Ventilatory and Auditory Findings among Workers in Asal's Furniture Factory at New Damietta City, Damietta Governorate, Egypt

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ABSTRACT

Background: Wood furniture production is one of the most hazardous industries. The workers are subjected to several hazards involving exposure to wood dust, solvents, isocyanates, finishes and noise.

Objective: To determine ventilatory and auditory findings among workers in Asal's furniture factory at New Damietta City, Damietta Governorate, Egypt. **Patients and Methods:** A descriptive comparative cross-sectional study was carried out on 183 wood furniture workers in Asal's furniture factory at New Damietta city, Damietta governorate and a matched comparison group, during the period from February 1, 2018 to November 24, 2018.

Results: The averages of the measured wood dust concentrations and noise levels were within the Egyptian maximum permissible limits, except for the noise levels in the woodworking building which were higher than the maximum permissible limits [90.8±7.1dB(A)]. As regards the ventilatory lung functions measurements among both woodworkers and finishing group, the means± SD of both measured and percent predicted values of FEV1/FVC, peak expiratory flow rate (PEFR) and FEF 25-75% were lower than those of the comparison group with a statistically significant difference ($p \leq 0.05$). Finishing workers had a statistically significant ($p \leq 0.001$) higher prevalence of obstructive ventilatory pattern. Sensorineural hearing loss was significantly ($p \leq 0.005$) prevalent among both woodworkers (26.2%) and the finishing workers (18%) compared to the comparison group (2.4%). Criteria of NIHL were met in 81.3% of woodworkers with sensorineural hearing loss, who accounted for 21.3% of all woodworkers.

Conclusion: The workplace environment in Asal's furniture factory adversely affects the ventilatory and auditory functions of their workers.

Keywords: Ventilatory, Auditory, Woodworkers, Finishing workers, Asal's furniture factory.

INTRODUCTION

Wood furniture production is one of the most hazardous industries. The workers are subjected to several hazards involving exposure to wood dust, solvents, finishes and noise [(1)].

Wood furniture industry has been reported to be one of the industries with heaviest wood dust exposure. High levels of wood dust are emmitted throughout the machining processes, such as chipping, sawing, drilling and sanding. Wood dust generated occupationally consists mainly of >5µm particles, that's is trapped in the upper respiratory tract. The particles with sub-5µm diameter, that range from 6% to 75% of the total wood aerosol [(2)], are particularly hazardous as they infiltrate into the lower respiratory tract through sedimentation and diffusion [(3)]. Wood dust may give rise to allergic rhinitis, chronic bronchitis, occupational asthma (OA), External allergic alveolitis (EAA) and Chronic Obstructive Pulmonary Disease (COPD) [(3)].

It is in the top ten causes of occupational asthma in the United Kingdom. Respiratory health effects associated with wood dust exposure, are directly affected by the wood type, wood dust concentration, duration of exposure, other chemical exposures, individual sensitivity, use of PPE and air ventilation system [(4)].

Wood furniture industry is considered one of the noisiest working environments. Hearing could be adversely affected due to exposure to noise and solvents [(5)]. Moreover, **Batkus *et al.*** [(6)] found that noise levels exceeded the permissible limits in 77% of the surveyed wood furniture workplaces in Lithuania. **Masterson *et al.*** [(7)] observed that the prevalence of NIHL among woodworkers in USA was 20.8%, which ranked the second among all studied industries.

Wood furniture industry adversely affects the ventilatory and auditory functions of their workers. Thus, it requires effective prevention and control [(8)]. For wood dust, **Health and Safety Executive (HSE)** [(4)] suggested local exhaust ventilation, fans and respiratory protective equipment. For noise exposure, occupational hearing conservation program is carried out in the workplace and must include periodic noise exposure monitoring, engineering and administrative control measures, hearing protection devices and annual audiometric evaluation [(9)]. In Egypt, there were 84 establishments engaged in furniture manufacturing with about 10,825 workers [(10)]. Damietta alone, accounts for over 1/4th of the enterprises working in wood furniture manufacturing [(11)].

Objectives:

The specific objectives of this study are (1) Determine ventilatory and auditory findings among workers in Asal's furniture factory at New Damietta City, Damietta Governorate, Egypt (2) Measurement the total and respirable wood dust concentrations and noise level in the workplace.

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SUBJECTS AND METHODS

A descriptive comparative cross-sectional study was carried out on wood furniture workers in Asal's furniture factory at New Damietta city **(Figure 1)**, Damietta governorate and a matched comparison group, during the period from February 1, 2018 to November 24, 2018.

Study Population:

The study included two groups:

A. **The exposed group (wood furniture workers):** comprised two subgroups; (1) Woodworking group **(Figure 2)** (122 workers). They were responsible for cutting and machining lumbers to the shape of the final furniture part; (2) Finishing group **(Figure 3)** (61 workers). They receive processed furniture parts from storage site then apply several layers of varnishes, lacquers, sealers and fillers.

B. **The non-exposed group (comparison):** included 125 male administrative employees and service workers from the industrial zone in New Damietta city. They were matched with the exposed group in most of confounding factors.

Study location:

Asal's factory is composed of three separate main buildings and a yard for storage of lumbers received before processing. The first building is for wood manufacturing and contains three floors. The second building is used for the finishing process, and it is also composed of three floors.

Figure (1): Asal's wood furniture factory buildings and its yard.

Figure (2): Woodworker.

Figure (3): Finishing worker.

Study Tools:

A. **Interviewer-administered questionnaire:** To collect data about the socio-demographic and occupational profiles of the study groups.

B. **Environmental measurements:**

1. **Wood dust concentration:** Total wood dust and respirable wood dust concentrations was measured by HAZ DUST Model HD-1100 in a private center (Nile Center for Environmental and Scientific Services). It was taken for every floor of the woodworking building
2. **Noise level:** Digital sound level meter (RadioShack CAT. NO. 3300099) was used to measure noise level in all factory departments at 3 different timings (9 am, 12 am, and 4 pm). Sound level meter was calibrated before use, adjusted on A weighting band with slow meter switch. The microphone was pointed to the sound source at a height 1.5 meter and 1 meter a way from walls. The meter displayed the average sound level in dB(A) during a one second sampling period and updates the number every 0.5 second. It was measured in both woodworking and finishing buildings.

C. **Investigations:**(1) Pulmonary function measurements. (2) Audiometric evaluation.

1. **Pulmonary function measurements:**

Method: It was carried out in the general supervisor office at the end of the working day. A calibrated "Digital" spirometer (Spirolab III MIR 980067) was used with explanation of the technique to each participant.

Technique: The test was conducted while the participant in sitting position. The participant was asked to take a deep inhalation followed by forced rapid exhalation with the nose was closed with nasal clip; into a disposable mouthpiece. At least 3 technically accepted trials were obtained with recording of the best one. The measured parameters were: FEV1: Forced expiratory volume in the first second; FVC: Forced vital capacity; FEV1/ FVC: Ratio between them; PEF: Peak expiratory flow rate; FEF25-57%: Forced expiratory flow 25-75%. The cut-off points for spirometric values: >80% of predicted values are considered normal [12].

2. **Audiometric evaluation:**

Method: It was carried out at the general supervisor office which was at a convenient distance from working site in the morning before starting work to avoid the temporary hearing loss following noise exposure. Also, windows and door were closed to impede outdoor noise. The apparatus used was audiometer 710-SISI portable pure tone audiometry, electromedizin (TUR), Berlin, Germany. The results were recorded for each participant on a pure tone audiogram sheet.

Technique: Ear phones were placed on both ears to measure air conduction of different frequencies. Each participant was asked to indicate whether he could hear the sounds or not for each ear at every frequency. Then bone conduction was measured by placing a small vibrator on the mastoid process for each ear separately also at the same frequencies. The intensity level measured by the audiometer ranged from -10 to 90 dB(A). Hearing threshold levels were measured in dB for the frequencies 250, 500, 1000, 2000, 4000, 6000 and 8000 Hz for both ears.

Diagnostic criteria for noise induced hearing loss (NIHL) were obtained from previous researches[13,14].

Ethical Consideration:

An approval of the study was obtained from Mansoura University Academic and Ethical Committee and Asal's factory administration. An informed verbal consent of study participants was obtained before the start of work with assurance of privacy and anonymity of the data. This work has been carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki) for studies involving humans.

Statistical analysis

Data were fed to the computer and analyzed by utilizing IBM SPSS software package version 16. Qualitative data were defined by utilizing number and percent. Quantitative data were described using median (minimum and maximum) for non-parametric data and mean±SD for parametric data after testing normality using Kolmogorov-Smirnov test. Chi-square test and Monte Carlo test were utilized for categorical variables, to compare between various groups as appropriate. Student-t test was utilized for parametric quantitative variables and Mann Whitney test for non-parametric quantitative variables. Significance of the obtained results was judged at the 5% level and all tests were 2 tailed. P value ≤ 0.05 was considered statistically significant.

RESULTS

The exposed groups of woodworking and finishing matched the comparison group in all sociodemographic characteristics. Regarding the age, the studied groups had mean age of 37.1±11.1 years for the woodworkers, 39.5±11.3 years for the finishing workers and 36.8±11.2 years for the comparison group. Concerning the level of education, the highest percentage of woodworkers (38.5%), finishing workers (39.3%), and comparison group (36%) had primary education. The majority of all the studied groups were married and from rural areas. Regarding smoking status, 35.2% of woodworkers and 41% of the finishing workers were current smokers. The majority of them were cigarette smokers with a median of 20 cigarettes/day and for a median duration of 20 years (no tabulated data).

Table (**1**) shows that, the median duration of employment was 20 years for woodworkers, 25 years for finishing workers and 22 years for the comparison group. About 16.4% of woodworkers and 19.7 % of finishing workers were having additional job related to furniture industry compared to 1.6% of the comparison group with a statistically significant difference (p≤0.001). Only about 5.7% of woodworkers and 4.9 % of finishing workers were using PPE.

Table (1): Occupational profile of the study groups.

Occupational profile	Comparison group N = 125		Exposed groups N = 183					
			Woodworking group N = 122		Test of significance and p value	Finishing group N = 61		Test of significance and p value
	No.	%	No.	%		No.	%	
Duration of employment (years)								
Median (Min – Max)	22 (3-47)		20 (2 – 45)		Z* = 1.008, p = 0.314	25 (2-47)		Z* = 0.932, p = 0.351
Having additional job related to furniture industry								
Present	2	1.6	20	16.4	χ^2 = 21.297, **p ≤ 0.001**	12	19.7	χ^2 = 25.268, **p ≤ 0.001**
Absent	123	98.4	102	83.6		49	80.3	
Personal protective equipment**								
Users	6	4.8	7	5.7	χ^2 = 0.109, p = 0.741	3	4.9	χ^2 = 0.249, p = 0.618
Non-users	119	95.2	115	94.3		58	95.1	

Z* *of Mann Whitney test,*

Personal protective equipment* *for respiratory and hearing protection (dust mask, respirators, ear plugs and muffs)*

Table (**2**) shows that, the mean levels of total wood dust concentration and respirable wood dust concentration were 0.36±0.04 mg/m³ and 0.21±0.04 mg/m³ respectively. In addition, the mean noise levels were 90.8±7.1 dB (A) and 80.5±5.3 dB (A) in woodworking and finishing buildings respectively. The averages of the selected environmental measurements were within the Egyptian maximum permissible limits, except for the noise levels in the woodworking building which were higher than the maximum permissible limits.

Table (2): Selected environmental measurements in woodworking and finishing buildings of Asal's wood furniture factory.

Parameters	MALs*	Woodworking building				Finishing building			
		First Floor	Second floor	Third floor	Total	First floor	Second floor	Third floor	Total
		Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD	Mean ±SD
Total wood dust concentration (mg/m³ TWA/8 hrs.)	10	0.36 ±0.02	0.33 ±0.04	0.26 ±0.07	0.36 ±0.04	0	0	0	0
Respirable wood dust concentration (mg/m³ TWA/8 hrs.)	5	0.22 ±0.07	0.22 ±0.04	0.17 ±0.02	0.21 ±0.04	0	0	0	0
Noise levels (dB [A]/ 8 hours)	90	91.8 ±5.9	91.5 ±5.7	89.3 ±5.8	90.8± 7.1	81.7 ±4.1	80.2 ±3.4	79.7 ±5.2	80.5 ±5.3

** Maximum allowable limits according to Egyptian Environmental Law* [15]

Table (**3**) shows that, as regards the ventilatory lung functions measurements among the woodworking group, the means±SD of both measured and percent predicted values of FVC and FEV1 were insignificantly slightly lower than those of the comparison group (p>0.05). In addition, the means of measured and percent predicted values of FEV1/FVC, PEFR, FEF 25-57% were statistically significantly lower than the comparison group (p≤0.05). For the finishing workers, it was found that the means±SD of both measured and percent predicted values of FVC and percent predicted FEV1 were slightly lower than those of the comparison group with a non-statistically significant difference (p>0.05). However, the means±SD of measured FEV1 and those of both measured and percent predicted values of FEV1/FVC, PEFR, FEF25-57% were lower than those of the comparison group with a statistically significant difference (p≤0.05).

Normal pattern of ventilatory lung functions was the most frequent among all the study groups. The pattern of pulmonary involvement did not differ significantly (p>0.05) between woodworkers and the comparison group. However, the finishing workers had a statistically significant (p≤0.001) higher prevalence of obstructive pattern of ventilatory lung functions.

Table (3): Ventilatory lung function measurements of the study groups.

<table>
<tr><th rowspan="3">Ventilatory lung function measurements</th><th colspan="2" rowspan="2">Comparison group
N = 125</th><th colspan="6">Exposed groups N = 183</th></tr>
<tr><th colspan="2">Woodworking group
N = 122</th><th rowspan="2">Test of significance and p value</th><th colspan="2">Finishing group
N = 61</th><th rowspan="2">Test of significance and p value</th></tr>
<tr><th colspan="2">Mean ± SD</th><th colspan="2">Mean ± SD</th><th colspan="2">Mean ± SD</th></tr>
<tr><td colspan="9">FVC</td></tr>
<tr><td>Measured (Liters)</td><td colspan="2">4.48±0.78</td><td colspan="2">4.35±0.7</td><td>t = 0.283,
p = 0.78</td><td colspan="2">4.33±0.9</td><td>t = 0.712,
p = 0.48</td></tr>
<tr><td>% Predicted</td><td colspan="2">98.2±14.3</td><td colspan="2">97.1±12.7</td><td>t = 0.644,
p = 0.52</td><td colspan="2">96.9±16.3</td><td>t = 0.494,
p = 0.62</td></tr>
<tr><td colspan="9">FEV1</td></tr>
<tr><td>Measured (Liters)</td><td colspan="2">3.76±0.7</td><td colspan="2">3.63±0.7</td><td>t = 0.43,
p = 0.668</td><td colspan="2">3.38±0.8</td><td>t = 2.1,
p = 0.037</td></tr>
<tr><td>% Predicted</td><td colspan="2">97.5±17.5</td><td colspan="2">96.1±15.8</td><td>t = 0.651,
p = 0.52</td><td colspan="2">92.4±16</td><td>t = 1.4,
p = 0.163</td></tr>
<tr><td colspan="9">FEV1/FVC</td></tr>
<tr><td>Measured</td><td colspan="2">85.8±8.2</td><td colspan="2">81.6±7.8</td><td>t = 4.11,
p ≤ 0.001</td><td colspan="2">77.9±8.9</td><td>t = 5.94,
p ≤ 0.001</td></tr>
<tr><td>% Predicted</td><td colspan="2">106.8±10.4</td><td colspan="2">101.5±9.5</td><td>t = 4.12,
p ≤ 0.001</td><td colspan="2">97.7±10.9</td><td>t = 5.49,
p ≤ 0.001</td></tr>
<tr><td>PEFR</td><td colspan="8"></td></tr>
<tr><td>Measured (L/sec)</td><td colspan="2">10.3±3.2</td><td colspan="2">6.6±1.8</td><td>t = 3.26,
p = 0.001</td><td colspan="2">5.8±1.6</td><td>t = 4.06,
p ≤ 0.001</td></tr>
<tr><td>% Predicted</td><td colspan="2">94.9±19.8</td><td colspan="2">72.2±19.3</td><td>t = 9.09,
p ≤ 0.001</td><td colspan="2">65.86±18.3</td><td>t = 11.43,
p ≤ 0.001</td></tr>
<tr><td>FEF25-75%</td><td colspan="8"></td></tr>
<tr><td>Measured (L/sec)</td><td colspan="2">8.7±2.6</td><td colspan="2">3.9±1.3</td><td>t = 2.45,
p = 0.015</td><td colspan="2">3.4±1.2</td><td>t = 2.31,
p = 0.013</td></tr>
<tr><td>% Predicted</td><td colspan="2">137.3±29.1</td><td colspan="2">88.4±25.6</td><td>t = 10.4,
p ≤ 0.001</td><td colspan="2">80.7±24.9</td><td>t = 10.9,
p ≤ 0.001</td></tr>
<tr><td>Interpretation</td><td>No.</td><td>%</td><td>No.</td><td>%</td><td rowspan="4">χ^2 = 4.373,
MEP* = 0. 497</td><td>No.</td><td>%</td><td rowspan="4">χ^2 =14.34,
MEP* = 0.001</td></tr>
<tr><td>Normal</td><td>117</td><td>93.6</td><td>106</td><td>86.9</td><td>45</td><td>73.8</td></tr>
<tr><td>Obstructive</td><td>3</td><td>2.4</td><td>9</td><td>7.4</td><td>11</td><td>18.1</td></tr>
<tr><td>Restrictive</td><td>5</td><td>4</td><td>7</td><td>5.7</td><td>5</td><td>8.1</td></tr>
</table>

MEP: Monte Carlo Exact Probability*

Table (**4**) shows that, regarding hearing impairment of the study groups, it was found that hearing loss was more prevalent among both woodworkers (34.4%) and finishing workers (22.9%) compared to the comparison group (7.2%) with a highly statistically significant difference (p≤0.005) for both exposed groups. Sensorineural hearing loss was significantly (p≤0.005) prevalent among both woodworkers (26.2%) and the finishing workers (18%) compared to the comparison group (2.4%). Criteria of NIHL were met in 81.3% of woodworkers with sensorineural hearing loss, who accounted for 21.3% of all woodworkers.

Table (4): Audiometric testing interpretation of the study groups.

Hearing impairment	Comparison group N = 125		Exposed group N = 183					
			Wood-working group N = 122		Test of significance and p value	Finishing group N = 61		Test of significance and p value
	No.	%	No.	%		No.	%	
Normal hearing	**116**	**92.8**	**80**	**65.6**	χ^2 = 27.93, **p ≤ 0.001**	**47**	**77**	χ^2 = 9.38, **p = 0.003**
Hearing loss	**9**	**7.2**	**42**	**34.4**		**14**	**22.9**	
Conductive hearing loss	**5**	**4**	**5**	**4.1**	χ^2 = 37.315, **MEP* ≤0.001**	**3**	**4.9**	χ^2 = 17.485, **MEP* = 0.002**
Mild	5	4	4	3.3		2	3.3	
Moderate to severe	0	0	1	0.8		0	0	
Severe	0	0	0	0		1	1.6	
Sensorineural hearing loss	**3**	**2.4**	**32**	**26.2**		**11**	**18**	
Mild	3	2.4	25	20.5		8	13.1	
Moderate	0	0	7	5.7		3	4.9	
Mixed hearing loss	**1**	**0.8**	**5**	**4.1**		**0**	**0**	
Mild	1	0.8	4	3.3		0	0	
Profound	0	0	1	0.8		0	0	

MEP: Monte Carlo exact probability*

Figure (**4**) shows that, the mean hearing thresholds of both air and bone conduction of the right and left ear of the exposed groups (woodworkers and finishing workers) were within normal levels (less than 25 dB), but were higher than those of the comparison group.

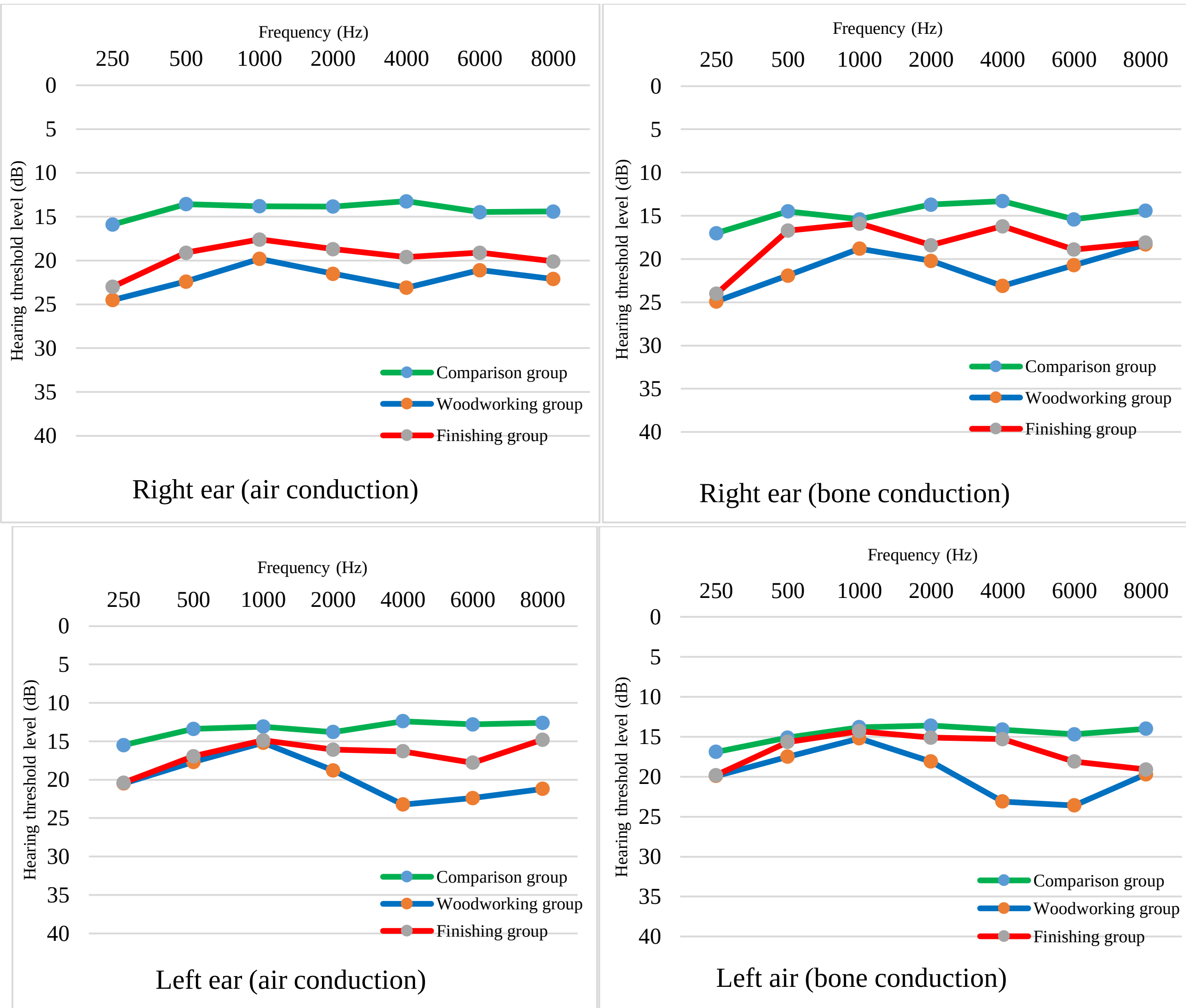

Figure (4): Audiogram showing air and bone conduction hearing threshold levels of the right and left ears of the studied groups.

DISCUSSION

Wood furniture industry is considered one of the most hazardous industries. About 3.5 million workers were occupied in wood furniture industry in the year 2000 worldwide. The workers are subjected to several hazards as exposure to wood dust, toxic chemicals and noise [(16)].

This study was carried out to explore the work environment, and to identify ventilatory and auditory findings among Asal's wood furniture factory workers in Damietta governorate. A convenient sample of 183 workers were included in this study. They comprised 122 workers engaged in woodworking and 61 in finishing (exposed groups), and a matched comparison group of 125 male administrative and service employees from the industrial zone in New Damietta city.

Regarding wood dust measurements, both mean total wood dust (0.36±0.04 mg/m³) and respirable wood dust concentrations (0.21±0.04 mg/m³) were within the Egyptian maximum allowable concentrations. That was in agreement with **Farahat *et al.*** [(17)], who found that the mean of respirable wood dust ranged from 1.9±0.87 to 4.46± 0.66 mg/m³ in four carpentry shops in Egypt. Moreover, **Douwes *et al.*** [(18)] found a mean of 0.6 mg/m³ respirable wood dust in three wood furniture factories in New Zealand. However, higher levels of respirable dust which exceeded the limit value of 5 mg/m³ were found by **Carrieri *et al.*** [(19)] in 8.8% of samples from five small Italian furniture factories.

The lower mean levels of both total and respirable wood dust concentrations in our study could be attributed to the efficient control of the local exhaust ventilation fitted to the machines at the source of wood dust emissions.

In addition, the current study revealed that, noise level in the woodworking building was 90.8±7.1dB(A)/8 hours which exceeded the permissible exposure limits. The higher noise levels in the woodworking building were probably attributed to the aerodynamic turbulence of rotating tools especially of the circular saws and cutter heads and the vibration emitted from machine frames. This was in agreement with **Reinhold *et al.*** [(20)] However, a lower mean noise level of 82.8±7.3 dB(A)/8 hours was detected across various furniture factories in Australia [(21)].

Ventilatory lung functions measurements among the woodworking group revealed that; the means of both measured and percent predicted values of FVC and FEV1 were insignificantly slightly lower among the woodworkers. In addition, the means of measured and percent predicted values of FEV1/FVC, PEFR, FEF 25-57% were statistically significantly lower than the comparison group. Yet, the pattern of pulmonary involvement did not differ significantly. That was similar to results of **Löfstedt *et al.*** [(22)]. However, significant affection of ventilatory lung functions including significant reduction of measured and percent predicted values of FEV1, FVC, FEV1/FVC ratio and PEFR suggesting obstructive pattern was detected by **Osman and Pala** [(23)] among woodworkers in a Turkish furniture factory.

The significant reduction in ventilatory measurements among woodworkers could be attributed to the adverse effects of wood dust on lung functions, as it may elicit pulmonary inflammation via induction of several pro-inflammatory cytokines which damage bronchial epithelial cells and increase bronchial responsiveness [(24)].

Among the finishing workers, it was found that the means of both measured and percent predicted values of FVC and percent predicted FEV1 were slightly lower than the comparison with ($p>0.05$). However, the mean values of measured FEV1 and of both measured and percent predicted values of FEV1/FVC ratio, PEFR, FEF25-57% were statistically significantly lower. There was a highly statistically significant ($p\leq0.001$) prevalence of obstructive pattern (18.1%) compared to the comparison group (2.4%). That was in accordance to studies [(25, 26)].

However, ventilatory lung functions were not found to be significantly changed in a study carried out by **Revathi and Chandrasekhar** [(27)] among spray painters in India, as they attributed their results to decreased duration of employment (less than 5 years) and adequate PPE use. Moreover, restrictive pattern was detected by **Gupta *et al.*** [(28)] among spray painter in India, who attributed their results to isocyanates inhalation that could lead to hypersensitivity pneumonitis.

The significant ventilatory lung functions reduction among the finishing workers could be attributed to exposures to isocyanates, which adversely affect lung functions either through reaction with body molecules (e.g., peptides/proteins), altering their conformation and creating neo-epitopes that stimulate the immune system, and/or inducing cell mediated allergic reactions and pulmonary irritation. This is associated with respiratory tract inflammation [(29)].

In the current work, the audiometric results among woodworkers revealed a statistically significant ($p\leq0.001$) higher frequency of hearing impairment (34.4%). Sensorineural hearing loss was the most frequent type among woodworkers (26.2%) who were exposed to noise levels of 90.8±7.1 dB(A). Twenty-six woodworkers (21.3%) were diagnosed as having NIHL. Noise induced hearing loss is principally caused by reversible or permanent damage to the stereocilia of cochlear hair cells and associated synaptopathy, leading to temporary or permanent threshold shift, respectively.

It was in accordance with **Robinson *et al.*** [(30)] who found that, 31% of carpenters in furniture factories in Nepal, met the criteria for NIHL. Moreover, **Mongare *et al.*** [(31)] stated that 37.3% of woodworkers in Kenya had NIHL and 93.6 % of them were exposed to noise levels more than 90 dB(A) for more than 8 h/day. However, a lower frequency of NIHL (l2.2%) was detected by **Eglite *et al.*** [32] among woodworkers in Latvia.

In the current study, the audiometric testing results of the finishing workers showed a significantly higher frequency of hearing loss. The hearing impairment among the finishing workers could be attributed to the ototoxic effect of organic solvents through the formation of reactive oxygen species and dysfunctions of transmembrane K+ fluxes, which irreversibly damage cochlear hair cells [33].

These results were in line with **Fuente *et al.*** [34] who found that solvent-exposed workers in a paint factory in Chile, had significantly poorer pure-tone hearing thresholds. However, **Loukzadeh *et al.*** [35] found no significant association between solvent exposure and sensorineural hearing loss in Iran. They attributed that to the short duration of employment.

Schaal *et al.* [5] on his study on shipyard workers in USA, concluded that hearing loss was significantly higher among workers exposed to both noise and solvents than workers exposed to noise only. They attributed that to the synergistic effect of both solvents and noise, as solvents can reduce the protective role of middle ear together with alteration of the membranous structures of the outer hair cells making them fragile and vulnerable.

Strength and limitation the study:

The current study used well-standardized tools to screen ventilatory and auditory functions. Nevertheless, some limitations should be acknowledged. The cross-sectional design cannot prove the link between the outcome and the exposure in the work place. The data of the study were obtained from only one factory which may impact the generalizability of the study. However, the current findings are considered a good addition to the limited local data of researches done before among furniture workers in Egypt.

CONCLUSION

The workplace environment in wood furniture industry adversely affects the ventilatory and auditory functions of their workers. Therefore, the improvement of the work environment through adoption of effective health and safety procedures, is necessary not only for the standpoint of workers, but also contributes significantly to increased productivity and economic growth.

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