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ASSESSMENT OF AUDITORY FUNCTIONS IN WORKERS EXPOSED TO STYRENE

By

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Abstract

Introduction: Ototoxicity is commonly medication-induced; however, there are increasing scientific data indicating that exposure to some industrial solvents and chemicals, including styrene, are associated with a risk of auditory impairment in humans. Many studies reported auditory system effects and poorer audiometric thresholds in styrene exposed individuals. **Aim of work:** The aim of the current study is to investigate the relationship between workers exposed to styrene in fibreglass reinforced plastic manufacturing and hearing threshold changes. **Materials and Methods:** All workers who met the inclusion criteria and agreed to participate in the study were 20 males. A control group of 24 individuals were randomly selected as to be matched with the exposed group. Full medical history was taken including personal, occupational, present, past and family histories. Pure-tone audiometry was done to the studied groups using portable audiogram device. **Results:** The prevalence of hearing impairment was higher among styrene-exposed group when compared to the non-exposed group; however, difference was not statistically significant. Different degrees of hearing impairment were found among the exposed group (mild, moderate and severe), whereas only a mild degree of hearing impairment was detected among the control group. In addition, there was no significant difference between exposed and non-exposed groups concerning hearing thresholds at all tested frequencies of audiometry in both ears. **Conclusion:** The results of this study did not support the assumption that occupational exposure to styrene is related to a significant decrease in hearing acuity.

Keywords: Audiometry, Styrene, Fibreglass, Audiogram and Hearing impairment.

Introduction

Styrene is an aromatic solvent belonging to the alkyl benzene family (Johnson, 2007). Styrene, as a precursor for polystyrene plastics, has a commercially significant importance in the manufacturing of products including insulation, fiberglass, pipes, automobile and boat parts, food containers, and reinforcement of the back of carpets (Boffetta et al., 2009).

Occupational exposure to styrene occurs mainly in the manufacture of fiberglass-reinforced polyester products, e.g. reinforced plastics and composites (Johnson, 2007).

Exposure routes for styrene include inhalation, skin absorption, ingestion, and/or eye contact (Phleban et al., 2017).

Styrene has been investigated in several human studies for the relationship of its occupational exposure to hearing loss (Johnson, 2007). Triebig et al. (2009) reported an increase in hearing thresholds at chronic and intense styrene exposure, with improvements in hearing thresholds during exposure-free periods. They also reported that the group exposed to high-long levels demonstrated stronger recovery during the holiday period.

On the other hand, Lawton et al. (2006) analysed seven cross-sectional studies with respect to hearing thresholds and concluded that hearing deficits due to occupational exposure to styrene at low concentrations have not been demonstrated by scientifically reliable argument and that further research is needed to investigate such relationship.Some studies done on the potential effect of styrene exposures on hearing loss in humans at workplaces had equivocal results (Hoffmann et al., 2006).

Aim of work

The aim of the current study is to investigate the relationship between workers exposed to styrene in fibreglass reinforced plastic manufacturing and hearing threshold changes.

Materials and Methods

Study Design: A cross-sectional comparative study.

Place and duration of the study: This study was carried out in a fibreglass manufacturing facility in Helwan city,

Cairo Governoate, Egypt, during the period from December 2016 to April 2017.

Study sample: The total number of exposed workers was 30 males. Workers who met the inclusion criteria were 24. Workers who agreed to participate in the study were 20, with a mean age of 50.9±6.8 years. Inclusion criteria for exposed group were exposure to styrene during fibreglass manufacturing for more than one year. Workers used styrene as an adhesive material for fibreglass in the production of reinforced plastics. They have been exposed to styrene for 8 hours per day, 5 days per week (with no rotation, special breaks or personal protective equipments) for a mean duration of 22.25±9.8 years.

Exclusion criteria included the exposure to noise or ototoxic drugs (e.g. acetyl salicylic acid and aminoglycosides) or substances (e.g. solvents such as toluene, xylenes, ethylbenzenes, chlorobenzene, trichloroethylene, n-hexane, n-heptane and carbon disulphide, metals such as lead and mercury, as well as pesticides) from other jobs outside the factory if any. Exclusion criteria for both groups also included the presence of ear diseases or hearing affection due to congenital anomalies, infections, tumours or trauma. Six workers were excluded according to these criteria.

The control group included 24 males with a mean age of 41.8±16.4 years. individuals were randomly selected to be matched with the exposed group as regards age, gender, and special habits of medical importance. They were workers coming to the occupational diseases clinic of Health Insurance in Helwan. They all had no history of exposure to noise at work and they gave no history of exposure to ototoxic drugs or chemicals.

Study methods:

- **Predesigned questionnaire**: history was taken by the authors using a predesigned questionnaire including age, sex, special habits, present, past, family and occupational histories.
- **Clinical examination:** Ear examination was done to exclude any external ear problems.
- **Audiometry measurement:** Pure-tone audiometry was done by the

authors to the studied groups using portable audiogram device.

Hearing impairment was defined as hearing threshold at or above 25 dB in one or more of the frequencies 500Hz, 1000Hz, 2000Hz, 3000Hz, 4000Hz, 6000Hz and 8000Hz (Rosowski et al., 2012). Hearing impairment was classified as mild (hearing threshold 25-40 dB), moderate (hearing threshold 41-60 dB), severe (hearing threshold 61-80 dB) and profound (hearing threshold over 80 dB) (Mathers et al., 2005).

Consent

An informed verbal consent was taken from subjects who agreed to participate in the study before the start of work with assurance of confidentiality and anonymity of data.

Ethical approval

Approvals of the administrative authority of the factory and the Health Insurance hospital were obtained. The study protocol was approved by the Ethical Committee of the Department of Occupational and Environmental Medicine, Faculty of Medicine, Cairo University.

Data management

The data was coded and entered using the statistical package SPSS version 20. Statistical differences between groups were tested using Chi Square test for qualitative variables and non-parametric Mann-Whitney test for quantitative variables. Correlations were done to test for linear relations between variables. p-values ≤ 0.05 were considered statistically significant. The following abbreviations are used to describe statistics of the present work: $\chi 2$ = Chi-Square, Z = Z-value of Mann-Whitney test, p = Probability, r = Correlation Coefficient.

Results

Table (1): Comparison between exposed and non-exposed groups as regards hearing impairment.

Groups		Frequency	Percent
Exposed (No=20)	NO	9	45.0
	Yes	11	55.0
Non-exposed (No =24)	NO	17	70.8
	Yes	7	29.2
Pearson Chi-Square (with Yates' Continuity Correction)	**$\chi 2$**		**Asymptomatic significance (2-sided) p**
	2.04		.153

Table (1) showed that the prevalence of hearing impairment was higher among exposed compared to control groups. A chi-square test for independence (with Yates' Continuity Correction) indicated that the difference was not statistically significant ($\chi 2$= 2.04, p=.153).

Table (2): Comparison between exposed and non-exposed groups as regards the degree of hearing impairment.

Groups		Frequency	Percent
Exposed	**Mild**	6	54.5
	Moderate	3	27.3
	Severe	2	8.2
Non-exposed	**Mild**	7	100
Pearson Chi-Square	**χ^2**		**Asymptomatic significance (2-sided) p**
	7.23		.065

Table (2) showed that different degrees of hearing impairment were found among the exposed group (mild, moderate and severe), whereas only a mild degree was detected among the control group. However, the difference was not statistically significant, χ^2= 7.23, p=.065.

Table (3): Comparison between exposed and non-exposed groups as regards Average Pure Tone Audiometry Hearing Threshold (in dB)

Frequency	Exposed		Non-Exposed		Mann-Whitney U	p
	Mean Rank	Mean±SD	Mean Rank	Mean±SD		
500 Hz	23.3	25.3±8.0	21.8	22.3±3.5	224	.68
1000Hz	20.9	22.3±4.7	23.8	21.7±2.7	272	.38
2000Hz	25.5	21.5±2.3	18.9	20.8±2.8	312	.07
3000Hz	22.1	22.0±3.9	22.8	21.6±2.6	248	.81
4000Hz	23.1	24.1±8.2	22	21.5±2.5	227	.73
6000Hz	25.1	27.9±13.6	20.3	21.9±3.0	188	.18
8000Hz	21.4	25.4±12.3	23.4	22.8±3.9	262	.55

Table (3) showed that hearing threshold levels were higher among exposed workers compared to non-exposed; however no statistically significant differences were found.

Table (4): Average Pure Tone Audiometry Hearing Threshold relationship with age and duration of exposure

Frequency (Hz)	Age		Duration of exposure	
	Correlation coefficient (r_s)	p	Correlation coefficient (r_s)	p
500	.183	.234	-.047	.763
1000	.021	.893	-.117	.448
2000	.034	.824	-.283	.063
3000	.033	.830	.026	.867
4000	.012	.937	.074	.635
6000	.055	.725	.222	.148
8000	-.077	.620	-.108	.486

Using Spearman's rank-order correlation in table (4), no significant correlations was found between age or duration of exposure and the threshold of hearing at all examined frequencies.

Discussion

Occupational exposure to noise has long been recognized to have the most deleterious work-related effect on hearing (Daniell et al., 2006). The impact of chemical-induced hearing affection, however, should not be underestimated (Morata, 2003). Styrene, one of the most widely used aromatic solvents in industry, has been the focus of many studies for its effect on hearing (Campo et al., 2013).

The aim of this work was to investigate the prevalence of hearing impairment among workers exposed to styrene in fibreglass industry and to compare it to that in a socioeconomically-matched non-exposed group.

In the current work, the prevalence of hearing impairment was higher among the exposed group (55%) compared to the non-exposed group (29.2%), though not reaching the statistically significant level (Table 1). Moreover, the severity of hearing impairment was also higher among the exposed group where 54.5% of workers had mild hearing impairment, 27.3% had moderate hearing impairment and 8.2% had severe hearing impairment. On the other hand, only mild degree of hearing impairment was found among the non-exposed group (Table2). Average hearing thresholds at different audiometric frequencies were mostly higher among the exposed group than the non-exposed group but also not to a statistically significant level (Table 3).

The results of the current work were in agreement with the results obtained by Fuente et al., 2013 who studied self-reported hearing performance among workers exposed to a mixture of solvents in paint making factories. These solvents included toluene, xylene, methyl ethyl ketone, and Stoddard solvent (turpentine). They found that 10% of solvent-exposed subjects showed abnormal audiograms as compared with 4% of non-exposed control subjects, yet the difference was, also, not statistically significant.

The results were also in partial agreement with Kowalska et al., 2003 who studied the ototoxic effects of occupational exposure to styrene and co-exposure to styrene and noise and found that the mean hearing thresholds were significantly higher in the styrene-exposed group than in the unexposed

reference group at all frequencies tested. Triebig et al, 2009, in their study on occupational styrene exposure and hearing impairment, also reported an increase in hearing thresholds with styrene exposure.

On the other hand Marioka et al., 2000 and Hoffmann et al, 2006, who explored possible effects of styrene on auditory functions, detected no effect of styrene exposure on audiometric testing. The later attributed that the small sample size of the study group, which is also a limitation of our study that might explain the lack of statistical significance of audiometric testing of the exposed group, when compared to the non-exposed.

In the current work, no significant correlation was found between duration of exposure and the threshold of hearing at all examined frequencies (Table 4). This was partly consistent with the results declared by Hoffmann et al., 2006 who reported that concerning the duration of styrene exposure; there was only one positive significant association with the hearing level at the frequency of 1 kHz, whereas correlation with other frequencies was statistically not significant.

On contrary, Triebig et al, 2009, in their study on occupational styrene exposure and hearing impairment, reported an increase in hearing thresholds at chronic and intense styrene exposure, with improvement in hearing thresholds during exposure-free periods. Also Kowalska et al., 2003 found a positive linear relationship existed between an averaged working life exposure to styrene concentration and a hearing threshold at the frequencies of 6 and 8 kHz.

Concerning the correlation between age and hearing thresholds, no significant correlation was found in the current study (Table 4). On contrary, Triebig et al., 2009 found a significant negative correlation between age and hearing thresholds at all measured frequencies. They stated that the dominant impact of age on the thresholds is obvious and decreases corresponding to the frequency ranges analysed. In agreement with this study, Fuente et al., 2013 found that the differences between styrene-exposed and non-exposed subjects may become more pronounced at older ages when the adverse effects of solvents on the

auditory system interact with peripheral and central auditory changes related to aging.

Conclusion and Recommendations

The results of the current work showed a higher prevalence of hearing impairment (and its severity) among the exposed compared to non-exposed group. However, this difference did not reach a statistically significant level, which might be attributed to the small sample size in our study. Therefore, more research on a larger sample size is recommended to further assess the risk of styrene exposure on hearing.

Conflict of interests

There were no conflicts of interests.

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References

1. Boffetta P, Adami HO, Cole P, Trichopoulos D and Mandel JS (2009): Epidemiologic studies of styrene and cancer: A review of the literature. J Occup Environ Med; 51: 1275-87.
2. Daniell W, Swan S, McDaniel M, Camp J, Cohen M, et al. (2006): Noise exposure and hearing loss prevention programmes after 20 years of regulations in the US. J Occup Environ Med; 63: 343–51.
3. Fuente A, McPherson B and Hormazabal X (2013): Self-reported hearing performance in workers exposed to solvents. Rev Saúde Pública; 47(1): 86-93.
4. Hoffmann J, Ihrig A, Hoth S and Triebig G (2006): Field study to explore possible effects of styrene on auditory function in exposed workers. Ind Health; 44: 283-6.
5. Johnson AC (2007): Relationship between styrene exposure and hearing loss: review of human studies. Int J Occup Med Environ Health; 20 (4): 315-25.
6. Kowalska SM, Szmytke ZE, Szymczak W, Kotyło P, Fiszer M, et al. (2003): Ototoxic effects of occupational exposure to styrene and co-exposure to styrene and noise. J Occup Environ Med; 45(1): 15–24.
7. Lawton BW, Hoffmann J and Triebig G (2006): The ototoxicity of styrene: a review of occupational investigations. Int Arch Occup Environ Health 79: 93-102.
8. Mathers C, Smith A and Concha M (2005): Global burden of hearing loss in the year 2000 Geneva, World Health Organization, 2005 (http://www who int/healthinfo/statistics/bod_ hearingloss pdf, accessed 20 January 2018).
9. Morata T (2003): Chemical exposure as a risk factor for hearing loss. J Occup Environ Med; 45: 676–82.
10. Pleban FT, Oketope O and Shrestha L (2017): Occupational Styrene Exposure on Auditory Function among Adults: A Systematic Review of Selected Workers. Saf Health Work; 8: 329-36.
11. Rosowski JJ, Nakajima HH, Hamade MA, Mafoud L, Merchant GR, et al. (2012): Ear-Canal Reflectance, Umbo Velocity and Tympanometry in Normal Hearing Adults. Ear Hear; 33(1): 19–34.
12. Triebig G, Bruckner T and Seeber A (2009): Occupational styrene exposure and hearing loss: a cohort study with repeated measurements. Int Arch Occup Environ Health; 82: 463-80.