in Table 1. The awareness of safety hazards caused by wood dust was much less than health hazards. Of the employees, 69.8% stated their belief that wood dust could not cause any hazard other than on health at the workplace. Dust is one of the reasons for work accidents caused by slipping. Furthermore, wood dust is flammable and, in certain situations, can cause fires or explosions (Health and Safety Executive 2019). The frequency values of Table 1 were combined to make it suitable for the Chi-square test. By using the new frequency values, there was no significant relationship between the hazards of wood dust on the safety at the workplace and the dustiness of the work atmosphere and the adequacy of the ventilation methods used according to Chi-square independence test results ($p_{(0.863)}>0.05$; $p_{(0.347)}>0.05$) (with Yates correction for continuity) respectively. According to the Mann-Whitney U test result ($p_{(0.852)}>0.05$), there was no significant difference between the number of machines and whether or not the wood dust may cause the hazards on the safety at the workplace.

Table 1. Wood Dust Hazards and Safety at the Workplace

Issues	Frequency	Percent
Fire hazard	1	1.9
It may cause non-health hazards	3	5.7
It may cause machine failure	3	5.7
It may be harmful to the environment	9	17
No, it has no safety hazard	37	69.8

Among the interviewed employees, no one was familiar with the concept of the "occupational dust exposure limit value". However, in Turkey the employer is obliged (i) to prevent exposure to dust and to take all necessary protective and preventive measures to protect employees from dust-related hazards, (ii) to make dust measurements at periodic intervals determined according to the risk assessment result, and (iii) to provide employee training and inform them according to the Anti-dust Regulation that came into force in 2013 (Official Gazette of the Republic of Turkey 2013). The fact that the occupational dust exposure limit value was unknown to all interviewed employees indicated that the legal necessities of this regulation were not being applied.

According to 83% of the enterprises, the workplace atmosphere was dusty. A total of 59% of those who stated that the work atmosphere was dusty believed that ventilation was insufficient. Lack of ventilation or inadequate ventilation and old machines were counted as other reasons for dust emitted in the workplace in Trabzon. The employees were not aware that some of their applications, such as cleaning of their workplace, machinery and work clothes, may also cause airborne wood dust (Government of Western Australia 2019). According to the result of the Chi-square independence test ($p_{(0.662)} > 0.05$), there was no significant relationship between the dustiness of the workplace atmospheres and the ventilation methods used in the workplaces. Again, no significant difference was found between the dustiness of the workplace atmosphere and the number of machines in the enterprises according to the Mann-Whitney U test result ($p_{(0.399)} > 0.05$). Employees believed that dust in the work atmosphere occurred because of the reasons summarized in Table 2. The majority of the interviewed employees (92.5%) were convinced that mechanical processing of raw material such as cutting, drilling, sanding and planning was the main source of dust. Mikkelsen *et al*. (2002), Baran and Teul (2007), and Rogoziński *et al*. (2015) reported that the main reason for the generation of wood dust was the processing of raw material.

Table 2. Reasons for Dust in the Workplace According to Employees

Reasons	Frequency	Percent	Cumulative Percent
No ventilation	1	1.9	1.9
Old equipment	1	1.9	3.8
Insufficient ventilation	2	3.8	7.5
Processing of raw material	49	92.5	100

A total of 29 companies reported that they produced all their goods in their own workplace. The remaining 24 enterprises declared that in times of high demand to cut and edge some parts of the furniture in other contracting enterprises. According to the Chi-square independence test result ($p_{(0.913)} > 0.05$) (with Yates correction for continuity), there was no significant relationship between these two production types and the adequacy of ventilation methods. According to the Mann-Whitney U test result ($p_{(0.01)} < 0.05$), there was a significant difference between the production types and the number of machines owned by the enterprises. Accordingly, the number of machines in the enterprises that manufacture the complete production was significantly higher. In addition, there was no significant relationship between the two production types and the use of dust mask according to the Chi-square independence test result ($p_{(0.804)} > 0.05$) (with Yates correction for continuity). Yamanaka *et al*. (2009) reported that enterprises with higher production volumes had a high average dust level. Outsourcing of some processes that cause dust formation may help to keep the dust level low. Approximately half of the enterprises surveyed in Trabzon used outsourcing according to the order amount from time to time. However, the intention of the enterprises here was not to reduce dust formation but to fulfil the orders in a timely manner.

When employees were asked about practices in the workplace in order to prevent the occurrence of wood dust, 20.8% of the enterprises stated that no effort was made. A total of 52.8% and 26.4% declared that a bag-type dust collector was purchased and the aspirator was turned on, respectively. However, these were applications that prevent the dispersing of the emitted dust into the work atmosphere or to evacuate the existing dust in the work atmosphere. Hence it can be concluded that the difference between preventing the formation of dust and preventing dust from entering the atmosphere was unknown. This means, in fact, that no enterprise had made any effort to prevent the generation of wood dust.

Of the workplaces in Trabzon, 68%, 19%, 9%, and 4% were cleaned every day, one time a week, at the end of each order, and every three days, respectively. According to the methods of cleaning the workplaces, the dustiness of the work atmosphere was summarized in Fig. 3.

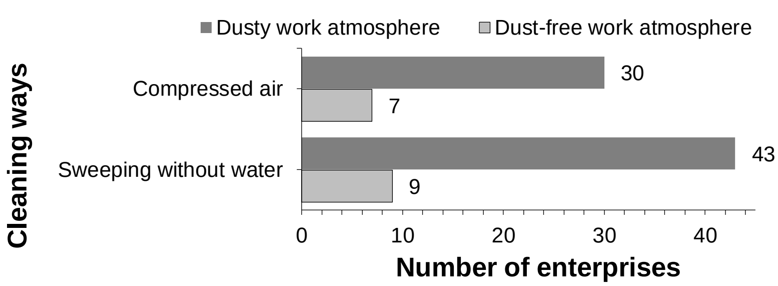

Fig. 3. Dustiness of work atmosphere according to workplace cleaning methods

Among the enterprises, 98.1% swept the workplace floor with dry brushes. In 69.8% of the enterprises, machines were cleaned by using compressed air. According to the Chi-square independence test result ($p_{(1.0)} > 0.05$) (with Yates correction for continuity), there was no significant relationship between cleaning methods and dustiness of the work atmosphere. Vacuum-cleaning tools were never used to clean the workplace. Yamanaka *et al*. (2009) revealed that clean-up workers were exposed to highest levels of wood dust in sawmills. Moreover, Alwis *et al*. (1999) revealed that the cleaning method used and the use of compressed air were the important determinants for wood dust generation in the woodworking processes. Martin and Zalk (1997) discussed the removal of the use of compressed air to reduce the amount of dust in the workplace atmosphere, improving the workplace layout, and increasing the power of the LEV system. However, Mikkelsen *et al*. (2002) reported that the use of vacuum to clean machines and clothing reduced the dust concentration in the work atmosphere. At the end of the working day, 87% of the employees declared to clean their overalls using compressed air and 13% changed their clothes. In Trabzon, micro-scale furniture manufacturing enterprises researched were using compressed air cleaning overalls or machines in a widespread manner. This increases the occupational exposure to wood dust.

In 75.5% of the enterprises, the employees used dust masks only when the workload was high. The rate of those who stated that they did not use any PPE was found to be 22.6%. No significant relationship was found between the use of dust mask and employees' disturbance by dust while working according to the Chi-square independence test result ($p_{(1.0)} > 0.05$) (with Yates correction for continuity). Also, no significant relationship was found between the use of dust mask and ventilation methods according to the Chi-square independence test result ($p_{(0.763)} > 0.05$) (with Yates correction for continuity). Risk perceptions may affect the use of PPE (Pidgeon 1998). However, the workers in this present study did not consider wood dust a serious health issue. Although 83% and 56.6% of the employees thought that the work environment was dusty and that the ventilation was insufficient, PPE was not used in 22.6% of the enterprises. In three-quarters of the enterprises, the simple dust masks were only used at high workload. A similar result was found by Alwis *et al*. (1999), who reported that the majority of workers (90%) in four different wood working processes (1 wood chipping, 4 sawmills, 2 loggings sites, and 5 joinery operations) did not wear appropriate dust masks. In this study, dust mask-wearing employees were not observed during the visits to the enterprises in Trabzon for the implementation of the survey. Mikkelsen *et al*. (2002) also observed that employees did not use protective face masks; Black *et al*. (2007) reported that employees tended to use respiratory protection only in very dusty jobs. These results are similar to those obtained in this study.

Table 3 shows the methods used to remove the dust generated during the processing of raw materials from the work atmosphere in the enterprises covered by the study. According to Table 3, the most common method of ventilation was natural ventilation and the least one was LEV. These methods were used in combination or alone. The suction hood used in LEV was connected to the machine at a fixed distance. The local ventilation frequency values and bag-type dust collector frequency values in Table 3 were combined to perform a Chi-square test. According to the Chi-square independence test results, no significant relationships were found between the ventilation methods and the following variables: dustiness of the work environment ($p_{(0.836)} > 0.05$), whether or not employees were disturbed by wood dust ($p_{(0.704)} > 0.05$), the adequacy status of ventilation methods ($p_{(0.935)} > 0.05$), all production produced or subcontracted ($p_{(0.913)} > 0.05$), and raw materials used ($p_{(0.918)} > 0.05$). Natural ventilation through an open door or/and window is usually inadequate in controlling occupational wood dust hazards (Government of Western Australia 2015). However, this was the most common way of ventilation used by micro-scale enterprises producing furniture in Trabzon, followed by bag-type dust collectors. The usage rate of bag-type dust collectors was 71.7%; LEV was available only in 11.3% of the micro-scale enterprises producing furniture. Lazovich *et al*. (2002) reported that almost all of the 48 enterprises employing between 5 and 25 employees and manufacturing solid cabinets and furniture had a central dust collection system. This difference may be due to the enterprises included in each study. Lazovich *et al*. (2002) examined not only micro-scale enterprises but also small ones. In this present study, only micro-scale enterprises were investigated and micro-scale enterprises were financially poorer than others (Park *et al*. 2002). Osman and Pala (2009) revealed that there was no ventilation system in the 45 businesses producing furniture in Bursa/Turkey. This result revealed by Osman and Pala (2009) is not consistent with the findings of the present study.

Table 3. Methods Used in the Ventilation of Workplaces

Ventilation Methods	Responses		Percent of Cases
	N	Percent	
Local exhaust ventilation	6	4.8	11.3
Forced ventilation (ventilator)	32	25.8	60.4
Bag-type dust collector	38	30.6	71.7
Naturel ventilation	48	38.7	90.6
Total	124	100	234

The start-up of the ventilation tools is shown in Table 4. For natural ventilation, 86.8% of enterprises kept their doors and windows open during their working hours. Of the bag-type dust collectors that were connected to the bench saw, 89.5% operated automatically when the bench saw was turned on. The ventilators on the wall were usually turned on and off manually. A total of 56.6% of the employees believed that the ventilation in the workplace was inadequate, and 43.4% believed it was adequate. There was no ventilator in 34% of the enterprises. Of the enterprises, 47.2% had one ventilator and 17% had two ventilators. The difference between the number of ventilators and the adequacy of ventilation was not significant according to the Mann-Whitney U test result ($p_{(0.326)} > 0.05$). There was no protective guard, and LEV was attached to the bench saw. The protective guard was removed because it was perceived as an obstacle complicating the manual work. All of the bag-type dust collectors were connected beneath the bench saws. There was no ventilation above the level of the bench saws. Martin and Zalk (1997) reported that most of the heavy and large wood dust particles will fall down, but relatively smaller wood particles cannot be controlled without ventilation above the level of the bench saw. This case defined by Martin and Zalk (1997) was in accordance with this study.

Fresh outdoor air was provided through doors and windows that were left open in all micro-scale furniture manufacturing enterprises surveyed in this actual study. Fresh air entered the enterprises without filtration. Black *et al*. (2007) reported that the polluted air was filtered in 1/3 of the 19 companies producing furniture and the filtered air was again introduced into the enterprises. Black *et al*. (2007) examined enterprises with fewer than 50 employees. Since there is a correlation between the business scale and the ventilation facilities, the difference between these results may be due to the business scales.

Table 4. Start-up of the Ventilation Tools

Start-up methods	Responses		Percent of cases
	N	Percent	
The door and window are always open	46	36.8	86.8
The door and window are open if dusty	2	1.6	3.8
The ventilator is always on	4	3.2	7.5
The ventilator is turned on manually	28	22.4	52.8
The bag-type dust collector is turned on automatically	34	27.2	64.2
The bag-type dust collector is turned on manually	4	3.2	7.5
The LEV is turned on automatically	2	1.6	3.8
The LEV is turned on manually	5	4	9.4
Total	125	100	235.8

MDF was the most widely used raw material in micro-scale furniture producing enterprises in Trabzon. Chipboard usage as a raw material was less than MDF. However, the enterprises were not restricted to the use of a single type of raw material. The number of enterprises using both MDF and solid wood was 34, the number of enterprises using both MDF and chipboard was 24, and the number of enterprises using all three materials was 17. According to the Chi-square test result ($p_{(0.833)} > 0.05$), there was no relationship between the raw material used in the production and the adequacy of the ventilation methods. There was also no significant relationship between the raw material used in production and the dustiness of the work atmosphere as $p_{(0.796)} > 0.05$. The use of composite materials such as MDF increased exposure to wood dust (Health and Safety Executive 2019). Although it was reported that more dust was produced during the processing of MDF (Black *et al*. 2007).

CONCLUSIONS

1. The majority of employees were aware of the fact that wood dust may bear health hazards. However, the employees had little or no knowledge of how wood dust is generated, the safety hazards, dust measurement, the dust exposure limit value, and practices preventing dust formation. As a consequence, they did not perceive wood dust as a serious health hazard. Employees who are aware of the work risk behave more safely (Oppong 2015). However, three-quarters of those who did not use PPE against wood dust believed that the work atmosphere of the enterprises where they work was dusty but they did not use any dust mask. As a result of the inconsistency between perception and protection, the analysis of the relationship between the variables was not statistically significant.
2. As a result of the fact that wood dust was not regarded as a serious health hazard by employees, the ventilation used in the micro-scale enterprises manufacturing furniture in Trabzon was also inadequate. Natural ventilation, which is inadequate in controlling wood dust, was the most common way in Trabzon. The bag-type dust collector was useful for the absorption of heavy and large wood dust since the suction duct is attached to the underside of the bench saws. However, because there was no local hood head attached to the top of the circular saw, the bag-type dust collector was insufficient to remove light and fine dust at its source.
3. Micro-scale enterprises have low capacities of utilization, and they usually manufacture their products to order. Low capacity utilization means that the amount of production and the formation of dust depending on the amount of production are also low. This may be the main reason for the inadequate ventilation and why employees do not pay attention to the wood dust as a serious health threat. However, there is a need to know the personal dust exposure values to allow this judgment. Personal dust exposure measurement was not performed in this study. The relationship between the personal dust exposure measured with 8 h time-weighted average sampling and workplace ventilation applications and the employees' perceptions of wood dust can be investigated in the micro-scale enterprises producing furniture in Trabzon, Turkey.

REFERENCES CITED

Alonso-Sardón, M., Chamorro, A-J., Hernández-García, I., Iglesias-de-Sena, H., Martín-Rodero, H., Herrera, C., Marcos, M., and Mirón-Canelo, J. A. (2015). "Association between occupational exposure to wood dust and cancer: A systematic review and meta-analysis," *PLoS ONE* 7, 1-16. DOI: 10.1371/journal.pone.0133024

Alwis, U., Mandryk, J., Hocking, A. D., Lee, J., Mayhew, T., and Baker, W. (1999). "Dust exposure in the wood processing industry," *Am. Ind. Hyg. Assoc. J.* 60, 641-646. DOI: 10.1080/00028899908984485

American Cancer Society (2018). "Known and probable human carcinogens," (https://www.cancer.org/cancer/cancer-causes/general-info/known-and-probable-human-carcinogens.html), Accessed 11 Dec 2018.

Baran, S., and Teul, I. (2007). "Wood dust: An occupational hazard which increases the risk of respiratory disease," *J. Physiol. Pharmacol.* 58, 43-50.

Barbosa, R. P., Fiedler, N. C., Silva, J. R., Paulo de Souza, A., Minette, L. J., and Oliveira, M. P. (2018). "Concentration and size of airborne particulates in woodworking shops," *Revista Árvore* 42, 1-6. DOI: 10.1590/1806-90882018000100009

Black, N., Dilworth, M., and Summers, N. (2007). "Occupational exposure to wood dust in the British woodworking industry in 1999/2000," *Ann. Occup. Hyg.* 51, 249-260. DOI: 10.1093/annhyg/mem007

Canadian Centre for Occupational Health and Safety (2019a). "Wood dust - Health effects," (https://www.ccohs.ca/oshanswers/chemicals/wood_dust.html), Accessed 12 Jul 2019.

Canadian Centre for Occupational Health and Safety (2019b). "OSH answers fact sheets," (https://www.ccohs.ca/oshanswers/prevention/ventilation/introduction.html), Accessed 18 Jul 2019.

Carton, M., Goldberg, M., and Luce, D. (2002). "Occupational exposure to wood dust. Health effects and exposure limit values," *Rev. Epidemiol. Sante Publique* 50, 159-178.

Eldridge, L. (2019). "Wood dust exposure and lung cancer risk," (https://www.verywellhealth.com/wood-dust-and-lung-cancer-whos-at-risk-3971878?print), Accessed 19 Jun 2019.

Gardner, D., Carlopio, J., Fonteyn, P. N., and Cross, J. A. (1999). "Mechanical equipment injuries in small manufacturing businesses. Knowledge, behavioural, and management issues," *Int. J. Occup. Saf. Ergo.* 5(1), 59-71. DOI: 10.1080/10803548.1999.11076411

Government of Western Australia (2019). "Guidance note controlling wood dust hazards at the workplace," (https://www.commerce.wa.gov.au/sites/default/files/atoms/files/guide_wood_dust_0.pdf), Accessed 18 Jul 2019.

Guney, A., and Celik, E. (2017). "Concept of unregistered employment and unregistered employment in Turkey," (In Turkish). *İktisadiyat* 1, 213-248.

Hancock, D. G., Langley, M. E., Chia, K. L., Woodman, R. J., and Shanahan, E. M. (2015). "Wood dust exposure and lung cancer risk: A meta-analysis," *Occup Environ Med* 72, 889-898. DOI: 10.1136/oemed-2014-102722

Health and Safety Executive (2019). "Wood dust controlling the risks, Woodworking Sheet No 23 (Revision 1)," (http://www.hse.gov.uk/pubns/wis23.pdf), Accessed 12

Jul 2019.
Jørgensen, K., Duijm, N. J., and Troen, H. (2010). “Accident prevention in SME using OR,” *Safety Sci.* 48, 1036-1043. DOI: 10.1016/j.ssci.2010.02.008
Lamm, F. (1997). “Small businesses and OH&S advisor,” *Safety Sci.* 25, 153-161.
Lazovich, D., Parker, D. L., Brosseau, L. M., Milton, F. T., Dugan, S. K., Pan, W., and Hock, L. (2002). “Effectiveness of a worksite intervention to reduce an occupational exposure: The Minnesota wood dust study,” *Am. J. Public Health* 92, 1498-1505.
Löfstedt, H., Hagström, K., Bryngelsson, I. L., Holmström, M., and Rask-Andersen, A. (2017). “Respiratory symptoms and lung function in relation to wood dust and monoterpene exposure in the wood pellet industry,” *Upsala J. Med. Sci.* 122, 78-84. DOI: 10.1080/03009734.2017.1285836
Martin, J. R., and Zalk, D. M. (1997). “Carpenter shop wood dust control: Practical experience to reduce hardwood dust exposures below the American Conference of Governmental Industrial Hygienists threshold limit values,” *Applied Occupational and Environmental Hygiene* 12, 595-605. DOI: 10.1080/1047322X.1997.10387727
Mikkelsen, A. B., Schlünssen, V., Sigsgaard, T., and Schaumburg, I. (2002). “Determinants of wood dust exposure in the Danish furniture industry,” *Ann. Occup. Hyg.* 46, 673-685. DOI: 10.1093/annhyg/mef082
Official Gazette of the Republic of Turkey (2013). “Tozla Mücadele Yönetmeliği [Anti-Dust Regulation],” Number of Official Newspapers: 28812, Date: 05.11.2013, Ankara, Turkey.
Oppong, S. (2015). “Risk chain process model: Linking risk perception to occupational health,” *Sigurnost* 57, 25-34.
Osman, E., and Pala, K. (2009). “Occupational exposure to wood dust and health effects on the respiratory system in a minor industrial estate in Bursa/Turkey,” *Int. J. Occup. Med. Environ. Health* 22, 43-50. DOI: 10.2478/v10001-009-0008-5
Park, H., Ha, E., Kim, J., Jung, H., and Paek, D. (2002). “Occupational health services for small-scale enterprises in Korea,” *Ind. Health* 40, 1-6. DOI: 10.2486/indhealth.40.1
Pavlovska, I., Martinsone, Z., Vanadins, I., Martinsone, I., Seile, A., and Sudmalis, A. (2016). “Occupational exposure parameters for characterization of nanoparticulate matter toxicity: Metal *versus* wood processing,” *Process Saf. Environ.* 102, 230-237. DOI: 10.1016/j.psep.2016.03.018
Pidgeon, N. (1998). “Risk assessment, risk values and the social science program: Why we do need risk,” *Reliab. Eng. Syst. Safe* 59, 5-15. DOI: 10.1016/S0951-8320(97)00114-2
Reinhold, K., Järvis, M., and Tint, P. (2015). “Practical tool and procedure for workplace risk assessment: Evidence from SMEs in Estonia,” *Safety Sci.* 71, 282-291. DOI: 10.1016/j.ssci.2014.09.016
Republic of Turkey Ministry of Trade (2018). “Mobilya sektör raporu [Furniture sector report],” (https://ticaret.gov.tr/data/5b87000813b8761450e18d7b/Mobilya.pdf), Accessed 24 Jan 2018.
Rogoziński, T., Wilkowski, J., Gorski, J., Czarniak, P., Podziewski, P., and Szymanowski, K. (2015). “Dust creation in CNC drilling of wood composites,” *BioResources* 10, 3657-3665. DOI: 10.15376/biores.10.2.3657-3665
Sørensen, O. H., Hasle, P., and Bach, E. (2007). “Working in small enterprises - Is there a special risk?,” *Safety Sci.* 45, 1044-1059. DOI: 10.1016/j.ssci.2006.09.005
Sripaiboonkij, P., Phanprasit, W., and Jaakkola, M. S. (2009). “Respiratory and skin effects of exposure to wood dust from the rubber tree *Hevea brasiliensis*,” *Occup.*

Environ. Med. 66, 442-447. DOI: 10.1136/oem.2008.042150

Stevens, G. (1999). "Features - Workplace injuries in small and large manufacturing workplaces: An analysis of the risks of fatal and non-fatal injuries, including figures for 1994/5–1995/6," *Labour Market Trends* 107(1), 19-26.

Tait, R., and Walker, D. (2000). "Marketing health and safety management expertise to small enterprises," *Safety Sci.* 36, 95-110. DOI: 10.1016/S0925-7535(00)00033-3

Top, Y., Adanur, H., and Oz, M. (2018a). "Use of personal protective equipment in micro-scale wood working enterprises," in: *Proceedings of the International Forest Products Congress*, Trabzon, Turkey, pp. 538-549.

Top, Y., Adanur, H., and Oz, M. (2018b). "Type, quantity, and re-use of residues in the forest products industry in Trabzon, Turkey," *BioResources* 13, 1745-1760. DOI: 10.15376/biores.13.1.1745-1760

TUIK (2002). "The general census of industry and business establishments-2002," (http://www.tuik.gov.tr/VeriBilgi.do?alt_id=1079), Accessed 16 Jun 2019.

United Nations (2019). "International standard industrial classification of all economic activities revision 3.1.," (https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev3_1e.pdf), Accessed 27 Jun 2019.

WorkSafe (2019). "Local exhaust ventilation," (https://worksafe.govt.nz/topic-and-industry/dust-and-fumes/fumes/local-exhaust-ventilation-quick-guide/), Accessed 18 Jun 2019.

World Health Organization (1999). "Hazard prevention and control in the work environment: Airborne dust," (https://www.who.int/occupational_health/publications/airdust/en/), Accessed 18 Jun 2019.

Yamanaka, M. W., Guidotti, T. L., Koehncke, N., Taylor, F. M., Taylor, C., and Harman, L. (2009). "Wood dust level in Alberta sawmills," *Arch. Environ. Occup. H.* 64(4), 270-277. DOI: 10.1080/19338240903338247

Yuan, N., Zhang, J., Lu, J., Liu, H., and Sun, P. (2014). "Analysis of inhalable dust produced in manufacturing of wooden furniture," *BioResources* 9(4), 7257-7266.

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