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RESEARCH ARTICLE

Evaluation of Toluene Vapors on the Hearing System of a Production Company Employee: A Carcinogenic Agent

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Abstract

Introduction: Hearing loss is one of the most common causes of disability of more than 1.33 billion people worldwide and, according to WHO research, failure to timely detect hearing loss has detrimental effects on the individual, the family and the world economy ($ 750 billion), Therefore, exposure to excessive noise and exposure to organic solvents can cause hearing loss in individuals. **Methods:** This descriptive-analytical study was performed on a manufacturing company with a statistical population of 17 people (8 employees of printing and electroplating unit with a mean age of 40±4.78 and 9 employees of Coldwell unit with a mean age of 4.33±41). Data were analyzed by SPSS software version 16 and paired T-test. **Results:** According to the pollutant results in the Coldwell unit, the noise level was exceeded, but the toluene levels were measured at the permissible level, which, according to the software output, showed a faster rate of hearing loss (Right ear sig = 0.007 and left ear sig = 0.002) and also, in the printing and plating unit, the sound level was above the permissible limit, but the toluene level was exceeded, which according to the software output of these units had a lower rate of hearing loss. **Conclusion:** The results of this study show that simultaneous exposure to noise and organic solvents such as toluene in the workplace accelerates the Occupational Hearing Loss Process, as well as employees who are not exposed to noise, are reasonably hearing impaired due to exposure to toluene.

Keywords: Noise- Audiometry- Occupational Hearing Loss- Measurement of Workplace Hazardous Factors

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Introduction

Noise is one of the most important physical harmful factors in the workplace, and noise-induced hearing loss is one of the ten most important work-related illnesses in the world [1] and has caused more than 1.33 billion people to be disabled in the world [2]. According to WHO research Failure to Identify Early Hearing Losses Causes Impacts on Individual, Family, and World Economy ($ 750 Billion) [3] Sensory-Neural Hearing Losses in both Temporary Threshold Shift and Temporary Hearing Loss Permanent Threshold Shift (PTS) occurs as a result of permanent or irreversible hearing loss due to permanent damage to the hearing system [4-5]. Exposure to excessive noise (over 85 dB) is a major cause of occupational hearing loss, but exposure to a variety of harmful factors, particularly organic solvents, in industrial environments can exacerbate the impact of noise on hearing loss. Intensify [6-7]. Occupational hearing loss due to exposure to chemical solvents often referred to as solvent-induced hearing loss (SIHL), and the most important of these solvents, according to studies include Styrene, xylene, ethylbenzene, trichloroethylene, carbon disulfide, ethanol, heptane, and hexane that some of them is carcinogenic [8-18]. Similar studies also emphasize that workers' exposure to chemicals, especially aromatic solvents (such as toluene, styrene, ethylbenzene and carbon disulfide) or simultaneous exposure to the above chemicals and noise in

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the workplace, exacerbates the risk of hearing loss. In these studies, it has been recommended that more attention be paid to the results of measuring workplace harmful factors [10-19-20]. Among the solvents and organic compounds used in the BTEX, industry are 4 benzene, toluene, ethylbenzene, and xylene and have similar physical and chemical properties and their main characteristic is their high evaporation rate [21], and workers are exposed to BTEX when working with a variety of thinners, paints and lacquers for work processes, as well as washing parts and equipment through inhalation, peeling and eating, which is the most important way is to inhale [22]. Also, Carcinogenicity of BTEX has been proven [23-24]. Toluene is widely used in the aromatic solvents industry[25]. Toluene comprises major components of adhesives, paints, industrial varnishes, polishers, oil cleaners, fuel additives and There are types of thinners [26].

Studies have shown the toxic and adverse effects of toluene on the auditory system [27] and also reduce hearing loss [28-29] and chronic exposure to aromatic solvents has adverse effects on the central nervous system [30-32]. Therefore, in the present study, we investigated the effects of toluene on workers' hearing systems in a manufacturing company during 2003-2009.

Materials and Methods

This descriptive-analytical study was carried out in a home appliance manufacturing company in 1398 in 16 years (1382-1398). The purpose of this study was to investigate the probability of exposure to chemical solvents on the auditory system. In this regard, different production units were investigated and staff of printing, electroplating, and Coldwell were exposed to solvents especially toluene. In the printing and electroplating sector, the noise level is exceeded, but in the electroplating section, the measurement is exceeded. The printing unit staff uses a mixture of liquid and thinner to label plastic parts, such as freezer basket lid, drawer (one-piece drawer), plastic box compartment, large fruit compartment, ice door, etc. They use Ritard and alcohol solvents to scrub the surface of scrap and clean the machine and prepare for the next working day, and the plating staff to paint the refrigerator condenser from a thinner-liquid mixture, and for lacquer evaporators and refrigerators. The freezer uses a mixture of lacquer and thinner. (Condenser and evaporator are cooling gas rotating chambers in the refrigerator.). Staff at the Coldwell Unit use a mineral thinner to wash all types of copper pipes to produce heater, jumper, etc., and then dry the aforementioned parts with compressed air, which raises the noise (over permitted) In the work environment.

In summary, the target group in this study included 17 people:

1. 8 employees with an average age of 40±4.78 and working experience of 17.25±1.98 in the printing and plating unit who deal directly with toluene and according to the measurements, the noise in the workplace is excessive and sometimes lower than allowed.

2. 9 employees with a mean age of 41±4.33 and working experience of 17.88±1.69 per unit who deal directly with toluene vapors and noise are too high in the work environment.

Sound measurement in the year 1382, in dosimeter [33] (which is the most reliable method of measuring and evaluating worker exposure because the device is during the shift with the worker and at the end of the shift shows the actual size of the received dose) at stations where the sound is received. Over frequency (over 85 dB) Frequency analysis, SIL interference level was also performed, it should be noted that the sound pressure level in network A using CEL-440 device equipped with filter, analyzer and The CASELA-CELL UK CEL-282 calibrator is designed to measure sound pressure levels in all three A, C and linear networks with a resolution of 0. It has 1 dB and the octave band analysis section of the device was performed in 11 bands with 16HZ-16KHZ octobond centers. And in 1389, the equivalent noise level (Leq: Equivalent Sound Level) was measured to measure different sound levels during shift work and to evaluate worker exposure. Audiometry [34-35] (the most important method of hearing assessment) of workers in plating, printing and Coldwell units from periodic examinations [36-40]. from 1382 to 1398 Extraction and airborne hearing threshold at low frequencies of 250, 500, 1000, 2000 And at high frequencies 3000, 4000, 6000 and 8000 [41] were measured by an experienced audiometer with the MEWOX SA15 audiometer. Occupational exposure limits are set to 8 hours per day and 40 hours per week and adjusted to 9-hour shifts (OEL - TWA *) daily for exposure times above normal using the Bariff and Scala model. Or weekly (OEL = modified) and to determine the daily reduction coefficient or FR of / 16 (24-hr) RF = 8 / hr * which is the hr of daily work hours, according to the two mathematical relationships above, the daily coefficient of reduction for a 9-hour shift is as follows:

$$RF = 8/9\times(24-9)/16 = 0.83$$

Therefore, by increasing the daily working hours from 8 to 9 hours, the permissible limit was calculated according to the NIOSH1501 [42] standard. Data were analyzed using SPSS 16 software and paired T-test.

Results

Concerning the explanations provided, the results of sound measurements in the Coldwell, printing and plating sections during 1382 and 1398 are presented in Table 1.

Measurements of toluene vapors in Coldwell, Printing, and plating sections were presented in Tables 2 and 3 during 1382 and 1398.

After analyzing the data from noise and toluene pollutants in the workplace and extracting the audiometric data from medical records, the data were analyzed by paired t-test and SPSS 16 software, and the results are presented in Tab 4. Due to the purpose of the study and considering that the concentration of toluene in the plating

Table 1. Sound Measurement Results in the Coldwell, Print, and Plating Sections

				Speech Interference Level (SIL)							
Row	Section	Year	Volume (dB)	125	250	500	1000	2000	4000	8000	SIL
1	Coldwell	1382	88	65	71	73	81	80	81	63	78
		1398	92	82	82	85	85	85	83	78	85
2	Print	1382	76	-	-	-	-	-	-	-	-
		1398	74	-	-	-	-	-	-	-	-
3	Plating	1382	78	-	-	-	-	-	-	-	-
		1398	75	-	-	-	-	-	-	-	-

Table 2. Results of Toluene Measurement in 1398 in Coldwell, Printing, and plating Sections

No	Section	Sampling time (minute)	The total volume of sampled air (liter)	Measurement method	Absorbent type	The concentration of toluene (PPM)	Result
1	Coldwell	87 min	15.66 = 7.92 ± 7.74			3.36	Optimal
2	Print	82 min	14.76 = 7.56 ± 7.2	NIOSH 1501	Coconut Shell charcoal	0.0014	Optimal
3	Plating	115 min	14.95 = 7.28 ± 7.67			28	Undesirable

Table 3. Analysis of Audiometric Data in SPSS Software with Paired T-test

Row	Section	Organ	Standard deviation± mean	Paired T value	Sig<0.05
1	Coldwell	Right ear 82	9.93 ± 1.77	T = -2.765	Sig-0.007
		Right ear 98	12.36 ± 7.01		
	Coldwell	Left ear 82	13.61 ± 9.72	T = -3.212	Sig=0.002
		Left ear 98	17.22 ± 13.13		
2	Print and Plating	Right ear 82	9.6 ± 4.36	T = -4.206	Sig=0.000
		Right ear 98	13.04 ± 7.99		
	Print and Plating	Left ear 82	10.07 ± 3.83	T = -4.619	Sig=0.000
		Left ear 98	14.68 ± 8.72		
3	Print	Right ear 82	9.21 ± 5.09	T = -4.268	Sig=0.000
		Right ear 98	13.75 ± 9.33		
	Print	Left ear 82	10.46 ± 3.88	T = -4.366	Sig=0.000
		Left ear 98	17.03 ± 10.06		
4	Plating	Right ear 82	9.68 ± 3.79	T = -2.161	Sig=0.039
		Right ear 98	12.34 ± 6.47		
	Plating	Left ear 82	9.68 ± 3.79	T = -2.161	Sig=0.039
		Left ear 98	12.34 ± 6.47		

area was exceeded, but in the printing unit, it was within the permissible range. Therefore, the results of these two units were examined together and presented separately in rows 2 and 3 of Table 3.

Discusstion

According to the results presented in Table 3, it was found that the employees of ColdWall Unit, with an average age of 41 4. ±4.33 and a working experience of 17.88 ± 1.69, had a faster hearing loss due to exposure to workplace noise and toluene vapors -This result is consistent with a similar study [43]- (Right ear sig=0.007, and Left ear sig=0.002) Employees of printing and electroplating units with average age of 40 ± 4.78 and work experience of 17.25 ± 1.98, due to the permissible noise level in their work environment, they have a slower process of hearing loss (Right and Left ear sig=0.000). This can be attributed to the organic solvents in the workplace, especially toluene, Thus, the results of this study are consistent with similar studies that have investigated the effects of organic solvents such as toluene, benzene, ethylbenzene, etc. on the auditory system [7-12-19-20-27-28], particularly in the study of Mohammadi et al (2009) Employees exposed to simultaneous exposure to organic solvents and noise should pay particular attention to a hearing protection program including shorter audiometric examinations as well as the use of appropriate protective phones [43]. To examine the subject more closely and to compare the effects of toluene on printing and plating staff gave that the amount of toluene in the print was allowed but this amount was exceeded

in the plating. According to the statistical comparison in Table 3, it was determined by separating the printing and plating units whose point of subsidence was as high as the noise level allowed , Employees of the plating unit (exposed to solvent-specific toluene 9 months per year) have a slower hearing loss than the print unit (exposed to solvent-specific toluene for 12 months per year). It can be concluded that daily exposure to toluene will only cause hearing loss in employees, which is significantly lower than the frequency of 4000 Hz in the left ear of the printing unit staff (sig = 0.049). However, there was no significant decrease in plating staff at high frequencies. It is suggested that in future studies, organic solvents in the workplace such as BTEX – as an environmental carcinogen [23-24] should first be analyzed by reputable laboratories and separated into its components. Moreover, the amount of benzene, toluene, ethylbenzene, and xylene should become clear and then study the target group (people exposed to toluene), Preference should be given more precisely to the measurement of hazardous factors in the workplace for the accuracy of the results, and the statistical population should include at least 30 people for exposure to toluene and noise when both are excessive, 30 people for exposure to toluene and noise when each Two are less than the limit and at least 30 should be considered when the toluene is too high and the noise is below the maximum.

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References

1. Nelson DI, Nelson RY, Concha-Barrientos M, Fingerhut M. The global burden of occupational noise-induced hearing loss. American journal of industrial medicine. 2005;48(6):446-58.
2. Ginawi I. Global, regional, and national age-sex specific mortality for 264 causes of death, 1980–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017;390(10100):1151-210.
3. Organization WH. Global costs of unaddressed hearing loss and cost-effectiveness of interventions: a WHO report, 2017: World Health Organization; 2017.
4. Schindler David N, Jackler Robert K, Robinson Scott T. Hearing loss. Current Occupational & Environmental Medicine Volume.10.
5. Ladou J. Occupational and environmental medicine, Appleton and Lange. Prentice Hall, Stamford/Connecticut, USA; 1997.
6. Luxon L, Furman JM, Martini A, Stephens SDG. A Textbook of Audiological Medicine: Clinical Aspects of Hearing and Balance: CRC Press; 2002.
7. Morioka I, Miyai N, Yamamoto H, MIYASHITA K. Evaluation of combined effect of organic solvents and noise by the upper limit of hearing. Industrial Health. 2000;38(2):252-7.
8. Fuente A, McPherson B. Occupational chemical-induced hearing loss. Hearing loss. 2012:171-90.
9. Australia SW. Managing the work environment and facilities: code of practice: Safe Work Australia; 2011.
10. Nies E. Ototoxic substances at the workplace: a brief update. Archives of Industrial Hygiene and Toxicology. 2012;63(2):147-52.
11. Hodgkinson L, Prasher D. Effects of industrial solvents on hearing and balance: a review. Noise and health. 2006;8(32):114.
12. Toppila E. Synergistic Effects of Noise and Solvents-what we Know and Future Research Needs. Synergistic exposure to noise, vibrations and ototoxic substances. 2010:33.
13. Yari S, Fallah AA, Varmazyar S. Assessment of semi-quantitative health risks of exposure to harmful chemical agents in the context of carcinogenesis in the latex glove manufacturing industry. Asian Pacific journal of cancer prevention: APJCP. 2015;17(205):11.
14. Yari S. Inherent safety design in compose of urban gas station. Safety Promotion and Injury Prevention. 2015;3(2):135-40.
15. Yari S. Assessment of potential risk by the failure mode and effects analysis in an air conditioning equipment manufacturing company. Journal of Safety Promotion and Injury Prevention. 2017;5(2).
16. Yari S, Pouyakian M, Jafari MJ, Alipour A, Varmazyar S. Preparation and psychometry of a safety assessment questionnaire for urban gas stations. Safety Promotion and Injury Prevention. 2018;5(3):169-80.
17. Nikpey A, Saeidabadi H, Sheikhi S, Yari S, Madarsara TJ. Evaluation of respiratory exposure to 4, 4-methylene diphenyl diisocyanate (MDI) vapors in foam injection workers in a household appliance manufacturing company: An Occupational Carcinogen. Asian Pacific Journal of Environment and Cancer. 2019;2(1).
18. Yari S, Saeedabadi H. Simulation the Probability of Liberalizing Chlorin Gas from Urban Water Chlorination System in Alborz: With the Cancer Approach. 2019.
19. Campo P, Morata TC, Hong O. Chemical exposure and hearing loss. Disease-a-month: DM. 2013;59(4):119.
20. Choi Y-H, Kim K. Noise-induced hearing loss in Korean workers: co-exposure to organic solvents and heavy metals in nationwide industries. PloS one. 2014;9(5):e97538.
21. Correa SM, Arbilla G, Marques MR, Oliveira KM. The impact of BTEX emissions from gas stations into the atmosphere. Atmospheric pollution research. 2012;3(2):163-9.
22. Samarghandi M, Mehralipour J, Shabanlo A, Rahimpoor R. The evaluation of personal exposure to BTEX compounds in the traditional restaurants in Hamadan in 2013. 2014.
23. Yari S, Asadi AF, Nourmohammadi M. Occupational and Environmental Cancer. Asian Pacific Journal of Environment and Cancer. 2018;1(1).
24. Yari S, Asadi AF, Jarrahi AM, Nourmohammadi M. CARcinogen EXposure: CAREX. Asian Pacific Journal of Environment and Cancer. 2018;1(1).
25. Meek M, Chan P. Toluene: evaluation of risks to human health from environmental exposure in Canada. Journal of Environmental Science & Health Part C. 1994;12(2):507-15.
26. Calabrese G, Martini A, Sessa G, Cellini M, Bartolucci G, Marcuzzo G, et al. Otoneurological study in workers exposed to styrene in the fiberglass industry. International Archives of Occupational and Environmental Health. 1996;68(4):219-23.
27. Morata TC, Fiorini AC, Fischer FM, Colacioppo S, Wallingford KM, Krieg EF, et al. Toluene-induced hearing loss among rotogravure printing workers. Scandinavian journal of work, environment & health. 1997:289-98.
28. Pryor G, Dickinson J, Howd R, Rebert C. Transient cognitive deficits and high-frequency hearing loss in weanling rats exposed to toluene. Neurobehavioral Toxicology and

Teratology. 1983;5(1):53-7.
29. Pryor GT, Rebert CS, Howd RA. Hearing loss in rats caused by inhalation of mixed xylenes and styrene. Journal of applied toxicology. 1987;7(1):55-61.
30. Greenberg MM. The central nervous system and exposure to toluene: a risk characterization. Environmental research. 1997;72(1):1-7.
31. Lazar RB, Ho SU, Melen O, Daghestani AN. Multifocal central nervous system damage caused by toluene abuse. Neurology. 1983;33(10):1337-.
32. Moller C, Odkvist L, Larsby B, Tham R, Ledin T, Bergholtz L. Otoneurological findings in workers exposed to styrene. Scand J Work Environ Health. 1990;16(3):189-94.
33. Golmohamadi R. Noise & vibration engineering: Tehran; 2003.
34. Ramkissoon I, Cole M. Self-reported hearing difficulty versus audiometric screening in younger and older smokers and nonsmokers. Journal of clinical medicine research. 2011;3(4):183.
35. Swanepoel DW, Eikelboom RH, Hunter ML, Friedland PL, Atlas MD. Self-reported hearing loss in baby boomers from the Busselton Healthy Ageing Study: audiometric correspondence and predictive value. Journal of the American Academy of Audiology. 2013;24(6):514-21.
36. Cullen MR, Rosenstock L, Kilbourne EM. Introduction to Occupational and Environmental Medicine. Textbook of Clinical Occupational and Environmental Medicine: Elsevier; 2005. p. 3-15.
37. Baker EL, Matte TP. Occupational health surveillance. Textbook of clinical occupational and environmental medicine Philadelphia, PA: Elsevier Saunders Company. 2005:76-82.
38. Rom WN, Markowitz SB. Environmental and occupational medicine: Lippincott Williams & Wilkins; 2007.
39. Control CfD. NIOSH recommendations for occupational safety and health standards 1988. MMWR supplements. 1988;37(7):1.
40. Sorgdrager B, Hulshof CT, van Dijk FJ. Evaluation of the effectiveness of pre-employment screening. International archives of occupational and environmental health. 2004;77(4):271-6.
41. Pourzarea G, Attarchi M, Valirad F, Mohammadi S. The effect of simultaneous exposure to organic solvents and noise on high frequency hearing loss in tire manufacturing company workers. Occupational Medicine Quarterly Journal. 2016;8(2):72-80.
42. Sciences HDoP. NIOSH, Manual of Analytical Methods: US Government Printing Office; 1994.
43. Mohammadi S, Labafinejad Y, Amiri Rigi A, Attarchi M. Effect of Contemporary Exposure to Mixed Organic Solvents and Occupational Noise on Hearing Thresholds of Workers. Zahedan J Res Med Sci. 2010;11(4):e94356.