**Health hazards among a sample of workers exposed to a combination of noise and organic solvents in a fermentation factory in Egypt**

**By**

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**Abstract:**

**Introduction and Aim of the study:** Exposure to noise can induce hearing impairment among industrial workers. Studying the impact of combined exposure to both industrial pollutants such as noise and organic solvents on hearing was scarcely pointed. The aim of the present work was to study the risk of hearing loss among a sample of fermentation plant workers in Egypt exposed to both noise and a mixture of organic solvents and compare them with matched group of workers exposed to neither noise nor organic solvents.

**Materials and Methods:** The exposed group consisted of 110 workers in a fermentation plant exposed to noise only (50 workers, group A) or to noise and mixture of organic solvents (60 workers, group B). The control group (30 workers, group C) were matched to the exposed group but were neither exposed to noise nor organic solvents. All filled a detailed questionnaire and subjected to complete medical examination. Audiometry was done for every worker using pure tone Audiometer (GS. Model 1703). The characteristic V-notch in the audiogram was used as early sign of hearing loss. Noise level at work place was carried out using a calibrated Percision sound level meter type 2232.

**Results:** Both exposed and control groups were matched for age, sex, socioeconomic status, smoking habit and systolic blood pressure. Noise level was comparable in groups A&B but significantly higher than in control work places. Thirty six percent of exposed workers suffered from hearing loss versus 3.3 percent in the control group (p < 0.001). Hearing loss was significantly higher among group B (24%) than group A (18%) (p< 0.05)

**Conclusion:** In a fermentation plant, both exposed groups had higher hearing loss than normal control. Workers exposed to both noise and organic solvents suffered from highest proportion of hearing loss compared to those exposed to noise alone, and so solvents may interact synergistically with noise.

**Key words:** Noise- organic solvents- hearing loss.

**INTRODUCTION**

 Noise may be considered very likely the most common ototoxic factor. Noise-induced hearing loss (NIHL) has been widely investigated in industrial and non-industrial fields WHO, 1980[1] and Wilson et al., 1999[2], Quaranta et al., 2000 [3]. Combination effect of noise and organic solvents in industry remains unclear, organic solvents have been widely used in industry, research and household works. In industry, they are used in plastics, rubber, paints, artificial silk and leather manufacture. An appreciable amount of solvents can be absorbed through inhalation and intact skin. Being mostly volatile, they can be toxic to most parts of human body Lynge et al., 1997[4], Fuente and McPherson, 2006[5], Matsuoka, 2007[6], Ebbehoj et al., 2008[7] and Herpin et al., 2009[8].

Exposure to a single solvent usually occurs in experimental conditions. In industry, workers are mostly exposed to a mixture of solvents at the same time, Hunter 1979[9], Kowalska at al., 2000[10] had reported that among health hazards of exposure to organic solvents in conjunction with noise is hearing loss. On experimental animals (rats), Johnson 1993, reported that combined exposure showed clear potentiation of ototoxicity [11] and recently Vyskosil, 2008 observed in rats, that trichloroethylene affects the auditory function mainly in the cochlear mid- to high-frequency range with a lowest observed adverse effect level (LOAEL) of 2000 ppm, no studies on ototoxic interaction after combined exposure to noise and trichloroethylene were identified in humans, but in rats, supra-additive interaction was reported. Further studies with sufficient data on solvents exposure of workers, are necessary to make a definitive conclusion [12].

 The aim of this study was to verify the risk of hearing loss among a sample of the fermentation plant workers exposed to noise and as well as a mixture of organic solvents.

**Material and methods:**

This controlled study was conducted on a sample of industrial workers at a fermentation plant in 2007. The material of this study included three groups of workers. Group A consisted of 50 workers exposed to industrial noise. Group B consisted of 60 workers exposed to noise and a mixture of organic solvents (Toluene, xylene, butylacetate and ethylalcohol) in the mixing and painting sections. The exposed workers were working for 42 hours per week. The control group included 30 workers (firemen, garage workers, and workers in the power supply station). They were neither exposed to noise nor to organic solvents. The exposed and control workers were matched for age, sex (all males) and socioeconomic status.

All workers were subjected to the same questionnaire including personal, occupational, and present histories. Clinical examination followed with special stress on systolic blood pressure and hearing impairment.

Finally environmental study of noise level at work place was carried out using "Bruel and Kjaer" precision sound level meter type 2232. The necessary calibration and calculation were carried out in order to obtain an accurate weighted noise level (dB/ A). Audiometry then followed for every worker using a simple, accurate audiometric recording pure tone audiometer. The testing was carried out after 24 hours of the last exposure to overcome Temporary Threshold Shift (TTS). A 0.5 dB correction for each year above the age of 50 was made whenever needed. The characteristic V-notch in the audiogram at 4000 Hz was used as an early sign of hearing loss Harris, 1979[13].

Results were tabulated and statistical analysis of data for groups of our study using standard statistical methods was done. Our level of significance was 95 percent i.e. a p-value of 0.05 or less was considered statistically significant.

Finally, recommendations according to results of our study were suggested.

**RESULTS:**

Table 1 shows the general characteristics of the study population divided into three groups namely exposed (A and B) and control. They were all matched for age, sex (all males) and socioeconomic status. All workers did not differ in their smoking habits (p >0.001).

Table 2 shows the recording of the systolic blood pressure for all workers. They showed no statistical difference (p >0.05).

The v-notched audiograms among the exposed and control workers at 4000 Hz was shown in Table 3. The exposed group showed significant difference, from the control group. (p <0.005).

Table 4 shows the average hearing loss among the two exposed groups. The difference was statistically significant. Comparing the exposed with the control, there was a statistically significant difference Ttable 5. The noise level at the three working places was shown in table 1. It was significantly higher in the workplaces of the two exposed groups than the control one.

**DISCUSSION:**

The damage of one or more of the body systems caused by exposure to organic solvents in industry has been widely investigated. Hathout 1971 has reported mild symptoms such as headache, vertigo, fatigue and numbness in exposed workers. Severe symptoms like drowsiness, stupor and even coma have been reported [14]. The result obtained from the study done by Uzma et al., 2008 indicates that there is a significant toxic effect of solvents and air pollutants on respiratory, haematological and thyroid functioning of workers exposed for longer duration [15].

Loquet et al., 1999 [16] in addition to [Hoet and](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Hoet%20P%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus) [Lison](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Lison%20D%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus) 2008 [17] reported that combined exposure to noise and solvents showed clear potentiation of ototoxicity in experimental animals. This had initiated this study of this combination on a sample of exposed industrial workers. The exposed and control workers were matched for age, sex, socioeconomic status and smoking habits. The only variable was the industrial exposure to noise and organic solvents as environmental pollutants. Studying the systolic blood pressure for the workers under investigation showed no difference as a health hazard. This was also reported by other investigators such as Hathout, 1971 [14], Amer, 1983 [18], Manninen and Aro 1979 [19] and Hirai et al., 1991[20]. However, others have reported raised blood pressure due to prolonged exposure to noise such as Johnson and Hannson 1977 [21], Rizk et al., 1986 [22], Fogari et al., 1994 [23]and Lee et al., 2009 [24].

The V-notched audiograms was used in our study as an early sign of hearing loss, as described earlier in literature Harris, 1979 [13] among the exposed workers. At 4000 Hz a significantly higher proportion of v-notch among the exposed than the control workers (p< 0.001) was found, this is in agreement with previous reports of Amer 1983 [17] and Rizk et al., 1986 [25]. The average hearing loss was also higher significantly among group B workers compared with group A (noise and solvents exposed and noise exposed only respectively). This was in spite of the fact that noise level (dB) was almost the same in both work places, Table 4. This finding is in agreement with Quaranta et al., 2000[3], Sliwinska-Kowalska et al., 2004 [26] and Hodgkinson and Prasher, 2006 [27]. The presence of volatile organic solvents in air of the sections investigated in concentrations exceeding the maximum allowable concentrations may explain the potentiation of ototoxicity of group B workers Hathout, 1971[14]. In addition, Chang et al., 2006 [28] suggested that toluene exacerbates hearing loss in a noisy environment, with the main impact on the lower frequencies. The significant difference in hearing loss between the exposed and the control groups goes with the fact that noise level was significantly higher in the workplace of the exposed workers. The same finding was previously reported by Beshir et al., 2001[29], Ritter and Perkins, 2001[30] and Bohnker et al., 2002a [31].

 These findings confirm the assumption of the potentiation of the ototoxic health hazard of organic solvents in exposed industrial workers. Effective intervention is needed to improve industrial safety of individuals experiencing ototoxic effects of solvents. However, more research is required to verify the mechanism of action of the two pollutants namely noise and organic solvents and exposed workers in an Egyptian industry.

**REFERENCES:**

1. WHO 1980: Noise Environmental Health Criteria No 12.
2. Wilson DH, Walsh PG, SanchezL, Davis AC, Taylor AW, Tucker G, Meagher I 1999: The epidemiology of hearing impairement in an Australian adult population. Int. J Epidemiol. 28: 247-252.
3. Quaranta A, Sallustio V and Quaranta N 2000: Noise induced hearing loss; summary and perspectives. NOPHER 7-10 july 2000 U.K; p.54.
4. Lynge E, Antilla A, Hemminki K, 1997: Organic Solvents and Cancer. Cancer causes Control; 8(3): 406-19.
5. Fuente A, McPherson B, 2006: Organic solvents and hearing loss; the challenge for audiology. Int. J Audiology. 2006; 45(7): 367-81.
6. Matsuoka M, 2007: Neurotoxicity of Organic Solvents-recent findings. Brain nerve, 59(6): 591-6.
7. Ebbehoj N e, Hein HO, Suadicani P, Gyntelberg F, 2008: ccupational organic solvent exposure, smoking, and prevelance of chronic bronchitis – an epidemiological study of 3387 men.
8. Herpin G, Gargouri I, Gauchard GS, Nisse C, Khadrhraoui M, Elleuch B, Zmirou-Navier D, Perrin PP, 2009: Effect of chronic exposure and subchronic organic solvents exposure on balance control of workers in plant manufacturing adhesive materials. Neurotox Res. ; 15(2)179-86.
9. Hunter, D 1979: The diseases of occupations, 5 th edition, p 541, p 544 and p 832.
10. Kowalska MS, Fiszer M and Szymez W. 2000: Risks of industrial hearing loss in workers exposed to organic solvents. NOPHER 2000 U.K
11. Johnson AC 1993: The ototoxic effect of toluene and the influence of noise, acetyl salicylic acid or genotype. A study in rats and mice. Scand Audiol Suppl.; 39:1-40.
12. Vyskocil A, Leroux T, Truchon G, Lemay F, Gendron M, Gagnon F, El Magidi N, Viau C. 2008: Ethyl Benzene should be considered ototoxic at occupationally relevant exposure concentrations.
13. Harris,CM 1979: Hand book of noise control. 2nd edition, 15-33.
14. Hathout, SM 1971:The toxic effects of solvents, MDThesis, chapter 1. p 15
15. Uzma N, Salar BM, Kumar BS, Aziz N, David MA, Reddy VD. 2008: Impact of organic solvents and environmental pollutants on the physiological function in petrol filling workers. Int J Environ Res. Public Health; 5(3) 139-46.
16. Loquet B, Campo P and Lataye R 1999: Comparison of Toluene induced and Styrene induced hearing losses. Neurotox. Teratol. 21(6); 698-97.
17. [Hoet P](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Hoet%20P%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus), [Lison D](http://www.ncbi.nlm.nih.gov/sites/entrez?Db=pubmed&Cmd=Search&Term=%22Lison%20D%22%5BAuthor%5D&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_DiscoveryPanel.Pubmed_RVAbstractPlus) 2008: Ototoxicity of toluene and styrene: state of current knowledge. Crit Rev Toxicol; 38(2):127-70.
18. Amer NM 1983: Effects of exposure to noise on hearing. MD Thesis, Cairo University.
19. Manninen, O and ARO, S 1979: Noise induced hearing loss and blood pressure. Intern.Arch. of occup. and environmental health, 42, 251-256.
20. Hirai A,TaKata M, Mikawa M, Yasumuto K, Iida H, Sasayama S, Kagamimori S, 1991: Prolonged exposure to industrial noise causes hearing loss but not high blood pressure: a study of 2124 factory laborers in Japan. J Hypertens; 9 (11): 1069-73.
21. Johnson, A and Hannson, L 1977: Prolonged exposure to a stressful stimulus (noise as a cause of raised blood pressure in man); Occupational Health, 1574.
22. Rizk SA and Singh KP 1986: Hearing loss and systolic blood pressure level among a sample of agriculture workers. Med. J. Cairo University; (54),4, 379-84.
23. Fogari R, zoppi A, Vansia A, Marasi G, Villa G, 1994: Occupational noise exposure and blood pressure. J. Hypertens; 12 (4): 475-9.
24. Lee JH, Kang W, Yaang SR, Choy N, Lee CR, 2009: Cohort study for the effect of chronic noise exposure on blood pressure among male workers in Busan, Korea.Am J Ind Med.
25. Rizk SA and Sharkawy AI and Hegazy N 1986: Impact of aircraft noise on residents around Cairo international airport. Med. J. Cairo Univ.; (54) 2, 603-8
26. Sliwinska-Kowalska M, Zamyslowska-Szmytke E, Szymczak W, Kotylo P, Fiszer M, Wesolowski W, et al. 2004. Effects of exposure to noise and mixture of organic solvents on hearing in dockyard workers. J Occup Environ Med 46: 30–3
27. Hodgkinson L, Prasher D 2006: Effects of industrial solvents on hearing and balance: a review. Noise Health; 8(32): 114-33.
28. Chang SJ, Chen CJ, Lien CH and Sung FC, 2006: Hearing Loss in Workers Exposed to Toluene and Noise**.** Environ Health Perspect 114:1283–1286.
29. Beshir et al., 2001: Some Health effects of noise with special reference to smoking as an additional risk factor; Egyp.I. of occupational medicine, 25(2) 155-73.
30. Ritter DC, Perkins JL, 2001: Noise inducing hearing loss among US air force cryptolinguists. Aviat space Environ. Med; 72(6): 546-552.
31. Bohnker BK, Page JC, Rovig G, Betts LS, MullerJG, Sack DM, 2002a: US Navy and Marine Corps Hearing Conservation Program: mean hearing thresholds for enlisted personnel by gender and age group. Mil. Med 167(2):132-135.

**TABLE 1:** General characteristics of workers under study

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Exposure Group | Control group | *p- value* |
| Age (years)Mean ± SDSmokingSmokers (%)Noise LeveldB / A | Group ANoise only*n= 50*28.0±7.160107.5 | Group Bnoise / organic solvents*n= 60*30.2±4.953.3105.5 | Group C*n= 30*31.3±5.646.654.0 | >0.001>0.001<0.001 |

**TABLE 2:** Systolic blood pressure of the exposure groups (group A and group B) and the control group

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Exposure Groups | Control group | *p- value* |
| Systolic blood pressureMean ± SD | Group ANoise only*n= 50*134.0±7.3 | Group Bnoise / organic solvents*n= 60*133.6±7.2 | Group C*n= 30*130.2± 6.7 | >0.05 |

**TABLE 3:** V-notched audiograms among the exposure and the control groups (at 4000 Hz)

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Exposure GroupGroup A and group B*n=110* | Control GroupGroup C*n= 30* | *p- value* |
| v-notchn% | 4036.6 | 13.3 | <0.001 |

**TABLE 4**: Comparison between the average hearing loss in the exposure groups i.e. Group A (noise only) and Group B(noise/ organic solvents)

|  |  |  |
| --- | --- | --- |
| Variable | Exposure Group | *p- value* |
| Hearing lossMean±SD | Group Anoise only*n= 50*18.2±4.2 | Group Bnoise / organic solvents*n= 60*24.2±9.8 | < 0.05 |

**TABLE 5**: Comparison between the average hearing loss in the exposure groups i.e. Group A (noise only) and Group B(noise/ organic solvents) with the control group.

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Exposure Group | Control group | *p- value* |
| Hearing lossMean ± SD | Group ANoise only*n= 50*18.2±4.2 | Group Bnoise / organic solvents*n= 60*24.2±9.8 | Group C*n= 30*11.4±3.0 | < 0.05 |